United States Environmental Protection Agency
Office of Toxic Substances (TS-778)
EPA/560/2-91-002
September 1991

EPA

Carpet Policy Dialogue

Compendium Report
September 27, 1991

CARPET POLICY DIALOGUE

Compendium Report

September 27, 1991

Prepared for:

Office of Toxic Substances
U.S. Environmental Protection Agency
Washington, D.C. 20460

Prepared by:

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ACKNOWLEDGEMENTS

September 27, 1991

As the Carpet Policy Dialogue comes to a close, I would like to take this opportunity to express my sincere appreciation to the members of the Carpet Policy Dialogue, the working Subgroups, and the project staff for their dedication to this year-long effort.

The Carpet Policy Dialogue has been a major initiative for the Office of Toxic Substances. It provided a first opportunity to apply pollution prevention principles to an issue concerning indoor air. The Dialogue process itself represented a new approach to problem resolution for the Office. The full and active participation by all members of the Dialogue was essential to achieving success with this project.

The basis for success in a Dialogue is measured by the willingness of all participants to find common objectives and then for the dialogue Group to encompass these points into voluntary actions for the public interest. I am aware that participation in the Carpet Policy Dialogue necessitated considerable focus of energy, thought, time, and resources. The Dialogue process involved listening to and sharing of views and ideas, and I greatly appreciate the willingness of all participants to work productively and cooperatively in this effort with Dialogue members who shared diverse viewpoints.

I would like to assure that the Environmental Protection Agency is committed to follow through on the recommendations of the Carpet Policy Dialogue. The actions set in place through the testing and reporting programs recommended by the Dialogue and implemented via a series of Memoranda of Understanding between EPA and the affected industries provide a viable and effective basis for the Agency to meet the objectives outlined in the April 24, 1990, Federal Register notice.

Thanks to all those who participated in helping the Environmental Protection Agency achieve notable progress on the issue of TVOC emissions from carpet floor covering products.

Sincerely,

Charles M. Auer
Director, Existing Chemicals Assessment Division

TABLE OF CONTENTS

Page

Foreword i

Executive Summary iii

1.0. Chapter 1: Carpet Policy Dialogue Plenary Report 1-1

1.1. Introduction 1-1

1.1.1. Background 1-1
1.1.2. Implementation of the Carpet Policy Dialogue 1-2
1.1.3. Structural Organization 1-3
1.1.4. Nature of Dialogue Consensus Statements and Voluntary Actions 1-3
1.1.5. Dialogue Discussions 1-4
1.1.5.1. Health Concerns 1-5
1.1.5.2. Proprietary or Confidential Information 1-6
1.1.5.3. TVOC Data and Chemical Speciation 1-6

1.2. Summary of the Subgroup Activities 1-7

1.2.1. Product Testing Subgroup 1-8
1.2.2. Process Engineering Subgroup 1-9
1.2.3. Public Communications Subgroup 1-10

1.3. Carpet Related Activities 1-11

1.3.1. Styrene Butadiene Latex Manufacturers 1-11
1.3.2. Carpet Manufacturers 1-12
1.3.3. Carpet Cushion Manufacturers 1-12
1.3.4. Adhesive Manufacturers 1-13
1.3.5. Consumer Product Safety Commission 1-13
1.3.6. EPA Carpet Installation Study 1-13
1.3.7. Floor Covering Installation Contractors Association 1-14
1.3.8. Collaborative Research 1-14
1.3.9. General Services Administration 1-14
1.3.10. Environmental Protection Agency and General Services Administration 1-15

1.4. Future Considerations 1-15

1.5. Summary 1-17

TABLE OF CONTENTS

Page

2.0. Chapter 2: Product Testing Subgroup: Methods and Accomplishments 2-1

2.1. Introduction 2-1

2.2. Test Method Development 2-1

2.2.1. Total Volatile Organic Compounds 2-2
2.2.2. Evaluation of Alternative Test Methods 2-2
2.2.2.1. Quality Control/Internal Processing Test Methods 2-3
2.2.2.2. Method Elements and Test Parameters 2-3
2.2.3. Standard Test Method 2-4

2.3. Consensus on Voluntary Testing Agreements 2-5

2.3.1. Carpet Testing Program 2-6
2.3.2. Carpet Cushion Testing Program 2-8
2.3.3. Carpet Installation Adhesive Testing Program 2-10

3.0. Chapter 3: Process Engineering Subgroup Summary Report 3-1

3.1. Introduction 3-1

3.1.1. Background 3-1
3.1.2. Charter and Charge of Dialogue 3-1
3.1.3. Dialogue Defined 3-2
3.1.4. Process Engineering Subgroup 3-3
3.1.4.1. Scope of Subgroup Activities 3-3
3.1.4.2. Organization and Operational Structure 3-3
3.1.4.3. Process Engineering Subgroup Proceedings 3-4
3.1.4.4. Purpose of This Chapter 3-8

3.2. Styrene Butadiene Latex Manufacturing 3-8

3.2.1. Process Description 3-8
3.2.2. VOC Reductions Already Achieved 3-13
3.2.3. Potential VOC Reduction Mechanisms 3-15
3.2.4. Process Engineering Subgroup Proceedings 3-18
3.2.5. Information and Research Considerations 3-19
3.2.6. Subgroup Recommendations to Plenary 3-20

TABLE OF CONTENTS

Page

3.3. Adhesives Manufacturing/Formulation 3-20

3.3.1. Overview of Carpet Adhesives and Formulation Process 3-20
3.3.1.1. Adhesive Properties 3-20
3.3.1.2. Types of Adhesives 3-21
3.3.1.3. Raw Materials and Formulation 3-22
3.3.2. Use of Adhesives During Carpet Installation 3-24
3.3.2.1. Multipurpose Adhesives 3-24
3.3.2.2. Pressure-Sensitive Adhesive 3-26
3.3.3. VOC Reductions Already Achieved 3-26
3.3.4. Potential VOC Reduction Methods 3-28
3.3.5. Process Engineering Subgroup Proceedings 3-31
3.3.6. Information and Research Considerations 3-31
3.3.7. Subgroup Recommendation to Plenary 3-32

3.4. Carpet Cushion Manufacturing Process Description 3-32

3.4.1. Process Description 3-32
3.4.1.1. Prime Urethane Foam Carpet Cushion 3-33
3.4.1.2. Bonded Urethane Carpet Cushion 3-38
3.4.1.3. Cellular Sponge Rubber Carpet Cushion 3-41
3.4.1.4. Rubberized Jute Carpet Cushion 3-43
3.4.1.5. Synthetic Fiber Carpet Cushion 3-44
3.4.2. VOC Reductions Already Achieved 3-45
3.4.3. Potential VOC Reduction Methods 3-46
3.4.4. Process Engineering Subgroup Proceedings 3-46
3.4.5. Information and Research Considerations 3-47
3.4.6. Subgroup Recommendations to Plenary 3-48

3.5. Carpet Manufacturing 3-49

3.5.1. Process Description 3-49
3.5.1.1. Carpet Face Fiber 3-49
3.5.1.2. Carpet Yarn Manufacturing 3-51
3.5.1.3. Carpet Coloration 3-51
3.5.1.4. Carpet Formation 3-65
3.5.1.5. Carpet Finishing 3-73
3.5.1.6. Stain Resist Technology for Nylon 3-79
3.5.1.7. Soil Release 3-82

TABLE OF CONTENTS

Page

3.5.2. VOC Reductions Already Achieved 3-85
3.5.3. Dr. Van Ert's Laboratory-Scale Study 3-85
3.5.4. Industry-Sponsored Plant-Scale Study 3-87
3.5.5. Process Engineering Subgroup Proceedings 3-88
3.5.6. Information and Research Considerations 3-89
3.5.7. Subgroup Recommendations to Plenary 3-89

3.6. Carpet Installation/Ventilation 3-89

3.6.1. Introduction 3-89
3.6.2. The Scope of Existing Guidelines for Installation 3-90
3.6.3. An Overview of the Installation Process 3-90
3.6.4. Training, Education, and Certification Programs 3-92
3.6.5. Specific Guidelines Which May Impact VOC Exposures 3-93
3.6.6. Practical Experience in Compliance With Installation Guidelines 3-94
3.6.7. Effects of Ventilation During Carpet Installation on VOC Emissions . . 3-95
3.6.7.1. Indoor Air Quality 3-95
3.6.7.2. Ventilation in Office Buildings 3-95
3.6.7.3. Effects of Ventilation Rates on Indoor Air Concentrations of 4-Phenylcyclohexene from Carpet Emissions 3-102
3.6.7.4. General Concepts of Physical Processes Affecting VOC Carpet Emissions 3-105
3.6.7.5. Practical Control Strategies for Carpet System VOC Emissions and Residual Indoor Air Concentrations 3-105
3.6.8. Process Engineering Subgroup Proceedings 3-109
3.6.9. Research Consideration 3-110
3.6.10. Subgroup Recommendations to Plenary 3-110

4.0. Chapter 4: Public Communications Subgroup Report 4-1

4.1. Introduction 4-1

4.2. Scope of Work 4-1

4.2.1. Setting Goals 4-2
4.2.2. Operating Procedures 4-3
4.2.3. Principles Governing Dialogue Communication Activities 4-3
4.2.4. Discussion Topics 4-4

TABLE OF CONTENTS

Page

4.3. Communications Planning 4-6

4.3.1. Step 1: Situation Analysis 4-6
4.3.2. Step 2: Set Objectives 4-8
4.3.3. Step 3: Identify Target Audiences 4-8
4.3.4. Step 4: Identify Issues and Concerns 4-9
4.3.5. Step 5: Develop Messages 4-9
4.3.6. Step 6: Establish Strategy 4-9
4.3.7. Step 7: Select Media/products 4-10
4.3.8. Step 8: Determine Budget 4-10
4.3.9. Step 9: Set Time Table to Implement Plan 4-10
4.3.10. Step 10: Evaluate Results 4-10

4.4. Public Communication Outreach Products 4-11

4.4.1. Interim Progress Report 4-13
4.4.2. Executive Summary 4-14
4.4.3. Public Information Brochure 4-15
4.4.4. Compendium Report 4-19

5.0. References 5-1

TABLE OF CONTENTS

Appendix A. List of Carpet Policy Dialogue Participants

Appendix B. Federal Register, Vol. 55. No. 79; Part VII, Environmental Protection Agency, Carpet Response to Citizens' Petition; Notice

Appendix C. Federal Register, Vol. 55, No. 130; Carpet Emissions Reduction; Policy Dialogue

Appendix D. Schedule of Carpet Policy Dialogue Meetings

Appendix E. Test Method for Determining Total Volatile Organic Compound Emission Factors from Carpet Under Defined Test Conditions Using Small Environmental Chambers

Attachment E-1. Annex

Appendix F. Carpet and Rug Institute Consensus Statement: Testing Program for Carpet Products

Attachment F-1. The Carpet and Rug Institute Consensus Statement: Carpet Emissions Decay Study

Attachment F-2. Minority Report on Carpet Testing Agreement

Appendix G. Carpet Cushion Council Consensus Statement: Testing Program for Carpet Cushions

Appendix H. Floor Covering Adhesive Manufacturers Committee Consensus Statement: Testing Program for Carpet Installation Adhesives

Appendix I. Memorandum of Understanding Between the Carpet and Rug Institute and the U.S. Environmental Protection Agency

Attachment I-1. Federal Register: Carpet Policy Dialogue; Memorandum of Understanding: Testing Program for Carpet Products and Receipt of the Carpet Policy Dialogue Interim Progress Report

TABLE OF CONTENTS

Appendix J. Memorandum of Understanding Between the Carpet Cushion Council and the U.S. Environmental Protection Agency

Attachment J-1. Federal Register: Carpet Policy Dialogue; Memorandum of Understanding: Testing Program for Carpet Cushion Products

Appendix K. Memorandum of Understanding Between the Floor Covering Adhesive Manufacturers Committee and the U.S. Environmental Protection Agency

Attachment K-1. Federal Register: Carpet Policy Dialogue; Memorandum of Understanding: Testing Program for Carpet Installation Adhesives

Appendix L. Memorandum of Understanding Between the Styrene Butadiene Latex Manufacturers' Council and the U.S. Environmental Protection Agency

Attachment L-1 Quantitation of 4-Phenylcyclohexene in Styrene Butadiene Latex

Attachment L-2 Federal Register: Carpet Policy Dialogue; Memorandum of Understanding: SBLMC Reporting Program for 4-PC

Appendix M. Final Text of Public Information Brochure: "Indoor Air Quality and New Carpet, What You Should Know"

Appendix N. Final Report: "Investigating the Impact of Various Cure Parameters on the Release of 4-Phenylcyclohexene (4-PCH) from Carpet Backed with Compounds Based on Carboxylated SBR Latex"

Attachment N-1 Preparation of Carpet Backed with Styrene Butadiene Rubber Latex

Appendix O. Effects of Selected Process Parameters on Emission Rates of TVOC From Carpet

Appendix P. CRI Commercial Carpet Installation Standard

Appendix Q. CRI Residential Carpet Installation Standard

Appendix R. Indoor Air Quality Evaluation of Carpet for the Carpet and Rug Institute

LIST OF TABLES

Page

Table 3-1. Technical Presentations Made to the Process Engineering Subgroup . . . 3-5

Table 3-2. U.S. Companies Producing SB Latex 3-11

Table 3-3. Adhesive Components and Associated VOC Range 3-25

Table 3-4. Prime Urethane Foam Carpet Cushion Components and Typical Raw Materials 3-34

Table 3-5. Raw Materials of Carpet Cushion--Ranked in Order of Use 3-39

Table 3-6. TVOC and 4-Phenylcyclohexene 24-Hour Emission Rates of New Carpet 3-86

Table 4-1. Tentative List of Discussion Topics for the Public Communication Subgroup 4-5

Table 4-2. Potential Public Communications Outreach Products 4-12

Table 4-3. List of Organizations That Agreed to Be Listed on the Brochure 4-18

LIST OF FIGURES

Page

Figure 3-1. Flowchart of the SBL Process 3-12

Figure 3-2. 4-Phenylcyclohexene Reduction History 3-14

Figure 3-3. VOC Range of Multi-Purpose Adhesives 3-29

Figure 3-4. VOC Range of Pressure Sensitive Adhesives 3-30

Figure 3-5. Flexible PUR Slabstock Process Line 3-37

Figure 3-6. Model of Simplified Loom 3-72

Figure 3-7. General Structure of Stain Resist Agents 3-80

Figure 3-8. Ventilation Rates and Indoor Air VOC Concentration 3-96

Figure 3-9. Flow Diagram of a Typical Building Ventilation System 3-97

Figure 3-10. Air Exchange Rates in the Portland East Federal Office Building . . . 3-99

Figure 3-11. Summary of Air Exchange Rates in Buildings Studies by NIST 3-100

Figure 3-12. Distribution of Air Exchange Rates in Buildings Studied by NIST . . . 3-101

Figure 3-13. Effect of Air Exchange Rate (Outside Air) 3-103

Figure 3-14. Effect of Airing Out Prior to Installation 3-104

Figure 3-15. Temperature and Vapor Pressure Relationship for Three Compounds . 3-106

Figure 3-16. Evaporation Under Equilibrium Conditions 3-107

Figure 3-17. Accelerated Evaporation in the Presence of Increased Contact Air Velocity 3-108

Figure 4-1. Communications Planning Process 4-7

EPA FOREWORD

The Carpet Policy Dialogue, convened by the U.S. Environmental Protection Agency,[1] was engaged in a 1-year effort to develop consensus and voluntary commitments with respect to approaches for minimizing exposure to volatile organic compounds (VOCs) emitted by carpet, carpet cushion, and carpet floor covering installation adhesives (FR: April 24, 1990 - "Carpet: Response to Citizens' Petition" p.17404-17409; and, FR: August 3, 1990 - "Carpet Emissions Reduction; Policy Dialogue" p.31640-34641).

This document conveys the Compendium Report of the Carpet Policy Dialogue Plenary regarding activities of the Carpet Policy Dialogue from August 21, 1990, through September 27, 1991. The report is an assembly of the various products and materials developed by the three working Subgroups of the Carpet Policy Dialogue (Product Testing, Process Engineering, and Public Communications). It is a summary document encapsulating the considerations, deliberations, accomplishments, conclusions, and recommendations reached by the Carpet Policy Dialogue and its various Subgroups during the Dialogue year. This report was a product of the Public Communications Subgroup of the Carpet Policy Dialogue. It has been reviewed by the Carpet Policy Dialogue Plenary and approved for distribution.

Approval of this report and other products and agreements of the Carpet Policy Dialogue were attained by the consensus process described in this report. Such agreement does not signify that the contents of such materials necessarily reflect the views and policies of the groups or organizations (governmental or nongovernmental) participating in the Carpet Policy Dialogue. Listing the names of individuals as participants in the Carpet Policy Dialogue (Appendix A) does not necessarily imply that these individuals concur with all aspects of the materials and products developed during the Dialogue year. Listing of these individuals also does not imply the official approval or endorsement by the organization (governmental or non governmental) they represented.

This report was submitted into the Carpet Emissions Administrative Record at the TSCA Public Docket Office located at: Environmental Protection Agency, Rm. NE-G004, 401 M St., SW, Washington, DC 20460. The Carpet Emissions Administrative Record will also contain data and information about TVOC emissions to be developed under the terms and conditions of a series of Memoranda of Understanding established between EPA and the Carpet and Rug Institute, the Carpet Cushion Council, the Floor Covering Adhesive Manufacturers Committee of the National Association of Floor Covering Distributors, and the Styrene Butadiene Latex Manufacturers Council. This report and the data bases to be developed under the previously mentioned voluntary testing and reporting programs responds to the charge set by EPA to the Carpet Policy Dialogue.

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[1] Activities of the Carpet Policy Dialogue were facilitated under Delivery Order #39 of Contract Number EPA 68-W8-0072 and Delivery Order #3 of Contract 68-W1-0014.

EXECUTIVE SUMMARY

September 27, 1991

CARPET POLICY DIALOGUE PURPOSE

Government, industry, and other interested parties worked together in a voluntary framework to reduce total volatile organic compound (TVOC) emissions associated with new carpet installation. These groups worked towards: (1) characterizing the nature of TVOC emissions from carpet, carpet cushion, and carpet installation adhesives; (2) developing a standard test method for measuring TVOC emissions; (3) increasing industry's commitment to conduct voluntary product testing for TVOC's; (4) evaluating potential process or engineering changes that could lead to reduction in TVOC emissions from newly manufactured carpet products and associated installation technologies for such products; and (5) providing the interested public with information on TVOC emissions from new carpet, carpet cushions, and adhesives used in carpet installation.

BACKGROUND

- In 1990, EPA received a citizen's petition under Section 21 of the Toxic Substances Control Act (TSCA) from Local 2050 of the National Federation of Federal Employees (NFFE). The petition focused attention on employee concerns about a variety of health reports claimed to be related to the emission of 4-phenylcyclohexene (4-PC) from newly installed carpets and sought EPA regulatory action to remedy exposure concerns. Following a review of the petition, EPA published a Federal Register notice (April 24, 1990) denying the petition on the basis that there was insufficient data to support the conclusions and remedies sought by the union. However, the EPA stated that as a matter of policy, "it is prudent to minimize indoor human exposure to VOC's where reasonable."

- The Carpet Policy Dialogue served as EPA's forum to encourage actions that will reduce TVOC emissions from carpet, carpet cushion, and carpet adhesive products. The Carpet Policy Dialogue was initiated on August 21, 1990. It was composed of representatives from industry, public interest groups, labor, other interested government agencies, and members of the scientific and research communities. To address the objectives (see above), the Carpet Policy Dialogue formed three technical subgroups: Product Testing, Process Engineering, and Public Communications.

- The Carpet Policy Dialogue was a 1-year effort which ended in September of 1991. Information gathered under the charter of the Carpet Policy Dialogue has been assembled into a Compendium Report which describes the information and findings from its deliberations. In addition, data and information developed from testing programs and other follow-on activities initiated during the Carpet Policy Dialogue year will be entered into the TSCA Carpet Emissions Administrative Record as they become available.

information developed from testing programs and other follow-on activities initiated during the Carpet Policy Dialogue year will be entered into the TSCA Carpet Emissions Administrative Record as they become available.

ACCOMPLISHMENTS

The Carpet Policy Dialogue made progress in several areas of exposure reduction (pollution prevention) and industry-wide product stewardship/responsible product care. The industry (i.e., manufacturers of carpet, carpet cushion, carpet installation adhesives, and raw materials such as fibers and latex) and installers of carpet systems demonstrated a willingness to commit the time and resources to working constructively toward an effective program to understand the role of new carpet, carpet associated products, and carpet installation practices on indoor air quality. The objective of the Carpet Policy Dialogue was to take practical steps to help reduce the public's exposure to TVOC emissions.

- The Carpet Policy Dialogue produced a standardized small chamber test method which was peer reviewed. TVOC emissions from carpet and related materials can be scientifically measured and compared. This procedure was submitted to the ASTM as the basis for a new standard method.

- The Carpet and Rug Institute (CRI) voluntarily agreed to conduct a major study to define carpet TVOC emission decay characteristics. In addition, the CRI will also conduct a comprehensive study of carpet product types, to provide the information necessary to assess and compare carpet emissions on an industry-wide basis.

- The Carpet Cushion Council voluntarily agreed to conduct a testing program which will report a profile of TVOC emissions coming from new carpet cushion. The voluntary testing program will include decay curve testing of TVOC emissions for each of the five carpet cushion product types available in commerce.

- Manufacturers of carpet cushion agreed to set in place technical and manufacturing task forces to investigate ways in which TVOC emissions from new carpet cushion can be reduced at the manufacturing and process level for each of the five generic types of carpet cushion.

- The Carpet Policy Dialogue encouraged participation of the Floor Covering Adhesive Manufacturers Committee of the National Association of Floor Covering Distributors to represent the carpet installation adhesives industry in the Carpet Policy Dialogue and to provide the vehicle by which this industry could address voluntary testing for these products.

- Members of the Floor Covering Adhesive Manufacturers Committee agreed to support the research activities necessary to modify the standard analytical test method to obtain TVOC emissions measurements for floor covering adhesive products.

- The Floor Covering Adhesive Manufacturers Committee committed to a voluntary testing program that will provide a baseline of comparative TVOC emissions information for floor covering adhesives and sealers.

- The Carpet Policy Dialogue reinforced a market climate which encouraged the introduction of low-emitting carpet adhesives.

- The Styrene Butadiene Latex Manufacturers Council report that this industry reduced VOC emissions from their product in recent years, and that they have completed a series of toxicity tests for a VOC contaminant (4-PC) in latex products.

- The Styrene Butadiene Latex Manufacturers Council agreed to provide data from their ongoing quality analysis programs and to report the company-by-company weighted average of 4-PC in styrene butadiene latex sold for carpet backing applications for 1991 and 1992 as the data becomes available. This information will be used to assess the feasibility of utilizing the information to develop future quality control activities.

- The Floor Covering Installation Contractors Association agreed to enhance training programs to include information about indoor air quality, educate carpet installers about proper installation procedures, and encourage installers to adhere to the Carpet and Rug Institute installation guidelines (CRI 104; CRI 105).

- The Carpet Policy Dialogue compiled information about conceivable process engineering research activities that deserve consideration for identifying potential control measures that may lead to reduced VOC emission levels in carpet related sources in the future.

- The Carpet Policy Dialogue suggested potential control strategies to minimize VOC emissions from carpet floor covering systems in new construction and renovation projects.

- The General Services Administration (GSA) established an initiative to develop requirements to make a low VOC carpet floor covering available for use in Government offices. It is anticipated that a low TVOC emitting carpet floor covering could be available from the GSA Federal Supply Schedule for the

contract period beginning April 1994, provided adequate technical data is available from the TSCA Carpet Emissions Administrative Record.

- The Carpet Policy Dialogue prepared a brochure to provide the interested public with information about carpet emissions, indoor air quality, exposure reduction (pollution prevention). Sixteen (16) organizations signed on as participants in the development of this brochure.

- The Carpet Policy Dialogue prepared a Compendium Report describing the group's activities, findings, accomplishments, and recommendations for the Dialogue year.

CHAPTER 1

Carpet Policy Dialogue
Plenary Report

1.0 CHAPTER 1: PLENARY REPORT

1.1. INTRODUCTION

This report of the Carpet Policy Dialogue Group documents the activities, accomplishments, findings, and recommendations of the Carpet Policy Dialogue. It summarizes information from minutes of meetings held between August 21, 1990, and September 27, 1991. While the activities of the Carpet Policy Dialogue concluded on September 27, 1991, the Dialogue process established mechanisms whereby follow-on activities, information, and data resulting from a series of voluntary agreements will continue to be reported into the Toxic Substances Control Act (TSCA) Carpet Emissions Administrative Record.

This report contains information based on discussions among Dialogue participants. These individuals presented their views independently and as representatives of the industry, group, and organization (governmental or nongovernmental) that invited them to participate in the Carpet Policy Dialogue. The Carpet Policy Dialogue accepts responsibility for accurately reporting the information presented to it; however, listing these individuals in Appendix A, List of Carpet Policy Dialogue Participants, does not imply that they specifically endorse all elements of the materials presented.

The Carpet Policy Dialogue Plenary Group and the Public Communications Subgroup reviewed this report. However, it should be noted that while this is a report of the Carpet Policy Dialogue Group, it does not necessarily reflect the opinion of individual constituent members of the industries, groups, and organizations (governmental or non-governmental) that provide representation to the Carpet Policy Dialogue.

The dialogue process on total volatile organic compound (TVOC) emissions for carpet and carpet floor covering materials is a nonregulatory approach. It focuses on product stewardship through voluntary actions on the part of industry. It also emphasizes exposure reduction (pollution prevention) philosophies, and addresses the public desire for information that could lead to consumer choice. The Carpet Policy Dialogue is an example of how Government, industry, the interested public, and the scientific community can work together to resolve exposure reduction and pollution prevention issues, including those related to indoor air exposures.

1.1.1. Background

On January 11, 1990, Local 2050 of the National Federation of Federal Employees (NFFE) petitioned the U.S. Environmental Protection Agency (EPA) under section 21 of the Toxic Substances Control Act (TSCA) to initiate rule making proceedings, under sections 4, 6, and 8 of TSCA to reduce emissions from new carpets (NFFE/USEPA 1989, 1990). The

EPA decided not to initiate the specific rule making proceedings requested by NFFE because the Agency disagreed with the specific assertions regarding health risks posed by carpet and with the remedies sought by NFFE. The EPA denied the petition (55 FR 17404, April 24, 1990). (See Appendix B.)

However, the EPA recognized that the combined total of VOC emissions from new carpet may significantly increase indoor air exposures to VOCs in general, and that it is prudent to minimize indoor exposure to these chemicals where reasonable. Thus, EPA sought an approach to reduce TVOC exposure in the absence of a well-defined health risk and to encourage manufacturer's efforts to reduce product emissions. In lieu of the section 21 proceedings, EPA convened the Carpet Policy Dialogue on August 21, 1990, and set a different mission for the group. (See Appendix C.)

The Carpet Policy Dialogue was initiated by EPA as a one year process to clarify scientific issues about carpet emission concerns and to identify methods for improving indoor air quality. The charges to the Carpet Policy Dialogue were laid out in the Federal Register notices of April 24, 1990 (55 FR 17404) and August 3, 1990 (55 FR 31640). These charges included:

- Develop standard methods for testing carpet emissions and obtain commitments from industry to voluntarily commence appropriate periodic testing of carpet to quantify the emissions of total VOCs from their products on a periodic basis so as to provide the interested public with comparative information on TVOC emissions from new products;

- Identify information needs for assessment of emission control feasibility, including data on carpet manufacture and installation technology and commercial activities associated with carpet installation;

- Evaluate potential controls for reducing emissions; and

- Identify VOC exposures which are associated with carpet installation but not necessarily from a carpet source and recommend any appropriate actions to reduce them.

1.1.2. Implementation of the Carpet Policy Dialogue

EPA oversight for the Carpet Policy Dialogue was assigned to the Office of Toxic Substances (OTS), Existing Chemical Assessment Division (ECAD). OTS/ECAD requested that the EPA Regulatory Negotiations Project provide facilitator and meetings support services via a contract with the Conservation Foundation and their subcontractor, CDR Associates. Several categories of participants were identified from the Federal Register notices. These included industry, public interest groups, representatives of labor, interested

Government agencies, and members of the scientific and research communities. In conjunction with representatives from EPA, the subcontractor identified a list of names of individuals and organizations to participate in the Carpet Policy Dialogue. In general, representation was sought and received from the following groups: industry (Carpet and Rug Institute [CRI], American Fiber Manufacturers Association [AFMA], American Textile Manufacturers Institute [ATMI], Styrene Butadiene Latex Manufacturers Council [SBLMC], Floor Covering Installation Contractors Association [FCICA], Carpet Cushion Council [CCC], and Floor Covering Adhesives Manufacturers Committee [FCAMC] of the National Association of Floor Covering Distributors [NAFCD], The Adhesive and Sealant Council, Inc. [ASC]), public interest groups (Consumer Federation of America [CFA], American Lung Association [ALA], and American Public Health Association [APHA]), representatives from labor (National Federation of Federal Employees, Local 2050 [NFFE], American Federation of State, County and Municipal Employees [AFSCME]), other Government agencies (Occupational Safety and Health Administration [OSHA], National Institute for Occupational Safety and Health [NIOSH], National Institute of Standards and Technology [NIST], Consumer Product Safety Commission [CPSC], General Services Administration [GSA]), other offices within EPA (Office of Air and Radiation/Indoor Air Division [OAR], Office of Research and Development [ORD]), and distinguished scientists from industry, academia, and the scientific community in general (Air Quality Sciences, Inc. [AQS], American Society for Testing and Materials, Subcommittee D22.05 on Indoor Air [ASTM], Georgia Tech Research Institute [GTRI], Research Triangle Institute [RTI]). A list of Carpet Policy Dialogue participants is included as Appendix A. Representatives to the Carpet Policy Dialogue were qualified on the basis of their technical expertise and training.

1.1.3. Structural Organization

All meetings of the Carpet Policy Dialogue were considered "open," to facilitate a solution-oriented, problem-solving approach to the issues discussed. Confidential materials that provided useful information for the purpose of deliberative discussions were identified as such. The distribution and use of confidential materials were limited to recognized dialogue participants who agreed that such information was restricted for any use beyond dialogue discussions. Statements issued to inform the public about dialogue meetings and deliberations were joint releases prepared and approved by the Carpet Policy Dialogue Plenary.

To address the Federal Register objectives, three technical subgroups were formed under the oversight of the Carpet Policy Dialogue Plenary. These subgroups were the Product Testing, Process Engineering, and Public Communications Subgroups. EPA provided staff to coordinate subgroup meetings and provide liaison among dialogue participants. The subgroups provided a forum for the presentation and discussion of information. Recommendations, conditional decisions, and reports developed by these subgroups were presented to the Carpet Policy Dialogue Plenary for discussion, approval,

and follow-up actions. The schedule of Carpet Policy Dialogue meetings is provided as Appendix D.

1.1.4. Nature of Dialogue Consensus Statements and Voluntary Actions

Proposed consensus statements were voluntary actions submitted to the Carpet Policy Dialogue Plenary for the benefit of a consensus process of review and comment. Consensus agreement by the Carpet Policy Dialogue Plenary indicates that interests and concerns were identified and discussed. After consideration of these various interests, solutions were developed to take these into account. A consensus does not mean unanimity. A consensus was the best agreement that could be obtained among the Carpet Policy Dialogue participants. It does not imply that all individuals or the industries, groups, or organizations (governmental or non-governmental) specifically endorsed all elements of such agreements. During consensus discussions, participants were provided the following options: (1) agree, (2) submit a minority report, (3) stand aside, or (4) block consensus. Minority reports were included in the public record, included with minutes to meetings, and as attachments to specific agreements. In reaching a consensus agreement, the Carpet Policy Dialogue Group indicated to its sponsor (EPA) that such a statement could provide the basis for a Memorandum of Understanding to initiate voluntary action(s) in response to the charter set by EPA in the Federal Register notices.

Voluntary agreements (e.g., to conduct TVOC emissions testing of products) were undertaken by dialogue participants as part of a continuing commitment to product stewardship, reduction of TVOC emissions, or public education. Voluntary actions implemented with respect to products as produced by the manufacturer may include industry guidelines for proper use, maintenance and care of products, or data base development. Such voluntary agreements will operate where reasonable and appropriate as governed by the economics of the designed program. As data are generated from such programs, they serve as the reference point for ongoing testing and evaluation, which was one of the goals of the Federal Register charter. Voluntary actions were implemented with consideration to preserve necessary proprietary information and establish the basis for appropriate inter-product comparison.

1.1.5. Dialogue Discussions

The Carpet Policy Dialogue was convened on August 21, 1990. At this meeting, participants of the Carpet Policy Dialogue Plenary discussed the scope of work, boundaries of the subject, composition of the Carpet Policy Dialogue, time constraints, technical approach, and criteria by which accomplishments would be measured. The Carpet Policy Dialogue Plenary accepted, in principle, the objectives defined in the Federal Register notices and recognized their responsibility for making final decisions (i.e., acceptance of materials produced by their deliberations). Procedural guidelines were set to identify the roles of the

facilitator, sponsor, dialogue participants and their alternates, resource individuals, observers, and relations with the press.

The Plenary group of the Carpet Policy Dialogue held nine (9) meetings during the Dialogue year. A record of these meetings has been recorded in the minutes prepared by the Carpet Policy Dialogue facilitator (CDR Associates). These minutes are available in the TSCA Carpet Emissions Administrative Record.

Meetings of the Carpet Policy Dialogue Plenary included: consideration of Agenda items, progress reports from the subgroups, summary presentations of data and information previously reviewed by the subgroups, proposals from industry representatives for consensus review, and project scheduling. The Carpet Policy Dialogue Plenary invested considerable effort in reviewing and finalizing text materials for the various products attributed to the Carpet Policy Dialogue.

Discussions of the Subgroups (Product Testing, Process Engineering, and Public Communications) are incorporated into Chapters 2, 3, and 4 respectively. It became apparent early in the Dialogue process that additional meetings of the Plenary were needed to review information and proposals emanating from subgroup activities, assess progress made by the subgroups and provide guidance or course changes as needed, resolve issues that impeded progress, and to signal its sponsor, EPA, when consensus agreement had been attained. Additional meetings were scheduled.

During the Dialogue year, several topics recurred during the course of deliberations. These topics included the subject of health concerns, the use of proprietary or confidential information, and the subject of chemical speciation. Some representatives to the Plenary and the Subgroups were of the opinion that sufficient latitude had not been provided to the Carpet Policy Dialogue to address the full charge set by EPA in the Federal Register notices; while other representatives shared the opionion that the Dialogue could operate within the boundaries described by the Federal Register notices. The Carpet Policy Dialogue addressed these issues giving consideration to the variety of views shared among the Dialogue representatives and the advantages and limitations of their decisions as set within the framework of the dialogue process, the scope of work, and the boundaries of the subject established by the Federal Register notices of April 24, 1990 (55 FR 17404) and August 3, 1990 (55 FR 31640).

1.1.5.1. Health Concerns

The dichotomy of separating health assessment from exposure reduction proved challenging to the Carpet Policy Dialogue. In general, most participants recognized a relationship between volatile organic compound emissions, indoor air quality, and health. Furthermore, participants acknowledged the rationale behind the EPA premise that it is prudent to minimize indoor exposure to volatile organic compound emissions where

reasonable, and that this was one of the prime objectives for the Dialogue. Nevertheless, the EPA charge to the Carpet Policy Dialogue specifically stated:

"The goal of the dialogue will be to characterize emissions and identify low-impact, feasible VOC controls that could be implemented in the near term, not to further characterize the health effects of chemicals emitted from carpeting."

The Group was directed by EPA to adhere to the objectives of the Federal Register and to refrain from becoming involved in the issues of health effects; it complied with that direction.

1.1.5.2. Proprietary or Confidential Information

During the course of the Dialogue year, it became necessary for the Carpet Policy Dialogue Plenary, the Product Testing, and the Process Engineering Subgroups to gain access to information that was considered proprietary or confidential by industry representatives. This was problematic as information presented to the Carpet Policy Dialogue would then become public knowledge. Industry representatives expressed concern that such information and preliminary data could be misunderstood by the general public or could compromise the competitive advantage among individual manufacturers. The Carpet Policy Dialogue Plenary responded to these concerns by establishing a mechanism whereby such information could be identified as confidential and restricted for any use beyond Dialogue discussions.

By the conclusion of the Dialogue year, much of the information that was initially marked as proprietary or confidential was released in original or blinded form for enclosure in the various reports associated with the Carpet Policy Dialogue or submitted to the TSCA Carpet Emissions Administrative Record. In general, participants to the Carpet Policy Dialogue agreed that a limitation inherent to the Dialogue process was the difficulty in obtaining this type of information for review and analysis by the various working groups of the Dialogue.

1.1.5.3. TVOC Data and Chemical Speciation

TVOCs implies the sum total of volatile organic compounds emitted from a test material as measured by a specified analytical test method. TVOC is specifically mentioned throughout the Federal Register notice (55 FR 17404) as the priority datum for consideration by the Carpet Policy Dialogue. Yet, neither the method by which TVOC was to be determined, nor the use of information gathered in the course of obtaining TVOC values was specified. Speciation issues were discussed at both the Product Testing and Process Engineering Subgroup.

The analytical test method developed by the Product Testing Subgroup produces a TVOC emission factor. The test method can also be used to identify individual VOC chemicals emitted from the test specimen. (See Appendix E.)

Some representatives noted that the limited data available for many of the products that would be included in the various testing programs showed that the TVOC levels were low after 24 hours and that reporting speciated data at such low levels would not only produce results which could be subject to misinterpretation, but could also result in disclosure of confidential business information. They questioned the value of committing the costly scientific resources needed to obtain chemical speciation. Some other representatives shared a different opinion on this subject (e.g., Hirzy, 1990).

For the testing program, EPA directed the Plenary and the Testing Subgroup to follow the charge of the Federal Register regarding TVOC for the purpose of testing. A minority report was filed on this subject and is included as Attachment F-2 to the Carpet and Rug Institute Consensus Statement (Appendix F).

The speciation issue was also addressed by the Process Engineering Subgroup. Some members of the Process Engineering Subgroup were of the opinion that the Subgroup could not fully address its charge to identify opportunities to reduce emissions in the absence of information about the nature of the materials used in product manufacturer that could contribute to VOC emissions. Other Subgroup members contended that such information was proprietary, not readily available, or that available information would not be relevant because of changes in analytical procedures or changes in manufacturing processes. Some Subgroup members expressed concern that without such information, the Subgroup would not be able to fully evaluate the advantages or limitations of various process variables among different manufacturing processes. EPA stated that, consistent with the directives of the Federal Register notice, new studies developing speciation data were not within the scope of the Dialogue but requested that existing speciation data be provided for consideration by the Process Engineering Subgroup.

An account of the deliberative proceedings on the speciated data issue can be found in Chapters 2 and 3. Additional information on this subject is included in the minutes to the meetings of the Carpet Policy Dialogue which are filed in the Carpet Emissions Administrative Record.

1.2. SUMMARY OF THE SUBGROUP ACTIVITIES

The Carpet Policy Dialogue accomplished numerous objectives during the Dialogue year. Products developed by the Carpet Policy Dialogue emanated from Subgroup activities. The primary focus of these products related to the Dialogue's objectives (e.g., progress in reducing TVOC emissions, data base development, identifying and conveying information). In some instances, Subgroup activities and Dialogue accomplishments reinforced ongoing

activities outside the Dialogue or encouraged new initiatives by other groups which related to the Dialogue's objectives.

1.2.1. Product Testing Subgroup

The mission of the Product Testing Subgroup was to develop standard test methods for testing TVOC emissions from carpet floor covering materials (carpet, carpet cushion, and carpet floor covering adhesives) and to obtain voluntary agreements from industry to conduct testing to quantify the TVOC emissions for newly manufactured products on a periodic basis. During the Dialogue year, the Subgroup held ten (10) meetings and numerous telephone conferences. A description of the deliberative activities and products developed by the Product Testing Subgroup are included as Chapter 2 of this report. The following summarizes the accomplishments of this Subgroup.

Related to the mission of this Subgroup was the development of criteria to understand the nature of TVOC emissions and the scientific considerations for obtaining analytical measurements of TVOC emissions from carpet floor covering materials. For the purposes of the Carpet Policy Dialogue, the Subgroup defined TVOCs as the sum of volatile organic compounds that can be analyzed and measured using a specified analytical method. On November 29, 1990, the Carpet Policy Dialogue Plenary accepted the recommendation from the Product Testing Subgroup that a small chamber method be used for measuring TVOC emissions from carpet floor covering materials.

The test method, "Standard Test Method for Determining Total Volatile Organic Compound Emission Factors from Carpet Under Defined Test Conditions Using Small Environmental Chambers" reports TVOC as an emission factor from flooring materials using standard test conditions. Quantitative measurement is determined by gas chromatography or gas chromatography/mass spectrometry. The observed test chamber concentration is converted to an emission factor, which may be a product specific variable. An addendum to document protocol changes necessitated for testing of carpet installation adhesives has yet to be finalized and will be attached to the principal document pending the results of preliminary studies in progress. (See Appendix E.)

The test method was peer reviewed by a select group of accomplished experts (listed in Appendix A). It is anticipated that the final method including addendum revisions will be submitted to the American Society for Testing and Materials (ASTM), subcommittee D22.05 on Indoor Air for ASTM balloting procedures as a proposed "Standard Method" during 1992. Further validation by interested laboratories is expected over the next 2 years.

The Product Testing Subgroup developed protocols for carpet floor covering product testing. Testing programs were individualized to give consideration to the unique characteristics for each component of a carpeted floor covering system (i.e., carpet, carpet

cushion, and carpet floor covering adhesives), the product types currently available in commerce, and the nature of the industries involved in the manufacture of these products.

These protocols were developed into consensus statements by industry representatives and submitted to the Carpet Policy Dialogue Plenary. The Carpet Policy Dialogue reached agreement on three consensus statements:

February 28, 1991	Testing Program for Carpet Products
June 28, 1991	Testing Program for Carpet Cushion
June 28, 1991	Testing Program for Carpet Installation Adhesives

Copies of the approved consensus statements along with all attachments are provided as Appendices F, G, and H.

Subsequent to the Carpet Policy Dialogue consensus approval of the testing programs, EPA entered into a series of Memoranda of Understanding (MOU) with the Carpet and Rug Institute (55 FR 37912, August 9, 1991), the Carpet Cushion Council (55 FR 61245, December 2, 1991), and the Floor Covering Adhesive Manufacturers Committee of the National Association of Floor Covering Distributors (55 FR 61246, December 2, 1991). The MOUs formally established the framework by which voluntary product testing programs sponsored by industry would be initiated in response to the desired outcomes described in the Federal Register notice (55 FR 17404, April 24, 1990). These MOUs and the corresponding Federal Register announcements are provided as Appendices I, J, and K. Test results, reports, and information on follow-on activities developed under the terms and conditions of these MOUs will become a matter of public record available from the TSCA Carpet Emissions Administrative Record.

1.2.2. Process Engineering Subgroup

The mission of the Process Engineering Subgroup was to evaluate potential process or engineering changes for reducing VOC emissions from carpet and carpet-related sources and installation activities; as well as, identification of information gaps. During the Dialogue year, the Process Engineering Subgroup held eight (8) meetings. A description of the deliberative activities and products developed by the Process Engineering Subgroup are included as Chapter 3 of this report. The following summarizes the accomplishments of this Subgroup.

Representatives from industry, labor, interested Government agencies, associated professional organizations, and scientific experts provided this Subgroup with information and a series of informative presentations summarizing research activities, describing manufacturing processes, and installation practices and procedures. For example, data relevant to determining improved carpet curing oven operating conditions were reviewed by the Subgroup. Specifically, the Subgroup received information about the manufacture of

styrene butadiene rubber latex, adhesive manufacture and formulation, carpet cushion manufacture, carpet manufacture, and carpet installation practices and building ventilation. Wherever possible, these presentations identified potential sources of VOC emissions from product formulations, manufacturing processes, and installation practices.

In its report to the Carpet Policy Dialogue (Chapter 3), the Process Engineering Subgroup provided information about the current state of knowledge on the manufacturing processes, procedures, and practices for the industries involved in the manufacture of carpet floor covering materials. This information includes a discussion of the process description, historical perspective on VOC reduction, evaluation of potential methods to reduce VOCs, ideas for assessing feasibility of additional process changes that would reduce VOCs, opportunities for research, and recommendations based on their deliberative findings.

The Subgroup expressed interest in the relationship between 4-phenylcyclohexene (4-PC) emissions that may contribute significantly to TVOC from styrene butadiene latex (SB latex) used for carpet applications and that data on 4-PC could potentially be made available from ongoing styrene butadiene latex manufacturers quality analysis programs. The Subgroup observed that 4-PC data could potentially provide useful information about TVOC emissions from SBR-latex and proposed that the Dialogue encourage industry reporting. The Carpet Policy Dialogue reached consensus agreement on this Subgroup proposal and recommended that the EPA and the SBLMC enter into a MOU for the SBLMC to conduct an industry wide survey of 4-PC levels in SBR-latex during the last quarter of 1991 and 1992 and to make such information publicly available through the EPA Carpet Emissions Administrative Record. This formed the basis for a Memoranda of Understanding between the EPA and the SBLMC which was signed on September 26, 1991. Details of this MOU (55 FR 61247, December 2, 1991) are described in Appendix L.

1.2.3. Public Communications Subgroup

The mission of the Public Communications Subgroup was to serve as the common voice for the Carpet Policy Dialogue in responding to the public communications objective stated in the Federal Register (55 FR 17404, April 24, 1990). This Subgroup held six (6) meetings during the Dialogue year to define the scope of work, identify potential communications products, consider mechanisms for message development, and to discuss communication strategies. A description of the deliberative activities and products developed by the Public Communications Subgroup are included as Chapter 4 of this report. The following summarizes the accomplishments of this Subgroup.

The focus of the Public Communications Subgroup activity was on communication outside the Dialogue. The Carpet Policy Dialogue Plenary provided oversight for review of materials developed by the Subgroup and offered a mechanism for approval and distribution of materials that convey information to the public about Carpet Policy Dialogue activities.

The products attributed to the Public Communications Subgroup included: 1) the Interim Progress Report of the Carpet Policy Dialogue (55 FR 37912); 2) a public information brochure - "Indoor Air Quality and New Carpet, What You Should Know" (Appendix M); 3) the Compendium Report of the Carpet Policy Dialogue, and 4) an executive summary of Dialogue accomplishments.

These products were submitted to the EPA in response to the public communications objective stated in the Federal Register (55 FR 17404, April 24, 1990) and made available to the public by announcements in the Federal Register and other distribution channels. They provide factual information for use by dialogue participants and those responsible for communicating information about the EPA Carpet Policy Dialogue process. In addition, these communication products provide the interested public with an explanation of the findings and information developed during the Dialogue year. The materials identify common denominators among Dialogue participants for message development and information distribution on the subject of TVOC emissions from carpet floor covering materials and indoor air quality and formed the basis for joint statements, agreements, and voluntary communications efforts supported by Carpet Policy Dialogue Participants.

1.3. CARPET RELATED ACTIVITIES

Several industries, groups, and organizations (governmental and nongovernmental) that participated in the Carpet Policy Dialogue have taken steps to voluntarily reduce TVOC emissions from products, develop TVOC emissions data, conduct other carpet related research, or support education and training awareness programs. The following is a brief description of these activities.

1.3.1. Styrene Butadiene Latex Manufacturers

The Styrene Butadiene Latex Manufacturers Council (SBLMC) reported several voluntary activities including sponsoring a series of toxicity tests for a VOC contaminant (4-PC). Results of these tests have been shared with EPA to assist in its study of indoor air quality issues. These data have also been made available to carpet manufacturers.

SBLMC also reported that in the past 2 years, they have achieved a 50 percent reduction in 4-PC in SBR-latex products through the implementation of engineering techniques. They made a commitment to provide the Carpet Policy Dialogue with additional 4-PC monitoring data for SBR-latex products sold to the carpet trade as part of the SBR-latex manufacturers' ongoing quality assurance program. (See Appendix L.)

1.3.2. Carpet Manufacturers

Under the leadership of the Carpet and Rug Institute (CRI), the carpet industry voluntarily conducted pilot testing of carpet products before the Carpet Policy Dialogue began. This preliminary set of data (Black et al., 1991) provided the Carpet Policy Dialogue with valuable information about the emissions characteristics of softback carpet and formed the basis for a consensus agreement for a Carpet Testing Program. (See Appendix F.)

Upon extensive discussion and consensus through the Dialogue process, the CRI voluntarily agreed to fund a testing program for 25 carpet product types. This will provide an industry-wide profile of comparative TVOC emissions for carpet product types currently available in the marketplace. The study will include both SBR and non-SBR latex-backed carpet types. Implementation of these actions are described in a Memorandum of Understanding between EPA and the Carpet and Rug Institute. (See Appendix I.)

In addition, the CRI committed to several voluntary actions beyond product testing for TVOC emissions. This includes (a) the generation of a history of TVOC levels through on-going, periodic monitoring, which would be available for trend analysis and could be used for remedial action (i.e., motivating manufacturers to voluntarily institute quality assurance measures to reduce TVOC emissions); and (b) a CRI-established certification program to encourage manufacturers to reduce emissions from new carpet. The CRI also committed to inform the general public and carpet customers of the carpet industry's quality assurance program and its results on a periodic basis.

1.3.3. Carpet Cushion Manufacturers

The Carpet Cushion Council, acting on behalf of 98 per cent of the carpet cushion industry, entered into a Memorandum of Understanding with the EPA wherein the industry will voluntarily conduct a testing program. (See Appendix G.)

The testing program is outlined specifically in the Consensus Statement which was agreed upon between the Carpet Cushion Council and the Carpet Policy Dialogue Plenary. (See Appendix J.) The voluntary testing program will include decay curve testing of TVOC emissions for each of the five carpet cushion product types available in commerce. It is the intent of this testing program to provide the basis of an ongoing profile study and to meet the objectives set out in the Federal Register notice (55 FR 17404).

Additionally, this industry agreed to set in place technical and manufacturing task forces to investigate ways in which TVOC emissions from new carpet cushion can be reduced at the manufacturing and process level for each of the five generic types of carpet cushion.

1.3.4. Adhesive Manufacturers

Prior to the Carpet Policy Dialogue, floor covering adhesive manufacturers did not have a common spokesperson to address regulatory issues. During the Carpet Policy Dialogue year, these manufacturers organized their industry under the leadership of the Floor Covering Adhesive Manufacturers Committee (FCAMC) of the National Association of Floor Covering Distributors (NAFCD).

This group agreed to support the research activities necessary to modify the standard analytical test method to obtain TVOC emissions measurements for adhesive products. (See Appendix E, Attachment E-1.) They also committed to a voluntary testing program that will provide a baseline of comparative TVOC emissions information for floor covering adhesives and sealers. (See Appendices H and K.) The data collected in the Carpet Installation Adhesive Testing Program will also form the basis for a series of proposed follow-on activities that include an annual reporting of the aggregate history of carpet installation adhesive product type sales performance for at least three years and the development of a program to motivate producers to institute voluntary indoor air quality assurance measures with respect to their installation adhesive products. Details of these follow-on programs will be worked out jointly by EPA and the Floor Covering Adhesive Manufacturers Committee.

Public concern in general has encouraged the introduction of low-emitting adhesives. In California, concern about hydrocarbon precursors to photochemical smog resulted in codification actions requiring reduction in VOC emissions (SCAQMD 1990). The Carpet Policy Dialogue has fostered these regional activities by offering a national forum to encourage continued emissions reduction for these adhesives products. There is an accelerated trend among floorcovering adhesive manufacturers to produce low VOC emitting adhesives to replace the high-emitters of the past.

1.3.5. Consumer Product Safety Commission

The Consumer Product Safety Commission completed limited small chamber testing to identify specific VOCs released from carpet. They are also conducting large-chamber testing at Lawrence Berkeley Laboratory to determine the VOC emission time profile from selected carpets. Additional small chamber testing is being conducted in order to compare small and large chamber measurements under similar environmental conditions. A report is anticipated in 1992.

1.3.6. EPA Carpet Installation Study

The EPA has conducted a study to measure VOC emissions from installed urethane backed carpet (USEPA 1991). Comparative VOC measurements were made using a dynamic chamber and ambient air measurements taken during installation and again one week after

installation. The report calculates the decay curve and speciates VOC's emitted from the carpet, carpet installation adhesives, and the carpet seam sealer used. This study demonstrated that the selection of low VOC emiting carpet floor covering materials can reduce TVOC concentrations following new carpet installation.

1.3.7. Floor Covering Installation Contractors Association

The Floor Covering Installation Contractors Association (FCICA) has undertaken an initiative to further develop industry-wide communications programs to educate carpet floor covering installers about the importance of proper installation procedures. In addition, the FCICA will include information about the availability of low VOC emitting materials (e.g., adhesives) in training courses offered to carpet installer instructors and carpet installers.

1.3.8. Collaborative Research

Information was provided to the Carpet Policy Dialogue from collaborative studies voluntarily undertaken by industry. Examples include extensive studies undertaken to evaluate the effects of process engineering variables on carpet curing with respect to carpet product integrity and VOC emissions (December 1989; Van Ert, 1990; and Hawkins et al. 1991).

1.3.9. General Services Administration

The General Services Administration (GSA) established an initiative to develop requirements to make a low VOC carpet floor covering available for use in Government offices (USGSA, 1991a; USGSA 1991b). GSA representatives will evaluate the use of the standard analytical test method to measure TVOC (Appendix E) as one consideration in establishing procurement requirements for low TVOC emitting carpet floor covering. Information provided to the TSCA Carpet Emissions Administrative Record from the various industry testing programs will also be considered by GSA.

It is anticipated that a low TVOC emitting carpet floor covering could be available from the GSA Federal Supply Schedule for the open season contract period beginning April 1994, provided adequate technical data is available from the TSCA Carpet Emissions Administrative Record.

1.3.10. Environmental Protection Agency and General Services Administration

EPA and GSA agreed to work together to identify low VOC-emitting carpet floor covering products. They agreed to exchange information and utilize data developed from the Carpet Policy Dialogue. This will include the data and materials submitted to the TSCA Carpet Emissions Administrative Record from the various industry-wide testing programs. The initiatives to improve indoor air quality, TVOC exposure reduction, and pollution prevention will provide the basis for this collaborative activity.

1.4. FUTURE CONSIDERATIONS

One factor in determining the accomplishments of the Carpet Policy Dialogue was the effect of the time constraint set by EPA. The Carpet Policy Dialogue was given a 1-year timeframe to complete the primary objectives of the mission outlined in the Federal Register notice (55 FR 17404). This time constraint not only served as a motivating force to drive the Dialogue, but also influenced the selection of priorities as well as the nature and extent of activities which the Dialogue could support during the course of the Dialogue year.

As a consequence, the Carpet Policy Dialogue established mechanisms by which information would continue to be developed under a series of proposed follow-on activities that were incorporated into the various testing program consensus agreements. In addition, the Carpet Policy Dialogue also identified other matters that could not be fully addressed within the 1-year term of the Carpet Policy Dialogue. These topics are listed here for the record as future considerations.

The Carpet Policy Dialogue recognizes that the testing programs initiated by industry are an initial step to understand the nature of TVOC emissions from the component elements of the carpet floor covering system. Important future considerations will be to gain a better understanding of TVOC emissions from carpet floor covering system assemblies (i.e., carpet and cushion; carpet and adhesive; carpet, cushion, and adhesive), as well as the role of aging carpet. This is needed to determine the relative and absolute TVOC contributions of the individual component materials. It can also provide information about these products as they are installed, rather than as newly manufactured or under predetermined test conditions such as those cited in the test method developed by the Carpet Policy Dialogue. To accomplish this, the Carpet Policy Dialogue recommends that additional test method development be initiated. This could take the form of modifications to the standard test method. Such modifications may include, but are not limited to, setting different procurement and conditioning or treatment protocols.

The Carpet Policy Dialogue notes that variability of TVOC emissions within any given carpet type (or from any given carpet mill) cannot be assessed under the existing carpet testing program. That is, the existing program was not designed to predict how often carpet of a given type (or from a given carpet mill) may be produced which emits at significantly

higher or lower rates than the values determined from the current testing programs. For these reasons, the consensus agreement reached by the Carpet Policy Dialogue calls for a technical evaluation by EPA for the purpose of determining the need for follow-on testing, if required. The EPA reserves the right to assess the suitability of test program results submitted for evaluation by industry to assure that the EPA has met the goals and concepts of the Federal Register notice. Issues identified by EPA will be discussed as follow-on activities with the parties named in the testing agreements. Details of these matters will be worked out by joint consultation by EPA and the industries sponsoring the testing and could be the subject of additional Memoranda of Understanding.

Although individual species of VOC emissions was not a major consideration of the Carpet Policy Dialogue, the Process Engineering Subgroup did consider that determining the dominant VOC species emitted from a carpet floor covering product could be helpful for assessing potential emission reduction measures in the future.

EPA will need to monitor and evaluate the information reported to the TSCA Carpet Emissions Administrative Record from the industry-wide testing and reporting programs. This information is expected to provide guidance about the nature of TVOC emissions and the overall effectiveness of the Carpet Policy Dialogue in influencing the reduction of exposures to VOCs from carpet floor covering materials. The data base can provide useful information to all parties interested in improving indoor air quality. EPA should seek opportunities to share this important information with decision makers involved in the purchase of or interior design consideration of the materials tested.

There is a need to evaluate the effectiveness of the various means for communicating information regarding carpet TVOCs and indoor air quality. A follow-up effort is needed to determine what information was communicated most effectively by the public information brochure developed by the Carpet Policy Dialogue Public Communications Subgroup. This effort should include consideration of the breadth of distribution among industry, installers, and retail outlets; as well as an assessment of additional or changing information needs of consumers.

The Plenary encourages the EPA to continue and expand research into developing an understanding of health effects from exposures encountered in the indoor environment which are a result of a variety of products and activities.

There is a need to expand efforts to understand how carpet attributes impact carpet's role as a re-emitting sink.

There is a need to expand efforts to understand how carpet cleaning and maintenance practices affect VOC concentrations in indoor air.

As noted previously, many of the consensus agreements of the Carpet Policy Dialogue contain provisions for follow-on activities. These include annual industry reports of data and

information useful to the goals and purposes of the Carpet Policy Dialogue, provisions for follow-on testing activities, if needed, development of a public communication program to inform the interested public about conclusions drawn from the various testing programs and TVOC emissions, establishment of an information repository in the Carpet Emissions Administrative Record, and in some cases establishment of quality product certification programs within particular industries. The reader is referred to more detailed discussions about follow-on activities which are described in the various consensus and MOU agreements developed by the Carpet Dialogue. (See Appendicies F, G, H, I, J, K, and L.)

1.5. SUMMARY

The Carpet Policy Dialogue Group has identified a series of accomplishments attained during the period of August 21, 1990, through September 27, 1991. These include:

- The Dialogue Group reached consensus agreement on three (3) testing programs to measure TVOC emissions factors from carpet, carpet cushion, and carpet installation adhesive products.

- The Dialogue Group contributed to the development of an analytical test method for determining TVOC emissions from carpet-related products which may provide the basis for an ASTM test method.

- The Carpet and Rug Institute (CRI) agreed to release TVOC decays of previously-tested SBR latex-backed carpet for review and determination of an appropriate point in time to conduct emissions testing.

- The CRI committed to a TVOC emission decay curve study for non-SBR latex-backed carpet product types.

- The CRI committed to an industry-wide profile study to provide comparative TVOC emissions of carpet product types currently available in the marketplace. The study will include both SBR and non-SBR latex-backed carpet types.

- The CRI committed to additional voluntary actions beyond product testing including: (1) generation of a history of TVOC levels through ongoing, periodic monitoring, which would be available for trend analysis; (2) motivating manufacturers to institute voluntarily quality assurance measures to reduce TVOC emissions through a CRI-established certification program; and (3) inform the general public and carpet customers of the carpet industry's quality assurance program and its results on a periodic basis.

- The Carpet Cushion Council (CCC) committed to a testing program to measure TVOC emissions from carpet cushion products.

- The CCC agreed to address the need for additional information about process engineering by formation of technical task groups in each product area to investigate ways to reduce VOC emissions from these products.

- The Floor Covering Adhesive Manufacturers Committee (FCAMC) of the National Association of Floorcovering Distributors (NAFCD) accelerated organizational activities to represent the floorcovering adhesives industry and become the vehicle by which this industry can develop information to address voluntary testing actions under the Carpet Policy Dialogue charter.

- The FCAMC committed to support research needed to modify the standard analytical test method to determine TVOC emissions from carpet installation adhesives and carpet seam sealers.

- The FCAMC committed to conduct preliminary testing studies to measure TVOC emission decays from carpet installation adhesives and carpet seam sealers.

- The FCAMC reported an accelerated trend in which low-emitting multi-purpose carpet adhesives are entering into the marketplace.

- The Carpet Policy Dialogue reinforced a market climate encouraging the introduction of low-emitting carpet adhesives. Most of the member companies of FCAMC are now producing such products.

- The Styrene Butadiene Latex Manufacturers Council (SBLMC) report that this industry reduced VOC emissions from their product in recent years, and that they completed a series of toxicity tests for a VOC contaminant (4PC) in latex products.

- The SBLMC agreed to provide data from their ongoing quality analysis programs and to report the company-by-company weighted average of 4-PC in styrene butadiene latex sold for carpet backing applications for 1991 and 1992 as the data becomes available. This information will be used to assess the feasibility of utilizing the information to develop future quality control activities.

- The Floor Covering Installation Contractors Association agreed to enhance training programs to include information about indoor air quality and educate installers about proper installation procedures and encourage them to adhere to carpet industry installation guidelines (CRI 104 and CRI 105).

- The Dialogue Group compiled information about manufacturing processes for carpet, carpet cushion, carpet installation adhesives, styrene butadiene latex, and carpet installation practice.

- The Dialogue Group compiled potential research which may identify process control measures to reduce TVOC levels in carpet-related sources that deserve consideration.

- The Dialogue Group compiled suggested potential control strategies to minimize carpet system VOC emissions in new construction and renovation projects.

- The General Services Administration (GSA) established an initiative to develop requirements to make a low VOC carpet floor covering available for use in Government offices. It is anticipated that a low TVOC emitting carpet floor covering could be available from the GSA Federal Supply Schedule for the contract period beginning April 1994, provided adequate technical data is available from the TSCA Carpet Emissions Administrative Record.

- The Dialogue Group developed a public brochure on information about new carpet and indoor air quality, which will be available for general distribution.

CHAPTER 2

Product Testing Subgroup: Methods and Accomplishments

2.0. PRODUCT TESTING SUBGROUP: METHODS AND ACCOMPLISHMENTS

2.1. INTRODUCTION

The Product Testing Subgroup was comprised of selected technical representatives of the carpet industry, related component industries, various consumer and public interest groups, academia and other organizations, and Government agencies participating in the Carpet Policy Dialogue Process. These individuals were selected by their respective organizations to provide technical support for the development of methodologies to test and quantify TVOC emissions from carpets and carpet flooring system products. They specify test protocols and sampling plans for the voluntary testing programs prescribed in the Federal Register notice. The Subgroup operated under the oversight of the Carpet Policy Dialogue Plenary Group.

Two primary accomplishments were achieved by the Product Testing Subgroup during the Carpet Policy Dialogue year. These accomplishments were (1) the development of a standard test method for testing TVOC emissions from carpets and related carpet flooring system products, and (2) the development of voluntary testing agreements for the carpet, carpet cushion, and carpet installation adhesive industries. Ten formal meetings and numerous teleconference calls and working party sessions were conducted to realize these achievements.

This chapter provides an overview of the approach followed by the Subgroup in meeting its goals. It documents the primary issues, concerns, and decisions made by the Subgroup during the development of the test method and the three industry testing programs. Numerous hours were spent discussing design options, resolving conflicts, and reaching consensus on the testing programs proposed by industry. This chapter summarizes the results of the successful negotiation and problem resolution process that evolved during these discussions. These successes are attributable to the positive spirit and degree of cooperation that was evidenced among Subgroup members.

2.2. TEST METHOD DEVELOPMENT

The development of a standard test method for the detection, identification, and quantification of total volatile organic compound emissions from carpets and related carpet flooring system products was a multifaceted process that involved several key technical issues. These issues are addressed below.

2.2.1. Total Volatile Organic Compounds

The Federal Register notice specifies that total volatile organic compound (TVOC) emissions be measured in the voluntary testing programs to be conducted by the carpet and its related component industries. Several discussions concerning the detection and quantification of the individual chemical constituents of TVOC emissions from carpet products were held. The Plenary, however, confirmed that the testing programs would focus exclusively on TVOC emissions. Nonetheless, it was agreed that the method endorsed by the Carpet Policy Dialogue should have the dual capability of measuring TVOC, as well as its chemical constituent, emissions.

The first task facing the Subgroup was formulation of a definition or algorithm for calculation of total volatile organic compounds. After consideration of the various options, it was agreed that the definition of TVOCs would be derived from the method chosen for use in the Carpet Policy Dialogue Testing Programs.

2.2.2. Evaluation of Alternative Test Methods

In initial discussions, it was decided that the Product Testing Subgroup would explore state-of-the-art methodologies that could be used to detect and quantify accurate and precise TVOC emission factors. Further, the nature of tests and their reporting should allow comparison to typical emission factors of similar products. However, it was agreed that the Subgroup would not develop method validation criteria, e.g., unit cost per analysis sample, specification of the number of laboratories needed to validate the method, and qualifications of personnel who would conduct the analyses.

The Subgroup members acknowledged that more than one method may produce reliable TVOC emission data. They also emphasized that a uniform, agreed-upon approach was needed for testing. A concern was raised that if multiple protocols were used in the testing programs or if a certain procedure was changed after testing had begun, the data analyzed by "inappropriate" methods would be invalidated. Thus, it was agreed that the Subgroup would pursue the development of one test method for use in the testing programs.

Several test methods were considered by the Subgroup. These included static headspace, purge and trap, and dynamic chamber techniques. There was early agreement that environmental chamber testing was the most appropriate method for measuring chemical emissions from carpets. This method would provide an accurate and realistic approach to measuring carpet emissions. It would also provide reproducible TVOC determinations, for both single-point-in-time measurements and decay curve analysis. Studies were cited which indicated no correlation between purge and trap and environmental chamber results. Although it was decided that the environmental chamber methodology would be the basic technology to be used in the testing programs, another method was briefly considered.

2.2.2.1. *Quality Control/Internal Processing Test Methods*

As stated in the Federal Register notice, it was initially believed that carpet products would need to be tested on a company-by-company, product-by-product basis. Intense market competition among product lines warranted the dissemination of comprehensive TVOC emission factor information to the consumer. In response to this need, the Subgroup investigated the feasibility of developing a quality control test method. This method could be used for on-line, process monitoring.

Early on in the development process, however, the Carpet and Rug Institute (CRI) presented exploratory data which indicated that the variability in TVOC emission factors between carpet products made with SBR latex was not significant and that testing at an aggregate or product class level, rather than at a company-by-company level, was appropriate. Further, the data demonstrated that TVOC emissions from carpets were relatively low, as compared to emissions from many other indoor products. While these assertions were neither supported nor rejected by the Subgroup, it was agreed that Dialogue testing would focus on the characterization of TVOC emission factors for selected product classifications or groups of product types. If it was found that more extensive testing (i.e., on a company-by-company and product line-by-product line basis) was needed, it would be pursued after completion of the Dialogue year. Additional details concerning the design of the testing program for carpets are provided in Section 2.3.1.

Although the value of a quality control type method was clearly recognized, it was acknowledged that one drawback to the use of the proposed method was that on-line product testing for TVOC emissions could not be completed in sufficient time to provide information to adjust process parameters. As such, it was not useful as a quality assurance tool. Further, it was concluded that correlation of TVOC measurements between the quality control and the environmental chamber test methods was impractical. Since it was unclear what compound(s) the quality control method was measuring, it was also believed that the method would not yield meaningful results. Thus, development of the quality control/process monitoring test method, as sponsored by the Carpet Policy Dialogue, was abandoned.

2.2.2.2. *Method Elements and Test Parameters*

Several technical issues needed to be resolved concerning the environmental chamber test method. One concern was whether the test method was sufficiently flexible to measure emissions from all carpet flooring system products, that is, from carpet cushions and carpet installation adhesives. Adhesives were cited as posing unique challenges for sample application, air sampling and chemical analysis techniques. For example, the emission profile of "wet" sources, like adhesives, will differ significantly from other components of the flooring system. In addition, different compound classes than those released from carpet products may be emitted from adhesives. After much discussion, it was agreed that the

environmental chamber test method, with minor modifications, should be able to identify and quantify TVOC emissions from carpets, as well as from other flooring products.

Other technical issues involved the specification of method elements and test parameters. Fifteen key elements of the test protocol for flooring materials were identified. These elements are:

- Product Collection;
- Product Packaging;
- Product Delivery;
- Product System Preparation;
- Chamber Preparation;
- Chamber Loading;
- Chamber Testing;
- Sample Collection;
- Sample Introduction;
- Chemical Analysis;
- Quantification;
- Results;
- Quality Assurance;
- Archiving Sample; and
- Report Format.

The environmental chamber test parameters discussed were chamber size, material, TVOC recovery, temperature, relative humidity, and air change rate. Sampling issues included time point(s), media, volume of air, and collection methods. Desorption temperature, time, and flow were important for sample introduction. The chemical analysis concerns included technique, methodology, and detection. Quantification involved the method detection limit (MDL) and minimum quantifiable limit (MQL). Calibration, use of internal and external standards, and response reporting were also cited. Quality assurance issues included chamber and analysis instrument controls and laboratory quality control samples. A test method working party was established to provide the details of the standard test method.

2.2.3. Standard Test Method

Based on the concerns and decisions described above, on November 29, 1990, the Carpet Policy Dialogue Plenary accepted the Product Testing Subgroup's recommendation that a small chamber method be used for measuring TVOC emissions from carpet products. This method was documented by the EPA in its report, "Indoor Air Sources: Using Small Environmental Chambers to Characterize Organic Emissions for Indoor Materials and Products" (EPA 600/8-89-074). It follows an ASTM standard, "Standard Guide for Small-

Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products" (ASTM D5116-90).

The test method, "Test Method for Determining Total Volatile Organic Compound Emission Factors from Carpet Under Defined Test Conditions Using Small Environmental Chambers," reports TVOC as an emission factor from flooring materials using standard test conditions. Quantitative measurement is determined by gas chromatography with flame ionization detection or gas chromatography/mass spectrometry. The observed test chamber concentration is converted to an emission factor, which may be a product specific variable. An addendum to document protocol changes necessitated for testing of carpet installation adhesives has yet to be finalized and will be attached to the principal document pending results of preliminary studies in progress. (See Appendix E.)

The test method was peer reviewed by a select group of accomplished experts (listed in Appendix A). It is anticipated that the method will be submitted to the American Society for Testing and Materials (ASTM), subcommittee D22.05 on Indoor Air, for ASTM balloting procedures as a proposed "Standard Method." Further validation by interested laboratories is expected over the next 2 years.

2.3. CONSENSUS ON VOLUNTARY TESTING AGREEMENTS

The second major accomplishment of the Product Testing Subgroup was the development of voluntary testing agreements from the carpet, carpet cushion, and carpet installation adhesive industries. These agreements describe each industry's commitment to conduct periodic testing to quantify TVOC emissions from newly manufactured products.

A component approach to testing was adopted by the Subgroup. That is, three testing programs, describing the sampling and analysis plans adopted by the carpet, carpet cushion, and carpet installation adhesive industries, were developed. Although the need for testing of the total carpet flooring system was cited, carpet assemblies will not be tested under the auspices of the Carpet Policy Dialogue. This approach is in recognition of the fact that from a pollution prevention standpoint, each manufacturer only has control over their respective component of the total flooring system.

The Federal Register notice states that EPA "will be requesting the carpet industry to voluntarily commence appropriate periodic testing (probably on a company-by-company, product-by-product basis) to quantify the total emissions of VOCs from their products to provide the interested public with comparative information on total VOC emissions from new carpets." In response to this charge to the Carpet Policy Dialogue, the Product Testing Subgroup embarked on a mission to design testing programs to obtain industry-wide product-specific TVOC emission data. This strategy was slightly modified during the Dialogue year as the needs of each component industry were addressed. Since testing will be conducted on newly manufactured products, the Subgroup agreed that the Dialogue testing would focus on

characterizing the TVOC emission profile of individual carpet, carpet cushion, and carpet installation adhesive products. A description of the process followed to obtain the three carpet industry agreements follows.

2.3.1. Carpet Testing Program

On October 25, 1990, in Plenary session, the Carpet and Rug Institute (CRI) presented the results of an exploratory effort, conducted in the previous year, which indicated that there may not be significant variability in TVOC emission factors between carpet products made with SBR latex. CRI recommended that future testing be conducted at a product class level, rather than at a company-by-company level. While the Subgroup neither accepted nor rejected this assertion, it was agreed that product testing should initially be conducted on a random sample of carpet products, selected from those product classifications identified by the industry as potential contributors to TVOC emissions. If it was determined that company-by-company and product line-by-product line testing was warranted, the carpet industry would pursue this approach in future testing.

In response to this decision, the overall objective of the Carpet Testing Program was redefined to characterize the distribution of TVOC emissions factor performance of carpet product types currently in commerce. The data collected under the program would address the question of TVOC emission variability, or lack thereof, across carpet product types. The specific goals of the Carpet Testing Program are to:

- Characterize TVOC emissions in a representative sample of carpet products;
- Determine the range of TVOC emissions in various carpet products;
- Assess whether TVOC emissions factors are different between specific product types; and
- Generate a data base of TVOC emission factors over time.

In order to meet these objectives, a description of the carpet product universe was needed. Carpets were defined as a variety of fabric products used for floor covering that are manufactured from various materials by tufting, weaving, knitting, needle punching, custom tufting, or fusion bonding. Six compositional elements are used in the manufacture of carpets. These elements are face fiber, primary backing, latex, secondary backing, dye/colorant, and topical treatment. There are numerous materials and processing procedures that can be brought together to form the many combinations that comprise the full range of carpet products currently available in the market place.

Carpet product types are further resolved into two general groupings: softback and hardback. The softback group is a broadloom carpet product, comprising 94 percent of the

total market share, and produced at about 151 finishing lines. The hardback group is a tile product with a thicker backing, comprising 6 percent of the market share, and produced at about 20 finishing lines.

For the purposes of Dialogue testing, three materials factors were used to classify carpet product types. These factors are face fiber (nylon, olefin, polyester and wool), topical treatment (no treatment, application of soil release treatment, and application of soil release and stain resistant treatment) and backing (Styrene Butadiene Rubber (SBR) latex, Amorphous Resin (AR) hardback, Urethane foam, Polyvinyl chloride (PVC) hardback, Ethylene vinyl acetate (EVA) hardback, Urethane hardback, and Bitumen hardback). A canvas of the industry was conducted by CRI in early 1991 to obtain information on current products. The survey found 25 carpet product types in commerce. Eight SBR latex-backed carpet product types, accounting for approximately 94 percent of the market, and 17 non-SBR latex-backed carpet product types, accounting for 6 percent of the market, were identified. It was judged that this roster comprised over 98 percent of carpet types produced for general and commercial commerce. A listing of the 25 product types is provided in the document, "Carpet and Rug Institute Consensus Statement: Testing Program for Carpet Products".

Upon further evaluation, it was realized that identification of an air sampling time point(s) for data collection was needed. That is, it needed to be determined whether a single number, or single air sampling time point, to indicate TVOC emissions was sufficient or whether emission time profile testing was required. Although it was acknowledged that for product testing of the universe of carpet products, a single number resulted in lower analysis costs, it was also recognized that in order to characterize the emission profile of specific product classes (e.g., softback versus hardback carpets), the method would have to provide more than a single number. Furthermore, in order to designate a sampling point(s), TVOC emission data to characterize the decay rate of the carpet product types specified in the design were also needed. As part of its exploratory work, CRI had collected decay curve data on TVOC emissions of carpets made with SBR latex. The Subgroup agreed that a 24-hour air sampling point was appropriate for analysis of softback carpets. However, corresponding data were needed for hardback products. CRI agreed to conduct testing to characterize the decay rate of hardback carpets.

The Carpet Testing Program is organized into two distinct studies. The first study developed decay curve emission data on six hardback carpet product types. Eighteen hardback carpet samples were collected and analyzed. A comprehensive decay curve analysis was conducted to determine the appropriate sampling time point was 24 hours to use in measuring TVOC emissions in an industry profile study. The second study began to build a data base of TVOC emissions from a representative sample of carpet product types. Information to assess whether average TVOC emissions factors between carpet product types are different was obtained. These data address the variability questions raised by CRI in its earlier work. Fifty-four SBR latex-backed carpet samples and 6 additional hardback samples

are being collected in the second study. All carpet samples are being obtained at the end of a manufacturer's finishing line.

The results of both studies will be combined and analyzed in an industry-wide profile study of TVOC emissions for carpet products currently available in commerce. A total of 78 carpet samples will be statistically analyzed in the Profile Study. The appropriate air sampling time point(s) will be used in this analysis. These data will also form the basis for a series of proposed follow-on activities that include an annual reporting of carpet TVOC emissions performance and a carpet product certification program. Details of these follow-on programs will be worked out jointly by EPA and the Carpet and Rug Institute.

The Plenary reached consensus agreement on the CRI Carpet Testing Program on February 28, 1991. The first study, on hardback products has been completed. The results of the decay curve analysis will be submitted to the EPA and a report will be entered into the Carpet Emissions Administrative Record when the EPA review and evaluation is completed. The second study, on all softback and several hardback products, began in the fall of 1991. A copy of the consensus statement and attachment to the consensus statement is provided in Appendix F.

2.3.2. Carpet Cushion Testing Program

A similar design process was followed in developing the Carpet Cushion Testing Program. Exploratory data on generic types of carpet cushions developed in 1990 for the Carpet Cushion Council demonstrated that TVOC emissions from carpet cushions, while different among product classes, approximate that of carpet emissions. It was also shown that carpet forms a barrier to emissions from carpet cushion that significantly slows down the permeation of TVOCs into indoor air. However, limited information about the characteristics of the decay curve for various carpet cushion product types exists. No data on the variability of TVOC emissions from cushions of the same product type (manufactured at different finishing lines) or on the differences between average TVOC emission factors for carpet cushion product types are available. Thus, decay curve data were needed on the various carpet cushion product types. The overall objectives of the Carpet Cushion Testing Program were defined to characterize the TVOC decay curve characteristics for each of the carpet cushion product types currently in commerce and to determine the appropriate air sampling time point(s) to use in measuring TVOC emissions in future studies.

Carpet cushions are composed of various raw materials, to a large extent, scrap materials from the manufacture of products used in other industries. The scrap materials are obtained from numerous worldwide sources and recycled for use in the manufacture of carpet cushions. As such, the chemical makeup of an individual cushion, in particular bonded and jute cushions, can vary and may be dependent on the time of the year and location of the purchase of its raw materials.

Carpet cushions are placed underneath carpet on a wall-to-wall type of installation that completely covers the surface and sides of the carpet cushion when installed. It was estimated that new carpet cushion is placed under approximately 50 percent of all new broadloom carpet sold. Vinyl non-skid rug pads and other non-skid rug pads weighing less than 14 ounces per square yard, for placement underneath area rugs, were defined to be beyond the scope of the Testing Program.

Carpet cushions are classified into five product types: bonded, prime, rubber, synthetic, and rubberized jute. These products are manufactured on an estimated total of 75 finishing lines, representing approximately 35 companies. Bonded cushions comprise 56 percent of the total market share (based on square yards shipped); prime cushions constitute 33 percent of the market. Rubber cushions constitute 6 percent of the total market, while synthetic cushions represent 3 percent of the market. Rubberized jute cushions comprise 2 percent of the market.

The Carpet Cushion Testing Program will be conducted in two phases. Fifteen samples will be collected in the combined testing program. The first phase will develop decay curve emission data on bonded and prime carpet cushion product types, representing 89 percent of the entire market. Three samples from each product type, or a total of six samples, will be tested. Phase II will collect corresponding information on rubber, synthetic and rubberized jute carpet cushions. A total of nine samples will be collected in Phase II. All carpet cushion samples will be obtained at the end of a manufacturer's finishing line.

The decay curve data established for the five carpet cushion product types will be compared with existing data on carpet cushion TVOC emissions. They will also be used to determine the appropriate air sampling time point, or points, to use in measuring TVOC emissions. This single point(s) will be used to characterize carpet cushion TVOC emissions in a larger industry-wide study, to be conducted as a follow-on activity to the Carpet Policy Dialogue. The industry study will build a data base of TVOC emissions, collected from a representative sample of carpet cushion products over time. Additional follow-on activities to be conducted by the Carpet Cushion Council include an annual reporting of the aggregate history of carpet cushion industry TVOC emission product performance for at least 3 years, and development of a program to motivate producers to institute voluntary indoor air quality assurance measures with respect to their carpet cushion products. Details of these follow-on programs will be worked out jointly by EPA and the Carpet Cushion Council.

The Plenary reached consensus agreement on the Carpet Cushion Council Carpet Cushion Testing Program on June 28, 1991. The Phase I study, on bonded and prime products, began in the fall of 1991. Phase II, on rubber, synthetic and rubberized jute products, will be conducted as resources become available but within a 1-year period. A copy of the consensus statement and attachment to the consensus statement is provided in Appendix G.

2.3.3. Carpet Installation Adhesive Testing Program

The process followed by the carpet installation adhesives industry in developing a test program was similar in many ways to the process followed by the carpet and carpet cushion industries. At the start of the Dialogue year, however, the Floor Covering Adhesive Manufacturers Committee had not been directing its efforts toward testing of TVOC emissions from adhesive products. It needed to organize its members to respond to the Federal Register notice and to address voluntary testing actions under the Carpet Policy Dialogue charter. Nonetheless, the Committee reacted promptly, and a testing program was developed.

Most carpet installation adhesive manufacturers have been calculating VOC content using standards set by the South Coast Air Quality Management District (ASTM D3960-81 and/or ASTM D2369-87). Prior to 1990, the majority of carpet installation adhesives were at a calculated VOC of 150 g/l or higher. With the pressure of South Coast's Rule 1168, manufacturers reformulated their products to a calculated VOC at or below the required 150 g/l limit ("Rule 1168 - Control of Volatile Organic Compound Emissions from Adhesive Application," Amended February, 1991).

A survey was taken in February, 1991, by the Floor Covering Adhesive Manufacturers Committee asking manufacturers to report on the range of calculated VOCs in the products they were making by product type -- current formulas versus new generation formulas. The responses ranged from 40 g/l to 150 g/l on current formula lines and from 0 g/l to 20 g/l on new generation lines. At the National Association of Floor Covering Distributors Convention, held May 5-8, 1991, 14 of the 15 carpet installation adhesive manufacturers who had booths displayed a low VOC emission carpet installation adhesive or a line of low VOC emission products. This trend in the manufacture of low-emitting multipurpose carpet adhesives is regarded as a significant accomplishment of the carpet installation adhesives industry. However, no data on the relationship between these calculated values to TVOC emission rates from carpet installation adhesives have been established.

Only a limited understanding about the decay curve characteristics of carpet installation adhesives exists. Additional information to address whether a single sampling point is sufficient to characterize TVOC emissions from carpet installation adhesives and whether there are significant differences in the emission profiles of various adhesive product types is needed. If a single point for TVOC measurement is reasonable, then the appropriate point must also be determined. Further, questions concerning the applicability of the standard test method described in Section 2.2.3. (e.g., application rate, method of application, and type of substrate material) were raised during technical discussions on the design of a testing program to characterize the decay curve of floor covering adhesive products. These data gaps resulted in the need to develop a different testing design for the adhesives industry.

In response to the data needs identified by the Product Testing Subgroup, the overall objective of the Carpet Installation Adhesive Testing Program was defined to characterize the decay curve characteristics of a sample or samples from each of the carpet installation adhesive product classifications currently in commerce. The program will not provide data on the distribution of TVOC emissions across the universe of carpet installation adhesive product types.

Carpet installation adhesives are formulated through a composition of several basic ingredients, combined in varying proportions depending upon the functions of the adhesive. Adhesive formulating and the choice of raw materials used is based on price, performance, and environmental issues. Six functional components are generally used: vehicle (e.g., water, solvents, or a combination of both), binder (e.g., latex (SBR is the major latex used) or resins (sometimes referred to as tackifiers), fillers (limestone, gypsum, sand, or clay), viscosity control agents, preservatives, and freeze-thaw stability agents (e.g., methanol or ethylene glycol). These raw materials are obtained from numerous sources and added to the final mixture in amounts determined by the manufacturer. Adhesive manufacturers typically offer a qualitative range of carpet installation adhesives, with good (economy), better, best (premium), and specialty products. Further, variations of adhesive formulas are needed in different geographical markets, due to variable temperature and humidity conditions.

For Dialogue testing, carpet installation adhesives were classified into five product classifications: multipurpose, pressure sensitive, vinyl backed, pad cement, and seam sealer. These products are manufactured by 16 member companies. Multipurpose adhesives comprise 75 percent of the total carpet installation adhesive market and are produced by 16 companies at 32 plants. Pressure sensitive adhesives constitute 17 percent of the market and are produced at about 26 plants, representing 16 companies. Vinyl backed adhesives constitute 5 pecent of the total market and are produced at 28 plants (17 companies). Pad cement (2 percent of the market) is produced at 17 plants by 12 companies. Seam sealers are produced at 15 plants (12 companies) and comprise 1 percent of the carpet installation adhesive market.

The Carpet Installation Adhesive Testing Program will be conducted in two phases. Prior to commencement of the program, a preliminary study was conducted to establish specific testing parameters for carpet installation adhesives. The Preliminary Study will provide data to refine the test protocol for use in characterizing TVOC emissions from the multipurpose and pressure sensitive carpet installation adhesive product classifications. It will create and evaluate alternative test protocols to determine which procedures are most appropriate for use in characterizing TVOC emissions from carpet installation adhesive products. Four samples will be tested.

Following preliminary testing, Phase I will determine the TVOC decay curve characteristics for multipurpose and pressure sensitive adhesives. These adhesives represent approximately 92 percent of the carpet installation adhesive market. TVOC decay curves will be analytically determined on a sample(s) of each of the product classifications.

Measurements will be taken at the number of time points determined in the Preliminary Study. This information could be used by the industry to determine the appropriate air sampling time point, or points, for follow-on activities. This single point(s) could also be used to characterize carpet installation adhesive TVOC emissions by individual companies as they test their products in a follow-on activity to the Carpet Policy Dialogue. Fifteen samples will be analyzed in the Phase I study.

Phase II will include decay curve testing on vinyl backed adhesives, pad cement, and seam sealers. This testing will be conducted as resources can be made available, but within a 1-year period. Preliminary test method development may also be needed prior to initiating testing of these three product classifications. The number of samples to be collected in Phase II testing will be determined upon the completion and evaluation of Phase I testing. All carpet installation adhesive samples will be obtained directly from the distributor. The Floor Covering Adhesive Manufacturers Committee indicated that these products have a rapid turnover at the distributor, ensuring that newly manufactured products will be sampled in the testing program.

The data collected in the Carpet Installation Adhesive Testing Program will also form the basis for a series of proposed follow-on activities that include an annual reporting of the aggregate history of carpet installation adhesive industry product type sales performance for at least 3 years and the development of a program to motivate producers to institute voluntary indoor air quality assurance measures with respect to their carpet installation adhesive products. Details of these follow-on programs will be worked out jointly by EPA and the Floor Covering Adhesive Manufacturers Committee.

The Plenary reached consensus agreement on the Floor Covering Adhesive Manufacturers Committee Carpet Installation Adhesive Testing Program on June 28, 1991. The Preliminary Study began in the summer of 1991. The Testing Program will begin as resources become available but within a 1-year period. A copy of the consensus statement and attachment to the consensus statement is provided in Appendix H.

CHAPTER 3

Process Engineering Subgroup
Summary Report

DISCLAIMER

The data/information presented in this report has not been subjected to formal peer review. In addition, there has been limited second source verification of information presented here. The recommendations of the Subgroup do not necessarily represent the positions and policies of individual Subgroup participants but represent a consensus view of the Subgroup.

3.0. PROCESS ENGINEER SUBGROUP SUMMARY REPORT

3.1. INTRODUCTION

3.1.1. Background

On January 11, 1990, the U.S. Environmental Protection Agency (EPA) received a petition from the National Federation of Federal Employees (NFFE), Local 2050, requesting EPA to promulgate rules under section 4, 6, and 8 of the Toxic Substances Control Act (TSCA), to reduce emissions from new carpets. [Federal Register, Vol. 55, No. 79, April 24, 1990]. In response, EPA denied the petition. However, the Agency believed that "an absence of scientific certainty does not necessarily mean an absence of risk." EPA recognized that "new carpet may be a significant source of human exposure to low levels of volatile organic compounds (VOCs)" and stated that "as a matter of policy it is prudent to minimize indoor human exposure ... where reasonable." The Agency, therefore, took three major initiatives:

> *"The Agency is formally requesting that the carpet industry undertake a voluntary program to conduct periodic total VOC analyses on a company-by-company and product-by-product basis to provide the interested public with comparative information on total VOC emissions. Second, the Agency is inviting all interested parties to participate in a one-year dialogue process designed to work out the details of the voluntary testing program mentioned above and to explore and, where possible, to reach agreement on a variety of issues including: the sampling and analytical methods for the voluntary testing, any additional information needed, and cost-effective process changes to reduce emissions.... Thirdly, the Agency will continue its on-going exposure reduction and research activities on indoor air quality issues generally and on the potential health effects of exposure to low level VOC mixtures, in particular."*

3.1.2. Charter and Charge of Dialogue

The charter for the Carpet Policy Dialogue was given in the Federal Register notice. To complement the new initiatives, the Federal Register notice also laid out the following "specific charges to the participants in the Dialogue."

> "1. Develop standard methodologies for testing carpet emissions and to obtain commitments to test carpeting. The Agency will be requesting the carpet industry to voluntarily commence appropriate periodic testing (probably on a company-by-company, product-by-product basis) to quantify the total emissions of VOCs from

their products to provide the interested public with comparative information on total VOC emissions from new carpets."

"2. Identify information needs for assessment of emissions control feasibility, including data on carpet manufacture and installation technology and commercial activities associated with carpet installation."

"3. Evaluate potential controls for reducing emissions, including product and/or emission standards, and labeling of carpet for VOC emissions."

"4. Identify VOC exposures which are associated with carpet installation but not necessarily from a carpet source (adhesives, floor preparation, etc.) and recommend any appropriate actions to reduce them."

3.1.3. Dialogue Defined

The Dialogue was initiated by an EPA Federal Register notice of August 3, 1990, "Carpet Emission Reduction; Policy Dialogue", p. 31640-41. The Dialogue was to run for 1 year, ending sometime in the April to August 1991 period. It was to be run on a consensus basis by a facilitator and be sponsored by the EPA. At the end of the process, when the Carpet Policy Dialogue Group meeting in Plenary had agreed on a response to the charges of its charter consisting of voluntary actions committed or undertaken by industry, the EPA would determine whether any rulemaking was necessary to obtain the information or produce the pollution-preventive action desired. The hope and goal of the Dialogue process was to engender voluntary actions by industry that would adequately address the issues raised and so obviate the need for Federal regulation under Sections 4 [testing] and 8 [reporting] of TSCA.

Participants in the Carpet Policy Dialogue included representatives from associations or manufacturers of carpet and carpet-related sources (latex, adhesive, and cushion), the installation industry, public interest groups, labor unions, research experts in assessment methodology, building consultants, the public health community, and other Government agencies.

Three Subgroups were formed to help carry-out the tasks in the Federal Register notice: the Testing Subgroup, the Process Engineering Subgroup, and the Public Communications Subgroup. The scope of work for the Process Engineering Subgroup is discussed below. The scopes of work for the other two Subgroups are discussed in other Subgroup Reports. All the Subgroups reported their findings and recommendations to the Dialogue Policy Group which then made the final decisions.

3.1.4. Process Engineering Subgroup

3.1.4.1. Scope of Subgroup Activities

The Process Engineering Subgroup was established in order to develop a response to the charter and charges for the Carpet Policy Dialogue Group. The scope of the Process Engineering Subgroup activities included charges 2, 3, and 4 listed in section 3.1.2. The goal of the Subgroup, based on these charges, was mainly to identify information gaps and potential cost-effective methods to reduce VOC emission from carpet and other related carpet sources and installation activities. Also, as stated in the Federal Register notice, this goal was to be achieved by sometime in April to August 1991.

In order to meet the commitments of the Federal Register notice, a boundary on the scope of work was set by the Carpet Policy Dialogue Group to include carpet, latex, adhesives, and cushion and installation activities, exclusively. The Carpet Policy Dialogue Group, in setting this boundary, acknowledged that there may be other sources of VOC contributors. Also, it was understood that the Agency, through its on-going research activities on indoor air issues, would consider other sources of VOC contributors.

3.1.4.2. Organization and Operational Structure

To effectively carry-out the charges above, the Process Engineering Subgroup had limited the number of participants in the Subgroup to include only representatives from the following participating organizations. These participants were chosen to provide adequate representations of all various interest and concerned groups in the Carpet Policy Dialogue Group. A complete list of Subgroup members and their affiliations is included in Appendix A.

Constituency	Individuals	Corporate or Organizational Affiliation
Architects	Hal Levin	ASTM Subcommittee D22.05 on Indoor Air
Carpet Adhesive Formulators	Charles Cline Ken Knudtzon Ron Swope	Floor Covering Adhesives Manufacturers Committee ALCO Chemical
Carpet Cushion Mfg.	William Oler	Carpet Cushion Council
Carpet Installers	James Dipelesi	Floor Covering Installation Contractors Association

(continued) Constituency	Individuals	Corporate or Organizational Affiliation
Carpet Mfg.	Ron VanGelderen	The Carpet and Rug Institute
	Ken McIntosh Joe Smrekar	Milliken and Company
EPA	Wardner Penberthy	EPA, Office of Toxic Substances
	Robert Axelrad	EPA, Office of Air and Radiation
	John Girman	EPA, Office of Air and Radiation
Fiber Mfg.	Henry Fogle	American Fibre Manufacturers Association
Labor	William Hirzy	National Federation of Federal Employees, Local 2050
National Institute of Standards and Technology (NIST)	Andrew Persily	NIST Indoor Air Quality Group
Styrene-Butadiene Latex Mfg.	Randy Arnott	Reichhold Chemicals, Inc.
	Werner Braun	Dow Chemical USA

The operational structure of the Process Engineering Subgroup consisted of a series of Subgroup meetings. The agenda for these meetings generally included presentations by representatives from various participating organizations. (See Table 3-1.) Topics covered included information on the manufacturing processes of latex, adhesives, cushion, and carpet; installation procedures; ventilation; and research activities. Available data on VOCs and VOC emissions from carpet and carpet-related sources were also presented.

3.1.4.3. Process Engineering Subgroup Proceedings

The Subgroup reviewed extensive amounts of technical information related to carpet and carpet component manufacturing processes, carpet installation, as well as data related to VOC emissions from carpet and carpet-related sources. By considering these topics, the

TABLE 3-1

TECHNICAL PRESENTATIONS MADE TO THE PROCESS ENGINEERING SUBGROUP

I. SB Latex

Tom Potts (Reichhold Chemicals, Inc.) and Jessie Roeck (Dow Chemical USA), 9/26/90. Presented information on latex manufacturing process, quality control, and 4-phenylcyclohexene reduction achievements.

Distributed copies of Dr. Van Ert's report to workgroup members on 9/26/90. The report summarizes Dr. Van Ert's laboratory-scale study of carpet oven curing parameters on VOC emissions.

Randy Arnott, Styrene-Butadiene Latex Manufacturers Council (SBLMC), 5/21/91. Presented company-by-company 4-phenylcyclohexene data from May 1988 to February 1991.

II. Adhesives

Ken Knudtzon, Floor Covering Adhesives Manufacturers Committee (FCAMC), 9/26/90. Gave an overview of carpet adhesive market and formulations.

Steve Chase, Floor Covering Adhesive Manufacturers Committee (FCAMC), 10/24/90. Presented detailed information on carpet adhesive formulations, components that make up adhesives, and potential VOC levels in those components.

III. Carpet Cushion

William H. Oler, Carpet Cushion Council (CCC), 9/26/90. Gave an overview of carpet cushion market, and manufacturing process of Bonded Carpet Cushion and Prime Urethane Carpet Cushion.

William H. Oler, CCC, 11/30/90. Presented information on manufacturing process.

William H. Oler, CCC, 4/9/91. Presented information on carpet cushion market and potential methods of reducing VOCs from carpet cushion.

IV. Carpet Manufacturing

Ron VanGelderen and others, Carpet and Rug Institute (CRI), 9/26/90. Presented information on carpet market and carpet manufacturing process.

TABLE 3-1

TECHNICAL PRESENTATIONS MADE TO THE PROCESS ENGINEERING SUBGROUP
(continued)

IV. Carpet Manufacturing (continued)

Alan Luedtke, Du Pont, 10/24/90. Presented data on an industry cooperative plant-scale study (Du Pont, Shaw, Dow, and Ciba-Geigy) on the effect of carpet curing oven operating parameters on VOC emissions.

V. Carpet Installation/Ventilation

Jim Dipelesi, Floor Covering Installation Contractors Association (FCICA), 9/26/90. Presented information on installation methods, installation parameters, and guidelines.

Jeff Davidson, EPA, 11/30/90. Gave a presentation on the EPA Carpet Installation Study about VOC emissions from installed urethane backed carpet (USEPA 1991). This study demonstrated that the selection of low VOC emiting carpet floor covering materials can reduce TVOC concentrations following new carpet installation. A copy of this study has been entered into the EPA TSCA Carpet Emissions Administrative Record.

Hal Levin, Hal Levin Associates, 4/9/91. Gave a presentation defining the relationship between building ventilation rates and indoor air VOC concentrations and setting forth practical control strategies for controlling carpet system VOC emissions.

Andy Persily, National Institute of Standards and Technology (NIST), 4/9/91. Gave a presentation reporting the results of an NIST Study comparing actual versus design ventilation rates in selected Federal Office Buildings.

Bruce Tichenor, EPA, 4/9/91. Gave a presentation on the effects of ventilation rates and conditioning times on indoor concentrations of 4-phenylcyclohexene.

John Girman, EPA, 4/9/91. Gave a presentation on general concepts of physical processes affecting VOC carpet emissions.

In order to provide a better understanding of the Subgroup deliberations of particular topics (e.g., latex manufacturing, carpet installations), this Summary Report includes a section called Process Engineering Subgroup Proceedings, which is included at the end of each chapter presenting the topic. Subgroup issues that were of a general nature or related to all the topics are discussed below.

At the first Carpet Policy Dialogue Plenary meeting, various industry participants raised their concerns about the open nature of the dialogue process. For example, concern was expressed that some information presented at the Plenary and Subgroup meetings may not have been peer-reviewed or verified for accuracy. It was suggested that information and documentation presented to the Subgroup should include all sources and references used. The Subgroup also suggested that a disclaimer be included in all draft documents presented to the Dialogue to reflect that some information could not be verified, was tentative, or that conclusions do not necessarily reflect positions of individual organizations participating in the dialogue. The suggested disclaimer was, "Not verified or endorsed as fact by the EPA Carpet Dialogue Group--For discussion purposes only. Do not quote or cite!"

A recurring issue in the Subgroup deliberations was whether speciated data on VOC components from carpet and carpet-related sources could be made available to the Subgroup. It was suggested by some members of the Subgroup that speciated data could allow the Subgroup to focus their investigations into reducing Total Volatile Organic Compounds (TVOC) in a more efficient manner. Also, it was suggested that this kind of data could allow the most significant TVOC sources to be targeted from more detailed evaluations of potential actions to reduce TVOC.

Some members of the Subgroup suggested that speciated data could not be shared with the public due to litigation. Other members suggested that speciated data might not be available; also, most current analytical methods might not be accurate in determining individual VOCs. No consensus agreement was reached by the Subgroup on this issue and, therefore, the issue was referred to the Plenary for further consideration.

It was suggested at the Plenary that existing sources of speciation data be investigated. Some very limited speciation data were later provided to the Subgroup by various industry groups. These data are included in this Subgroup Summary Report. Details on the discussions of this issue can be found in the Carpet Dialogue minutes of the October 25, 1990; November 29-30, 1990; February 27-28, 1991; April 8-10, 1991; and May 21-22, 1991, meetings; a March 5, 1991, letter from Hal Levin to Charles Auer citing sources of speciated data on carpet emissions; a presentation by William Hirzy on the need for data, given to the Plenary at the November 29, 1990, Plenary Session; and the Minority Report to the Carpet Testing Agreement.[1]

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[1] Available in the Administrative Record.

Another recurring issue in the Subgroup deliberations was how proprietary information could be handled. The Subgroup, in general, sought as much process information as possible about the carpet and carpet TVOC related sources, especially manufacturing process information. Much of this information was considered proprietary by Subgroup members. One mechanism used to help protect proprietary information was blinding or aggregating the pertinent data. In addition, confidentiality agreements were at times used. However, in many circumstances, proprietary interests of the companies involved prevented extremely detailed discussion of some relevant process information or related issues. In some of these instances, issues that could not be addressed by the Subgroup have become an information or research item or recommendation to the Plenary for further consideration.

3.1.4.4. Purpose of This Chapter

This Chapter is intended to partially fulfill part of the requirements of the Federal Register notice--mainly the identification and evaluation of potential methods of reducing VOC emissions from carpet and carpet-related sources and installation activities and identification of information gaps. This Chapter presents information that was presented in the Process Engineering Subgroup meetings and recommendations the Subgroup has made based on this information. Section 3.2 presents information on styrene-butadiene latex manufacturing process. The section presents information on process description, historical perspective on VOC reduction, evaluation of potential methods to reduce VOCs, and identifies information and research considerations and Subgroup recommendations. Subsequent sections, structured in a similar format to Section 3.2, include information on adhesives, carpet cushion, carpet manufacturing processes, and installation practice and ventilation, respectively.

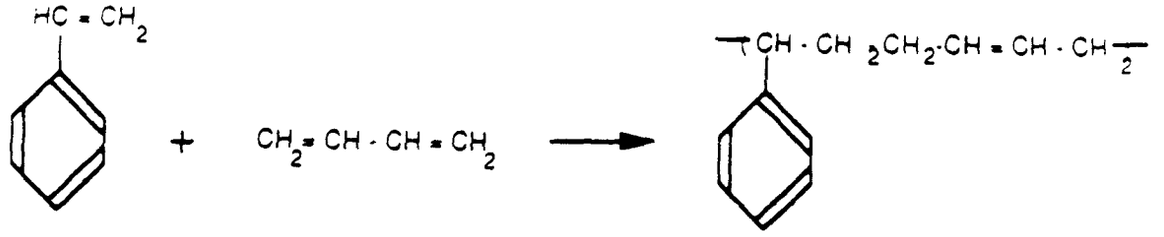
Each section of the Chapter was initially written by representatives of the various industry sectors who presented the information to the Subgroup.

3.2. STYRENE BUTADIENE LATEX MANUFACTURING

3.2.1. Process Description

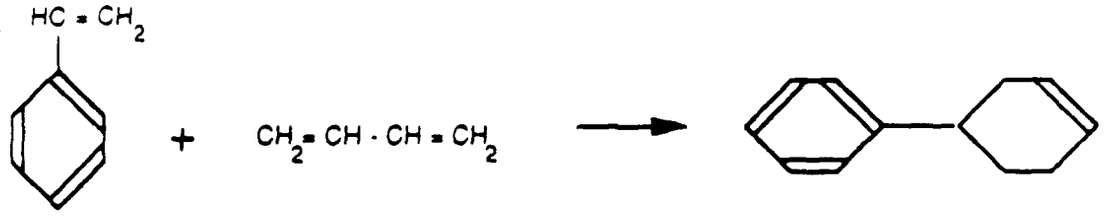
This section provides an overview of the styrene-butadiene (SB) latex manufacturing process. A great majority of information presented in this section was provided to the Process Engineering Subgroup of the Carpet Policy Dialogue by the Styrene-Butadiene Latex Manufacturers Council (SBLMC).

Emulsion polymerization processes are used to manufacture styrene butadiene latexes (SBL) for carpet manufacturing. SBL is a copolymer of styrene and 1,3-butadiene. The reaction sequence is as follows:



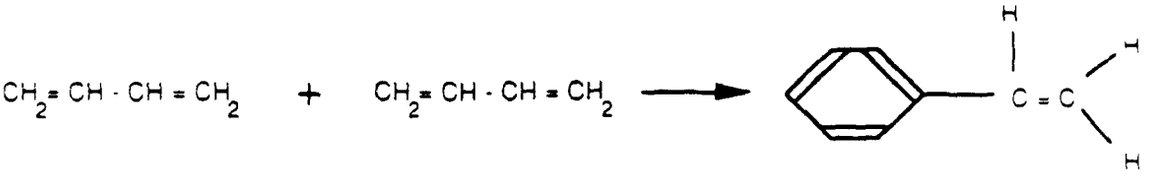
Styrene Butadiene Styrene-butadiene unit

During polymerization, an unwanted byproduct, 4-phenylcyclohexene, is formed as a result of the Diels-Alder side reaction of butadiene with styrene. This side reaction proceeds as follows:



Styrene Butadiene 4-Phenylcyclohexene

Another possible byproduct of the polymerization reaction is 4-vinylcyclohexene. This unwanted byproduct is formed as a result of a Diels-Alder side reaction of two butadiene molecules. The reaction proceeds as follows:



Butadiene Butadiene 4-Vinylcyclohexene

Emulsion polymerization is the polymerization of monomer droplets suspended in a dilute aqueous phase. Prior to and/or during polymerization, the monomers (styrene and butadiene), soap solution, initiator, and modifiers, are fed to the reactors. The amounts and types of these ingredients vary among manufacturers. The soap solution acts as an emulsifier. The initiator facilitates the generation of free radicals at lower temperatures, and the modifier controls the chain length and molecular weight distribution of the SBL.

In most plants, polymerization temperature is typically about 60° - 100°C. Some plants employ "cold" processes, which are operated at about 4°C. In the cold process, which is employed in less than 5 percent of carpet latex manufacturing, conversion of monomers to copolymer is less complete than is achieved by the hot process. A list of companies, manufacturing plants, and their production methods is included in Table 3-2.

Normally, polymerization takes from 4 to 24 hours to complete. Polymerization proceeds in the reactor vessels to 96 - 99 percent completion. A shortstop is added to halt the polymerization.

Following polymerization, the newly-synthesized latex is directed to a blowdown tank where unreacted monomers, monomer impurities, and byproducts remain. The latex is then transferred to flash tanks where 1,3-butadiene is vaporized and then fed to a steam stripper for the removal of styrene. (See Figure 3-1.) The latex is then transferred to process tanks where additives, including anti-oxidants, are introduced. Subsequently, the latex is filtered and sent to storage from which the latex is packaged into drums or loaded into rail tank cars or tank trucks for delivery to carpet mills.

Styrene-butadiene latex products sold to the carpet industry are produced on a consistent basis utilizing Quality Management and Statistical Process Control techniques. Raw materials used in the latex manufacturing process are monitored for conformance to specifications prior to use. Certificates of Analysis are required and supplier audits are periodically performed. TVOC content is not currently a raw material specification.

Critical process parameters in the polymerization phase are monitored during the reaction and adjusted to maintain statistically established control limits. Typical latex properties specified for analysis include: pH, total solids, residual monomer (styrene), particle size, and viscosity. Only latex that meets all specifications agreed to by a supplier and its customer is released for shipment. To further assure quality products and conformance to rigid specifications, Technical Sales and Service personnel are available on customer request to offer technical assistance at carpet manufacturing locations.

Styrene-butadiene latex suppliers recognized many years ago the importance of providing products that consistently meet customer needs. Through the development of computerized and statistical process controls, along with tighter customer performance specifications, a high quality product is assured. TVOC or 4-phenylcyclohexene are not currently specifications of SB latex product.

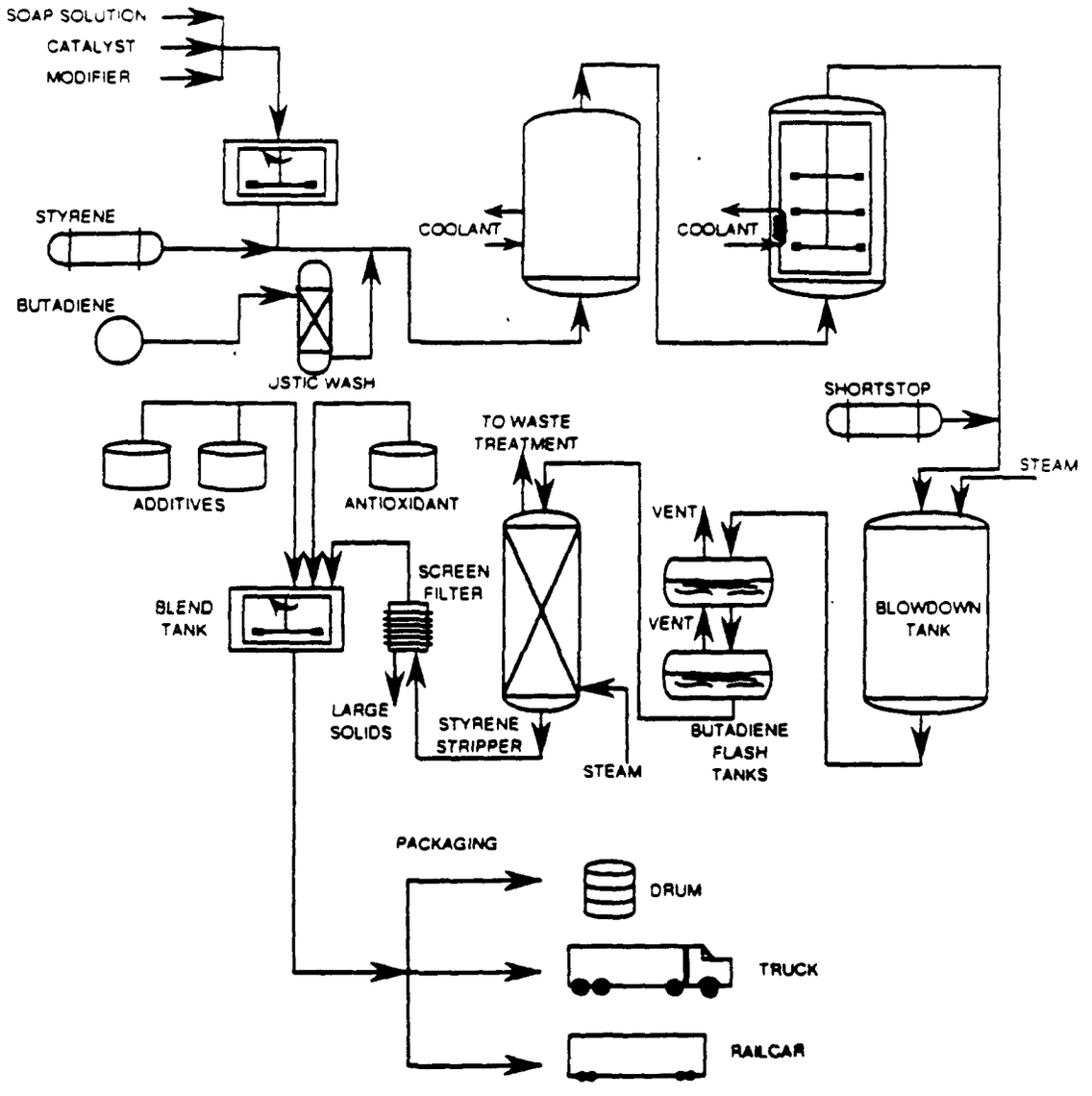
TABLE 3-2 U.S. COMPANIES PRODUCING SB LATEX

COMPANY NAME	LOCATION	METHOD OF PRODUCTION	CAPACITY, 10^3 METRIC TONS/YEAR	PLANT AGE
Dow Chemical	Dalton, GA Freeport, TX Gales Ferry, CT Midland, MI Pittsburg, CA	Emulsion	154	1960's
General Tire & Rubber Company	Mogadore, OH	Emulsion, hot	55	1966
Goodyear Tire & Rubber Company	Calhoun, GA	Emulsion, hot	35	1977
W.R. Grace & Company	Owensboro, KY	Emulsion	8	1959
Polysar, Incorporated	Monaca, PA Chattanooga, TN	Emulsion Emulsion	20 32	1950's 1960, 1972
Reichold Chemicals, Incorporated	Cheswold, DE Kensington, GA	Emulsion Emulsion	20 35	1957 1969
Unocal Corporation (Union Chemical)	Charlotte, NC La Mirada, CA	Emulsion Emulsion	17 15	1969 1969

Source: PEI Associates, Inc. Worker Exposure to 1,3-Butadiene in the Plastics and Rubber Industry Prepared for the U.S. Environmental Protection Agency. 1984

FIGURE 3-1

FLOWCHART OF THE SBL PROCESS



Source: PEI Associates, Inc., 1984. Worker Exposure to 1,3-Butadiene in the Plastics and Rubber Industry. Prepared for the U.S. Environmental Protection Agency.

More detailed technical information describing emulsion polymerization processes can be found in the published technical literature.

The sources of VOCs in the manufacture of SB latex include: unreactable monomer impurities, unwanted Diels-Alder reaction products (4-phenylcyclohexene and 4-vinylcyclohexene), and residual unreacted monomer. Unreacted monomer is typically the highest concentration of VOC components found in latex at the conclusion of polymerization, and is reduced via steam stripping. (See Section 3.2.3. below.)

Typically, the most persistent VOC component in the finished latex, and the finished carpet, is the Diels-Alder reaction product of styrene and butadiene, 4-phenylcyclohexene, which is unavoidably formed during the polymerization process.

Process variables which can affect SB latex 4-phenylcyclohexene concentrations are discussed in Section 3.2.3.

3.2.2. VOC Reductions Already Achieved

In mid-1988, in light of questions raised about 4-phenylcyclohexene, SB latex manufacturers began to review the levels of 4-phenylcyclohexene present in their finished product. SBLMC began several research projects, including the development of a validated analytical method, to assure consistent results. Latex manufacturers individually examined their processes to determine if process changes could reduce the levels of 4-phenylcyclohexene.

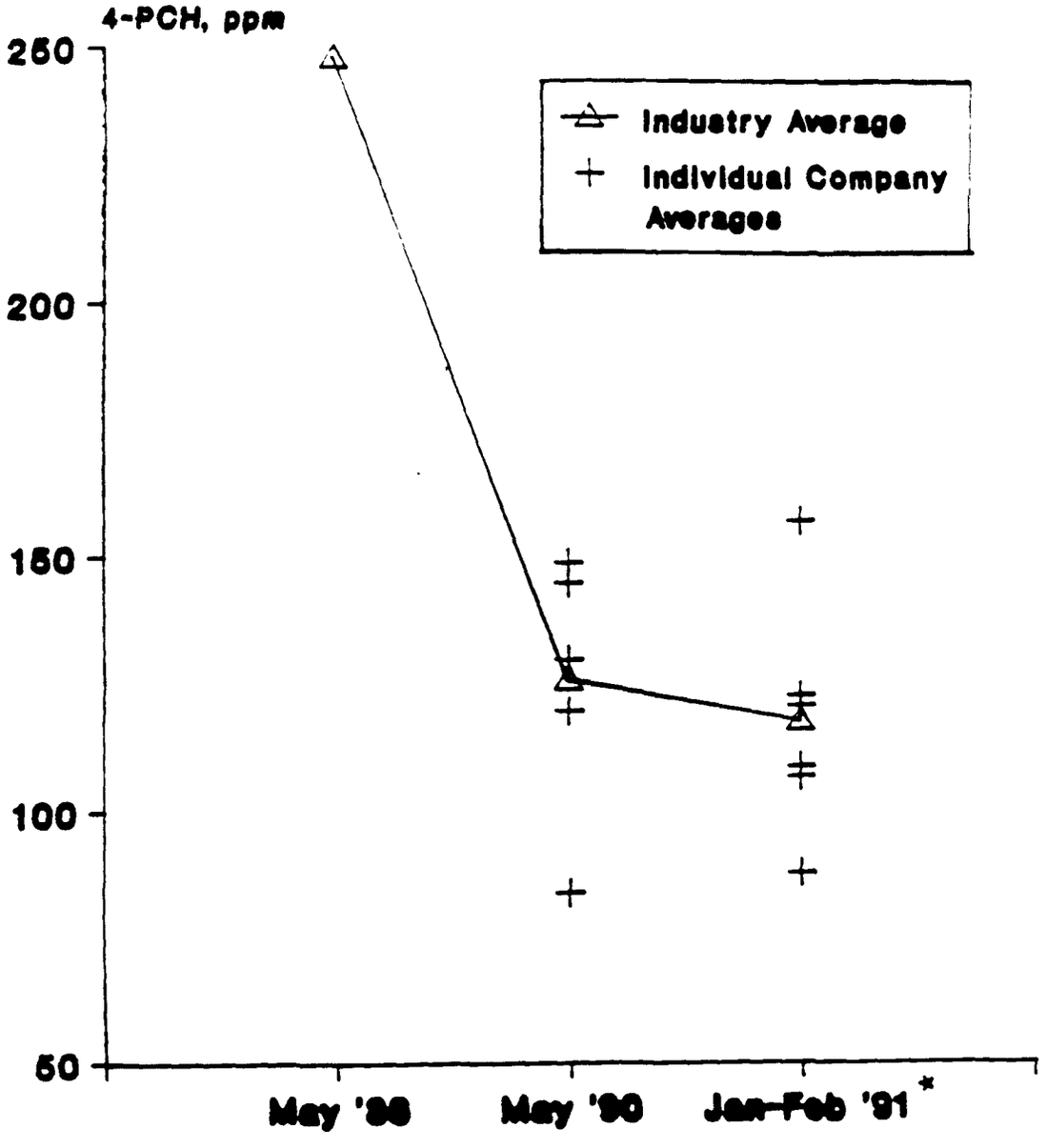
Voluntary actions by individual latex manufacturers have achieved significant reductions in 4-phenylcyclohexene levels over the last 2 years. Because 4-phenylcyclohexene was not an issue until recently, and because the current validated analytical method was only developed in 1989, manufacturers are unable to provide comparable quantitative data on historical levels of 4-phenylcyclohexene in latex used in carpet manufacturing prior to 1988.

In the 2 years between 1988 and 1990, latex manufacturers have voluntarily improved processes so as to reduce 4-phenylcyclohexene content in latex sold to the carpet manufacturing industry by almost 50 percent, to an industry average of about 125 ppm. (See Figure 3-2.) These data were compiled from information provided confidentially by SBLMC members for the months of May 1988, May 1990, and January to February 1991. This 50 percent reduction has been achieved only through major technical efforts and significant operating and capital costs estimated at about $10,000,000.

Each SBLMC member company has expended considerable effort to reduce 4-phenylcyclohexene levels. Each member company also recognizes that reduction of VOCs presents an opportunity for a competitive advantage. Any company that could develop a latex with substantially reduced VOCs could market the product with a considerable

FIGURE 3-2

4-PHENYLCYCLOHEXENE REDUCTION HISTORY



Styrene Butadiene Latex
Manufacturers Council
May 1991

*Data include 320 individual measurements representing approximately 94% of Jan.-Feb. 1991 shipments to the carpet trade. This represents an average of 50% reduction since 1988.

advantage in the existing highly competitive marketplace. This is the operative mechanism that has already resulted in lower 4-phenylcyclohexene levels.

3.2.3. Potential VOC Reduction Mechanisms

During the course of the Carpet Policy Dialogue, questions have been raised concerning the effect of several recipe and process control variables on the concentration of 4-phenylcyclohexene in SB latex.

During the last 2 years, all six SBLMC member companies dedicated considerable research and development efforts toward reduction of 4-phenylcyclohexene in their respective latexes. While process and recipe variables were studied, these parameters are unique for each plant. Each manufacturer has a unique configuration of equipment combined with a unique production recipe which has been developed over years to work efficiently on that equipment. The proprietary nature of these methods differentiates competitors in a highly competitive market. The details of these efforts constitute valuable trade secrets. The following process variables theoretically can affect 4-phenylcyclohexene formation and removal: (1) reactor temperature; (2) reactor pressure; (3) reactant concentration; (4) reactor residence time; (5) reaction catalyst and initiators; (6) additives and anti-oxidants; and (7) stripping conditions.

Reactor Temperature

The reaction rates to form both 4-phenylcyclohexene and polymer are temperature dependent. It is almost impossible, therefore, to utilize temperature independently as a variable to reduce 4-phenylcyclohexene levels without adversely affecting polymerization rates and end-use polymer performance.

Reactor Pressure

Reactor pressure itself is not an independent factor in 4-phenylcyclohexene formation. Reactor pressure is a measured parameter in the polymerization of styrene and butadiene and is indicative of the unreacted butadiene in the vessel. Therefore, higher observed pressures may indicate a higher concentration of reactants in the reactor, which would favor both 4-phenylcyclohexene and polymer formation as described below.

Reactant Concentration

To produce carpet latex with the desired performance properties, the ratio of styrene to butadiene during polymerization must be near a 1:1 molar ratio. Molar equivalency is worst case in favor of Diels-Alder formation of 4-phenylcyclohexene. To obtain the desired product properties with a 1:1 monomer molar ratio, it is also important to polymerize the monomers in a nearly random fashion which requires them to be present in the reaction

vessel simultaneously. Deviation from this random polymerization results in a significantly different product with unacceptable physical properties.

Any parameter that may affect the concentrations of styrene and butadiene during polymerization will also affect the formation rate of 4-phenylcyclohexene. In addition, the monomer concentration cannot be changed arbitrarily without affecting the performance properties of the final latex. The polymerization parameters have been optimized during product design to produce a latex that will have the performance required by the customer. These parameters include polymerization temperature, initiator level, and reactant concentration. Having achieved the necessary product performance, no obvious options remain for changing the monomer concentrations to reduce 4-phenylcyclohexene formation rates during polymerization.

Monomer concentration is the most significant factor in the formation of 4-phenylcyclohexene. Increased monomer concentration will increase the Diels-Alder formation of 4-phenylcyclohexene. This factor is greatly influenced by the uniqueness of manufacturing processes and uniqueness of recipes.

Reactor Residence Time

Residence time is not a factor in 4-phenylcyclohexene formation, except as it relates to reactant concentration. Longer residence times for semi-batch polymerizations could yield reduced unreacted monomer concentrations at any given point in time. Lower concentrations of unreacted monomer could potentially yield reduced 4-phenylcyclohexene formation as described in "reactant concentration." However, reactor residence time is a major factor in end-use performance of the polymer and cannot be significantly lengthened without unacceptable product and production impact.

Reaction Catalysts and Initiators

The generally recognized distinction between catalyst and initiator is that a reaction initiator is consumed in the reaction and a catalyst is not. Latex manufacturers do not use catalysts in the polymerization of SB latex and, therefore, catalysts are not a factor. Although in some cases it may be possible to catalyze Diels-Alder reactions, no catalyst is needed and none is present in the latex polymerization reactor.

The rate of the Diels-Alder reaction of styrene and butadiene to form 4-phenylcyclohexene is not affected by free radicals. Most mechanistic evidence suggests that the reaction takes place by a one-step, concerted process that does not involve free radicals. Further, there is no known means for inhibiting the Diels-Alder reaction. (See J. March, Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 2nd edition, McGraw Hill, 1977, pp. 761-767.)

Free radical initiator concentrations affect the polymerization rate of styrene and butadiene monomers and, therefore, might have an indirect effect on a 4-phenylcyclohexene formation. Increasing the polymerization rate will lower the monomer concentration in the reactor at any point in time. As previously described, monomer concentrations cannot be arbitrarily changed without significant negative impact on the performance properties of the latex.

Additive and Anti-Oxidants

No additives that would reduce 4-phenylcyclohexene formation are known. Post-reaction additives are not known to contain 4-phenylcyclohexene and, therefore, are not likely to affect levels other than through very slight dilution. Similarly, anti-oxidants will not reduce 4-phenylcyclohexene content.

Stripping Conditions

All SB latex producers currently steam strip final polymerization batches to reduce residual monomers. As a consequence, other volatile components, including 4-phenylcyclohexene, are also reduced. However, industry claims further significant 4-phenylcyclohexene reduction through additional steam stripping is considered impractical because of adverse impact on product quality and increased energy, capital and other costs.

During steam stripping, the removal rate for a volatile component depends primarily on its vapor pressure and molecular weight. Since the vapor pressure of 4-phenylcyclohexene is much lower than that of styrene, an amount of stripping that provides a 50 percent reduction in styrene concentration will only reduce 4-phenylcyclohexene concentration by about 4 percent. Industry claims increases in residence time, or decreases in feed rates for column strippers could reduce TVOC but will have only a minimal effect on 4-phenylcyclohexene reduction. No information is available to the Subgroup which would help to define the optimum conditions for TVOC removal.

The mechanical stability of SB latex may be adversely affected by severe steam stripping. Extreme stripping could result in products that do not meet customer specifications and major difficulties in carpet manufacturing would arise. However, the maximum TVOC removal that can be realized without unacceptable impact on SB latex properties remains to be defined. The impact of steam stripping on latex product quality needs to be considered when defining optimum conditions.

The manufacture of SB latex may be viewed as two sequential steps: (1) the reaction step; and (2) the monomer removal (steam stripping) step. Most plants have been designed so that these processes take roughly the same time. Therefore, an increase in the time of steam stripping could result in a loss in plant capacity. For example, twice as much batch stripping could potentially cut the plant capacity in half.

Additional steam stripping sufficient to lower 4-phenylcyclohexene levels significantly could also create more organic-contaminated condensate and solid latex waste that would need to be disposed or further processed. Aqueous effluent from the plant could increase roughly in proportion to the additional stripping.

In summary, additional steam stripping, which is energy intensive and potentially detrimental to product quality and plant capacity, could require considerable further capital and operating costs. No studies are available to the Subgroup which quantify TVOC reductions, increased capital and operating costs, reduction in plant capacity, and negative impacts on latex product quality as a function of more extensive steam stripping.

3.2.4. Process Engineering Subgroup Proceedings

At the September 26, 1990, Process Engineering Subgroup meeting, the SBLMC presented an overview of the latex manufacturing process and reported that since 1988, concentrations of 4-phenylcyclohexene in latex have been reduced by 50 percent. This presentation provided the basis for a chapter of the Summary Report on the latex manufacturing process and Subgroup discussions of this topic.

Comments on this chapter were discussed by the Subgroup at the February 28, 1991, meeting. The Subgroup expressed interest in having company-by-company and/or plant-by-plant data, as opposed to aggregated industry-wide data, to support the conclusion that a 50 percent reduction has been achieved. SBLMC positively responded by presenting company-by-company data at a later meeting. The Subgroup showed a keen interest in better understanding the relationship between 4-phenylcyclohexene and TVOC levels in latex.

An additional topic of discussion included the effects of SB latex manufacturing conditions (particularly the reaction and stripping operations) on 4-phenylcyclohexene levels in latex. Due to the highly proprietary nature of related process information, discussions of the details of the reaction operation were limited. The Subgroup considered whether the steam stripping operation could be generically discussed. One suggestion was to perform a computer simulation of this operation which could result in a paper parametric study on VOC residuals. The Subgroup deferred undertaking development of a generic model pending the company-by-company 4-phenylcyclohexene data to be later provided by SBLMC.

The Subgroup discussed whether information on individual VOC components in SB latex could be made available to the Subgroup by SBLMC. It was suggested that these kind of data could be useful to the Process Engineering Subgroup; the data could help evaluate potential controls for reducing TVOC emissions. SBLMC commented that they only had 4-phenylcyclohexene data and that they would provide these data to the Subgroup. These data were later provided by SBLMC and are included in this Summary Report.

In general, a wide range of issues related to carpet TVOC emission rates was discussed in the Subgroup sessions. Issues that could not be resolved were included in the Subgroup's list of information or research considerations or recommendations forwarded to the Plenary.

At the May 21, 1991, Subgroup meeting, the Subgroup recommended that the Plenary accept SBLMC's proposal to conduct an industry wide survey of 4-phenylcyclohexene levels in SB latex during 1991 and 1992 and to make such data publicly available through EPA. The Subgroup also recommended that SBLMC and Carpet and Rug Institute (CRI) investigate the feasibility of developing an industry standard for 4-phenylcyclohexene and report to the EPA periodically on their progress. These information/research considerations and Subgroup recommendations are cited in detail in sections 3.2.5 and 3.2.6 below.

3.2.5. Information and Research Considerations

The following ideas were raised by some members of the Subgroup considering information that may help in identifying control measures to reduce TVOC. These suggestions do not necessarily represent the consensus of the Subgroup. These are presented as suggestions for future consideration of EPA or industry.

1. While the focus of the Carpet Policy Dialogue is TVOC and not 4-phenylcyclohexene, the 4-phenylcyclohexene reduction achievements of the SBLMC are very important. To expand the relevance of the 4-phenylcyclohexene data presented, a discussion of whether SB latex 4-phenylcyclohexene levels relate to TVOC and, if such correlation exists, how this correlation or lack of correlation has been determined.

2. An evaluation of technological alternatives to steam stripping for removing TVOC from SB latex.

3. An evaluation of the impact of stripping conditions on latex VOC emissions would be helpful. While detailed information on reactor operation is extremely important, stripping may have a greater impact on TVOC removal. Stripping could be a method of further reducing the levels of VOCs in latex. Therefore, a detailed quantitative evaluation of stripping as a method of reducing VOC contents in latex should be undertaken. This evaluation should quantify TVOC reductions, increased capital and operating costs, reductions in plant capacity and negative impacts on latex product quality as a function of more extensive stripping.

4. A comprehensive list of VOCs in the final latex product would be very useful, as well as individual plants' TVOC and 4-phenylcyclohexene levels in final latex. These data could provide insight into the specific sources of VOCs in the final latex product and could help better define the potential for process or engineering

changes for reducing SB latex VOC emissions. The correlation of latex TVOC to carpet TVOC would also be helpful.

3.2.6. Subgroup Recommendations to Plenary

1. The Plenary should make a recommendation to the Agency to consider developing a Memorandum of Understanding (MOU) regarding SBLMC's proposal for an industry-wide survey of 4-phenylcyclohexene levels in SB latex in 1991 and 1992 to demonstrate continued quality assurance.

2. The Plenary should recommend to SBLMC and CRI to jointly discuss the feasibility of developing an industry standard for 4-phenylcyclohexene in SB latex and report to EPA on their progress. The Agency should consider developing a MOU on this issue with SBLMC and CRI.

3.3. ADHESIVES MANUFACTURING/FORMULATION

3.3.1. Overview of Carpet Adhesives and Formulation Process

This section provides an overview of the carpet adhesives and formulation process. A great majority of this section was supplied to the Process Engineering Subgroup of the Carpet Policy Dialogue by the Floor Covering Adhesives Manufacturers Committee (FCAMC).

3.3.1.1. Adhesive Properties

The success or failure of any adhesive depends upon its ability to adhere to the materials being bonded, and its own internal strength characteristics. Although the phenomenon of how one material adheres to another is still not well understood, what makes an adhesive fail to adhere is well known. Failure to adhere-or bond-means the adhesive system does not have the ability to bond adequately due to lack of, or weakness in, one of the following characteristics.

Wetting

The ability of an adhesive to wet (or distribute itself over) the surfaces to which it is bonding. Wetting is an essential property in that it maximizes the points of contact between the adhesive and the adherents (substrates).

Mechanical

The facility by which a rough and irregular surface provides undercuts and a jagged condition conducive to locking - or keying - which induces mechanical meshing and a good bond. An example of good locking - or keying - is the way in which metal lath holds gypsum plaster.

Chemical

The ability of an adhesive to adhere by an internal force to another substance, just as the opposite poles of a magnet attract.

These characteristics are affected by three human-related factors that are common causes of bond failure. The first is in the improper choice of the adhesive itself - using the wrong product for the job. The second is improper preparation of the surfaces, the result of lack of experience or carelessness. The third is improper application of the adhesive, resulting from lack of know-how or from the rush to finish the job.

3.3.1.2. Types of Adhesives

There are generally five types of carpet adhesives: multipurpose adhesives, pressure-sensitive, vinyl-back adhesives, pad cements, and seam sealers. Of these, the multipurpose and pressure-sensitive adhesives represent over 90 percent (by volume) of the adhesives being used and are discussed in more detail below.

Multipurpose adhesives used in carpet installation are thick pastes that are applied to the floor by a notched trowel. The amount of adhesive applied is controlled by the size and spacing of the trowel notches. The amount required is dependent upon several factors, including the type and construction of the carpet back and the subflooring material. A coverage of 10-15 square yards-per-gallon is typical.

Pressure-sensitive adhesives are, as the name implies, materials that remain tacky after drying. They are used predominantly when it is desirable that the carpet can be removed from the floor and reapplied a number of times during its useful life or more recently for foam pad in double-stick applications.

Pressure-sensitive adhesives may be applied to the floor with a notched trowel, with a napped roller similar to a paint roller, or by spraying. The amount of adhesives required depends upon the substrate type and conditions and the carpet backing. The coverage rate for pressure-sensitive adhesives is approximately 35-50 square yards-per-gallon.

3.3.1.3. Raw Materials and Formulation

3.3.1.3.1. Multipurpose adhesives

Multipurpose adhesives, produced by 15-20 adhesive manufacturers, typically are made in a variety of grades from economy to premium products. The choice of the adhesive is based principally upon the performance characteristics required and the warranty of the carpet. Obviously, the adhesive must perform its function for the lifetime of the carpet. The various grades are achieved by varying the ratio of the ingredients discussed below. In addition, the density of the adhesive ranges from 9.0 to 10.0 pounds per gallon, with an average density of 9.5 pounds-per-gallon.

Different formulas for the same grade of adhesive are needed in different geographical markets due to different temperature and humidity conditions. For example, there is a great difference in application conditions in Florida, New Mexico, or North Dakota.

Vehicle

The vehicle is the liquid portion of the adhesive that maintains the product in a fluid state until it is applied. As the vehicle evaporates, the adhesive's characteristics appear. The earliest manifestation of the loss of the vehicle is tackiness followed by progressive increases in the strength of adhesion between the subfloor and the carpet.

The predominant vehicle in multipurpose adhesive is water augmented by petroleum solvents such as mineral spirits and VM & P naphtha. Water may constitute up to 50 percent of the adhesive formulation. In recently developed formulations, solvents represent 0 to 5 percent of the adhesive formulation.

Binder

The binder used in multipurpose adhesives is an elastomeric polymer usually in an emulsion (latex) form. A variety of polymers have been used including natural, neoprene, acrylic, styrene-butadiene, etc. Styrene-butadiene latex is the predominant choice. The styrene-butadiene latex used in the multipurpose adhesive is usually manufactured by the "cold polymerization" process. This gives a more "rubbery" characteristic than the styrene-butadiene rubber typically used in carpet backing.

According to a leading SB latex manufacturer, the typical SB latex used in the manufacture of carpet adhesive has less than 10 ppm of 4-phenylcyclohexene when tested by the method specified by SBLMC.

Fillers or Extenders

Fillers or extenders are inert materials generally inorganic in nature such as limestone, gypsum, silica, or clay, that are used to extend and reinforce the adhesive. Greater cohesive strength and lower materials cost can be achieved by incorporating extenders into the formulation. Extenders may comprise 20-40 percent of the total adhesive formulation with the economy grades containing the highest proportions.

Freeze-Thaw Stabilizers

Freeze-thaw stabilizers are incorporated into the formulation to protect the adhesive at reduced temperatures encountered during storage and shipment. The most often used stabilizers are ethylene glycol and/or methanol and may constitute 1 to 5 percent of the adhesive formula. Various manufacturers stabilize their products to different levels ranging from -15° to +15°F. It is expected that the adhesive may be cycled 3-5 times through these temperatures without destabilizing.

Resins

Hydrocarbon resins provide adhesion and tack to the adhesive. The resins are the polymerization product of a variety of unsaturated petroleum feed stocks derived from the ethylene cracking process. For incorporation into the formulation, resins which are hard and brittle are usually predissolved in processing oils and solvents.

Processing Oils

Processing oils which are refined petroleum hydrocarbon oils are used to plasticize or soften the adhesive formulation. As the level of processing oil increases, the adhesive (in its dry state) becomes softer. In combination with resins, processing oils also enhance tack.

Viscosity Modifier

Without the incorporation of viscosity modifier, the adhesive would be thin and watery and incapable of being applied in a useful manner by trowel. Examples of viscosity modifiers used in adhesives are sodium polyacrylate solutions and alkali-soluble emulsion polymers.

Preservatives

Because some of the materials in adhesives are nutrients for bacteria and fungi, a biocide is usually added to control their growth. A wide variety of biocides are available and are chosen based upon their cost and efficacy. They usually comprise less than 0.10 percent of the total adhesive composition.

3.3.1.3.2. Pressure-sensitive carpet adhesive

Pressure-sensitive carpet adhesives are used primarily for the installation of carpet squares and for adhering carpet pad to the subfloor in double-stick installations. Most of the manufacturers producing multipurpose adhesives also produce this type of product. These products do not have the grade classifications associated with multipurpose adhesives.

The principal ingredient in pressure-sensitive carpet adhesives is a pressure-sensitive polymer latex derived from acrylic ester copolymer. Comonomers may include styrene, vinyl acetate, ethylene, etc. Typical modification includes viscosity adjustment with the same type of viscosity modifier discussed above and the incorporation of a freeze-thaw additive. A tackifying resin emulsion may also be included. Preservatives are used in these products.

3.3.1.3.3. VOC ranges in adhesive components

Table 3-3 presents a table of the VOC content of the various components of adhesive and the approximate percentage amount of each component in adhesive products.

3.3.2. Use of Adhesives During Carpet Installation

3.3.2.1. Multipurpose Adhesives

Installation of broadloom carpet with adhesive begins by laying out the carpet and rough cutting to the area dimensions. The carpet is then folded back into 1/2 carpet widths and the adhesive spread over the exposed subfloor at the recommended rate.

When the spread adhesive begins to feel "tacky" to the touch, the carpet is unfolded into the adhesive, the other carpet folded back, the process repeated. Smoothing and rolling of the carpet completes the installation with the exception of any seaming that must be done and trimming the excess carpet at the wall.

In very large areas, several breadths of carpet may be installed. The installation crew starts at the longest wall and follows the above procedure breadth by breadth.

Multipurpose adhesives "cure" by dissipation of the vehicle either by absorption into the substrate or evaporation through the carpet. The rate of evaporation is controlled by the type of substrate, the carpet construction, temperature, humidity, and ventilation. Generally, 90 to 95 percent of the ultimate strength of the adhesive is obtained after 24 hours and is usually completely "cured" within 7 days.

TABLE 3-3

ADHESIVE COMPONENTS AND ASSOCIATED VOC RANGES

MATERIALS	RANGE OF VOC IN COMPONENT	AMOUNT OF COMPONENT IN ADHESIVE
Vehicle	0-10%	30-55%
Binder	<0.1%	5-15%
Fillers/Extenders	0	20-30%
Resins	<0.1%	5-15%
Process Oil	<0.1%	5-15%
Freeze-Thaw Stabilizers	100%	1-5%
Viscosity Modifier	0-3%	<2%
Preservatives	0-100%	<0.5%

Source: C. Cline, Para-Chem Southern, Inc. Letter to Ward Penberthy, U.S. Environmental Protection Agency, July 3, 1991.

Adhesive installation of carpet should be done only in well ventilated areas. The Carpet and Rug Institute's Bulletin CRI-104 stresses proper ventilation and details by which to achieve it. (See section 3.6.)

3.3.2.2. Pressure-Sensitive Adhesive

Carpet squares or modules are usually set in a bed of pressure-sensitive adhesive. A thin film of the adhesive is troweled, rolled, or sprayed on the substrate and allowed to dry. This requires 30 minutes to an hour depending on the temperature, humidity, and ventilation. The squares are then placed into position.

The advantage of this type of installation is that individual squares can be removed and repositioned without the need for additional adhesive. Wiring ducts or terminals in the floor or occasional damage to the carpet makes this installation attractive in offices or other commercial buildings.

A recent innovation is the installation of broadloom carpet over pad with adhesives. In this case, the carpet pad is adhered to the subfloor with a pressure-sensitive adhesive and the broadloom carpet adhered to the pad with a multipurpose-type adhesive as described above.

3.3.3. VOC Reductions Already Achieved

During the last 10-15 years, there have been many major advances to provide safer, less hazardous and less VOC-emitting floor covering adhesives. The initial advancements were in response to reducing the flammability of these products. This was done by replacing the flammable solvents with either nonflammable chlorinated solvents or with water/solvent blends containing a lower VOC content. Although the non flammable chlorinated solvents did not reduce VOC content, they were preferred over the water/solvent blends because they performed more like the solvent-based adhesives favored by customers. The nonflammable chlorinated solvent-based adhesives provided a useful transition between the fast setting, flammable solvent-based adhesives and the less aggressive, slower setting, water-based adhesives which did provide a lower VOC content. It also gave the adhesives industry the time necessary to develop water-based adhesives with performance more similar to solvent-based adhesives, while at the same time allowing customers to adjust to this change in technology. As this change reduced the fire hazards associated with floor covering adhesives, the need to reduce solvent levels and eliminate the problem of indoor air emissions became the next priority.

Today, most floor covering adhesives for the installation of carpeting are high solids (50 to 65 percent), nonflammable, water/solvent blends. With time, testing, and research, the solvent blends have dropped significantly over the past 5-7 years from levels averaging 8

to 12 percent to current levels of less than 5 percent without significantly affecting the performance of these materials. Further reduction/elimination of solvents will be costly and time consuming but necessary in order to further reduce indoor air emissions. The challenges facing the adhesives industry lie not only in further reducing solvent levels but also in improving adhesive performance without the use of solvents to meet the installation needs of today's carpet backings.

Other responsible adhesive changes and advancements made recently are as follows:

- Developed latex-based carpet pad adhesives to reduce the need for solvent containing pad adhesives;
- Developed water-based pressure sensitive adhesives for the releasable installation of carpet tile;
- Developed high solids, latex-based adhesives. This reduces the amount of solvent needed.

Some limited data were provided to the Carpet Policy Dialogue by the Carpet and Rug Institute. These data should not be considered broadly representative of carpet adhesive TVOC emission rates. The measurements reported* were:

Sample	TVOC Emission Rate (mg/m^2 hr)	
	24 hr	144 hr
Multipurpose Latex	90.0	11.9
Multipurpose Latex	76.6	3.95
Multipurpose Latex	99.0	17.2
Synthetic, "Low VOC"	0.698	0.076

* Data are extracted from "Volatile Organic Compound Emissions from Carpet and Associated Products," by Marilyn S. Black et al., January 8, 1991.

Due to the varied manufacturing complexities and raw material choices available today, it is extremely difficult to list and subsequently regulate individual VOCs. Therefore, regulatory agencies such as the South Coast Air Quality Management District (SCAQMD), have adopted rules governing TVOC.

Prior to 1990, the majority of floor covering adhesives used to install carpet were at a calculated VOC of 150 g/l or higher. However, with the pressure of Rule 1168 of the California South Coast Air Quality District, all of the manufacturers reformulated to calculated VOC of 150 g/l or lower. By September 1990, one manufacturer introduced a

new generation adhesive with a calculated VOC of 0 g/l. By February 1991, eight manufacturers reported they had developed solvent-free, low emission adhesives. At the NAFCD Convention, held May 5-8, 1991, 14 of the 15 adhesive manufacturers who had booths displayed a low emission adhesive or a line of low emission products. According to the FCAMC, the adhesives industry has already committed to meeting the SCAQMD VOC limits for carpet adhesives on a nationwide basis.

A survey was taken in February of 1991 asking manufacturers to report on the range of calculated VOCs in the products they were making by product type -- current formulas versus new generation formulas. The responses ranged from 40 g/l to 150 g/l on current formula lines and 0 g/l to 20 g/l on new generation lines. Figures 3-3 and 3-4 indicate VOC levels in multi-purpose and pressure-sensitive adhesives, respectively, for various adhesive manufacturers.

3.3.4. Potential VOC Reduction Methods

While the industry has already obtained significant VOC reductions in adhesives, the very low TVOC adhesive products have not gained total acceptance in the marketplace. The capability exists to produce adhesives with nearly no VOC, but the performance characteristics are not as yet fully acceptable. The most noticeable performance deficiency is adhesion development during installation. Ultimate adhesion with the newer products is considered satisfactory.

To reduce VOCs, the industry is or will be examining SB latexes, resins, freeze-thaw additives, processing oils, and viscosity control additives. Certain solvents could be replaced with water with similar final bond results. The current freeze thaw level is -15°F, but the industry may be able to shift this level to a higher temperature, such as 0°F. However, according to the FCAMC, few manufacturers would give up freeze-thaw capability, as it would be very easy to lose truckloads of adhesives in cold weather, and users may neglect to store adhesives in a nonfreeze location. The performance need and demand by installers for quicker grabbing adhesives has made it difficult for the adhesives manufacturing industry to move as quickly as it could to sell reduced VOC adhesives.

The cost of reduced VOC raw materials must also be balanced with performance and the benefit gained in TVOC reduction. As producers of the raw materials attempt to reduce VOCs, their processing costs are likely to increase, resulting in an increase in the cost of the raw material and hence the adhesive with only marginal reduction in TVOC of the finished adhesive.

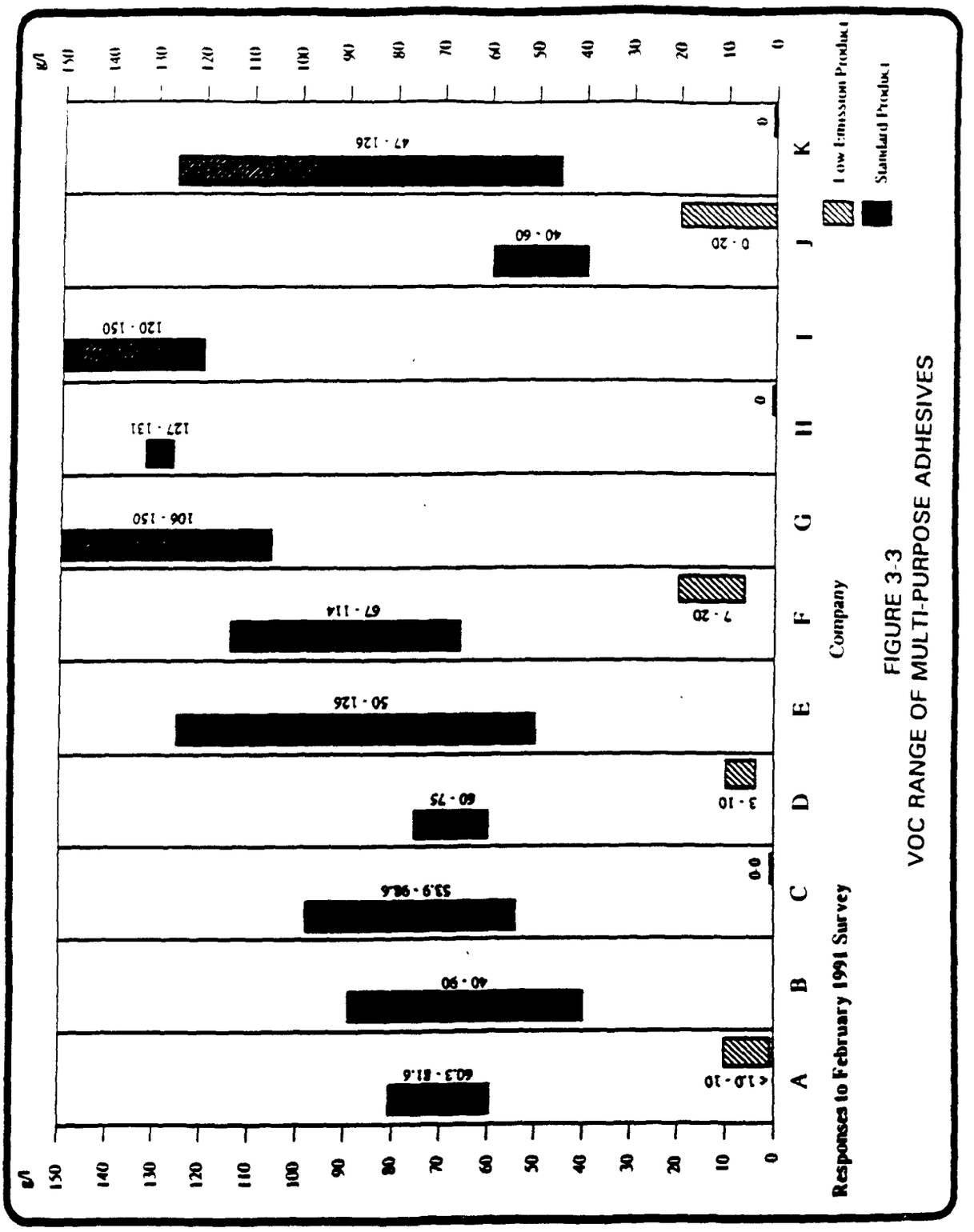


FIGURE 3-3
VOC RANGE OF MULTI-PURPOSE ADHESIVES

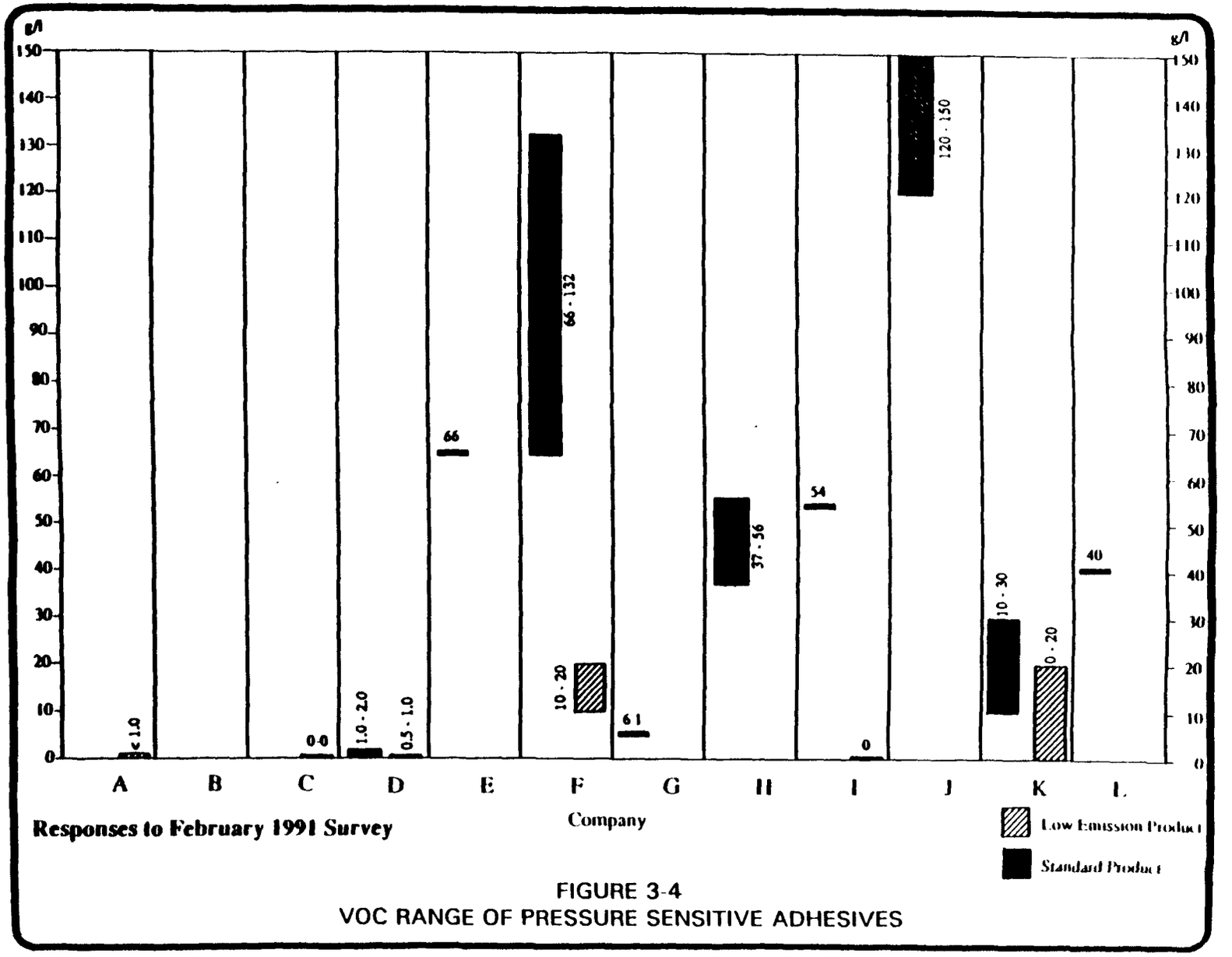


FIGURE 3-4
VOC RANGE OF PRESSURE SENSITIVE ADHESIVES

3.3.5. Process Engineering Subgroup Proceedings

At the September 26, 1990, Process Engineering Subgroup meeting, the FCAMC presented an overview of the carpet adhesives market and product formulations. Additional information on the carpet adhesives manufacturing/formulation processes was presented to the Subgroup at the October 24, 1990, meeting. These two presentations provided the basis for a chapter of the Summary Report on adhesives manufacturing and Subgroup discussions of this topic.

Comments on this chapter were discussed by the Subgroup at the April 8, 1991, Subgroup meeting. The Subgroup expressed interest in the identification of specific chemicals which contribute most to TVOC levels in adhesive formulations as well as their concentrations in carpet adhesives. At the May 12, 1991, Subgroup meeting, the FCAMC responded to the Subgroup's request by presenting company-by-company TVOC levels in various types of adhesive formulations and products.

The Subgroup also discussed briefly the feasibility of raising the industry freeze-thaw standard from -15° to 0°F, and whether this could be a viable TVOC reduction strategy. The Subgroup discussed this idea as a possible recommendation to the Plenary. FCAMC commented that the industry freeze-thaw standard might not be lowered any further. It was suggested that, as an alternative, an investigation into the feasibility of alternative freeze-thaw agents that could reduce adhesive TVOC be conducted. The Subgroup later agreed to make this suggestion a research item for future consideration of EPA or industry. The main freeze-thaw agent additives currently in use are ethylene glycol and methyl alcohol which are VOCs.

It was suggested that existing data on TVOC levels in adhesives and the adhesives manufacturers' efforts to comply with the SCAQMD standard of 150 g/l of TVOC in adhesive formulations should be included in the Summary Report. Information was provided to the Subgroup by FCAMC and is included in this Summary Report. The role of viscosity control agents and preservatives as a source of VOCs in adhesive formulations was also discussed on a limited basis. The Subgroup considered making a recommendation to the Plenary to reduce the VOC contribution from these potential sources. These information/research considerations and Subgroup recommendations are cited in detail in sections 3.3.6 and 3.3.7 below.

3.3.6. Information and Research Considerations

The following ideas were raised by some members of the Subgroup considering information that may help in identifying control measures to reduce TVOC. The suggestions do not necessarily represent the consensus of the Subgroup. These are presented as suggestions for future consideration of EPA or industry.

1. An investigation into the contribution of 4-phenylcyclohexene from adhesive formulation to TVOC emission rates after carpet system installation.

2. An investigation into the feasibility of alternative freeze-thaw agents that could reduce adhesive TVOC.

3.3.7. Subgroup Recommendation to Plenary

1. The Plenary should encourage the Floor Covering Adhesives Manufacturers Committee to advise the manufacturers to continue their search for low TVOC freeze-thaw agents, viscosity control agents, and preservatives.

3.4. CARPET CUSHION MANUFACTURING PROCESS DESCRIPTION

3.4.1. Process Description

This section presents an overview of the carpet cushion manufacturing process for five cushion products. A great majority of the information presented in this section was supplied to the Process Engineering Subgroup of the Policy Dialogue by the Carpet Cushion Council (CCC).

The carpet cushion industry is made up of 35 manufacturers. Sixteen of these manufacturers are part of the Carpet Cushion Council, which represents 75 percent of the carpet cushion produced.

There are five different types of carpet cushion, each having different shares of the market:

Bonded Urethane	56%
Prime Polyurethane	33%
Rubber	6%
Synthetic Fiber	3%
Rubberized Jute	2%

3.4.1.1. Prime Urethane Foam Carpet Cushion

The following description of the raw materials and the manufacturing process for flexible prime urethane foam carpet cushion is general in nature and is intended to provide a broad overview of the process. It is not intended to be a definitive technical treatise, but rather to provide a general understanding of the manufacturing process.

Flexible urethane is used as a principal part of many products serving many markets, a few of which are the furniture, bedding, automotive and textile markets. The same manufacturing process is common to the manufacture of almost all of these products including carpet cushion. Prime urethane carpet cushion represents 33 percent of total U.S. carpet cushion manufacture.

Raw Materials

There are four principal raw materials used in the manufacture of prime urethane foam carpet cushion: polyol, TDI, water and laminating film. The predominant raw materials are polyol, TDI, and water, which make up about 95 percent of the finished product.

Polyol is a chemical derived from propylene oxide. TDI, or toluene diisocyanate, is reacted with polyol and water to form flexible polyurethane foam. Small amounts of catalysts, surfactant, and possibly auxiliary foaming agents are also added to cause the mixture to rise once the reaction starts. (See Table 3-4.)

Laminating film is used as a coating on most prime urethane carpet cushion products to make it easier for the carpet to slide over the cushion during installation. It is used on only one side of the cushion and is applied at the very end of the manufacturing process. Laminating film is a very thin coating of polyurethane polymer or a combination of polyethylene and ethylene acrylic acid or sometimes ethylene vinyl acetate polymers. Laminating films account for 1 or 2 percent of the weight of carpet cushion.

Manufacturing Process

Most flexible polyurethane foams are manufactured in a continuous process from the reaction of the diisocyanate, water and the polyol. The reaction occurs by the addition of the

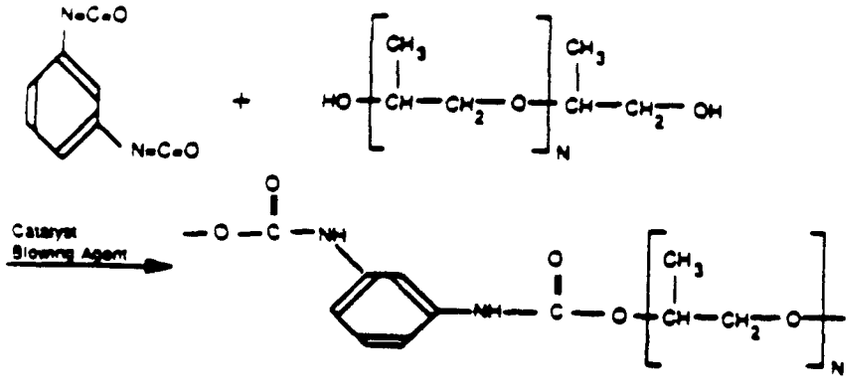
TABLE 3-4

PRIME URETHANE FOAM CARPET CUSHION COMPONENTS AND TYPICAL RAW MATERIALS[1]

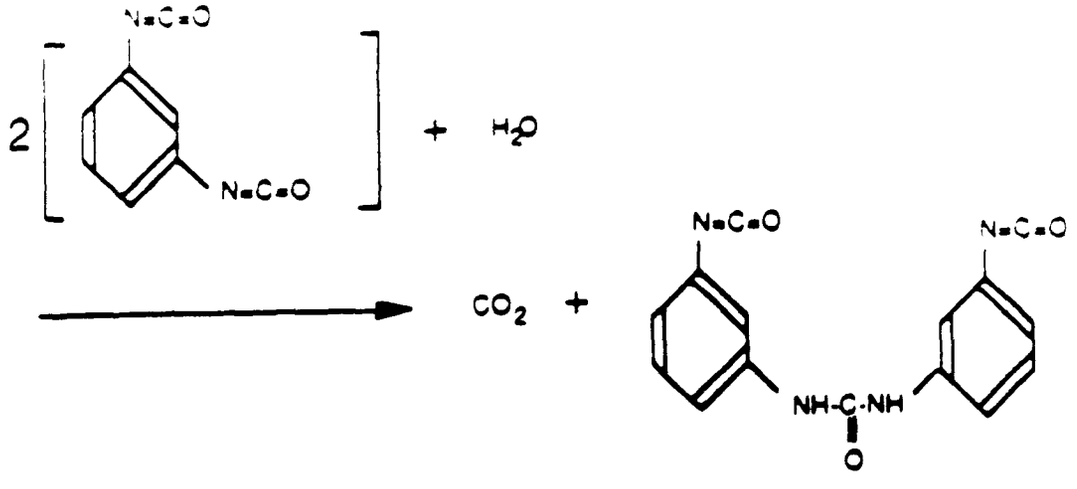
COMPONENT	TYPICAL MATERIALS	RELATIVE AMOUNTS USED WITHIN INDUSTRY
Diisocyante	Toluene diisocyanate (TDI) Methylenebis(phenylisocyanate) (MDI)	90% 10%
Polyol	Polyether	>90%
Water	Water	100%
Catalyst	Tertiary amines Stannous octoate	67% 33%
Surfactant	Polysiloxanepolyester glycols	
Blowing Agents	CFCs Methylene chloride Methyl chloroform	

[1] Data obtained from Bruce Ernst, Marketing Manager, Flexible Slabstock Polyurethane Foam, APCI, Trexlertown (Allentown), Pennsylvania, March 25, 1991.

alcohol bond of the polyol to the nitrogen-carbon isocyanate bond to form a carbamate or urethane as follows:



The water added in the process reacts to form carbon dioxide (CO_2) and a substituted urea.



The diisocyante formed can further react with polyol to become part of the polymer.

The polymerization reaction takes place in the presence of a blowing agent. A common blowing agent used in the past has been CFC-11. Flexible urethane foams have open cells that release the blowing agent during foam formation. No information on residual amounts of the blowing agent in manufactured prime urethane foams was made available to the dialogue.

Most flexible prime urethane foam manufacturing today brings the principal ingredients of polyol, TDI, water and other chemicals together in a mixing head at a point just ahead of a trough about 6-feet wide and 3- to 4-feet high. A conveyor trough about 60-

feet long, lined with a special release paper, bottom and sides, moves the mixture along as the foaming process takes place. The initial few feet of the trough contains complex geometry pertinent to the speed and type of reaction which will take place. The mixing head meters the chemicals in a precise manner and distributes the mixture evenly across the front of the trough. As the reaction takes place, the liquid mixture forms a cellular structure which rises to a height of 3 to 4 feet depending on the product being produced.

Flexible prime urethane foam is produced by two main processes: slabstock and molded. There are an estimated 105 facilities operated by 47 firms producing flexible polyurethane slabstock, which is the source of prime urethane foams in carpet cushion, and 39 facilities operated by 28 firms which produce flexible polyurethane molded foam. Flexible slabstock foam facilities typically operate less than 4 hours per day, while flexible molded foam facilities operate from 8 to 24 hours-per-day. Both types of facilities typically operate 250 days-per-year.

Slabstock--Figure 3-5 presents a process flow diagram for the production of slabstock foam. Flexible foam slabstock is produced primarily by the "one-shot" process, where the foam is in a bun or a loaf. For this continuous process, the polyol, polyisocyanate, water, and auxiliary blowing agent are pumped from pressurized storage tanks, through heat exchangers, and to a multiple stream metering and mixing head. The foam mixture is then poured onto a continuously moving conveyor belt where it expands to fill the foam tunnel. Most foam machines use "trough dispensing" where the liquid foam mixture is dispensed into a trough at the front end of the conveyor. This type of foam injection applies a more evenly spread liquid onto the conveyor resulting in a more rectangular slab requiring less trimming waste. Once the foam travels through the foam tunnel, a bun is cut off of the slab which is cured and stored until it is sold.

The process is continuous. Depending on the type of finishing machinery available, the reacted foam product, or "bun", keeps coming out of the end of the foaming machine and can reach a length of 200 feet before it is cut and moved to a storage area for curing and cooling. Since the reaction is exothermic, heat keeps building in the "bun" after it has been stored, and it can take 1 to 2 days before the reaction is complete and the "bun" is ready for the next operation.

After curing, many "buns" are cut into short lengths and shipped to fabricators for use in other industries. "Buns" for carpet cushion must be slit into proper thickness for finished product. In general, there are two types of slitters: horizontal and circular:

1) Horizontal - The horizontal slitter is usually a reciprocating table which places a slab 60 feet in length on the slitter table and slits carpet cushion in finished lengths for transfer to laminating.

2) Circular - The circular slitter, or "Baumer Loop" is a spectacular piece of equipment which looks like a ferris wheel. A 200-foot "bun" is placed in this machine

1) Chemical storage; 2) Multiple-stream metering and mixing head; 3) Traversing dispersing head (if used); 4) Feed trough (Max-Foam®); 5) Conveyor enclosure with exhaust fans and stacks; 6) Top surface wrapping rolls (optional); 7) Side paper take-off rolls; 8) Bottom liner paper roll; 9) Bun saw exhaust hood; 10) Bun saw and operator station

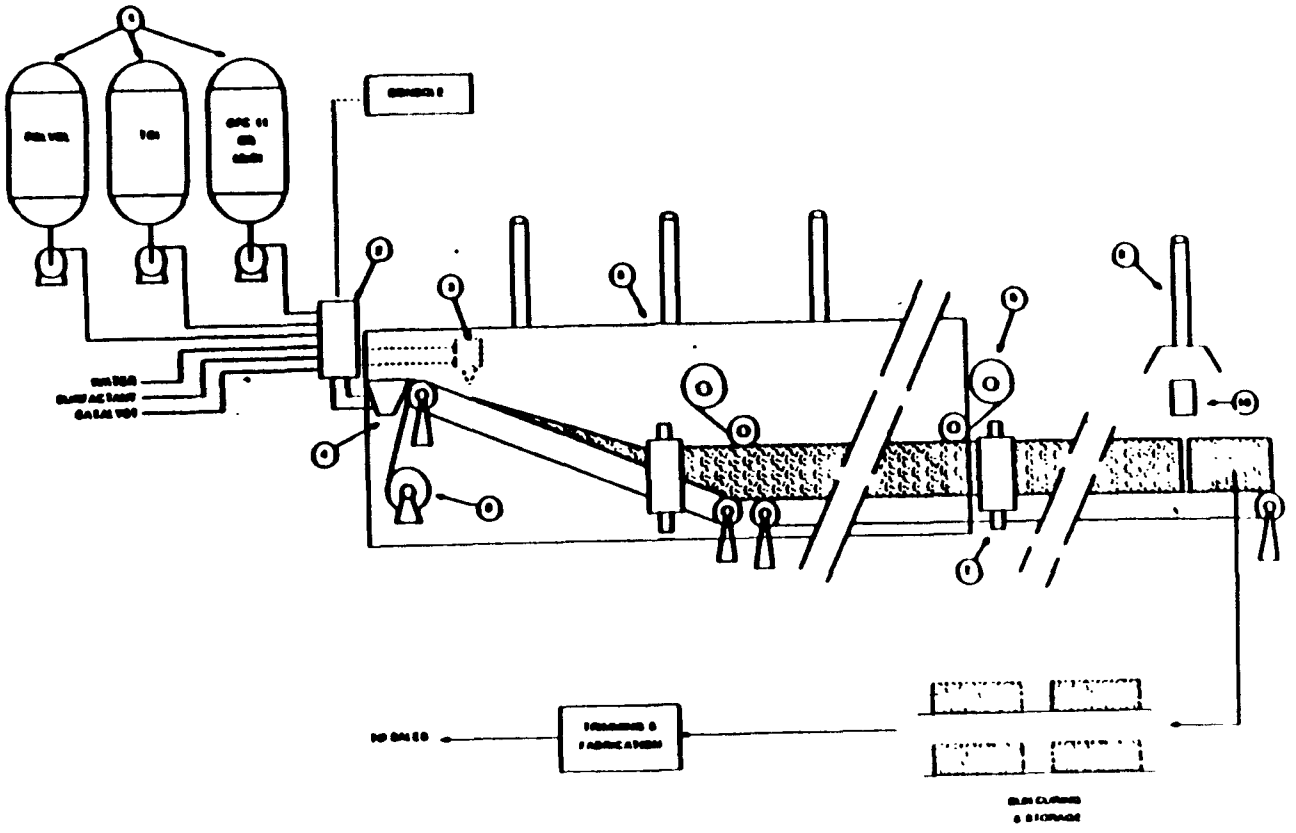


FIGURE 3-5 FLEXIBLE PUR SLABSTOCK PROCESS LINE

where it is fed around the loop until the front and back ends meet, where they are cemented together to form a complete circle. The machine then starts rotating around a fixed blade which slits a predetermined thickness and creates master rolls of carpet cushion for transfer to laminating.

Laminating film measuring .7 to 1 mil in thickness is placed on a roll in a laminator, and fed on top of the prime urethane foam carpet cushion coming from another roll. A heated cylinder applies pressure and fuses the laminating film to the surface of the prime urethane foam carpet cushion which is being rolled up, cut into 60-foot finished lengths and loaded into a polyethylene bag for transfer to a finished goods warehouse. Sometimes a spun bonded nylon or polyester non-woven scrim is placed in a similar manner to the top of the prime carpet cushion to give it a more durable surface. In this case the polyethylene film which is placed between the scrim and the cushion acts as a fusing agent.

3.4.1.2. Bonded Urethane Carpet Cushion

Bonded urethane carpet cushion manufacturing represents approximately 56 percent of the total 605 million-square-yards of carpet cushion produced in the United States.

Raw Materials

There are three raw materials used in the manufacture of bonded urethane carpet cushion: scrap polyurethane foam, prepolymer and laminating film. The raw material, scrap polyurethane, accounts for approximately 90 percent of the weight of bonded carpet cushion. Table 3-5 presents approximate percentages for the raw material composition of bonded urethane carpet cushion and other carpet cushion types.

Scrap polyurethane foam comes from leftover material from the fabrication of flexible polyurethane foam parts destined for use in other industries. While there are many uses for flexible polyurethane foam, the principal markets are:

a) The upholstered furniture market for use in sofas and chairs;
b) The bedding market for use in mattresses;
c) The automotive market for use in door panels, seat cushions, padded sun visors and headliners;
d) The prime urethane foam carpet cushion market; and
e) The textile and clothing market for use as liners and insulators.

Between 400- and 50-million pounds of scrap polyurethane foam are gathered annually from all over the world from the fabrication of products for the above markets. It is compressed, baled and transported to about 30 factories throughout the United States, where it is converted into bonded urethane carpet cushion making it one of the largest uses of reused materials in the world.

TABLE 3-5

RAW MATERIALS OF CARPET CUSHION - RANKED IN ORDER OF USE

	Percentage By Weight in Product
Bonded Urethane	
Scrap Polyurethane	90%
Binder	
Polyol	7%
TDI (or TDI/MDI Mixture)	3%
Prime Polyurethane	
Polyol	69%
TDI	27%
Water	2%
Other chemicals in varying quantities	2%
Catalysts	
Surfactants (e.g., silicones)	
Fire Retardants (e.g., phosphate esters)	
Pigments	
Rubber	
Whiting (calcium carbonate)	60%
Rubber (natural or synthetic)	25%
Other processing chemicals in varying quantities	15%
Plasticizers (e.g., stearic Acid)	
Fire Retardant (e.g., aluminum trihydrate)	
Viscosity reducers (e.g., process oil, tall oil)	
Antioxidants (e.g., zinc oxide, sodium bicarbonate)	
Vulcanizing Agents (e.g., sulfur)	
Accelerators and other chemicals (MBT, MBTS, TMTD, methyl zymate, BIK, Celogen OT)	
Synthetic Fiber	
Waste synthetic carpet fiber	90%
Fire Retardant (aluminum trihydrate)	5%
Carrier (polyprolylene mesh)	5%
Resin (at times)	up to 10%
Rubberized Jute	
Jute, bagging and shredded carpet strips	85%
Fire Retardant (e.g., aluminum trihydrate)	5%
SBR Rubber latex coating	7%
Carrier (Polypropylene mesh)	3%

Prepolymer, which makes up about 8 to 9 percent of the weight of bonded urethane carpet cushion, is made from two chemicals: Polyol and TDI (or a mixture of TDI and MDI). It is the bonding agent for bonded urethane carpet cushion and is made from the same two chemicals that are the principal raw materials for the flexible polyurethane foam products from which the scrap itself is made.

Laminating film is used as a coating on most bonded products to make it easier for the carpet to slide over the cushion during installation and to add tensile strength. It is used on only one side of the cushion and is applied at the very end of the manufacturing process. Laminating film is a very thin coating of polyethylene polymer or a combination of polyethylene and ethylene acrylic acid or sometimes ethylene vinyl acetate polymers. Laminating films account for 1 or 2 percent of the weight of carpet cushion.

Manufacturing Process

Scrap is received from vendors in a compressed, baled state. It is first released from the bales and then put into a shredder and grinder which reduces the scrap to pieces ranging from 1/4 inch to 1 inch depending upon the characteristics desired in the end product. It is then fed into a blender where it is mixed with the prepolymer.

Prepolymer, made from polyol and TDI (or TDI and MDI), is premixed and stored in tanks at the plant site. It is piped to the blender where it is mixed with the polyurethane foam scrap just prior to entry into the bonding mold.

Although there are two types of manufacturing processes, Box Type and Cylinder Type, from which bonded urethane carpet cushion is produced, both use the same casting concept. In the Box Type process, the blend of scrap and prepolymer is fed into a rectangular steel box measuring about 6 feet by 10 feet, to a height of 30 to 48 inches depending on the density required. A platen of the same dimensions is lowered on top of the mixture compressing it to about 24 inches in height. Casting is accomplished by injecting a catalyst to start the bonding reaction. Water is the catalyst. In most operations water is injected in the form of steam, although some plants inject it in its liquid state. The catalyst starts the reaction between the polyol and the TDI in the prepolymer accomplishing the bonding process. Since the reaction is exothermic, a considerable amount of heat is created. This takes about 10 minutes. After that time, the bonded block is released from the box and stored for cooling and drying for removal of excess moisture, which takes several hours depending on the ambient temperature and humidity. Six blocks are placed end to end and cemented together to form a slab 6 feet wide and 60 feet long. It is then placed in a horizontal slitter where rolls of carpet cushion are produced, rolled up and staged for laminating.

In the Cylinder Type process, the blend of scrap and prepolymer is fed into a cylinder measuring up to 5 feet in diameter and standing between 10- and 15-feet high permitting scrap to be loaded freely. After loading the blend, a circular platen of the same diameter is

lowered on top of the blend compressing it to about 6 feet in height. The bonding reaction is accomplished in the same way as in the Box type process. After cooling, the cylindrical block is turned on its side, cored and placed on a rotating cutting machine which peels the cylinder in the thickness required for the finished carpet cushion. It is then rolled up and staged for laminating.

Laminating film measuring from .7 to 1 mil in thickness is placed on a roll and placed on top of the carpet cushion coming from another roll. A heated cylinder applies pressure and fuses the laminating film to the surface of the bonded urethane carpet cushion which is being rolled up, cut into 60-foot finished lengths and loaded into a polyurethane shipping bag for transfer to a finished goods warehouse. Sometimes a polypropylene netting is placed between the laminating film and the carpet cushion to add abrasion resistance and tensile strength.

3.4.1.3. Cellular Sponge Rubber Carpet Cushion

Sponge rubber is by definition an elastic porous mass with interconnecting cells obtained by compounding with gas releasing materials which react prior to vulcanization, thus providing the structure from which its name is derived. There are only three manufacturers of sponge rubber carpet cushion in the United States today and the product makes up about 6 percent of the market.

Raw Materials

There are two principal raw materials in cellular sponge rubber carpet cushion - rubber and filler. Together these raw materials make up about 85 percent of the product. The balance is made up of various accelerators, blowing agents, plasticizers, anti-oxidants and other chemicals which are critical to the vulcanization process.

The rubber used in the manufacturing of sponge rubber carpet cushion is either natural rubber from the plantations in Southeast Asia, Nigeria, and South America, or synthetic rubber made from styrene and butadiene developed by our rubber tire companies during World War II. Both are rubber hydrocarbon resins and arrive at manufacturing plants in solid form packaged in bales from the producers. Rubber hydrocarbon makes up between 20 to 25 percent of the finished carpet cushion product.

By far the most widely used filler is whiting (limestone) from large deposits in the southern and southwestern United States and from smaller limestone deposits all over the country. This inert mineral makes up about 60 to 65 percent of the finished carpet cushion product. In order to meet certain flammability requirements, some of the whiting may be replaced by hydrated aluminum oxide.

Manufacturing Process

In order to be introduced into the forming line, a rubber compound must first be processed into a thin film. Most forming lines or "ranges" in the industry are 9-feet wide, although some are 54 inches. Getting the rubber compound into a thin film 9-feet wide is a complicated process.

It starts with the rubber resin arriving at the plant in a bale. Even though rubber is a solid, it is usually packed in polyethylene bags before baling to keep the bales separate and also to keep them from flowing if extremely bad weather is encountered during the long ocean trip.

The manufacture of rubber carpet cushion is an energy intensive process. Bales are broken up in a guillotine type cutter and sent to large banbury mixers to start the compounding process. The rubber resin must be thoroughly mixed with the filler and other chemicals in order to assure uniformity and proper viscosity before going to the next step in the process. Banbury mixers require a lot of horsepower to break up the resin bales and mix them with fillers and other chemicals.

Motors as large as 600 horsepower are not unusual in this phase of the process. Resin, chemicals and fillers are precisely measured before being sent to the banbury. In order to reduce viscosity, plasticizers are introduced also at this point in the form of petroleum or organic oils.

Proportions and types of chemical ingredients which are used in the process are proprietary and are carefully protected trade secrets.

From the banburies, rubber compounds are sent to primary and secondary calendars which take the compounds and gradually reduce the mixture into a thin rubber film. This film is then placed on a moving steel belt which is shaped in the form of a grid. The steel belt carries the rubber film into the "range" which is a vulcanizing oven about 100- to 120-feet long. Heat activates the blowing agents which chemically expand the rubber into the grid to form the rippled appearance of the finished product. The heat in the range rises to about 450°F which finally vulcanizes the whole sheet.

At the end of the "range", a very thin scrim made of spun bonded nylon or polyester is placed on top of the rippled surface while the rubber is still hot. This scrim provides dimensional stability to the carpet cushion as well as making it smooth so that carpet may be easily spread over it during carpet installation.

After the scrim has been applied to the cushion, it goes into an accumulator and then to a roll-up machine where the 9-feet wide carpet cushion is slit into 54-inch widths and cut to length. It is then placed into a polyethylene bag and sent to a warehouse for storage.

3.4.1.4. Rubberized Jute Carpet Cushion

Rubberized jute or hair and jute carpet cushion is the oldest type of carpet underlay used in this country. It was introduced around the turn of the century and was originally a product made strictly from cattle hair. Cattle hair was obtained as a byproduct of the leather tanning process. Its great resilience and durability made it a natural product for carpet underlay.

With the great growth of the carpet industry during the 1930s, 1940s, and 1950s, carpet product far outstripped the availability of cattle hair and so a substitute was sought. The jute plant was discovered to impart similar qualities. Hair carpet cushion gradually became a mixture of more and more jute. The chemical tanning process, which dissolves cattle hair, all but eliminated cattle hair from the market. Today, only one manufacturer offers a hair underlay. That manufacturer and two others make a rubberized jute product which comprises the bulk of the natural fiber market. At that, the natural fiber share of the carpet cushion market is less than 2 percent.

Raw Materials

There are two principal raw materials which make up the bulk of rubberized jute carpet cushion - jute and latex rubber. Jute, which is provided in three forms, makes up between 85 to 90 percent of the product with latex rubber making up the balance. The percentage of each which is blended into the product (jute cuttings, bagging, or carpet strips) is a function of economics and availability at any given time.

Jute Cuttings - Jute is a fibrous plant that is grown in Bangladesh and Thailand. It is harvested there and sent to India for processing and weaving into jute backing for carpet and for burlap bags. In the harvesting process, the lower part of the plant, or jute butt, is unsuitable for weaving and is baled and sent from Bangladesh and Thailand directly to the United States for use in the carpet underlay market. Between 10,000 and 15,000 tons of this product are consumed in this market annually.

Foreign and Domestic Bagging - Burlap bags are used for packaging products in all parts of the world. After their use has been exhausted, these bags are collected and shipped to the carpet cushion plants for reuse in rubberized jute carpet cushion.

Carpet Strips - Carpet which has been tufted into jute primary backing or which has a jute secondary backing applied is edge cut prior to finishing. These strips are collected and sent to carpet cushion plants for reuse in rubberized jute cushion. With most carpet being tufted into synthetic primary and secondary backing today, carpet strips are less desirable as a raw material than they once were since they are more difficult to shred and do not have the resilience of jute. Nevertheless, they still provide bulk and make up about 10 percent of the product.

Between 10 and 15 percent of rubberized jute carpet cushion is made up of latex rubber. This is a filled SBR latex which is applied as a coating on both sides of the jute product to act as a sealer and to ease installation.

Manufacturing Process

Jute cutting, bagging, and carpet strips are received at the manufacturing sites in bales. The bales are sent to a guillotine type cutter which breaks up the bales into small pieces. The material is processed through opening equipment, such as a card willow and pickers, and transported to rotary devices called garnets. Garnets separate and align fibers into layers that are either air or mechanically laid onto a moving belt 12-feet wide, which conveys them to a needlepunch loom.

A needlepunch loom is comprised of a board with needles spaced about 1/2-inch apart which comes down through the web into a board with matching holes below the web. The layers of fibers usually have a carrier which is introduced between the layers to make sure the mass stays contiguous. This carrier is generally a polypropylene mesh with 1/4-inch or 1/2-inch spacing. The needlepunch press is about 12-feet wide. It holds a single needle board about 12-inches deep which contains several thousand needles.

The web will go through at least two looms before the webbing is at the proper thickness and density. After the webbing has been properly formed, it goes into a spray area where the latex coating is applied, first one side and then the other. Usually about 2 to 3 ounces of latex per square yard are sprayed on each side. The web then passes over embossing rolls which impart a pattern into the latex coating for customizing the finished product.

After latexing, the product goes across an inspection table and into a roll-up machine which cuts the product into a finished roll. Usually this roll is slit into two 6-foot widths, although it may also be left in its full 12-foot width and then wrapped in either paper or polyethylene. Finished rolls are transported to a warehouse for storage.

3.4.1.5. Synthetic Fiber Carpet Cushion

The synthetic fiber industry has grown at an extraordinary rate over the last three decades. The use of synthetic fiber in the carpet industry alone has catapulted its consumption to over 2-billion pounds annually just in the United States. Likewise, large amounts of synthetic fiber are used in the manufacture of clothing and other textile products. In these manufacturing processes, off-specification material is produced, sometimes in very large quantities. Needlepunching it into a carpet cushion underlay is a natural end use. Today, synthetic carpet cushion makes up 3 percent of the carpet cushion market.

Raw Material

Almost 100 percent of synthetic fiber carpet cushion is made from off-specification synthetic fiber. It is collected from fiber producers, spinners, dyers, and yarn producers from all over the world. The fiber is baled and transported to about seven or eight synthetic carpet cushion producers in the United States.

Manufacturing Process

Waste synthetic fiber is furnished in bales to the synthetic carpet cushion plants. Bales are placed in breakers where the fiber is broken down into manageable portions and then fed into garnets which separate the fibers and align them. A garnet has a number of cylinders with wire teeth on them which perform the alignment process.

Fibers are then spread onto an apron by mechanical means in widths up to 12 feet. Frequently, but not always, a woven polypropylene carrier is included with the web for purposes of providing stability and strength to the product.

The apron carries the web to a needlepunch loom where the product is punched and needled into itself. The needlepunch loom (greater than 12-feet wide) incorporates either a single needle board or multiple needle boards. These boards are approximately 12-inches deep and contain thousands of needles spaced in a specific needling pattern. The web may go through one or more needling looms before the product is finished. In some manufacturing processes where the fiber length is short, a resin binder may be used to further bind the fiber web.

Packaging

The needled synthetic carpet cushion comes off the end of the line and is rolled up in a paper wrapping, or placed in a polyethylene bag. It is usually split into two 6-foot widths, but may also be left in its 12-foot width prior to wrapping. Finished rolls are then sent to a warehouse for storage.

3.4.2. VOC Reductions Already Achieved

No specific actions that have resulted in carpet cushion VOC reductions have been reported to the Carpet Policy Dialogue's Process Engineering Subgroup. Extremely limited data (three small chamber emission rate measurements) on carpet cushions were supplied to the Carpet Policy Dialogue by the Carpet and Rug Institute. These data should not be considered broadly representative of carpet cushion TVOC emission rates. The measurements reported were:

Product	TVOC Emission Rate (mg/m^2hr)	
	24 hr	144 hr
Polyurethane Rebond	0.123	0.059
Hair/Jute	0.240	0.012
Flat Rubber	3.36	8.11

* Data are extracted from "Volatile Organic Compound Emissions From Carpet and Associated Products," by Marilyn S. Black and et al., January 8, 1991.

Clearly, more data are needed to better characterize carpet cushion TVOC emission rates.

3.4.3. Potential VOC Reduction Methods

No potential TVOC reduction methods were identified for carpet cushion manufacturing by the Process Engineering Subgroup. The result does not indicate that methods do not exist, but only there was insufficient technical information accessible to the Subgroup for a meaningful review of possible TVOC reduction strategies.

3.4.4. Process Engineering Subgroup Proceedings

The Carpet Cushion Council (CCC) gave several presentations to the Process Engineering Subgroup. At the September 26, 1990, Subgroup meeting, the CCC presented an overview of the carpet cushion market, manufacturing processes of Bonded Carpet Cushion and Prime Urethane Carpet Cushion. At the November 30, 1990, Subgroup meeting, the CCC presented additional information on the manufacturing processes. At the April 9, 1991, meeting the CCC presented information on the carpet cushion market and potential methods of reducing VOCs from carpet cushion.

At the February 28, 1991, meeting, the Subgroup discussed the scrap materials used to produce carpet cushion and the possible VOC contributions from these materials. Also discussed were an overview of the raw materials used in the various processes and whether some of the raw materials could be VOCs. Other issues discussed included the significance of process steps and conditions such as the use of blowing agents, additives, and the temperature and residence time of the curing process on VOC emissions. No definitive recommendations were developed by the Subgroup.

The Subgroup discussed the possible availability of some Air Quality Science (AQS) data on carpet cushion VOC emissions as well as the possible inclusion of these data in the Carpet Manufacturing chapter of the Summary Report. These data are included in this document. Also discussed were the feasibility of establishing standards for urethane scrap

and whether industry efforts in reducing TVOC from carpet cushions should focus on treating scrap or establishing raw materials scrap requirements.

It was suggested that the identification of raw materials which could be VOCs, as well as specific additives and process variables that affect cushion VOCs for the various manufacturing processes, could be useful information to include in the Summary Report.

At the May 21, 1991, Subgroup meeting, comments on the carpet cushion chapter of the Summary Report were reviewed by the Subgroup. During that meeting, the Subgroup made a recommendation to the Plenary to accept the CCC's proposals to form five task forces to conduct TVOC reduction studies. The charge to the task forces is to examine manufacturing processes of the respective carpet cushion types with the objective of reducing TVOC in the finished products. These information/research considerations and recommendations are cited in detail in sections 4.5 and 4.6 below.

3.4.5. Information and Research Considerations

The following ideas were raised by some members of the Subgroup considering information that may help in identifying control measures to reduce TVOC. These suggestions do not necessarily represent the consensus of the Subgroup. These are presented as suggestions for future consideration of EPA or industry.

1. Development of a baseline data set that can be used to characterize TVOC emission from carpet cushion.

2. An evaluation of the potential sources of TVOC and process variables that affect cushion VOCs for the various manufacturing processes should be undertaken. This evaluation should consider such questions as:

   Bonded Carpet Cushion

   a. Are blowing agents significant VOC sources? Are VOC blowing agents a viable process change?

   b. How do foam curing process conditions like temperature, pressure and residence time impact carpet cushion residual TVOC?

   c. Of the two casting processes, which process creates the most VOCs? What are the percentages for industry's use of these two casting processes?

   d. During box type casting, does the drying of the bonded block accelerate the release of VOCs?

e. Can scrap polyurethane be treated to remove TVOC before being converted to bonded carpet cushion?

Prime Urethane Foam Carpet Cushion

a. Are blowing agents significant VOC sources? Are VOC blowing agents a viable process change?

b. How do foam curing process conditions like temperature, pressure, and residence time impact carpet cushion residual TVOC?

Cellular Sponge Rubber Carpet Cushion

a. A discussion on the effect of vulcanization process conditions like temperature, curing time, and oven residence time on cushion TVOC emissions should be included.

3.4.6. Subgroup Recommendations to Plenary

1. The Plenary should make a recommendation to the Agency to consider obtaining an agreement from the Carpet Cushion Council to sponsor a monitoring program which makes available to the public data on carpet cushion TVOC emissions. This program should be conducted on an ongoing basis to demonstrate continued product quality assurance. This monitoring program will be the same as the testing program agreed to in the Testing Subgroup.

2. The Plenary should make a recommendation to the Agency to consider adopting the Carpet Cushion Council's preliminary proposal to form five task forces of technical and manufacturing personnel of each type of carpet cushion to study the means by which TVOC can be reduced. The charge to each of these task forces is to examine manufacturing processes of the respective carpet cushion types within the constraints permitted by proprietary considerations with the objective of reducing TVOC in the five generic cushion types taking into consideration, along with other factors as may be identified by the task forces, suggestions made by the Plenary in 4.5 above. Results will be reported to the EPA on a basis to be determined.

3. The Plenary should make a recommendation to the Agency to consider obtaining an agreement from the Carpet Cushion Council to solicit all carpet cushion manufacturers for information concerning historical work done in reducing TVOC from carpet cushion. Information regarding specific VOCs already available from manufacturers or vendors will be used in the evaluation of the various manufacturing processes by the task force groups.

3.5. CARPET MANUFACTURING

3.5.1. Process Description

This section presents an overview of the carpet manufacturing process. A great majority of this section was supplied to the Process Engineering Subgroup of the Carpet Policy Dialogue by the Carpet and Rug Institute.

3.5.1.1. Carpet Face Fiber

The key to any discussion of modern carpet manufacturing is a close look at the fibers used in the surface of the carpet. The face yarn or face fibers represent between 70 and 85 percent of the carpet cost and is, therefore, the single most important economic factor affecting carpet costs. Additionally, the characteristics of today's fibers, in many cases, dramatically affect the manner in which carpet will perform when placed into service.

Within the United States, where approximately 46 percent of all carpet is manufactured worldwide; the manmade fiber, nylon, is the most important product for use in carpet. Historically, wool was the important fiber in the carpet industry, but as the market exploded in growth from 1960 onward, it was impossible for this natural fiber to compete economically or for it to be processed readily through some of the more modern manufacturing equipment. To clearly understand the role of face fiber in carpet, a brief analysis of the various fiber types used for the manufacture of carpet in the United States is presented.

Nylon

Around 1955, nylon staple fiber which previously had been used in blends of wool and acrylic, was used to produce early nylon staple carpet. It was during this time that loop pile styling was predominant in the United States. It was quickly determined that with the spinning systems available at that time, woolen spun nylon did not produce acceptable loop pile carpet. The problem was associated with pilling and fuzzing.

In 1956 - 1957, initial experiments were made with long staple spinning of staple nylon to see if the pilling and fuzzing problems could be overcome. This problem was alleviated to some degree, but by 1958, Du Pont had internally developed the first bulked continuous filament (BCF) nylon for carpet, Nylon BCF, in combination with the tufting machine, began what could be described as an "industrial revolution" in itself. Although there were initial problems associated with yarn streaking and processing, Du Pont, and later the other major fiber manufacturers, produced BCF nylon yarns which created an entirely new carpet industry. Bulked continuous filament nylon can be received by the tufted carpet manufacturer directly from the fiber producer and rapidly processed into white carpet (called

greige goods). It can then be dyed, one or more rolls at a time, to produce exactly the number of rolls of the correct color required by the marketing department. This is a far more rapid turnaround of raw materials, and hence money, as opposed to the old stock dyed processing required for wool fiber. In the case of wool, the carpet manufacturer first buys the fiber, which then must be sent to the dye company and then to the spinning company or division within the major corporations prior to obtaining the fiber in "yarn form", for tufting and weaving. In order to dye and process by this technique, relatively large amounts of material had to be produced in one color at one time, resulting in not only expensive processing, but in high inventories of colored carpet which might not be selling at that time.

Following rapidly on the heel of BCF nylon, staple nylon became more interesting to the carpet manufacturers who developed a new and different spinning system. This spinning system, the modified worsted or parallel spinning system, was more economical, but the new system allowed for the production of 7-inch or longer staple yarns which performed better in the carpet being produced.

Polyester

In the early 1960s, polyester was introduced into the carpet industry. It was during this time that polyester/cotton had become a standard household world because of the easy care fabrics so popular at that time. Polyester, as a carpet fiber, was introduced to the carpet consumer as an easy care material, much like the clothing material the consumer was accustomed to using. Polyester also had the advantage of long staple processing which had been developed primarily for nylon.

Polypropylene

Immediately prior to 1960, polypropylene was similar to nylon in many ways with the exception that it was not possible to piece dye the fiber. This meant that there were greater limitations in color choice for the ultimate consumer.

Polypropylene's accelerated growth into the carpet industry came with the development of indoor/outdoor carpet. Indoor/outdoor carpet was initially a needlepunch product, but when the true outdoor synthetic grass carpet was made using polypropylene ribbon yarns, then polypropylene began an accelerated growth within the market.

Polypropylene is a by-product of the oil refining business, and the technology associated with the extrusion of polypropylene is considerably less difficult than the technology for extruding nylon.

Wool

Wool was originally the important fiber used for carpet, not only in the United States, but also worldwide. Authorities differ in their estimates by several hundred years, but wool carpet was produced at least as early as the 14th century.

Although wool represents only about 1 percent of the fiber used to produce carpet in the United States, it is still the most prestigious of fibers. One of the primary reasons wool no longer dominates the market is the simple fact that it would be impossible for all carpet throughout the world to be made from wool because of insufficient production of wool worldwide. Not all wool can be used in carpet. Surprisingly, Australia, recognized as one of the major wool producing areas of the world, does not produce any wool for use in carpet applications. The major production areas for this type of wool today are New Zealand, Argentina, and China. However, if all the production from these countries and other countries that produce wool for carpet was shipped to the United States, the 20 largest carpet manufacturers in this country alone would have produced more square yards of carpet in 1986 than could have been produced from all this wool available. This type of demand would cause a shortage of wool which would in turn skyrocket the price, deter the growth of the carpet industry, and prevent growth in carpet wools.

3.5.1.2. Carpet Yarn Manufacturing

Since the carpet yarn manufacturing process may be considered a mechanical/physical operation with no chemical applications, no process details or information are included in this report which has been prepared for distribution to the EPA Carpet Dialogue Group.

3.5.1.3. Carpet Coloration

Basically dyeing techniques can be divided into two major categories. First there is pre-dyeing, which is the technique used to dye the loose fiber or the yarn before the carpet is manufactured. Post-dyeing is the technique whereby the carpet is dyed after it has been produced. This latter method offers considerable advantages to the carpet manufacturer in that it allows for longer color line choices to be made available to the consumer without additional large inventory costs.

3.5.1.3.1. Pre-dye systems

Solution Dyeing

Solution dyeing represents approximately 10 percent of the carpet market's dye systems. Solution dyeing is the addition of color pigments to the molten polymer prior to

extruding the fiber. Pigments can be added to the polymer at a number of stages during the manufacturing process. These pigments are either inorganic or metallized-organic compounds and, as far as color is concerned, they simulate paint coloring products in that the pigments are highly colored microscopic particles, and they are suspended within the fiber polymer. Choice of pigments must be carefully made. Items of importance include:

Particle size - uniformity and dispersibility;
Sunlight resistance;
Resistance to gas fumes;
Resistance to ozone; and
Compatibility with the polymer.

Stock Dyeing

Stock dyeing involves taking cut staple fiber, packing it into a kettle, and then forcing dye liquor through the "pack" and recirculating the liquor as temperature is increased to the maximum. The dyeing continues until the dyestuff has completely exhausted from the bath onto the fiber.

Stock dye kettles come in two types, atmospheric and pressure. In the first, dyeing is done at or close to the boil; in the second, pressure is adjusted to increase dyeability but not enough to cause tendering or damage to the fiber involved. Since wool fiber represent by far the most used stock dyed fiber for carpet, the great majority of stock dyeing is atmospheric. However, when dyeing polyester and occasionally nylon, where high pressures do not affect the fiber and where high pressures can significantly accelerate the dyeing, pressure dyeing units are used. In particular, when dyeing polyester, the use of a pressure unit makes it unnecessary to use dye assist chemicals to achieve the darker colors.

Most stock dyeing kettles range from 200- to 1000-pound capacity. They are fed from a circulating tank equipped with a centrifugal pump and the fiber pack is encapsulated in the kettle in a manner that allows uniform flow through the fiber pack with a minimum of "channeling" of the dye liquor.

After dyeing, the residual liquor is drained and the fiber is thoroughly rinsed while still in the kettle. At this point, an afterscour or hydroscour can be applied to minimize cracking or bleeding of the dyed fiber and in the final bath an application of softeners or finish is made to the fiber to facilitate yarn spinning.

The dyed fiber is then removed from the kettle and placed into a centrifuge to remove excess water. It is then dried in an oven on an endless belt or rotating drum type dryer. It is also possible to finish the dyed staple on a continuous line, where an endless belt feeds into an air blower-conveyer system and then directly on to a baling operation.

Different fibers require different dyestuffs and the dyes and chemicals involved in each dyeing vary considerably. However, general information is available from all the dyestuff suppliers who will supply formulations and dye recommendations along with the performance testing of the resultant dyed product. A typical general formula and procedure for stock dyeing wool and nylon follows:

Wool

Prescour to remove oil, dirt, etc.
2 - 4% Scouring Agents (Non-Ionic surfactant)
4 - 6% Bleaching/Reducing Agent (Sodium Bisulfite) 20 minutes at 180°F

Dyeing

X% Acid Dyestuffs, premetallized acid dyes or chrome dyes.
7% Sodium Sulfate (Glaubers Salt)
0.4% Sequestrant
0.1 Sodium Thiosulfate (Antichlor)
0.5% Leveling Agent (Non-Ionic Surfactant)
Y% Acetic Acid (to lower pH to 4.0 - 5.0)

Dyestuffs are boiled and strained, then added to the mixing tank with the chemicals listed above. The dye liquor is then heated to 140°F and metered into the dyeing kettle, circulating with an inside-out flow. Heat is raised 2° - 3°F per minute and after reaching the boil, bath is held for 30 - 45 minutes. When batch is checked satisfactory for shade, the liquor is drained and the fiber pack is rinsed until clear of dyestuff residuals. If a spinning finish is required, this is added and circulated at about 130°F for 20 minutes in order to allow the fiber to assimilate the finish from the water bath. The liquor is then dropped, and fiber removed from the kettle for centrifuge extracting, followed by drying.

Note: For atmospheric stock dyeing, a temperature of 210° to 212°F is used. For pressure dyeing, temperatures of 220° to 225°F are the maximum that should be used, since excessive temperature tends to tender and weaken the wool fiber.

Nylon

Acid dyes, premetallized acid dyes,and selected disperse dyes can be used in the pressure kettle.

X% Dyestuff
0.5% Dyeing Assistant (Anionic Surfactant)
2.0% Monosodium Phosphate (M.S.P.)
0.4% Sequestrant
0.2% Sodium Thiosulfate (Antichlor)
Y% Acetic Acid (to pH 4.5)

The procedure is generally the same as for wool; however, in some instances, prescouring can be omitted. The afterscour is usually not required, as rinsing alone is sufficient. A finish bath is required with nylon, and cationic type finish is used in order that subsequent yarn processing will be satisfactory. This can be applied either in the kettle, or as an after finish application in the continuous washer systems available in some plant operations.

Yarn Dyeing

One of the classic ways to color yarns is to make a skein and apply the dyestuff to the fiber while it is in this form. All fibers, primarily wool and nylon, may be dyed by this method.

It is possible to skein dye at either atmospheric pressure or under pressure similar to stock dyeing. A modern skein dye unit usually has a perforated arm on which the skeins are loaded. During dyeing, the dye liquor is forced through holes in the arms. When immersed, this allows for uniform application and absorption of the dye by the yarn. If the skeins are not uniformly loaded, dye liquor channeling can occur, thus causing streaky or un-level dyeing of the skeins.

There is a considerable amount of manual labor involved with skein dyeing. Listed below are the steps involved:

Skein preparation and lacing;
Loading of the dyeing arms;
Dyeing operation, including rinsing and finishing;
Centrifuging or extracting;
Dyeing;
Conditioning;
Expanding the skeins to remove tangles; and
Reconing.

The primary use for solid color skein yarn dyeing in the carpet field is for woven carpeting. It is also used for accent colors in the Omnipoint and Graphic tufting styles. Here the requirements for many colors, some in very small quantities such as 200 - 400 pounds-per-color, requires a method of production for which skein dyeing is entirely suitable. This type of system also provides a product with excellent bulk and a lofty hand, both desirable characteristics.

The dyeing procedure is dependent upon the type of fiber involved, but the same principles apply to all dyeing.

1. Prewash to remove oil and foreign materials, rinse.
2. Mix dyes and chemicals - add to holding tank.
3. Add to kettle.
4. Raise temperature uniformly at 2° to 3°F per minute until proper dyeing temperature is reached.
5. Dye to exhaustion - 30 to 60 minutes (dependent on fiber) at the dyeing temperature.
6. Drop bath - rinse.
7. After-scour, if necessary.
8. Add finish - 10 - 20 minutes dwell for exhaustion at 120° to 140°F.
9. Drop bath - centrifuge.

Typical formulation for nylon:

X% Level dyeing acid dyestuffs;
1-5% Leveling agent (anionic surfactant);
0.4% Non-Silicon antiform;
0.5% Sequestrant; and
0 -.4% Sodium Thiosulfate.

Package Dyeing

There is very little package dyeing used today for dyeing yarns to be used in carpets. The prime use is only in a few woven carpet styles, and it is essentially used only for special colorations such as effect colors in Axminster designs. The cost of package dyeing has been one of the main reasons for the lack of interest in this system.

In package dyeing, the yarn is wound onto a special cone, usually a perforated tube or a stainless steel spring. It is then placed onto a carrier with special perforated rods designed to emit dye liquor and force it through the yarn package. The entire unit is then enclosed in a pressure kettle and dye liquor forced through the yarn and recirculated until the dyestuff is exhausted from the bath.

Space Dyeing

The modern space dyeing technique for production of carpet began in approximately 1959 - 1960 as a technique developed to change the color of the yarn approximately every 1/4 inch along its length. In the late 1960s and early 1970s, the space dyed look in the carpet represented at least 15 percent of all pounds of yarn dyed and converted into carpet. Today, it is less popular and presents approximately 5-percent share of the market.

This system is based on knitting a plain circular knit tubing or a sock from the supplied yarn. These knitting units are usually dependable, trouble free units requiring a minimum of attention and technology, provided the supply yarn is uniform and contains a

minimum of knots or splices. There are numerous variations possible, but a 3-inch diameter circular knitting unit seems to be the most commonly used system, however there are some space dyers using a flat bed machine that knits up to a 25-inch flat tube to be used in the space dyeing process. In either case, the coloration techniques are the same, whereby the knit yarns are printed with dyestuffs in a multicolored pattern after which they are then steamed, washed, extracted, and dried, and the yarn de-knitted and rewound onto cones.

Various types of printing heads are used, the most common being the engraved roller printer. Normally there is a base shade that is applied by a pad dyeing technique where the tubings are completely covered in solid dye or print bath, then forced through a press roller to give a residual 90- to 100-percent take-up of pad dye liquor. This is followed immediately by a series of engraved rollers that overprint "wet-on-wet" several other colors in stripe patterns onto the tubings. In order to minimize "chevroning" or patterning in the carpet, it is necessary to print the stripes at various angles to the tubing. It also is a necessary practice to print several colors on one side of the tube and then turn the tubing over to print several other colors on the reverse side without getting too much of one color applied to the same side. Patterns are quite complicated, but once a good pattern has been developed, it usually enjoys a long production life.

In printing, it must be remembered that there is usually a base color, and that all shades on the "print" are "overprints" or shades <u>including</u> the base shade color. This involves careful color matching and requires considerable expertise.

After the printer, the tubing is plaited into an endless belt steamer for fixing the print color onto the yarn. In most instances, steaming time of 6-12 minutes is needed and temperatures of 220° to 230°F are desirable. There are more sophisticated steamers available capable of higher temperatures and dwell times, but normally the above quoted requirements are adequate. Immediately after the steamer, a series of wash boxes and/or pressure sprays remove excess color from the tubing.

At this point, it is usually necessary to have an extra wash bath equipped with pad rolls where an antistat finish is added to the yarn to assist in the subsequent de-knitting and tufting process. After the finish bath, the tubing is then processed through a drying operation. There are various types of driers, and the choice of drier usually depends upon the required production. After drying, the knit tubings are collected in individual boxes or cans, one tube per box and then reversed so that they will de-knit more readily. It has been found that when an attempt is made to pull the yarn out of the stock tube by starting the yarn from the wrong end, considerable processing difficulties are encountered. This loosened yarn end is then threaded through several tension bar guides and wound directly onto a cone to be shipped to the tufting or weaving mill.

3.5.1.3.2. Post-dye systems

Beck Dyeing

The beck dyeing process involves placing undyed carpet in a stainless steel vat or beck and rotating the carpet in dye liquor as the water, chemicals, and dyestuffs are slowly heated. When the dyes have been transferred from the water or dyebath to the carpet, the dyeing process is complete and the beck is drained. The beck is then refilled with water and the carpet is rinsed free of loose dye particles and other dyebath residuals. The carpet is then removed from the beck, placed in buggies and made ready for the drying process.

The mechanical handling of the volume and weight of a 12- or 15-foot wide carpet hundreds of yards long can obviously be a major problem; the modern carpet beck has been designed to handle these problems well.

It is important that the temperature of the carpet and the dyebath be kept as uniform as possible and not subjected to rapid temperature changes. A carpet dye beck is filled to about 3/4 capacity with water and dyes. As the carpet is rotated, it is lifted out of the water and the dye liquor cascades over the exposed carpet section. Considerable dyeing occurs during this part of the operation, and it is necessary to keep the dye liquor and the carpet from cooling off during this time. Modern dye becks have doors which can be closed to minimize loss of heat by evaporation and radiation.

If a prescour is required, before dyeing, the beck is filled with warm (100°F) water. Scouring compounds are then added and the bath is heated to about 120° to 130°F and held for 5 to 10 minutes while soil and yarn lubricants are removed from the carpet. At this point, if necessary, the carpet may be pre-bleached to remove excess tints. For bleaching, higher temperatures up to 160° to 165°F are used.

Bleach Scour Procedure:

Set fresh bath with water at 80°F with:

4.0% Sodium Perborate (mild bleach);
0.15% Non-ionic Surfactant;
0.25% Trisodium Phosphate (Detergent - pH control);
Enter carpet and run 5 minutes at 80°F;
Raise temperature to 60°F and run 15 minutes; and
Drop bath - rinse warm at 100°F.

After draining, the beck is refilled with water, the dyestuffs are added along with the dyebath ingredients such as retarding agents, detergents, and sequestering agents. The bath is then raised slowly to the dyeing temperature at a rate of 2° to 3°F per-minute. At 205° to 210°F, the bath reaches its operating temperature and dyeing continues for 30 to 45 minutes.

During the entire operation, the reel on the beck is constantly rotating and moving the carpet through the dyebath.

After approximately 30 to 45 minutes, a sample is taken to determine whether the carpet is "on shade." This is done by cutting a small square from the carpet in three places (edge-center-edge) across the width, so that any evidence of unevenness can be assessed; samples are then dried and checked against the standard.

If the color is incorrect, then a dyestuff addition is needed to bring the carpet on shade. These additions to the beck are made by dropping the temperature to 180°F, slowly allowing the dye liquor to return to the dyeing temperature and continue for 15 to 20 minutes. Sampling is repeated and again the shade is checked to the standard. Once on shade, the carpet is rinsed by dropping the dyebath, refilling with fresh water and rinsing for 5 to 10 minutes or until the rinse bath is clear. After rinsing, in some cases, a final finish bath may be required. If so, a finish bath is prepared by adding the chemicals involved to a clear bath, raising temperature to 130°F and running for 5 to 15 minutes. The bath is then dropped, and the carpet is removed.

The carpet is unloaded by stripping out the sewing thread seam or cutting the sewn edge. Next the carpet is threaded around the outside unloading reel and then plaited into a large stainless steel or plastic tub with casters and drainage holes in the bottom and sides. Then the carpet is positioned for extraction of excess water and the drying process.

There are two basic types of beck dyeing:

(1) Open width; and
(2) Rope dyeing.

Open Width

In the case of open width dyeing, the beck is equipped with a "spreader" roll. This is a full- length, spiraled roller over which the carpet is pulled and literally spreads the carpet so that it does not tangle or crease during its passage through the dye liquor and around the reel. The carpet is sewn in an endless belt and passed over this spreader roll and/or also over the top of the reel. The reel is a circular or oval cylinder which is usually covered with cloth to prevent "snagging" of the back of the carpet. The cloth surface also gives the reel the ability to pull the carpet without excessively distorting or abrading the surface. The reel is motor driven and the better quality becks are equipped to change the revolutions or speed of the reel. The optimum surface speed of carpet should be about 60 to 80 yards-a-minute; faster speeds distort the carpet, slower speeds tend to give the carpet time to fold or crease, and, therefore, dye unevenly.

Rope Dyeing

The procedure for rope dyeing is basically the same as open width dyeing except the manner in which the carpet is loaded into the beck and the elimination of the spreader roll. The carpet is entered by first roping or pleating the carpet to form a short width and then allowing the carpet to plait in a crushed or pleated manner into the beck. The carpet is then sewn into a continuous loop. The roping at the start of the loading causes the carpet to slowly advance from one side to the other side of the beck during the dyeing process.

As would be expected, this procedure allows creases in the carpet during dyeing; however, a surprising number of carpet constructions can be dyed crease-free by this roping system. The creases formed are soft and can be readily penetrated by the dye liquor and for this reason a large number of operations prefer the rope dyeing method. They claim it gives a better fabric finish, side to side color match, and the beck can handle a greater load than with open width dyeing.

Super Capacity Becks

In beck dyeing, the size of the vessel governs the maximum capacity of a given dye lot; thus, if the carpet to be dyed exceeds the becks capacity, then more than one dyeing will be required to complete the order. Unfortunately, when multiple dyeings are made of the same color, they may not match perfectly. This was one of the prime reasons for the development of continuous dyeing; however, continuous dyeing also has its disadvantages. Certain carpet styles are aesthetically and technically more desirable to dye in a beck--thus, the development of the super becks.

The super becks, unlike the normal size becks that are still very numerous in the industry, are oblong in shape giving them a greater capacity. Some of these becks can dye twice the amount of carpet as to the regular dye beck.

Due to the large amount of carpet and design of the beck, it is necessary to dye in open width form. An intricate part of the design of the super beck is the complicated pumping and filtering systems which are used to circulate the dyebath evenly throughout the vessel.

Pressure Dye Becks

In pressure dyeing, the dye beck has the ability to exceed the boiling point temperature which will increase diffusion of dye molecules into the fibers of the carpet. This is particularly desirable when dyeing polyester fiber because of its hydrophobic nature.

The original pressure becks developed over 20-years ago were designed very similar to an open atmospheric dye beck with the exception of the doors which could be sealed. Due to carpet handling problems and variances in temperature of the dye bath, this original type

of pressure beck never became very popular. The new pressure becks, referred to as "jet becks", being used in the carpet industry today are radically different in design from the older pressure becks.

The cost savings that pressure "jet" becks offer carpet manufacturers can be quite significant. Another attractive feature of these pressure "jet" becks is the dye lot size. Depending on supplier, these becks can dye up to 5,000 pounds of carpet.

The machine construction consists of a long stainless steel vessel with a diameter of approximately 80 inches and a length of approximately 50 feet. Inside the beck is a transition tube with the venture and drive reel. The flush flow out of the venture transports the carpet to the end of the transition tube where the carpet lays out freely and relaxed. The dye liquid which is recycled through a filtering system and heat exchanger.

Continuous Dyeing

There are two categories in which all continuous dyeing can be placed.

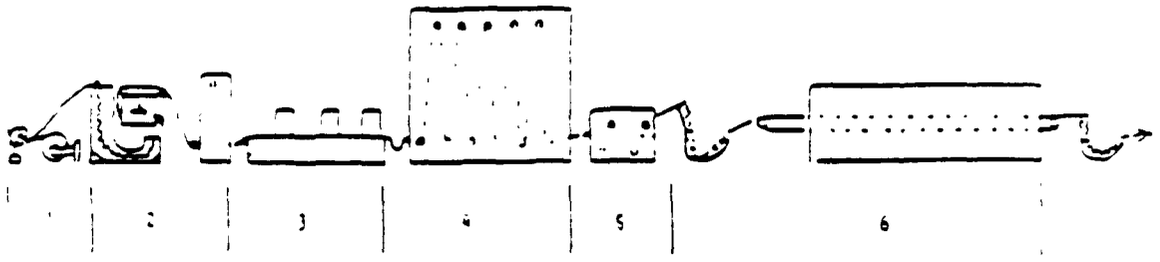
1. Solid Color Carpets and
2. Multicolored Carpets.

Both systems will utilize the same basic equipment with the exception of the dye applicator itself. For solid color dyeing only one applicator will be used coloring the carpet evenly with dye liquors from side to side of the carpet. When using the dye range for multicolored carpets, a series of applicators will be used. Some applicators will apply color to the carpet in random type pattern effects while other applicators will dye the remainder of the carpet a solid color. There are many possible variations of sequence and placement of the individual machines to consider. Cost, productivity, and operational efficiency must be prime considerations in addition to the more exciting aspects of color styling and versatility. Even the most exotic coloration system is of little value if it cannot produce a rapid return on investment for the carpet manufacturer.

The sequence in which these applicators are used to produce different styles are too numerous to count. Because more than one applicator may be utilized, the space requirements are somewhat increased, but the versatility of the dye range is greatly enhanced.

Composite Dye Range

The following schematic indicates the six steps used in carpet dyeing. These six steps are described in subsequent sections.



1. Sew In Area

Buggies or rolls of carpets are sewn end to end to create a continuous belt of carpet. Afterwards the carpets are fed into a holding box (J-Box). The most important factors at this stage in production are to have enough linear footage accumulated to ensure that at no time the production line has to be stopped and that the carpet is squarely sewn end to end.

2. Pre-Conditioning

In this area of the production dye range a couple of different things happen: 1) the carpet is almost always back-beaten and vacuumed to remove as much loose fiber and trash as possible; and 2) the carpet is wet out by either spraying with pre-mixed water and wetting chemicals, or by dipping in pre-mixed water and wetting chemicals.

The primary reason for wetting out the carpet is to slow down the absorption of dye liquors in order to aid in the overall levelness of the dye application. The secondary reason for wetting out the carpet is to remove spinning oils, tint, etc., from the fiber to promote better performance when dyeing.

After the wetting out processes, the carpet is then extracted or squeezed to remove excess water and level out the consistency of moisture content across the width of the carpet. Approximately 100 percent or less pick up (increase in weight) is the average for the carpet industry.

Some companies prefer to pre-steam instead of wet out. This does introduce moisture to promote bulkiness and elevates the surface temperature of the fabric, which is believed to increase total color yield. This process is especially desirable for the new type dye applicators such as the Kuster Fluidyer which can utilize thermal dyeing technique.

3. Dye Applicators

This is the area where dye liquors are applied either by a single applicator for solid color carpet or by multiple applicators for the multicoloration styles.

As the industry moved into the mid 1970s, a company called Kuster developed a precise applicator for dyestuffs. A plain roller rotating in a trough containing dyestuffs, water, and chemicals, picked up a surface coating of these dyestuffs which were then carefully "doctored off" the surface of the roller and allowed to evenly flow down a metal or fiberglass sheet angled at 45 degrees to the surface of the carpet where it was absorbed as the carpet passed underneath the doctor blade. Following this application of dye liquors, the carpet again was processed through a steaming chamber for fixation of dyestuff.

As technology advanced in the early 1980s, a more precise applicator was developed by Kuster. The versatility of this piece of equipment suited the carpet manufacturer very well in that it was much more flexible where speeds were concerned having a maximum of 150 feet-per-minute and a minimum of 20 feet-per-minute. The average pick up (total dye liquor applied) used by the carpet industry is between 300 and 350 percent; however, as low as 50 percent can be applied if foam is utilized. The change from one running color to another running color could be made in a matter of feet, whereas, the predecessors would virtually have to stop the line and rethread the entire range, thus losing much time just in order to change from one color to another.

Carpet is fed towards the dye applicator head where there is a slot approximately 3/8-inch wide, which is fed by a series of individual tubes 1-inch apart. All these tubes come from a central distributor thus having an even flow and pressure of dye liquor in the slot at any one time. As the carpet passes under the slot, an air cushion forces the carpet tightly against the slot, thus forcing the dye liquors into the pile yarns of the carpet, then immediately after exiting, the carpet enters a steam chamber for dye fixation.

The developments of the multicoloration effects resulted from the solid color applicator, which picks up the dyestuff on a smooth roller and then delivers a sheet of dyestuff onto an incline plane that is then poured onto the surface of the carpet. By having oscillating bars, wire fingers or squeegees that could break apart the sheet of dye liquor, it was found that droplets of color could be placed onto the surface of the carpet. By having two, three or four of these applicators each with a different color, random coloration effects, which were initially aimed at producing space dye type carpet but evolved into more of the multicolor effects which are known today, were produced. The first systems became known as the TAKE or Multi-TAKE coloration methods. By combining some of these processing techniques where drops of color are placed randomly on the surface of the carpet with gum layers and other chemical modifications, attractive random multicolor fabrics were produced, but they could only generally be duplicated, never exactly duplicated.

Kuster TAKE Unit: This is a programmable color drop applicator operated by forming color rivulets and intersecting them with moving wires. The volume of rivulet flow, the speed of the wire drop cutters, the oscillation of the rivulets and the sequence spacing of the rivulet streams are all adjustable through a relatively wide range to give multicolor effects in random so called patterns. This unit usually has two color capability; and there are Quadra-TAKE units that have four separate colors operating simultaneously. Styling

possibilities of TAX units are limited, since they cannot produce anything but random effects. However, when the system is equipped with gum applicators (one in front, one in back of the TAKE), a variety of multicoloration effects are possible and this unit represents the classic "Gum TAKE" styling machinery.

Kuster Multi-TAKE: The multi-TAKE can be considered an ultimate effort at pattern formation from a standard TAKE unit. The primary change involves replacing the solid doctor blade with a patterned doctor blade. This results in producing strips of color on the polished roll, and these can be altered into geometric patterns of color when the doctor blade is oscillated in precise relation to the roller speed and the speed on the carpet. The multi-TAKE is still sufficiently versatile to be styling tool in the industry today.

Kuster Color: This unit involved the basic solid color Kuster applicator with the addition of an oscillating jet roller As a sheet of dye liquor was scraped off the applicator roller, the jet roller would send a burst of air to displace the dye to form a pattern effect. The jet ports could be plugged in any given manner to produce different effects.

A further development of this technique was the Jet Kuster which basically was a Kuster Color with a unit on top of which there are 56 flexible tubes that are fed by separate dye liquors. This unit utilized the foam dying system so that the liquors are interblended, but not mixed; therefore, a marbleized effect is obtained.

Multicolor Spray Dyeing: The Otting Jet Foam unit was the first spray applicator known to be specifically developed for commercial broadwidth carpet dyeing. Dye liquor is pumped in precise measured quantities to jets in front of which compressed air is introduced into the feed line, resulting in a fine spray of dye solution being directed at the carpet pile. Spray dyeing is the newest technology in multicoloration. By putting three different spray bars in place across the width of the carpet and by turning these on and off in various sequences, it is possible to obtain the type of multicolor carpet that is still in demand. Each spray head applied one color. The jets are turned on and off by a series of sensors reading an acetate design or by the newer computer system.

4. Steamer

Steamers, regardless of their configuration and design, serve a simple, common function: to provide the energy necessary to exhaust the dye liquor onto the fiber, whether it be continuous solid color, multicolor, or printing. Most solid color continuous dye lines, after the dye liquor application, go directly into a vertical type steamer where the carpet moves up and down over a series of rollers. The dyestuffs can cascade back and forth achieving a good overall levelness of color. On a multicolor dye range, normally the carpet enters a horizontal steamer to fix the dyestuffs that were applied in some form of pattern effect before entering the vertical steamer. If not, then smearing and loss of pattern would be the final result.

There are many types and producers of steaming equipment for the carpet industry. The basic parameters that any steamer has to meet are to have an even temperature from side to side and front to back; sufficient wet-bulb temperature (212°F) to get good diffusion of dyestuffs into the fiber; and sufficient dry-bulb temperature (slightly over 212°F) to keep down condensation inside the steamer.

Normally, the carpet will remain in the steamer anywhere from two to six minutes, depending on the speed at which the dye range is operating and the accumulation of carpet inside the steamer.

In the older type steamers, the carpet entered through the top then went downwards around the first roller and proceeding back to the top. Much energy was lost in the entrance and exits of these steamers. These steamers usually work with the principle of a wet sump in the bottom of the steamer; there are still many of these in operation in the United States.

The newer technology "cloud" steamers with the carpet entrance and exit in the bottom below the steam layer (cloud) are much more energy efficient as very little steam is vented. The principle behind these steamers is to use low-pressure, superheated steam instead of a wet sump.

5. Washing

In this area as the carpet immediately exits the steamer, it is either dipped or sprayed and vacuumed by a series of devices. The most important function at this stage in production is to remove all residual dyestuffs and chemicals that were used during the dyeing process. If not washed thoroughly, then quality problems such as fastness to water, shampoo, and cracking may arise at a later date.

6. Dryer

There are many types and fabricators of drying ovens in the carpet industry. All of them accomplish one design function which is the removal of moisture from the carpet. Immediately after exiting the washing cycle the carpet enters the dryer, usually carried by tenter chains to hold the carpet tightly during the drying process.

Two basic design principles governing most dryers:

1) Impingement dryers--the carpet is surrounded by heat top, sides and bottom.

2) Flowthrough dryers--hot air passes through the carpet top to bottom or bottom to top and is then recirculated.

The latter of the two is more efficient and is utilized more in continuous dyeing; the other is primarily processed. After drying, the carpet is rolled up and is readied for the secondary backing.

3.5.1.4. Carpet Formation

As in the case of yarn manufacturing, the carpet formation operation may be considered a mechanical/physical process with no chemical applications. However, a general overview of carpet formation information is presented so that members of the EPA Carpet Dialogue Group can develop an understanding of various methods and materials used in the final finished composite carpet product.

There are numerous techniques for producing pile floor covering:

Tufting;
Weaving;
Fusion Bonding;
Hand Knotting; and
Braiding.

These techniques are described in the remainder of this section.

Tufting

Tufting is a process whereby tufts of yarn are inserted into a woven or non-woven fabric or primary backing. The tufts of yarn are inserted by vertical, reciprocating needles similar to the principle of conventional sewing machines. In fact, a modern tufting machine can be visualized as a giant sewing machine having hundreds of threaded needles in a row across the width of the machine.

A closer look at a tufting machine will reveal that individual cones of yarn or large beams are arranged in racks or a creel. A guide or tube is provided for each yarn end coming from the creel which feeds on needle. From the creek, the yarns pass through guides or tubes to the yarn puller rolls of the tufting machine. Adjusting the speed of these puller rolls controls the amount of yarn supplied to the machine, and with other factors determines the pile height of the carpet.

Following the feed rolls, the yarns pass through a series of vertically aligned, fixed guides. These guides direct the flow of the yarns without becoming tangled to the jerker bar. The jerker bar forms a combination of guides consisting of a fixed guide attached to the machine body and a guide located on the top of an arm extending from the needle bar of the machine. When the needle bar moves up and down, the relationship between the two guides is changed to take up the slack yarn delivered during the upward stroke of the needles.

From the jerker bar, the yarns are threaded through their respective needles in the needle bar. Modern tufting machines normally have hundreds of equally spaced needles arranged in a row along the length of the needle bar. For example, a 12-foot, 5/64th-gauge machine will have approximately 1868 needles while the more popular 3/16-inch gauge machine 12-feet wide will have 780 needles. The needles tuft simultaneously between 500 to 1400 strokes or stitches per minute on conventional tufting machines. At such speeds, a tufting machine in good condition can produce up to 8000 square yards of 12-foot carpet in an eight-hour shift, or more than 6.0 million square-yards-per-year.

The primary backing into which the yarns are inserted is supplied in roll form, located in front of the tufting machine. Spiked rolls positioned on the front and back sides of the tufting machine draw the backing over the bed plate and through the machine. The speed of the spiked rolls controls the stitches per inch. Moving the primary backing slower produces more stitches per inch while a faster rate produces fewer stitches per inch.

Located below the bed plate of the tufting machine are loopers (for loop pile) and looper and knife combinations (for cut pile and cut/loop only) which pick up and hold momentarily the yarns carried by the needles. In both cases, the loopers' work is timed with the stroke of the needles. When tufting cut pile, the looper and knife combinations hold and cut the yarns in a single operation. When forming loop pile, loopers shaped like inverted hockey sticks are positioned in the machine so that the formed loops move away from the loopers as the backing is advanced through the machine.

Loopers for a cut pile are reversed C-shape with a cutting surface on the top inside edge of the crescent shape. They are used in combinations with knives having a ground cutting edge on one end. As a backing advances through the machine toward the cut pile loopers, the yarns pick up from the needles are cut with a scissor-like action between the back of the looper and knife cutting against the edge of the looper.

For a cut/loop construction, a special looper and conventional cutting knife combination is used. The looper is similar to a cut pile looper, however, a special spring clip device is positioned at the top of the looper. In a conventional cut/loop construction, if a loop pile desired, a patterning device slows the feed of the yarn and thus applies more tension to the yarn. This tension is enough to cause the yarn loop already formed on the looper to pull itself past the spring clip tension device and become loop pile. If a cut pile section is desired, the patterning device feeds more yarn which in turn reduces tension to such a degree that there is not enough tension to pull the yarn off the looper and thus is cut similar to a conventional cut pile construction.

Tufting Machine Characteristics:

1. Surface Textures

There are three basic surface constructions of tufted carpet commonly being used in the industry today. These constructions are loop, cut, and cut-loop. The loop pile was the first construction introduced in the tufted carpet industry and was followed by tufted cut pile carpets and lastly by the cut-loop construction.

a. Loop

The loop pile construction can be further subdivided into three different categories. In level loop constructions, all loops are the same height from row to row. The next classification is that of high-low or patterned loop which uses a patterning attachment to achieve different pile heights in a pattern repeat tufted to either two different pile heights or in some cases three different pile heights. The third classification of loop pile construction is that of textured loop. Although there is some pile height variation in textured loop in order to give the carpet more surface interests than regular level loop, the pile surface interests the regular level loop, the pile height differentiation is usually slight and has little or no pattern definition as in the case of the patterned loop.

b. Cut Pile

With conventional cut pile tufting machines, the carpet pile surface is always level with all of the yarn tufts being the same pile height. Patterned effects can be created in the cut pile constructions by using different colors of pre-dyed yarns and through a pattern attachment called a shifting needle bar, various geometric designs can be created.

c. Cut-Loop

The cut-loop classification can be broken down into two subcategories. The first category is the more common high-low construction where patterning is achieved by the high pile always being cut pile and the low pile always being loop pile. By using a pattern attachment similar to that used in the high-low loop construction, a cut-loop construction can be attained by selectively varying the yarn tension, which controls whether the tuft will be cut of loop in form.

The second cut loop construction deals with a variation of cut-loop whereby the tufting machine make tufts of cut pile and loop pile at the same pile height to give a more woven-like effect. These are commonly referred to as the "Velva-loop" and "Level-Cut-Loop" tufting machines.

2. Gauge

Gauge can be defined in a number of ways; however, it is the density or the positioning of yarns as defined by the number of needles across the needlebar, or the width-wise portion of the tufting machine. Normally, gauge is referred to in fractions of an inch. For example, a 5/32 gauge means that the center of each needle is 5/32 of an inch apart. A 1/8 gauge has the needles 1/8 of an inch apart (gauge is the equivalent of pitch on the weaving loom).

3. Stitches Per Inch

The control of yarn weight and density in the lengthwise direction of carpet is achieved by varying the stitches per inch. Assuming a single row of needles positioned in a straight line in the needle bar and that the needle bar is connected to the main drive shaft, each stitch is in actuality a row of tufts across the width of the carpet.

4. Pile Height

The third dimension of pile height is generally measured from the surface of the primary backing to the top of tufted yarn. The height of the tuft can be controlled by a number of methods, such as the height of the bed plate, which is the metal surface on which the primary backing rests, in its relationship to the needle. The degree of penetration of the needle through the primary backing can be adjusted. Slight adjustments in the pile height can also be made by the amount of tension placed on the yarn as it is being fed from the creel.

The pile height of carpet is also influenced by the gauge of the tufting machine. Finer gauge tufting machines obviously mean a higher number of tufts per square inch which result in heavier weight carpets. In order to reduce the weight of the carpet face yarns, the pile height can be lowered. Therefore, as a general rule, finer gauge carpet normally have a lower pile height than coarser gauge carpets.

Pile height is the second most often used factor in adjusting yarn weight. It involves more time and detail that stitches per inch; however, there are times when stitches per inch can only be adjusted to a certain degree after which pile height must be adjusted.

High Speed Tufting

High speed tufting involves speeds in excess of 1,000 rpm and in most cases applies to cut pile tufting machines. Recently, however, many loop pile and cut-loop tufting machines have been built using high speed frames.

If a shifting needlebar attachments are used, machine speeds are obviously reduced because of the additional time and mechanical force required for shifting of the needlebar. In

most cases, the shifting needlebar attachments are operated at speeds in the range of 600 - 800 rpm.

Creels

1. Yarn Package Creels

A creel is a devise to hold yarn as the yarn is tufted. There are two basic types of creels; yarn package creels and beams.

The yarn package creel is a large metal framework with a special yarn cone holding device for each cone of yarn as well as an additional or back-up cone. A nylon tubing is run from each yarn package to the yarn feed rolls of the tufting machine.

The main advantage of a yarn package creel is that it is more efficient with lower waste on longer production runs and more flexible in case of off quality yarns. Most importantly, yarn package creels can be used on all constructions. Any machine that uses a patterning device for a cut-loop or high-low loop style constructions must exert various tensions or yarn feeds which make the use of beams virtually impossible since a beam must feed all yarn at uniform rate of speed.

Some disadvantages of a creel are that they require a greater amount of floor space than beams. This is especially significant in finer gauge where there are a greater number of needles per inch and thus more cones of yarn.

2. Beams

Beaming involves winding packaged cones of yarn onto large wooden or metal spools or beams. After beaming the yarn, the beams are taken to beam racks and positioned for tufting.

The main advantage of a beaming operation is that it generates relatively lower waste poundage on smaller yarn lots than yarn package creels. On most machines, especially finer gauge machines, beams reduce the among of necessary floor space.

The disadvantages are that beams that require the intermediate operation of beaming the yarn can cause some processing problems, the main disadvantage being that they cannot be used on high/low patterned constructions and thus can only be used for level loop, textured loop and cut pile constructions.

Primary Backing Characteristics

1. Jute

Jute as a primary backing material is basically non-existent in today's carpet market. It was originally used as a primary backing in the early days of the tufted carpet industry, however, during the 1960s and 1970s, its use as a primary backing has gradually declined to the point where it is no longer a viable portion of the market.

2. Woven Polypropylene

Woven polypropylene primary backings totally dominate the carpet market at the present time. The main reason these backings dominate the market is their consistency and uniformity of quality, price, and supply.

Fusion Bonding

Fusion bonding is a recent manufacturing technique. Basically, bonding involves implanting yarns, fiber webs, or fiber batts in cut pile or loop configuration onto an adhesive-coated backing. Thus, with bonding, more yarn is on the surface of the carpet instead of on the back or through the backing as is the case with tufting. Bonded carpets in the United States are less than 1 percent based on total square yards sold.

To simplify the techniques, fusion bonding can be divided into two major sub-categories:

1. Single Ends Implantation and

2. Multiple Fold Implantation.

Single End Implantation

Single end implantation refers to a single end of yarn being implanted on an adhesive backing. Several systems have been developed for commercial use, while other have not made it past initial development stages.

1. Bondi

The process begins with a special shuttleless loom and pattern device. The pattern device reads the pattern. According to the pattern, different sequences of different colored filling yarns are woven with a minimum number of warp yarns, and is some cases, no warp yarns at all.

The woven "fabric" is then folded in a precise zigzag or accordion formation known at a "pack". The pack of folded yarn is then turned at a right angle to the backing and cut to a certain pile height for implantation into the backing.

After cutting the pack, a bonded carpet is formed with the cut ends of the pack of fill yarn giving a pinpoint pattern depending on the spacing of the different colors during weaving. In other words, the Bondi system is a cross section of the pack that is secured to a backing and thus forming a bonded patterned carpet. Pile heights are infinitely variable up to 1.2 inches.

Multifold Implantation

1. Neko Process

Basically, the process is as follows: From opposite sides of the machines, backing fabrics move toward the center of the machine. Before reaching the center, an adhesive is applied to the top of the backings. At the center of the machine, the coated backings turn 90 degrees into a narrow, vertical section of the machine. At the top of the column, two reciprocating blades fold the fiber web into a corrugated form. The ends of the corrugated folds are pressed into the adhesive backing by the pressure from the reciprocating blades to form a corrugated yarn "sandwich".

The face-to-face carpet moves through a infra-red oven section to cure the adhesive. From the oven, a cutter is used to cut the face-to-face carpet down the middle to form two separate rolls of carpet. This cutting technique is similar to the method used in plush weaving.

2. Vernier System

This bonding system is similar to the Neko process except, at the manufacturer's option, a hot melt type of adhesive may be used which eliminates the need for an oven section. Also, the Vernier system uses a four blade system rather than the Neko two blade system.

3. Milstar Process

One of the most familiar bonding techniques in the United States is the Milstar Process. This patented process is a yarn utilizing variation, of the Vernier bonding system.

4. Titan or Deletex

The Titan or Deletex is similar to the Milstar and Neko systems previously mentioned. The system can produce two cut pile carpets or one loop pile carpet. If two cut pile carpets are being manufactured, two 12-ounce per-square-yard jute, PVC-coated backing

fabrics are fed into the pile formation area. Similar to the Neko System and Milstar, yarn is implanted into the two coated backings that are facing each other to form a face-to-face carpet similar to Milstar and Neko.

The carpet then passes through a heating zone to cure the PVC plastisol. A cutting section then cuts the two carpets apart as in the other bonding systems.

If a loop pile carpet is desired, only one backing is used so the loop will be formed on the opposite side where the second backing would normally be.

Woven Carpet

The fundamental principles underlying machine woven carpet may be illustrated by a simple loom. A wood frame, a piece of cardboard, a bodkin, and a comb are sufficient to construct such a loom as shown in Figure 3-6, below.

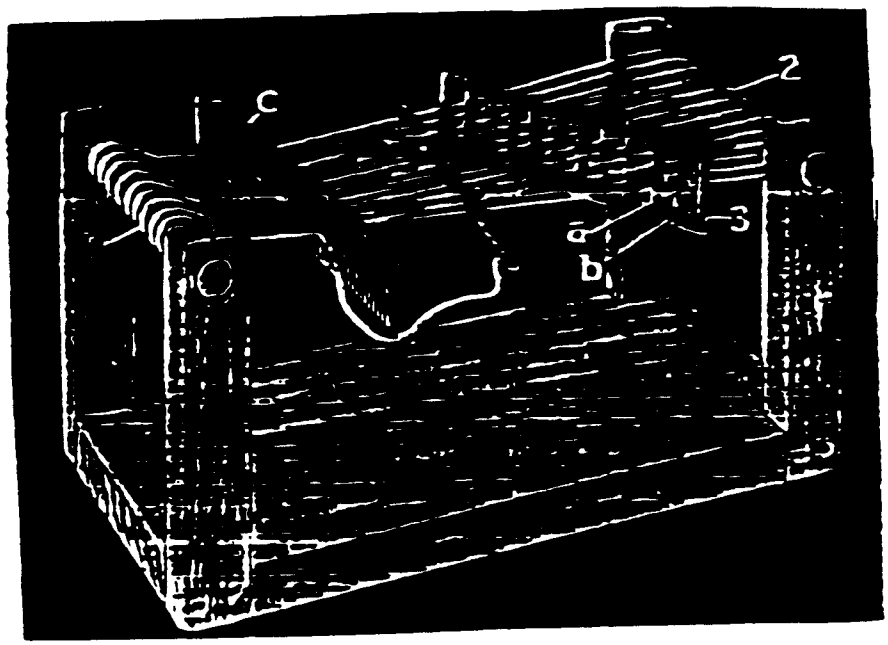


FIGURE 3-6 MODEL OF SIMPLIFIED LOOM

Weaving is reduced to its simplest terms on the homemade loom. (1) and (2) represent the warp beams. The piece of cardboard (3), the equivalent of the heddle in the power loom, has alternate holes (a) and slots (b). The comb (c) represents the reed in the power loom. A bodkin takes the part of the shuttle. Warp yarns are threaded alternately through the holes and slots of the heddle and fastened securely to the warp beams. The warp sheds for the passing of the bodkin- shuttle are formed by alternately raising and lowering the heddle. The comb is used to beat-up each shot of weft against those preceding.

Although there are several different methods of carpet weaving, there remains a number of basic similarities within each type. In general, the back or body of the woven carpet is provided by the interweaving of warp and weft yarns.

3.5.1.5. Carpet Finishing

The final and probably the most important step in the manufacturing process of producing a square yard of carpet involves the finishing of the product. The finishing operations are often a multiple step process which is used to give the carpet its final appearance and finish before being shipped to the customer.

The basic steps in the finishing process involve the following sequence of events:

1. Drying;
2. Pre-shearing;
3. Application of secondary backing; and
4. Final shearing.

3.5.1.5.1. Drying

The first stage of carpet finishing involves drying of the dyed carpet. It is of importance to note that the only time during which it is possible to improve the hand and surface appearance of carpets containing thermoplastic fibers is when they are in a hot, wet, or damp stage. It follows, therefore, that during drying of the carpet, some effort must be made to reduce wrinkles or creases, to attempt to erect crushed or matted areas of the pile, and to create a full, fluffy, uniform hand to the carpet. Due to this situation, a good carpet dryer is set up to have several "pre" and "post" mechanical aids to maximize the bulk development, pile raising, and crease removal.

As a start, carpet must enter the dryer in a uniform state of moisture. A wet-out bath followed by a vacuum extractor represents the first step in the system. On exiting from the extractor slot, the carpet is usually given a rapid vibration and "back beating" on a series of rapidly rotating serrated rolls and/or back beater beltings. This vibrates or flutters the carpet to open up any crushed pile and to remove soft creases and distortions in the carpet. During

the process, the carpet is held first by a tenter frame arrangement that carries the carpet through the dryer. The tenter frame is required to accurately control the width of the carpet and thus inhibit any change of dimension or shrinkage during the drying phase.

The dryer is usually of the impingement type, in which the heated air is forced into the carpet from either one or both sides; or of the through-flow circulation types where air is forced completely through the carpet, usually from the face side. The "through-flow" dryers operate at a higher speed because of increased efficiency; however, some constructions, such as high pile shags and saxonies, do not receive as good as texture and appearance from "through" circulation as from the impingement type dryers.

Beater bar system can be used both on the face and the back of carpet and at both ends of the dryer to give a more uniform appearance and texture and to erect the pile by high speed mechanical agitation. After drying, a cooling stage is included because some fibers will permanently deform if rolled up while still hot.

3.5.1.5.2. Pre-shearing

During the dyeing and drying operations, many carpets develop a very hairy and fuzzy appearance on the surface. This is caused by loose fibers coming to the surface during all the mechanical agitation which occurs during the dyeing and drying processes.

It is necessary to remove these loose fibers in order to obtain the most attractive appearance of the finished carpet. This operation was normally done after the secondary backing was applied to the carpet; however, in recent years, with the trend to finer gauges and smaller yarn counts, it has been found that the best finish can be achieved by pre-shearing prior to the application of the secondary backing. The unbacked carpet is softer and more pliable, allowing the tufts to be opened up and presented more uniformly to the shearing machine.

The shearing machine is a unit which heavily brushes the carpet pile to make it both erect and uniform. Carpet then passes under a series of rotary cutting knives which shear or cut off the fiber tips at a precise and controlled height. These rotary cutting heads have spiraled cutting blades imbedded into the surface. The carpet is passed over a small diameter (approximately 3/4 inch) roller bar in an inverted "V" configuration. This opens up the pile yarns and presents the individual tufts to the shearing head which allows a precise and uniform cut.

3.5.1.5.3. Secondary backing

Introduction

After the drying and pre-shearing operations, it is then necessary to apply some sort of secondary backing material to the carpet. This is done primarily to stabilize the carpet and reduce shedding of pile yarns by applying a coating of adhesive followed by the lamination of a secondary fabric or foam material onto the back of the carpet. Some of the more important aspects of the secondary backing are as follow:

- To anchor the pile yarns and prevent pull-out of the tufts;
- To minimize loosening of the pile and reduce shedding;
- To obtain dimensional stability;
- To prevent edge fraying during cutting;
- To improve resilience;
- To improve sound and thermal insulation; and
- To provide cushioning underfoot.

A good secondary backing system should meet all of the above requirements and in addition, be easy to apply. Otherwise, the system must offer some unique or special technical performance criteria that cannot be achieved with conventional systems. There are many available products which have been used for secondary backings.

Woven carpets as a rule are backcoated with an adhesive and/or resins in order to achieve tuft bind and reduce pilling and fuzzing, as well as give improved hand in finish to the carpet. Because of the woven structure of the carpet, no secondary type scrim is required.

Tufted carpets are normally backcoated with a latex which is used to achieve tuft bind, reduce pilling and fuzzing, and improve edge raveling resistance. The tufted carpet can be installed with this pre-coating of adhesive only, particularly when it is going to be glued directly to a floor and not installed over padding and tack-strip. Normally, however, the adhesive coating also acts as a laminant in order to glue a jute, woven polypropylene, or non-woven polypropylene scrim material to the back of the carpet. The function of this scrim is to add further stabilization to the carpet as well as additional hard and resilience.

Attached foam cushion backings can also be applied to the carpets using either latex, PVC, or urethane. The attached cushion backings, once a significant segment of the secondary backing market, are now limited to specialty areas.

Secondary Backing Types

Over the years, there have been numerous systems and types of secondary backings developed and tried for the carpet industry. The original woven type carpets utilized a

coating of plain latex, starch, or other resin which was used primarily as the stabilizing agent, as well as giving tuft bind and resistance to pilling and fuzzing.

With the advent of tufted carpets, the same basic technology and equipment was used for applying simple coatings of adhesive to the back of tufted carpets to give the same properties that were required of woven carpets. However, it was found that for most uses, a simple coating of adhesive was not sufficient to give adequate stability to tufted type carpet constructions, but that another secondary backing material was required for the additional strength and stability required for the tufted carpets.

Many different types of scrim or fabric material were tried as the secondary backing for tufted carpets. Initially, a type of woven craft paper scrim was laminated to the back with natural latex adhesive. Although the material was cheap, it was not found to have sufficient technical performance properties that would make it suitable for secondary backing material.

Finally, a woven jute material was developed that was sufficiently inexpensive and had the proper technical performance criteria which made it suitable for a secondary backing application. Jute has been the dominant secondary backing for tufted carpets until very recently.

Jute backing material is not available from U.S. suppliers, but instead comes from either India or Bangladesh. The many problems in supply of jute from a foreign country such as fluctuating prices, shipping delays, dock strikes, droughts, civil wars, etc., which have caused the U.S. carpet manufacturers to actively look for an alternative domestically produced material that is more readily available at stable prices.

Attached cushion secondary backings, while at one time a significant part of the U.S. secondary backing market, now represent only a very small portion of the total backing consumption. Other materials have been used on a limited basis, however, it has been found that most of these cannot compete economically with jute or woven polypropylene secondary backings.

The unitary type secondary backings have obtained a substantial share of the market. In recent years, the institutional contract market has seen increased usage of unitary type backings where the carpets have a direct glue-down installation in heavy traffic commercial areas. This market segment can be expected to increase during the coming years as the commercial contract market becomes a more important segment of the total industry.

The other types of backing materials such as PVC are used for very specialized end use applications. Specifically in the commercial contract tile market, a heavy weight, high-density product is required for stability and lay down properties.

Jute or Synthetic Backing Application

Both of these types of backings are applied in exactly the same manner and procedures. The first step involves applying a coating of styrene-butadiene rubber latex which has been filled with calcium carbonate or alumina trihydrate. This coating of adhesive also acts as a laminant in order to adhere the jute or synthetic backing to the underside of the carpet.

Lamination is used primarily in tufted carpet and has an important functional role in making tufted carpet a stable product which will perform properly when installed. The backing also enhances the aesthetics and hand of the carpet.

Jute or synthetic backing is a multi-step operation where first the back of the carpet is coated, usually by means of a roller rotating in the latex mix, the top side of which contacts the bottom side of the carpet. This is immediately followed by a doctor blade which spreads and evens the application of the liquid latex. The latex is a viscous solution, usually from 12,000 - 20,000 centipoise viscosity. The function of the doctor blade is to force latex into the base of the tufts on the primary backing. Normally, between 24 and 32 ounces of latex are applied, depending of the construction and style of the carpet. This latex coating acts as an adhesive for the pile yarns and also to attach the secondary jute or synthetic backing.

The second part of the coating operating occurs when a separate roll of secondary backing (jute or synthetic) is positioned onto the latex coating which has previously been placed on the back of the tufted material. This secondary backing has to be positioned carefully in order to have the edges match the tufted product and the two materials must be carefully pressed together by a marriage roller. This laminate is then dried and cured through a long oven, usually from 80- to 200-feet long where the latex is dried and cured at from 240° to 300°F. Approximately 2 to 5 minutes of curing time are required, depending upon oven efficiency, latex weight, moisture content, etc.

Normally, the first zone or penthouse will use elevated temperatures since the carpet and backing materials must be heated up. Here the temperatures on the back may be as high as 450°F, while the pile side is usually lower, 400° to 425°F. Temperatures in the subsequent penthouses are reduced to about 350° to 375°F to avoid burning of the carpet and to reduce energy consumption. In the longer ovens, the temperature may even be cut off completely in the last penthouse. Even though high temperatures are used, proper air circulation and control must be used to avoid heating the pile yarns and backing materials above 270° to 280°F.

A high rate of evaporation is important for carpet drying and the ovens must have adequate forced hot air movement along the precisely controlled heating zones. It is important that, as the carpet goes through the dryer and after it leaves the dryer to the cooling station and the wind-up station, that the carpet remains flat and unflexed. During most of the passage through the dryer, the latex curing is incomplete. If the partially cured

film is flexed, creased or otherwise disturbed, the film breaks down and results in poor lamination of the backing to the carpet.

Although double lamination backcoating is almost mandatory for most residential type carpets, there are several large volume uses of broadloom carpet that can utilize merely the latex unitary coated carpet, namely direct glue down commercial applications and room size rugs. In this instance, a single coating of about 24 to 32 ounces of latex is applied without a secondary backing of any kind.

Vinyl - Polyvinyl chloride

In the specialized area of backcoating, there is the vinyl (polyvinyl chloride) application. This can be applied as either a sheet or a foam, depending on requirements. Vinyl has some advantages over latex from the standpoint of strength, pile lock, mold-ability and slip resistance. Unfortunately, there are several problems to the use of vinyl.

Vinyl must be cured at very high temperatures; 1 to 15 minutes at 300° to 400°F is required. This requires either very slow oven speeds and/or extra heat capacity or a longer oven to adequately process the product. In the case of foams, the same situation occurs.

In the commercial tile market, approximately 100 ounces-per-square-yard of PVC are applied to the back of the carpet. Normal procedures for applying the PVC involve gauging a layer of thickness of the PVC onto a teflon-coated, continuous fiberglass belt. The tufted carpet is then laid on top of this coating of PVC and passed through the curing section of the oven. The curing is accomplished by a series of heated coils underneath the belt which activates the PVC curing process.

Hot Melt Adhesives

These hot melt adhesives are special co-polymers of ethylene vinyl acetate with terpene resins and petroleum waxes. They have particular properties in that they can be melted and calendared freely onto a substrate. As they cool, they return to a solid state with almost complete encapsulation of the substrate surface. In tufted carpets, this means that hot melts give excellent and superior tuft lock to latex and can be applied in considerably lower add-on amounts than can conventional latex. In the past, the speed of operation of hot melt lines was significantly faster than conventional latex. The average speed of a hot melt line is 60 ft./min. This compares to present day speeds of 50 to 90 feet-per-minute on conventional styrene-butadiene rubber latex.

The objectionable feature to hot melts is the fact that they require a completely new machine and compounding equipment to apply them to carpet. In operation, the carpet is fed into a tenter frame to fix the width and then onto the hot melt head, to a post heating tunnel, to refrigerated nip rolls, through sets of cooling rolls and, finally, to a roll-up mechanism.

The post heat tunnel holds the hot melt temperature at about 375°F to control the polymer's geometric penetration to the carpet back. Correct spread of the hot melt to the fiber bundle is vital to get proper tuft and bundle lock without melt migration onto the carpet face yarns. The secondary backing is placed in contact with the carpet as it emerges from the hot melt head and at this point the laminate is welded together by the liquid molten polymer.

3.5.1.5.4. Final shearing

After drying and backcoating, the carpet surface should have a level color and a uniform appearance. However, due to the mechanical drag and abrasion that occurs in the final finishing operation, the surface of the carpet may become fuzzy and "hairy". This appearance detracts significantly from the carpet. In order to correct the problem, it is necessary to lightly post-shear the carpet.

The final shearing operation is identical to the pre-shearing process that is explained in section 3.5.1.5.2, Pre-Shearing. In the final shearing operation, it is common to have at least two shearing heads operating in line. It is better to have two very light cuttings rather than one heavy cutting in order to achieve the maximum effect at higher speeds.

3.5.1.6. Stain Resist Technology for Nylon

3.5.1.6.1. Introduction

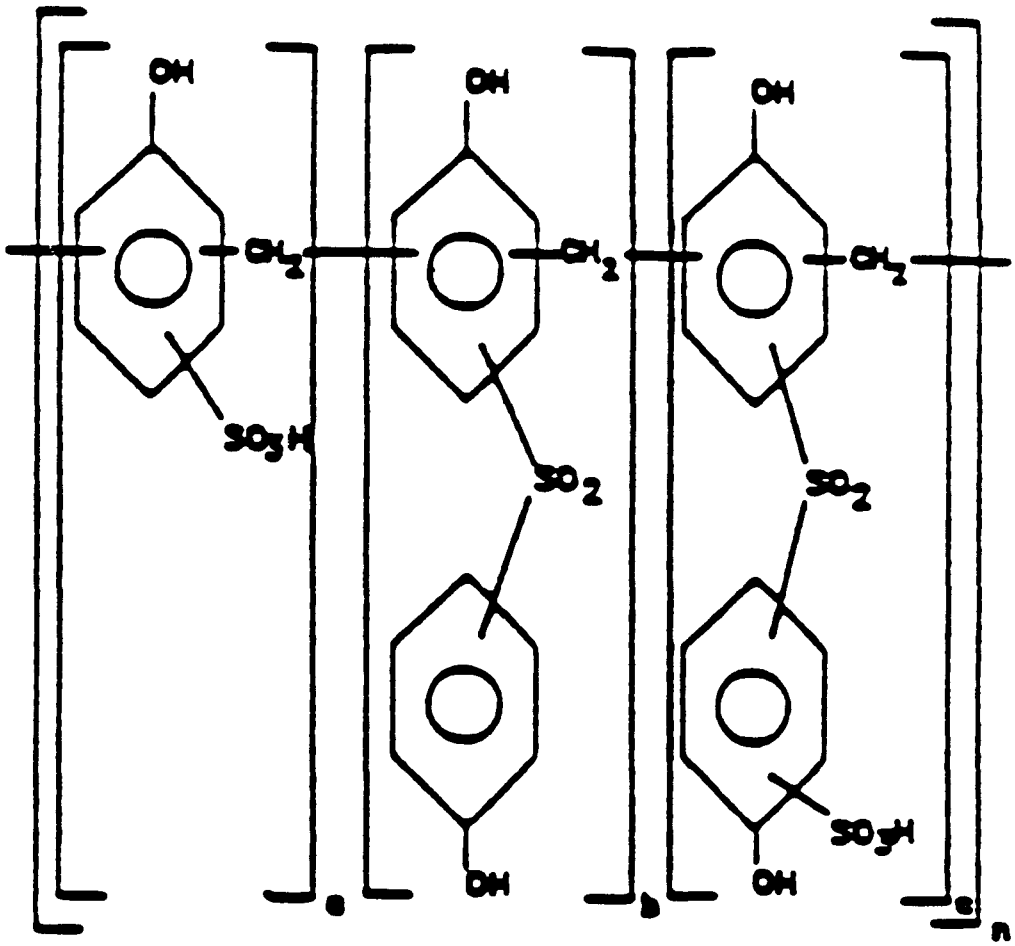
The use of stain-resist agents for common food dyes on nylon carpet has become prevalent. The success of stain-resist technology in the carpet industry has resulted in widespread use of a class of complex mixtures called "syntans", sulfonated novolacs, or sulfonated aromatic aldehyde condensation products (SACs). The general structure of these compounds is represented in Figure 3-7, which generally describes most structures. It is possible to include in the condensation other aromatic compounds not shown here. A random sequence of the various monomer units is implied, with subscripts "a" through "c" representing mole fractions, and subscript "n" related to the number average molecular weight. The nature of the complex mixtures resulting from this flexible chemistry makes careful study of this type of material difficult. The very flexibility of the synthesis makes possible a wide variety of mixtures with overall different characteristics.

3.5.1.6.2. Stain-resist mechanism

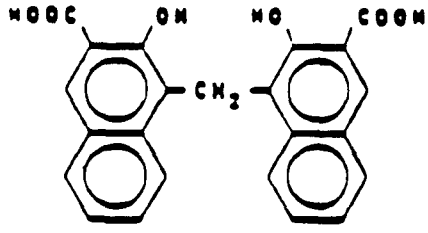
Since the number and type of compounds in a particular mixture are quite numerous, the exact mechanism by which these materials impart stain resistance to fibers is not

FIGURE 3-7

GENERAL STRUCTURE OF STAIN RESIST AGENTS



completely understood. Previous workers in the field (although most were investigating SACs for use in wetfastness enhancement, not as stain-resist agents) have suggested that a barrier effect against the diffusant is the principal mechanistic concept, and that this barrier may be both physical and electrical in nature. It was also thought to be most effective as a result of concentration of the SAC near the fiber surface creating a "ring dyed" placement effect. In work performed using model compounds such as pamoic acid:



and also the acetate ester of pamoic acid, dye sorption measurement of the treated materials indicated that for anionic diffusants, the electrical part of the barrier effect is the most important, the ester derivative having significantly greater dye up-take. It is thought that the degree to which the SAC hinders the diffusion of nonionic diffusants depends on the SAC molecular volume, and packing near the surface end results in increased tortuosity to the diffusant. It has also been shown that the anion-rich barrier more effectively slows the diffusion of the more basic anionic dyes. Therefore, the key to the use of SACs as "stain barriers" is because most water soluble food colorants are, in fact, dibasic acid dyes. Recent work suggests that these concepts as they related to stain resistance in general is correct and provides supportive evidence that concentration of the SAC near the fiber surface is critical to the effectiveness of the stain resist properties of the treated fiber. This surface concentration effect is influenced by the nature of the SAC chemistry, the morphology of the fiber, and the application conditions. Therefore, optimization of the chemistry and application conditions is essential for the best stain resistance performance.

3.5.1.6.3. Application of stain-resist chemistry

The main attractive forces between the stain-resist and the fiber are hydrogen bonding between the uncharged polar hydroxyl groups of the stain-resist agent and the amide linkages in the nylon and electrostatic attraction between the sulfonic acid groups of the fiber. The stain-resist treatment performs best when applied at pH of less than 2.5. This is believed to be related to both increased exhaustion of the material onto the surface and also the high electrostatic attraction for the nylon which inhibits diffusion into the fiber. The addition of divalent salts, such as magnesium sulfate (epsom salt), to the treatment liquor may often enhance the stain resistance properties of the treated carpet. The effective concentration generally varies depending on the morphology of the substrate being treated and the concentration of the SAC in the application bath. While this effect is not completely

understood, a possible mechanism is that the salt modifies the SAC micelle formation in water and increases the sorption of the SAC at the fiber/liquor interface.

The most used method for application of the stain-resist chemistry is by an "aftertreatment," after the carpet is already dyed. This minimizes any influence on the dyeing process, makes the application more easily controlled, and yields the most repeatable carpet performance.

The aftertreatment may be either a batch or continuous process. The most commercially significant aftertreatment process involves continuous application of the treatment liquor using a specially designed applicator, such as a Kuster Flex-nip or Otting Thermal Chem, which is then followed by a dwell period at elevated temperature using a short vertical steamer.

The application of 1-percent on the weight of the fiber (owf) of the SAC in a batch process is normally carried out at a 30:1 liquor-to-fiber ratio, adjusted to a pH of 2 with sulfamic acid. The fiber carpet is introduced into the bath at 26°C. The temperature is raised to 71°C at approximately 1.5°C per minute, and then held at 71°C for 20 minutes. The carpet is rinsed thoroughly in cold distilled water, extracted of excess water.

3.5.1.6.4. Conclusions

Industry experience clearly indicates that the molecular size distribution and polarity are critically important parameters for successful use of SACs as stainblockers. In addition, the placement of, or concentration of the chemistry near the fiber surface is shown to be the most important criterion.

3.5.1.7. Soil Release

3.5.1.7.1. Introduction

In 1972, after extensive research, a soil resistant fluorochemical finish, sturdy enough to withstand the abrasive punishment to which carpet is subjected, was developed. Today, most residential carpets have a fluorochemical treatment which, according to applications research, allows the carpet to remain clean up to three to four times longer than untreated carpet.

3.5.1.7.2. Soil release chemistry

Fluorochemical is a general term applied to a wide variety of organic fluorine compounds. Such compounds are man-made, uniting the elements carbon and fluorine. When these compounds contain an aliphatic group where all carbon-bonded hydrogen atoms are replaced by fluorine, the designation perfluoro- is used. Compounds which contain a perfluoro- chain or ring, attached to a reactive group to facilitate further synthesis as shown:

CF_3-C_xF_{2x}-Z
Perfluoro-compound

The principal qualities of all fluorochemicals are: 1) their extreme stability as a compound; 2) their incompatibility with oil and water; and 3) their outstanding surface properties. The composition of the fluorochemical can be varied to provide different performance. Compounds can be designed for use as protective finishes for textiles, paper and leather; as inert fluids for testing in the electronic industry; as fluoroelastomers or rubbers with special resistant properties; as surfactants, or as fire fighting foams with special surface properties.

Perfluoro-compounds are often converted to polymers or high molecular weight chemicals for use as textile finishes. When dried or cured on a fiber, the fluorochemical tails orientate themselves away from the fiber to produce a very low surface energy barrier.

The theory of repellency can be explained in part by surface energy and spreading coefficients. It has been found that a direct correlation exists between wetting ability and surface energy. Materials having low surface energy are difficult to wet. Fluorochemicals having long chain perfluoroaliphatic groups produce the lowest surface energy of any class of materials.

The spreading coefficient measures the tendency for the individual fibers to be wet by a liquid. It relates surface energy of the substrate, surface tension of the liquid, and interfacial tension between the substrate and the liquid. It does not take into consideration the surface roughness, capillary effect, or uniformity of the treatment on the textile substrate.

Simply stated, fluorochemicals derive their repellency properties by lowering the critical surface energy of the treated fabric surface below that of the wetting liquid. This provides a chemical barrier to liquid penetration. There is no need to incorporate a continuous physical barrier. In addition, fluorochemicals function at relatively low levels. Therefore, a fluorochemical treatment can provide a protective barrier without unduly affecting other desired properties. On a practical basis, this means that as a textile treatment, a fluorochemical surface resists wetting by oily and watery liquids. And, a properly designed fluorochemical will also provide resistance to soiling. It also means that there is minimal effect on hand, feel or breathability of the fabric.

Fluorochemical textile finishes offer specific performance properties that set them apart from all other textile finishes. They have the unique property of oil repellency, plus the properties of water repellency and soil resistance. They have greater durability to laundering or drycleaning. Lower chemical add-on is required, thereby providing advantages in having less effect on shade change, mark-off, hand (or feel), and breathability of the fabric.

3.5.1.7.3. Application of soil-resist on carpet

In the carpet market, soil resistance is one of the most desired features. The fluorochemical compound is required not only to be highly soil resistant, but must be durable to walk-on, provide good durability to cleaning, and also be abrasion resistant. Soil gets tracked onto the carpet; dirt is ground into the carpet with walking; and carpets are vacuumed to remove the dirt.

Soil resistance protects the carpet by keeping dirt from sticking so tightly to the fiber. Loosely held dirt can be removed more easily from the treated carpet with regular vacuuming. A degree of oil repellency is needed because most soils are oily in nature. Abrasion resistance and durability to walk-on prevents the fluorochemical from being worn off or vacuumed away. Durability to cleaning is also required for eventually even a treated carpet will get dirty enough to require cleaning.

Fluorochemical treatment of carpets is most commonly done by spray application. They spray equipment must be designed to provide uniform chemical application, adequate penetration, and variable liquid output. Amount of chemical and required output depend on the carpet face fiber weight, and the operating speeds at the drying/curing oven. Fluorochemicals can be applied to all carpet constructions and most fiber types. For the purposes of treating, carpets fall into two categories: wet carpet or dry carpet.

Spray treating wet carpet is preferred, because less additional moisture is needed. Wet carpets are found after piece dying or rinsing operations. Solution wet pick-up of 10 to 20 percent is sufficient since penetration can be more easily accomplished if the carpet is already wet. Fluorochemical treatments deposit between 0.3- to 0.6-percent solids depending on the weight of the carpet face fiber.

Spray application on dry carpet requires higher moisture add on to ensure adequate penetration. Dry carpets are found at the back coating or laminating operation. Solution wet pick-up of 20 to 40 percent is desirable, applying similar levels of fluorochemical solids; i.e., 0.3 to 0.6 percent.

3.5.2. VOC Reductions Already Achieved

No specific actions that have resulted in carpet VOC reductions have been reported to the Carpet Policy Dialogue. However, some data on carpet emissions were supplied to the Carpet Policy Dialogue by the Carpet and Rug Institute. These data should not be considered broadly representative of carpet system TVOC and 4-phenylcyclohexene emission rates. The measurements reported are presented in Table 3-6.

3.5.3. Dr. Van Ert's Laboratory-Scale Study

This laboratory scale study, conducted by Dr. Mark Van Ert and his associates at the University of Arizona, was initiated by SBLMC to investigate the relationship between 4-phenylcyclohexene release from latex-backed carpet and selected carpet curing oven operating variables. The study was completed using a laboratory-scale oven that may or may not have been representative of industrial carpet curing ovens. Details of the study and the results are included in Appendix N.

The variables selected for study in this set of experiments were: 1) cure time, 2) cure temperature, and 3) air exchange rate. Other dependent factors that were considered during the course of the study to determine their potential relationship to 4-phenylcyclohexene release from the carpet samples included: humidity within the cure oven and moisture content of carpet samples. In addition, the study included a preliminary investigation into the effect of high velocity air on the release of 4-phenylcyclohexene from latex backed carpets.

Two types of latex were used: type A, which contained about 700 ppm and type B, which contained about 250 ppm 4-phenylcyclohexene. The carpet samples, after coated with these latexes, contained approximately 20- to 60-ppm 4-phenylcyclohexene by weight. In order to account for the slight variation in the 4-phenylcyclohexene content in the carpets, all data reflecting the impact of various cure parameters on the release of 4-phenylcyclohexene were reported as a percentage of the absolute amount of 4-phenylcyclohexene remaining in a latex coated carpet sample for the individual test run.

Inferences that may potentially be drawn from Dr. Van Ert's laboratory scale study that may be relevant to industrial scale carpet curing ovens include:

1. Operating curing ovens at higher temperature may result in lower 4-phenyl-cyclohexene emission rates (and possibly lower TVOC emission rates) from carpet.

2. Operating curing ovens at higher air velocity may result in lower 4-phenyl-cyclohexene emission rates (and possibly lower TVOC emission rates) from carpet.

TABLE 3-6

TVOC AND 4-PHENYLCYCLOHEXENE 24-HOUR EMISSION RATES OF NEW CARPET

GENERIC CARPET DESCRIPTION				
FACE FIBER TYPE	DYE METHOD	SOIL/STAIN RESIST[1] TREATMENT	TVOC EMISSION RATE[2]	4-PHENYLCYCLO-HEXENE EMISSION RATE[2]
1	Continuous	No	0.071	0.064
1	Continuous	Yes	0.109	0.091
1	Continuous	Yes	0.183	0.152
1	Continuous	Yes	0.045	0.040
1	Continuous	No	0.098	0.075
1	Beck	No	0.097	0.087
1	Solution	No	0.131	0.106
1	Solution	No	0.102	0.035
1	Continuous	Yes	0.166	0.034
1	Continuous	Yes	0.041	0.025
1	Continuous	Yes	0.182	0.033
1	Continuous	Yes	0.179	0.025
1	Continuous	No	0.060	0.045
1	Continuous	No	0.054	0.062
2	Beck	No	0.127	0.064
3	Solution	No	0.500	0.043
4	Stock	No	0.195	0.082
2	Beck	Yes	0.092	0.042
1	Solution	No	0.438	0.110
		Mean	0.151	0.064
		Standard Deviation	0.123	0.034

[1] The exact treatment was not known.

[2] Emission rate taken after a 24-hour equilibration period within the environmental chamber.

3.5.4. Industry-Sponsored Plant-Scale Study

A study with the objective of evaluating VOC as a function of process variables has been completed. The text and data from this work is located in Appendix N.

The focus of the study was on four factors associated with application of secondary backing to the carpet (finishing). The variables, curing oven residence time, curing oven make-up air, carpet latex loading, and latex type, were selected from a broad spectrum of potential factors. These particular variables were anticipated to be important based upon the collective understanding of the participants of their respective products and of the carpet manufacturing process.

The actual experiment was based upon a two-level factorial design. High and low levels were selected slightly outside of reasonable operational limits. Routine production at these operational limits would result in a significant increase in unacceptable products (discoloration or delamination).

Multiple regression analysis of the TVOC data provided reasonable models. The R2 for the 24-hour model was 0.77, which indicates the variables account for a fair amount of the variance in the data set. The 1-hour data were also collected, but correlated less well with the variables studied (R2 = 0.58). The statistically significant process variables were curing oven residence time and curing oven make up air.

Two additional qualitative observations can be made of the data. The range of TVOC encountered at 24 hours was 0.174 mg/m^{2}h, which in the view of the study's authors was not particularly wide considering the test design. The average for the data set (24 hours) was 0.071 mg/m^2-h. It was also observed that the emission factors for all samples dropped significantly between the 1-hour and 24-hour sampling times--the majority were below 0.100 mg/m^2-h. The decline in TVOC is consistent with data obtained in other studies.

The results of the study suggest only limited opportunity for reductions in TVOC levels in the indoor environment where styrene-butadiene rubber backed carpet is used (in part because the levels attributable to latex-backed carpet are already low) via these process factors. For example, the normal operating conditions for this process line are near the center of the range of variable studied except for make-up air, which is close to the upper extreme. If it were possible to push the key operating conditions to the "edge," the estimated reductions in 24-hour TVOC levels would be no more than 20-30 ug/m^2-h. Recognize again, however, that manufacturers would face an unacceptable risk to carpet aesthetics (more off-shade goods) and obviously higher energy consumption at the most severe conditions tested.

Broader application of the above statements to other process lines and their resultant products would, of course, be speculative. Nonetheless, it is important to recognize that regardless of the specific line orientation and operating conditions, all styrene-butadiene

rubber backed carpets are taken to a similar endpoint in finishing; i.e., a cured latex, which is principally the removal of water. It is also very unlikely that a carpet mill will run a finishing line process in a way that presents the possibility of yielding a "wet" backing out of the curing oven. The result would be delamination, and, hence, unsalable carpet. Therefore, one would predict other finishing lines will produce styrene-butadiene rubber backed carpets with comparable TVOC emission levels to those observed in this study.

Only a few recommendations from this study can be made to the carpet industry. It might be prudent for carpet mills to evaluate curing oven make-up air to ensure they were removing water and VOC as efficiently as possible. Increasing oven residence time can be considered, however, it is recognized this is more difficult to justify given the magnitude of the reductions (approximately 30 ug/m^2-h) predicted by this study. Decisions, of course, will be mill (process line) dependent and balanced upon factors such as energy consumption, capacity, cost, yield of first-grade product, etc. Research into reductions of VOC via the products supplied to the carpet industry is known to be ongoing, but specifics are beyond the scope of this report.

3.5.5. Process Engineering Subgroup Proceedings

Two technical presentations were given to the Subgroup on carpet manufacturing process. At the September 26, 1990, Process Engineering Subgroup meeting, the Carpet and Rug Institute (CRI) presented information on carpet market and carpet manufacturing process. Also, at this meeting, a report on a laboratory-scale study of carpet oven curing parameters on VOC emission was distributed by the SBLMC.

At the October 24, 1990, Subgroup meeting, CRI presented some data on an industry cooperative plant-scale study on the effect of carpet curing oven operating parameters on VOC emissions. CRI then provided the Subgroup with a draft chapter of the carpet manufacturing process to be included in the Summary Report. Comments on this draft chapter were discussed by the Subgroup at the April 8, 1991, Subgroup meeting. It was suggested that the Summary Report should include a discussion of the market shares of the various types of carpet fiber, dyeing systems, carpet formation techniques and carpet finishing alternatives. It was also suggested that the document should include identification of VOC components in all the manufacturing steps. Some of this information was provided to the Subgroup by CRI and is included in this document.

The Subgroup endorsed the inclusion of the Air Quality Science (AQS) data on carpet VOC emission rates (supplied to the Plenary on a confidential basis) in the Summary Report to provide some perspective on VOC emissions from carpet as well as summaries of the results obtained from the laboratory scale and plant-scale studies on the effect of carpet curing oven parameters on VOC emissions from carpet. In addition, it was recommended that CRI should provide guidance to its members on the impacts of carpet curing oven parameters on carpet TVOC.

The Subgroup also discussed potential research suggestions which included a comprehensive assessment of the contribution of the various sources to carpet TVOC levels and an evaluation of the feasibility of increasing carpet "airing out" time before shipment, and increasing carpet curing oven time, temperature and air exchange rates. The information and research considerations and Subgroup recommendations are cited in detail in sections 3.5.6 and 3.5.7 below.

3.5.6. Information and Research Considerations

The following ideas were raised by some members of the Subgroup considering information that may help in identifying control measures to reduce TVOC. These suggestions do not necessarily represent the consensus of the Subgroup. These are presented as suggestions for future consideration of EPA or industry.

1. A comprehensive assessment of the contribution of the various sources to carpet's TVOC levels would be useful. For example, how significant are SB latex TVOC levels to final carpet TVOC levels.

2. Evaluation of the feasibility of increasing carpet "airing out" time before shipment; and increasing carpet curing oven time, temperature, and air exchange rates.

3.5.7. Subgroup Recommendations to Plenary

1. The Plenary should make a recommendation to the Agency to consider obtaining an agreement from the CRI to provide guidance to its members on the impacts of carpet curing oven operating conditions on carpet TVOC.

3.6. CARPET INSTALLATION/VENTILATION

3.6.1. Introduction

This section presents an overview of the carpet installation process along with applicable guidelines developed by the Carpet and Rug Institute to minimize TVOC emissions during and after the installation process. The great majority of the information regarding installation procedures and industry guidance was provided by the Floor Covering Installation Contractors Association (FCICA). This section also includes information from presentations by Mr. Hal Levin (ASTM Subcommittee D22.05 on Indoor Air), Mr. Andy Persily (NIST), Mr. Bruce Tichenor (EPA), and Mr. John R. Girman (EPA), regarding the relationship between building ventilation rates and indoor air VOC concentrations.

3.6.2. The Scope of Existing Guidelines for Installation

Until 1982, the floor covering installation trade operated without the benefit of consistent industry guidelines for installation. The Carpet and Rug Institute undertook the task of coordinating input from installers, retailers, manufacturers, end-users, testing laboratories, and others with specialized experience in the field to formulate a written set of minimum standards known as CRI-104, "Commercial Carpet Installation Standard". In 1990, the Carpet and Rug Institute published CRI-105, "Residential Carpet Installation Standard". These voluntary guidelines, included as Appendices P and Q, respectively, to this Summary Report, are becoming the standard accepted by the installation community. They are increasingly being specified by architects, designers, and carpet specifiers. As installation methods and product technology have changed, the guidelines have been updated to reflect these changes. The acceptance of these voluntary guidelines has been enhanced through the use of the printed inserts included in each roll of carpet by manufacturers, the development of the Floor Covering Installation Board national certification program primarily based on compliance with the CRI-104, the development of the multi-industry Floor Covering Installation Training Council, and the incorporation of the standards into the training programs sponsored by each segment of the installation community. The standards have also been embraced by most schools which train installers, inspectors, and claims adjusters. As the acceptance of these standards broadens, it is becoming increasingly difficult for installers to operate at levels less than acceptable under these guidelines.

3.6.3. An Overview of the Installation Process

Residential Installation

The residential market comprises well over one half of the carpet manufacturing and installation industry. The residential installer will usually operate with one helper and will either be self-employed as an "independent" or as an employee of a residential retail store or installation firm. The majority of residential installers operate as "independents" and, although not treated as employees, will be paid by the retailer upon completion of each job. The typical residential installation occurs in the following sequence:

1. The installer and helper report to a retail store to receive or to competitively bid (low bid) a job. In the case of an employee installer, the retailer assigns the job to the installer.

2. The retailer provides the carpet and cushion, work order form, and sometimes a sketch or diagram. The carpet should be cut to room size at the retail shop or workroom.

3. The installer loads the carpet and cushion into his vehicle and picks up any supplies needed for the day at a local tool and accessary distributor. In the case of

an employee installer, the workroom or retailer will provide the supplies. These supplies will normally include tackless strip, seaming tape, adhesives, and sundries. Product selection will be based on previous experience and recommendation by the supplier.

4. Upon arrival at the customer's home or installation site, the installer will begin preparation for the installation. This may involve moving furniture, removal of existing carpet and/or cushion, preparation of the floor, and layout of new carpet.

5. The installation procedure will follow the general guidelines outlined in CRI-105. Power stretching carpet and sealing all seam edges are procedures now being monitored more closely and being more widely practiced by installers as the direct result of industry acknowledgement and acceptance of the CRI-104 and 105 guidelines.

6. Upon completion of the installation, the installer obtains the customer's signature on the work order and leaves.

Commercial Installation (or Contract Installation)

Accounting for less than one half of all installation, commercial installation jobs are generally either negotiated or obtained through the competitive bid process. The management of these installations tends to be more complex due to the wide variety of parties which may be involved on any given project, such as, architects/specifiers, building owners, general contractors, commercial carpet retailers, and labor contractors. Working conditions in the commercial installation industry can be very challenging due to construction time deadlines, maintaining proper environmental conditions, transporting carpet into multi-story buildings, and compliance with Federal safety and employment standards. A simplified example of a commercial installation is as follows:

1. A building owner or tenant commissions an architect to design specifications for a project.

2. The architect develops the specifications and puts the project out for competitive bids or the owner may negotiate directly with a general contractor. These specifications will normally include and detail the carpet and installation procedures. A growing number of specifications require strict adherence to CRI-104.

3. The general contractor obtains the bid for carpet installation from a dealer who will either perform the installation or will subcontract the labor to an installation labor shop.

4. The dealer orders and receives the carpet, cushion, adhesives, and other supplies at his warehouse, labor shop, or the job site.

5. The installation crew(s) will transport the materials to the job site or report to the job site to begin the installation.

6. Once at the job site, the installers will handle floor preparation and begin the actual installation of the carpet according to the specifications and the installation instructions provided by the carpet, cushion, and adhesive manufacturers. The job site conditions are checked prior to the arrival of the installers for excessive moisture or alkalinity in concrete floors, extreme temperatures, and high humidity levels.

7. Upon completion of the installation, a walk-through inspection is conducted by the general contractor and owner. Upon addressing any recommended corrective measures, the subcontractor receives his final payment. It is common for ten percent of the subcontractor's bid price to be withheld by the general contractor until acceptance of the installation.

3.6.4. Training, Education, and Certification Programs

The most comprehensive and consistent installation has been traditionally provided through joint labor/management apprenticeship training programs. However, only about 15 percent of all carpet installation is performed by union installers. These union programs are active in many areas of the country and also provide continuous education to the journeymen. FCICA has estimated that the percentages reflecting employment classifications of installers would be as follows: 85 percent are independent (self-employed); 10 percent are payroll employees of bona fide installation firms; and 5 percent are employed by retail dealers. The challenge of providing education and training to these installers is being addressed by many organizations and programs. There are vocational school programs offering introductory instruction in installation; installation schools are being conducted by certified instructors through the Floor Covering Installation Training Council; clinics and schools are conducted by the FCICA; independent training schools providing intensive schooling and on the job training; product manufacturer sales clinics updating product developments; workshops sponsored by local product distributors and retailers for installers. In addition, videos and training tools are available which promote professionalism, installation guidelines, and product application. The FCICA has recently produced a video summary of CRI-105 designed to promote the residential standard and to educate the residential installation community on the guidelines recommended in the document. Installation firms may participate in a voluntary certification program by agreeing to submit their firm to the scrutiny of an independent board of their peers and representatives of the carpet manufacturing and design communities. In addition, these installation firms agree to abide by the CRI-104 installation guidelines and to a Ten-Point Plan for Installation Excellence.

This Floor Covering Installation Board (FCIB) certification program has seen a significant increase of applications during the past year, and this trend is continuing. The ultimate goal is to have the program recognized by the entire industry, from the specifier to consumer.

3.6.5. Specific Guidelines Which May Impact VOC Exposures

CRI-104 and CRI-105 both contain sections devoted to environmental and carpet conditions. The identification of these sections follows:

CRI-104:

page 4/section 5.3

"Conditions - The carpet and adhesive shall be conditioned on site in a heated dry space at a minimum temperature of 65°F (18°C) and a relative humidity between 10 and 65 percent for at least 48 hours before installation. These conditions shall be maintained night and day during installation and for at least 72 hours after completion."

page 7/section 6.4

"Relax Carpet - Whenever possible and conditions permit, all carpet shall be unrolled, relaxed, and allowed to ventilate with the induction of fresh air."

page 7/section 6.5

"Environmental Conditions - Fresh air ventilation during installation shall be maintained by opening windows and doors, by utilizing exhaust fans, and by operating the ventilation fans system at full Capacity. When conditions warrant, fresh air ventilation shall be maintained after installation for 48-72 hours at normal room temperatures by operating the ventilation fan system at full capacity and by opening windows and doors if possible. This will help eliminate the existence of any lingering odors."

CRI-105:

page 6/Consumer Checklist

"Ventilation... as with most new products, new carpet may initially have a slight odor. This is normal. Adhesives or hot melt seaming tapes used to install the carpet may have a slight odor while they are curing. Existing carpet or cushion, while being removed, may create an odor. All removal or installation processes are best handled under optimum fresh air ventilation conditions. During installation, be sure that

windows and doors are open, conditions permitting. Ideally, the heating/air conditioning/ventilation system should be operating at normal room temperature with maximum fan speed. If you, a member of your family, or other occupants are sensitive to certain odors, you may wish to be absent during installation. After the installation has been completed, you may wish to ventilate the premises with fresh air by opening windows and doors and operating the ventilation system at normal room temperature with fan speed at maximum capacity for at least 48-72 hours. This will help eliminate the existence of any lingering odors."

page 9/Good Customer Relations

"Carpet, cushion and adhesives used for seaming and/or installation often have a slight odor while they are curing. This is normal. However, if the customer expresses a sensitivity to these odors, be sure to recommend that the windows be kept open and that the ventilation system continue to operate at full fan speed for at least 48-72 hours after the installation has been completed. Settings of the heating/air conditioning system should be left at normal room temperature levels. This will help eliminate the existence of any lingering odors."

page 24/Specific Reference Section

"6. Environmental Conditions - Fresh air ventilation during installation shall be maintained by opening windows and doors, by utilizing exhaust fans, and by operating the ventilation fan system at full capacity. When conditions warrant, fresh air ventilation shall be maintained after installation for 48-72 hours at normal room temperatures by operating the ventilation fan system at full capacity and by opening windows and doors if possible. This will help eliminate the existence of any lingering odors. Be sure that the room is adequately ventilated while you are working. Windows and doors should be opened. The ventilation system should operate at full fan speed. Utilize plenty of fresh air."

3.6.6. Practical Experience In Compliance With Installation Guidelines

Meeting the ventilation guidelines of the standards is often hindered by factors beyond the control of the installer. Residential installations historically are more generous in the opportunities to provide fresh air ventilation and air circulation. However, in severe weather conditions, opening windows is impossible if other necessary environmental conditions are to be maintained. In commercial installations, the installer is often faced with severe time deadlines, the absence of proper ventilation systems, and conducting the installation in occupied buildings. Maintaining full ventilation for 48-72 hours following the installation cannot be guaranteed by the installer. However, it is a guideline which can be, and is, recommended for the customer or owner.

The process of conditioning the carpet and allowing it to be unrolled and to "relax" is limited by time deadlines and other factors. The carpet is usually unrolled to be inspected, measured, and cut for the specified areas prior to being delivered to the job site.

3.6.7. Effects of Ventilation During Carpet Installation on VOC Emissions

The purpose of this section is to define the relationship between building ventilation rates and indoor air VOC concentrations, report on ventilation rate studies in selected buildings, set forth the physical processes involved when VOCs are emitted from carpet assemblies as well as the factors affecting these processes, and to provide some practical control strategies for carpet system VOC emissions.

3.6.7.1. Indoor Air Quality (H. Levin, ASTM Subcommittee D22.05 on Indoor Air, April 9, 1991)

The graph in Figure 3-8 demonstrates the theoretical relationship between building ventilation rates in Air Changes Per Hour (ACH) and indoor air VOC concentration. The graph shows curves for three different source strengths.

It is known that increased ventilation or ACH will reduce pollutant levels, but the graphical relationship makes it clear that there is a point of diminishing return and a section of the curve on either side of the vertex where the maximum reduction in VOC concentration can be achieved with the minimum increase in ACH. For weak sources, this point of maximum pollutant reduction will be at lower ventilation rates than for strong sources. This range of ventilation rates or ACH will vary from situation to situation but once defined will serve to optimize the change in ACH required to reduce VOC concentrations to acceptable levels. Most buildings operate in the range of 0.6 to 1.5 ACH.

3.6.7.2. Ventilation in Office Buildings: Studies by the National Institute of Standards and Technology (A. Persily, NIST, April 9, 1991)

Ventilation rate studies were conducted on both new and existing office buildings. Findings included frequent discrepancies between designed ventilation rates and measured values; considerable influence of outdoor climate conditions on ventilation; and common ventilation system operational problems during construction. Operational problems are also common after construction.

Figure 3-9 is a flow diagram of a typical building ventilation system. In many of the buildings tested, infiltration was found to be of the same order of magnitude as the air intake rate. Thus, in similar cases, pollutant levels will be better reduced by source reduction than change in ventilation.

FIGURE 3-8

VENTILATION RATES
AND INDOOR AIR VOC CONCENTRATION

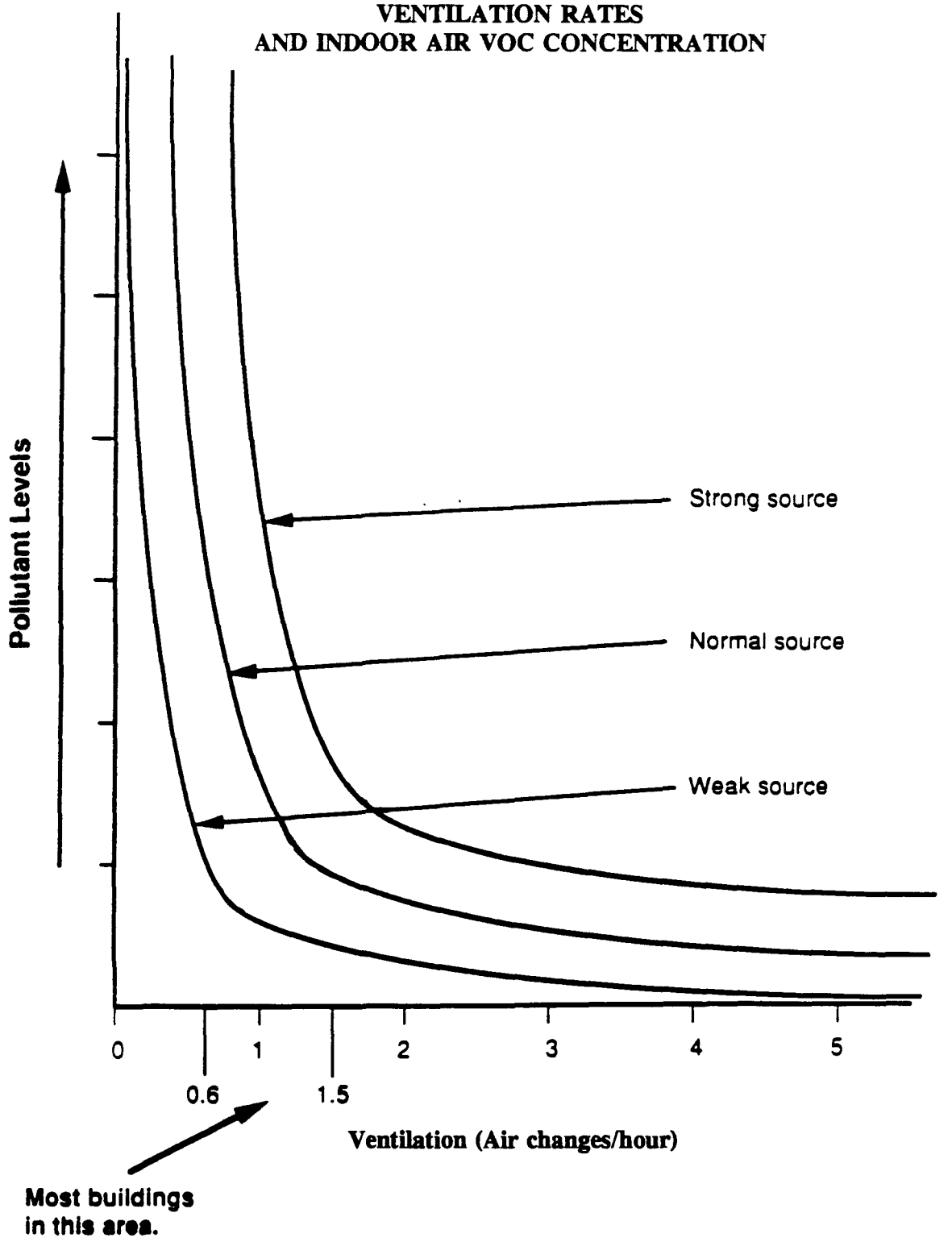


FIGURE 3-9

FLOW DIAGRAM OF A TYPICAL BUILDING
VENTILATION SYSTEM

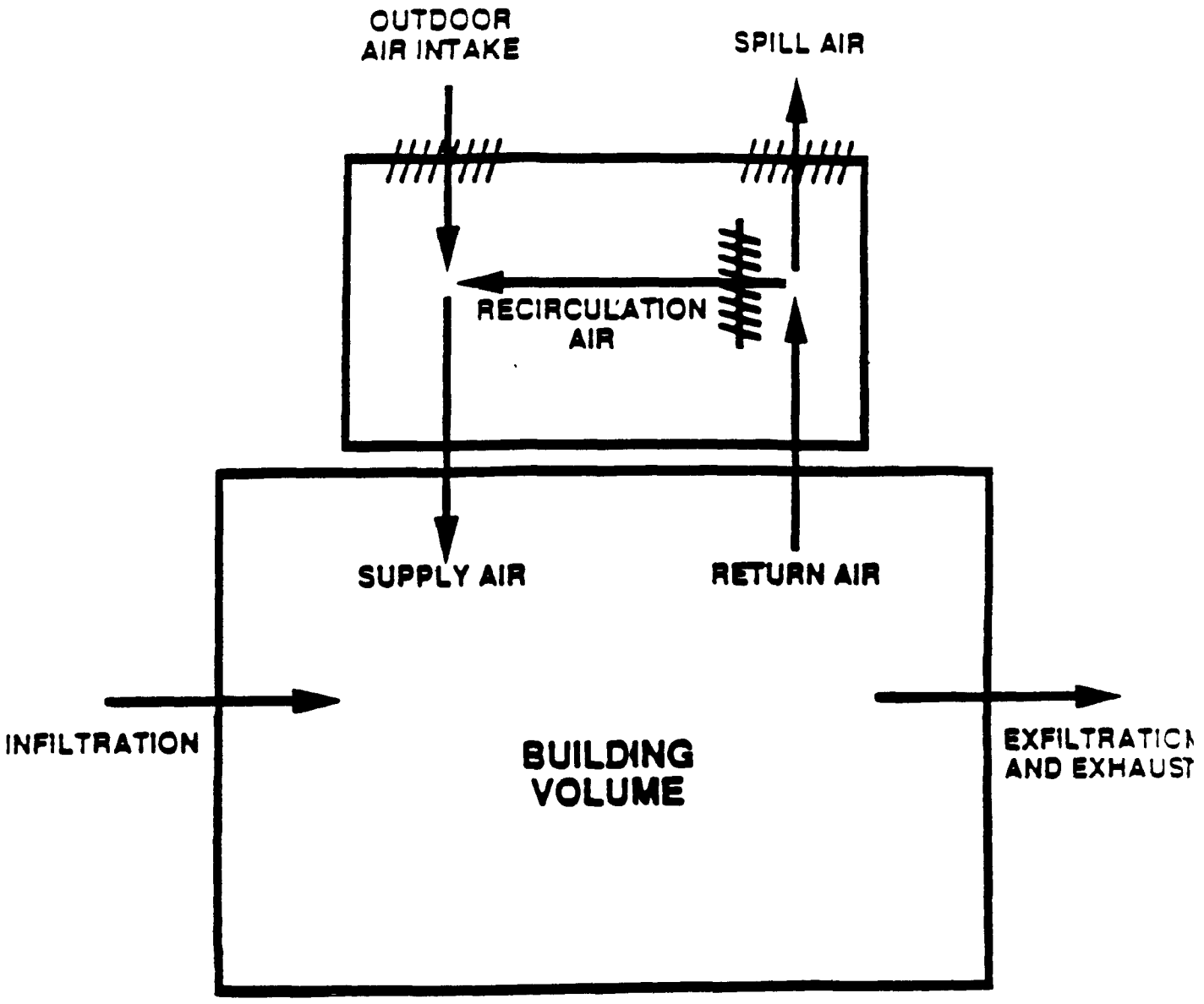


Figure 3-10 shows actual air exchange rates in the Portland East Federal Office Building. The graph demonstrates the considerable influence of outdoor climate conditions (temperature differentials) on ventilation.

Figure 3-11 summarizes actual exchange rates found in buildings studies by the National Institute of Standards and Technology (NIST). Design values of minimum outdoor air intake rates were found to vary from .36 to 1.7 air-changes-per-hour.

Figure 3-12 presents the distribution of air exchange rates in the buildings studied by NIST. Forty percent of the measured air change rates were below the minimum design specifications for outdoor air intake. The same percentage of the measured rates was below 20 CFM/person, the recommendation contained in the ASHRAE Standard 62-1989.

Actual ventilation rates and design rates were found to vary as a result of:

- Conditions during construction,
- Deviation from design, and
- Building-to-building and within-building variability.

Because of the common differences between design and actual ventilation rates, one needs to consider carefully the reliance on ventilation for pollution control, during construction including carpet installation. Examples of important issues to consider regarding ventilation rates are:

- Fans
  - Is the fan on or off?
  - Is the fan operating in the proper direction?
  - Is the impeller turning with the motor?
- Airflow rates
  - Is there a restricted supply?
  - Is the outdoor air intake blocked?
- Dampers
  - Are the dampers in the proper position?
  - Are the dampers in a fixed position and properly balanced?

FIGURE 3-10

AIR EXCHANGE RATES IN THE PORTLAND
EAST FEDERAL OFFICE BUILDING

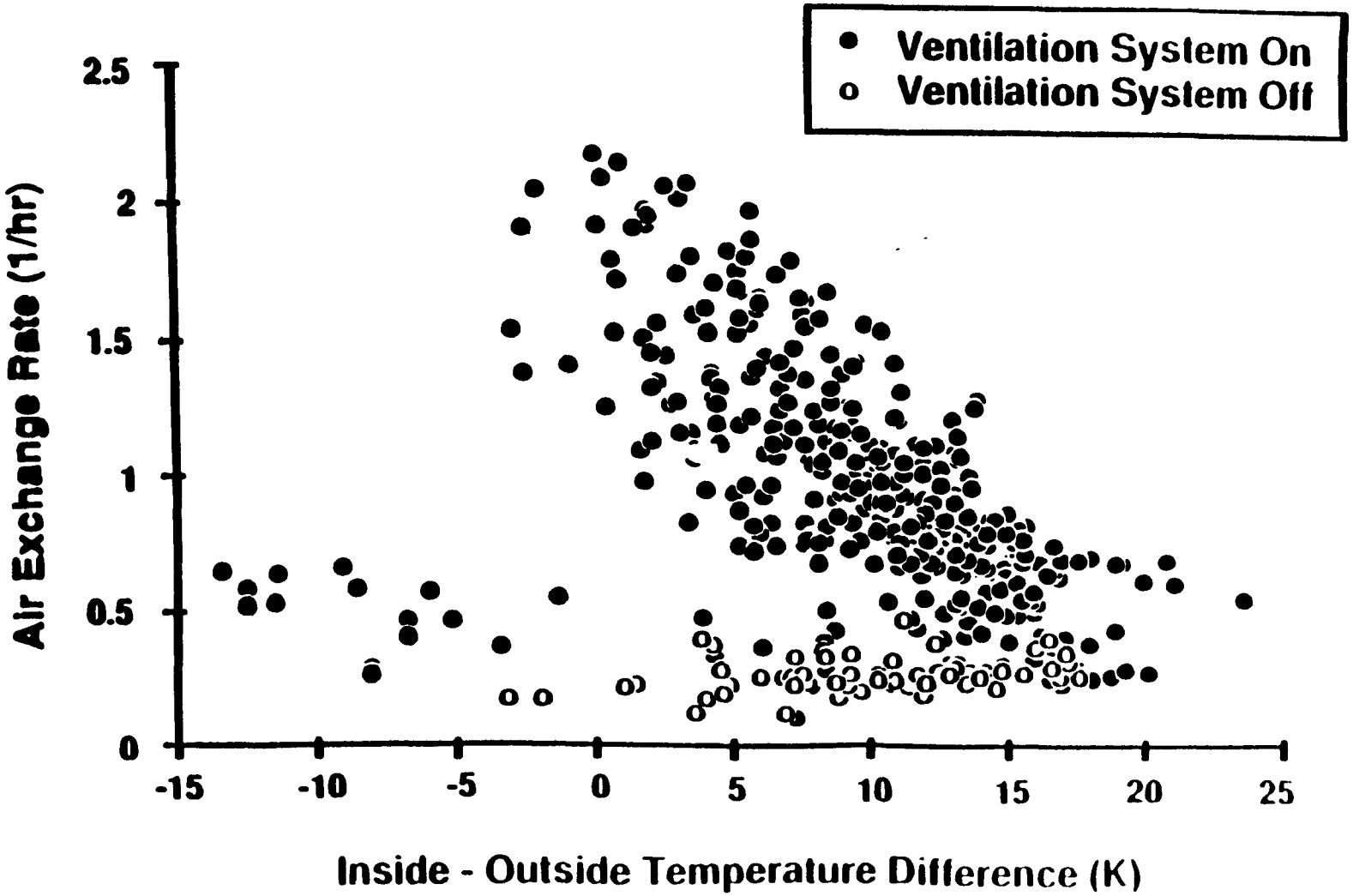


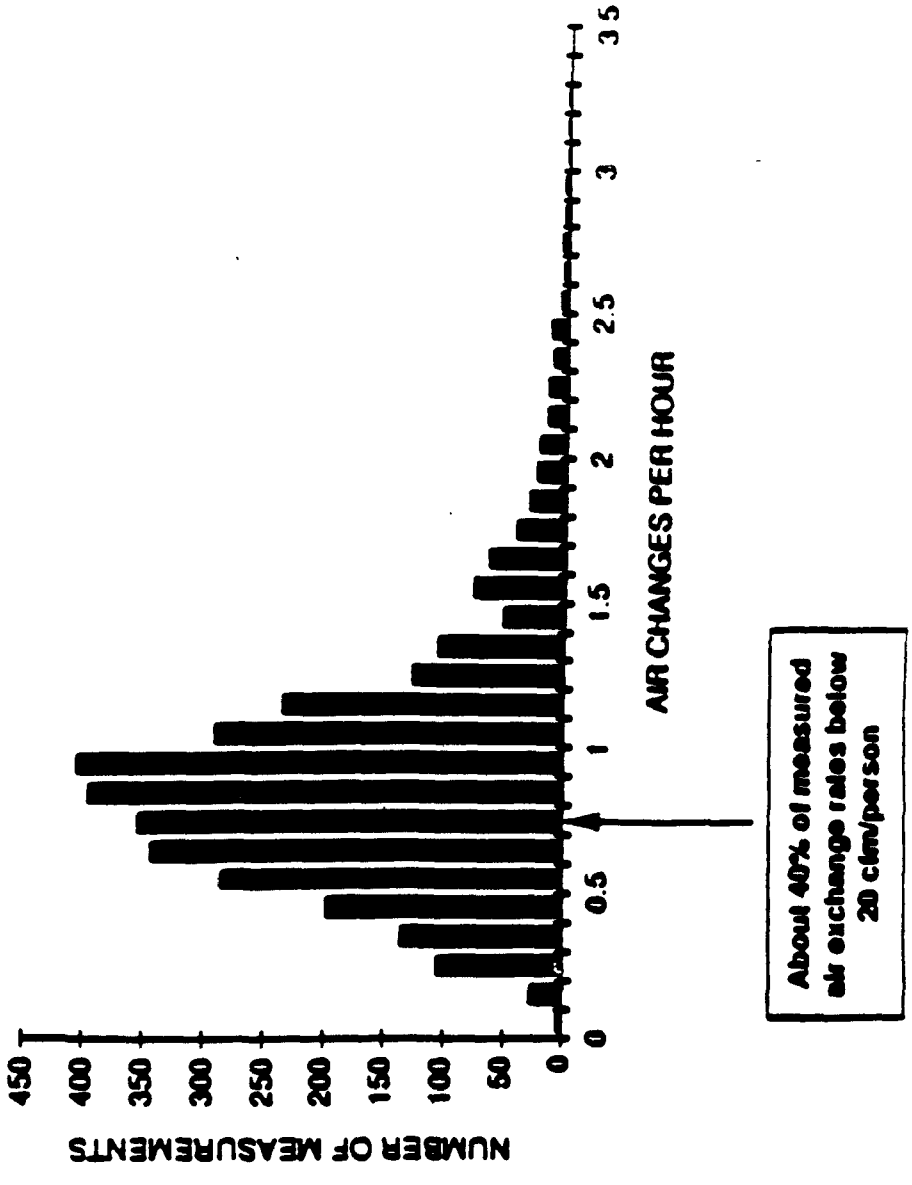
FIGURE 3-11

SUMMARY OF AIR EXCHANGE RATES
IN BUILDINGS STUDIES BY NIST

	DESIGN (ach)		MEASURED		
Building	Supply Air Capacity	Minimum Outdoor Air	Average ACH	% <20 cfm	%<Design Minimum
A	•	•	1.73	0%	•
B	•	•	0.97	27%	•
C	1.7	1.70	0.90	82%	100%
D	4.3	0.72	0.99	23%	23%
E	4.3	0.72	0.80	49%	49%
F	•	•	1.15	24%	•
G	•	•	0.89	25%	•
H	3.1	0.77	0.78	64%	37%
I	•	•	0.75	59%	•
J	3.1	0.67	0.29	98%	100%
K	5.5	0.90	0.54	81%	81%
L	3.8	0.36	0.73	60%	5%
M	2.4	0.53	1.19	39%	30%
N	2.8	0.36	0.99	30%	16%
		ALL DATA	0.94	49%	43%

FIGURE 3-12

DISTRIBUTION-OF AIR EXCHANGE RATES
IN BUILDINGS STUDIED BY NIST



- Control system

  - Is the control system operating?
  - Is the control system sensor calibrated and operating?

It is clear that one cannot assume that a building is being ventilated or can be ventilated at a stated rate. This is an even less valid assumption early in the life of the building.

3.6.7.3. *Effects of Ventilation Rates on Indoor Air Concentrations of 4-Phenylcyclohexene from Carpet Emissions (B. Tichenor, EPA, April 9, 1991)*

The effects of ventilation rates and conditioning times on indoor concentrations of 4-phenylcyclohexene emitted from carpets were studied assuming first-order emission rate decay:

$$EF = EF_0(e^{-kt}).$$

From curves based on the EPA study of Waterside Mall carpet (B. Tichenor, August 25, 1988):

$$EF_0 = 0.15 \text{ mg/m}^2 \text{ hr}$$
$$k = 0.0036 \text{ hr}^{-1}$$

From the AQS study of 19 carpet samples:

$$EF_0 = 0.03\text{-}0.20 \text{ mg/m}^2 \text{ hr}$$
$$k = 0.0034\text{-}0.018 \text{ hr}^{-1}$$

The effect of air exchange rate (outside air) on 4-phenylcyclohexene concentration over time is shown in Figure 3-13. The effect of conditioning times or airing out prior to installation is shown in Figure 3-14. ACH was held constant at 1.0. The preliminary conclusions derived from the study, which is contained in Appendix R, are:

- Increasing the air exchange rate (outside air) will reduce the indoor levels of 4-phenylcyclohexene from carpets.

- Airing out new carpet prior to installation will reduce indoor levels of 4-phenylcyclohexene.

FIGURE 3-13

EFFECT OF AIR EXCHANGE RATE (Outside Air)

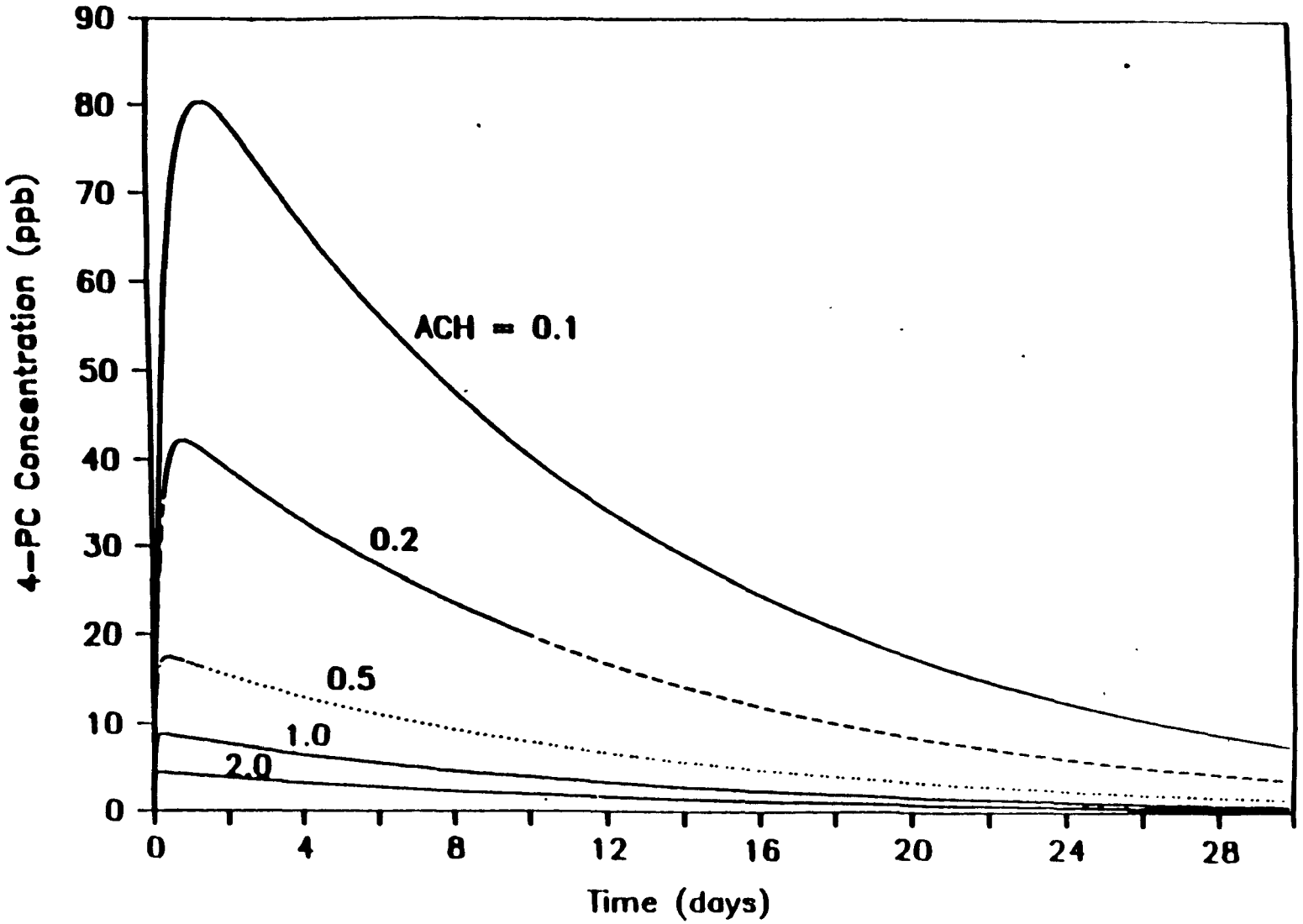
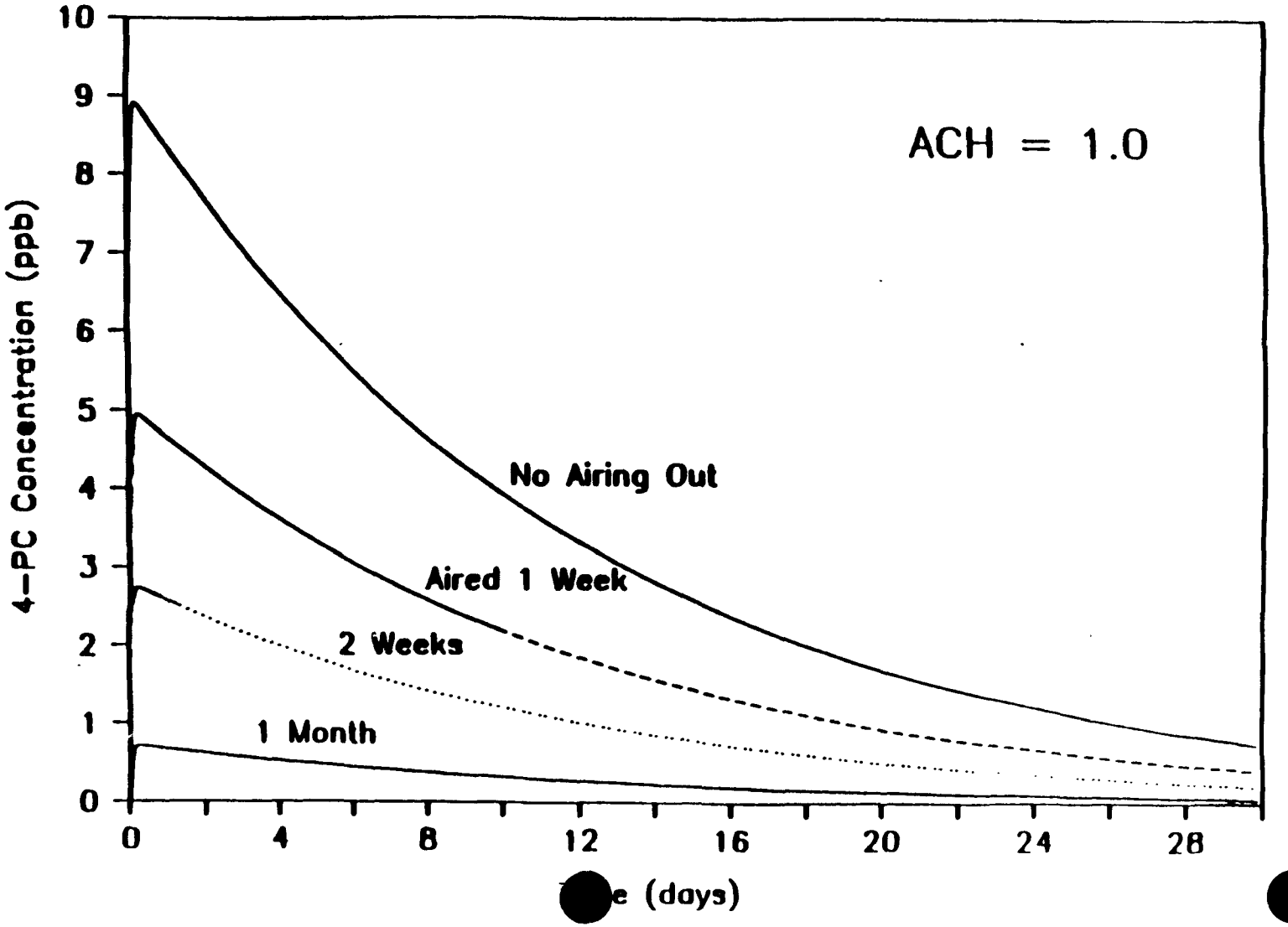


FIGURE 3-14

EFFECT OF AIRING OUT PRIOR TO INSTALLATION



3.6.7.4. General Concepts of Physical Processes Affecting VOC Carpet Emissions (J. Girman, EPA, April 9, 1991)

There are a number of physical processes involved when VOCs are emitted from carpet assemblies as well as factors affecting these processes. These processes include:

- Diffusion - movement of matter in the absence of bulk flow. Diffusion is a weak function of temperature and is also dependent on:

  - Concentration difference between the carpet system and the indoor air
  - Distance over which diffusion occurs; and
  - Chemical characteristics of the contaminant such as molecular size.

- Evaporation - driving force is vapor pressure. Figure 3-15 shows the significant relationship between temperature and vapor pressure for selected compounds. Figures 3-16 and 3-17 portray evaporation under equilibrium conditions and accelerated evaporation in the process of increased contact air velocity, respectively.

- Adsorption - carpet will sorb materials other than those inherent in the carpet manufacturing process (e.g., paint). For this reason, the location of carpet storage is extremely important.

3.6.7.5. Practical Control Strategies for Carpet System VOC Emissions and Residual Indoor Air Concentrations (H. Levin, ASTM Subcommittee D22.05 on Indoor Air, April 9, 1991)

It is clear that ventilation can have a major role in efforts to minimize VOC emissions from carpet systems in new construction and renovation projects. Practical control strategies include:

- Careful product selection based on knowledge of product performance;
- Product modification;
- Pretreatment prior to installation;
- Changes in installation procedures;
- Changes in ventilation system operating procedures;
- Treatment in situ through the bake out process; and
- Use of air cleaning techniques to control air contaminants.

FIGURE 3-15

TEMPERATURE AND VAPOR PRESSURE RELATIONSHIP FOR THREE COMPOUNDS

Vapor Pressure (torr)

	Ethanol	Water	Toluene
20°C	43.9	17.5	22.3
40°C	135.3	55.3	59.1
$\frac{40°C}{20°C}$	3.08	3.16	2.65

FIGURE 3-16

EVAPORATION UNDER EQUILIBRIUM CONDITIONS

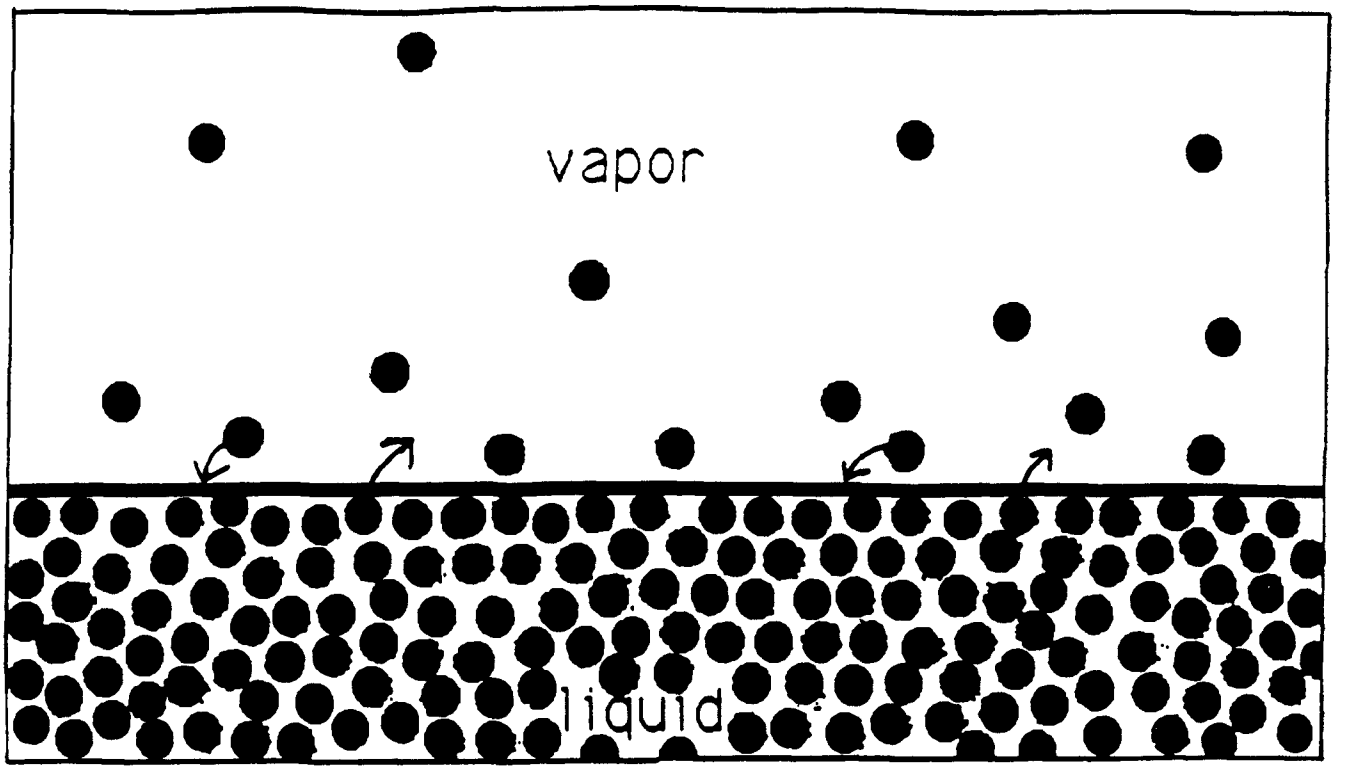
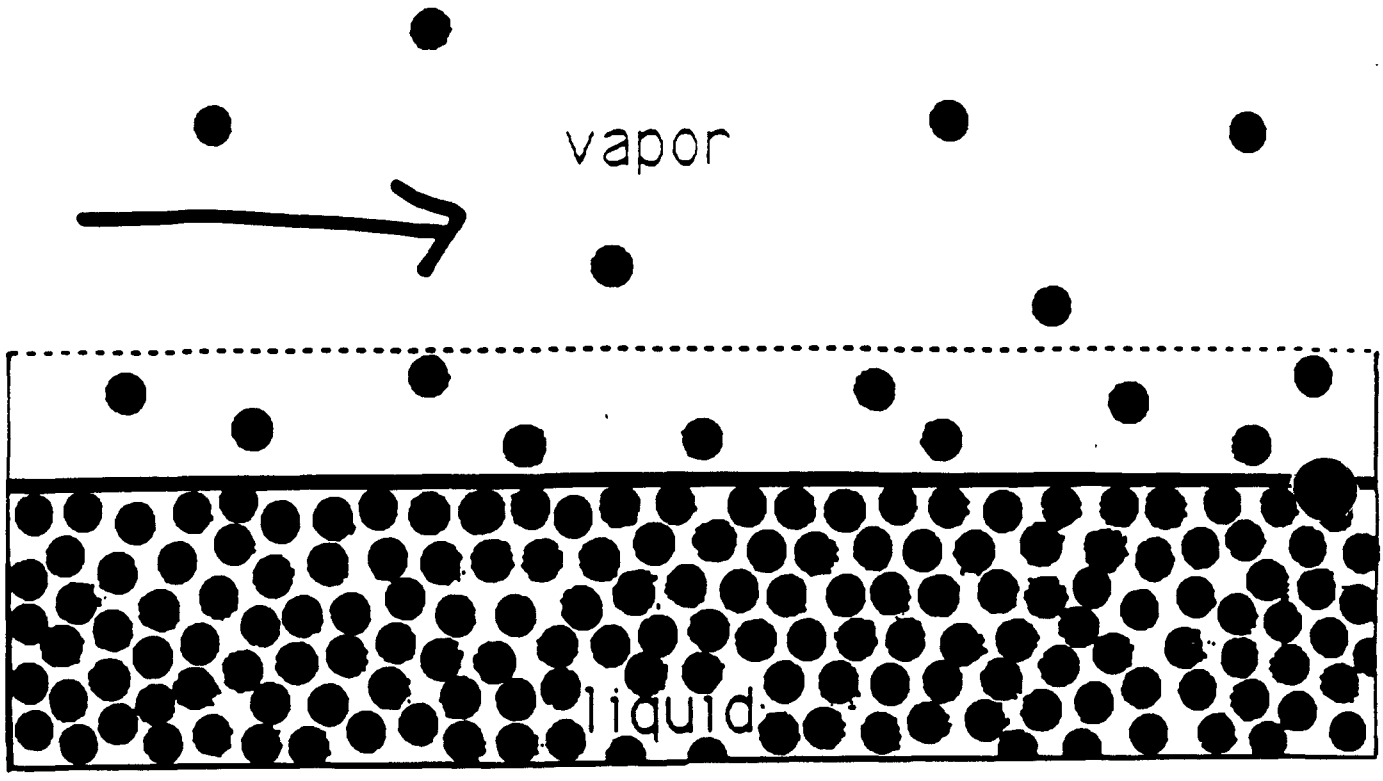


FIGURE 3-17

ACCELERATED EVAPORATION IN THE PRESENCE
OF INCREASED
CONTACT AIR VELOCITY



Adequate ventilation before, during, and after installation of carpet system will mitigate TVOC emissions.

3.6.8 Process Engineering Subgroup Proceedings

Several presentations were given to the Process Engineering Subgroup on carpet installation and the effects of ventilation on VOC emission during carpet installation process.

At the September 26, 1990, Subgroup meeting, The Floor Covering Installation Contractors Association (FCICA) presented some information on installation methods, installation parameters, and installation guidelines.

At the April 8, 1991, meeting, several presentations on the effects of ventilation on VOC emissions during carpet installations were given to the Subgroup. Hal Levin representing ASTM presented information on the relationship between building ventilation rates and indoor air VOC concentrations and discussed practical control strategies for controlling carpet system VOC emissions. Andy Persily of NIST reported the results of an NIST study comparing actual versus design ventilation rates in selected Federal Office Buildings. Bruce Tichenor and John Girman of EPA presented information on the effects of ventilation and conditioning times on indoor concentrations of 4-phenylcyclohexene and general concepts of physical processes affecting VOC carpet emissions. In general, the presenters indicated that ventilation can have a major role in efforts to minimize VOC emissions from carpet systems.

It was recommended that the Carpet and Rug Institute (CRI) and FCICA should expand their efforts to educate carpet installers through FCICA's ten-point education program. It was also recommended that the CRI/FCICA should encourage all carpet outlet/retail store owners to use installers who have been through FCICA's installation program and communicate to all their installers about the importance of proper installation procedures and encourage them to adhere to CRI installation guidelines.

The Subgroup considered a recommendation to obtain commitment from CRI and FCICA to develop a program to educate customers about the recommended installation guidelines and potential impacts of installers not abiding by them. Additionally, the Subgroup considered a recommendation to obtain commitment from CRI and FCICA to develop standard contract/bid conditions which will provide for additional money or time to allow installers to comply with installation guidelines if architects, engineers, or owners do not provide appropriate circumstances for compliance.

The Subgroup considered an evaluation of the quantitative impacts of not following specific installation procedures on carpet system TVOC exposures as an information suggestion for future consideration by the Plenary.

The information/research considerations and Subgroup recommendations are cited in detail in sections 3.6.9 and 3.6.10 of this document.

3.6.9. Research Consideration

The following idea was raised by some members of the Subgroup considering information that may help in identifying control measures to reduce TVOC. This suggestion does not necessarily represent the consensus of the Subgroup. It is presented as a suggestion for future consideration of EPA or industry.

1. An evaluation of the quantitative impacts of various installation procedures on carpet system TVOC exposures.

3.6.10. Subgroup Recommendations to Plenary

1. The Plenary should make a recommendation to the Agency to encourage CRI and FCICA to study the impact of various installation procedures on carpet system TVOC exposures, with the results to be shared with EPA.

2. The Plenary should make a recommendation to the Agency to consider obtaining a commitment from CRI and FCICA to further develop industry-wide communications programs which educate installers about the importance of proper installation procedures and encourage them to adhere to CRI installation guidelines. These programs should also target as many installation contractors as possible.

3. The Plenary should make a recommendation to the Agency to consider obtaining a commitment from CRI and FCICA to develop a program to encourage that all carpet outlet/retail store owners require their installers to be certified.

4. The Plenary should make a recommendation to the Agency to consider obtaining a commitment from CRI and FCICA to develop a program to educate customers about the recommended guidelines and the potential impacts of installers not abiding by them.

5. The Plenary should make a recommendation to the Agency to consider obtaining a commitment from CRI and FCICA to develop standard contract/bid conditions which will provide for additional money or time to allow installers to comply with installation guidelines if architects, engineers, or owners do not provide appropriate circumstances for compliance.

6. The Plenary should encourage NIOSH to become involved in carpet installation worker training programs sponsored by CRI and FCICA.

7. The Plenary should encourage OSHA to review CRI carpet installation guidelines for consistency with ongoing OSHA programs.

CHAPTER 4

Public Communications Subgroup: Report to the Carpet Policy Dialogue

4.0. PUBLIC COMMUNICATIONS SUBGROUP REPORT

4.1. INTRODUCTION

This chapter provides an overview of the Public Communications Subgroup activities in response to the Federal Register notices (55 FR 17404; 55 FR 31640) about the Carpet Policy Dialogue and the objectives set by the Carpet Policy Dialogue Plenary. It describes the topics discussed, concerns addressed, and products developed by the Subgroup.

The Public Communications Subgroup was established at the request of the Carpet Policy Dialogue Plenary on January 8, 1991. The purpose of the Subgroup was to serve as the common voice for the Carpet Policy Dialogue. The Public Communications Subgroup made recommendations to the Carpet Policy Dialogue Plenary on the type of information to be communicated to the public. It also identified strategies and mechanisms by which such information could be assembled and disseminated. The Subgroup's activity was focused on communicating outside the Dialogue.

The Subgroup provided a forum for discussion and resolution of general and specific issues of concern to the public communications effort. It offered opportunity for review and incorporation of comments on various products prepared on behalf of the Carpet Policy Dialogue. General activities of the Subgroup included administration of Carpet Policy Dialogue Plenary reports, message development, and conveyance strategy. Another function of the Subgroup was drafting, assembly, and review of products, materials, and information presented to and discussed by Dialogue participants. The Subgroup provided a means to bring consistency to the reporting of the wide spectrum of materials developed during the Carpet Policy Dialogue year.

The Subgroup included standing representation from EPA, other Government agencies, labor, industry, and public interest groups. In addition, the Subgroup sought assistance, as needed, from ad hoc consultants with special expertise in communications. The composition of the Subgroup included expertise in public communications, communications strategy, public education, environmental protection, consumer product safety, indoor air quality, carpet and carpet floor covering product manufacture, carpet installation, and carpet product testing. Members of the Public Communications Subgroup are listed in Appendix A.

The Subgroup held six meetings. The themes of these meetings were:

Meeting #1	2/27/91	Introduction and Overview
Meeting #2	4/8/91	Message Development
Meeting #3	5/21/91	Implementing Outreach Communications
Meeting #4	6/27/91	Proposed Brochure Development

Meeting #5	7/30/91	Compendium Report Assembly
Meeting #6	9/26/91	Compendium Report Review

4.2. SCOPE OF WORK

During the initial meetings, the Public Communications Subgroup set goals, established operating procedures, developed criteria that would govern the nature of materials developed during the Dialogue year, and identified discussion topics for consideration during their deliberations. These discussions determined the scope of work and breadth of the public communications activities for the Subgroup.

4.2.1. Setting Goals

The Subgroup identified two goals. The first goal was to satisfy the requirements of the Federal Register notices (55 FR 17404; 55 FR 31640). However, in referring to the Federal Register, the Subgroup noted that the only requirement stated was for the Dialogue to provide the interested public with comparative information on TVOC emissions based on information developed from voluntary product testing program(s). One option for communicating such information included the use of product labeling. The Federal Register provided no further direction to the Subgroup about the extent of public communications activities for the Carpet Policy Dialogue.

The Subgroup acknowledged that it would be difficult to follow the requirement set by the Federal Register due to the lack of available information about TVOC emissions for carpet floor covering products. It was apparent to the Subgroup that only preliminary data about TVOC emissions from carpet floor covering materials might be available before the conclusion of the Dialogue year. The Subgroup concluded that it was not prudent to communicate such information as it could convey a false message or be misinterpreted. In view of this dilemma, the Subgroup adopted the approach that the interested public be provided with useful information about the Carpet Policy Dialogue, accomplishments that occurred during the Dialogue year, and a description of follow-on activities.

The second goal set by the Subgroup was to review and recommend for approval by the Carpet Policy Dialogue Plenary communication materials prepared by the Subgroup during the Dialogue year. In relation to these goals the Subgroup identified a series of communication products that could be developed to convey information to the interested public. These included: 1) an interim progress report to the EPA, 2) an executive summary suitable for release to the interested press, 3) a public information brochure or leaflet, and 4) a compendium report summarizing information from the Carpet Policy Dialogue.

4.2.2. Operating Procedures

The development of draft communication materials was a collaborative effort among Subgroup participants. Finalizing communication products was an interactive process shared between the Public Communications Subgroup with the Carpet Policy Dialogue Plenary. EPA staff coordinated these activities.

As the Subgroup identified the need for a communication product, Dialogue participants forwarded their initial thoughts to EPA staff who were responsible for compiling these draft materials and assembling them in a logical flow. Wherever possible, draft materials underwent a review cycle prior to discussion at scheduled meetings. Comments received from these reviews were given consideration and incorporated into subsequent drafts. Draft documents were further embellished during discussions at Subgroup meetings. Documents endorsed by the Subgroup were forwarded to the Plenary for approval. Text revisions developed during discussions at Plenary meetings were an essential component in establishing consensus agreement for the public communications products developed during the Dialogue year.

4.2.3. Principles Governing Dialogue Communication Activities

The Subgroup established principles to guide the development of Subgroup products. Recognizing that most of the information developed during the Dialogue year would be of a technical scientific nature, the Subgroup sought to include lay language that was understandable to the general public wherever possible. Furthermore, the Subgroup accepted the responsibility that clear reporting was needed to explain that the purpose of the Carpet Policy Dialogue was to reduce exposure to volatile organic compounds, encourage pollution prevention, develop a standard analytical test method, and encourage industry to test and report TVOC measurements for carpet floor covering products. It was equally important to communicate that the mission of the Carpet Policy Dialogue did not include an evaluation of health concerns or fostering a correlation between TVOC measurements with potential impact on public health.

Another governing principle adopted by the Subgroup was that reports and other materials developed for the Carpet Policy Dialogue should focus on facts. The Subgroup agreed that it was appropriate for these reports to identify information gaps since, in many instances, Dialogue discussions addressed the frontier of analytical science. In conjunction with this, the Subgroup acknowledged its responsibility that new concepts such as TVOC should be fully explained and that there was a need to communicate the scientific rationale for the use of TVOC measurements of consumer products in relation to indoor air quality and consumer choice.

The Subgroup also developed guiding principles about the content and use of public communication materials developed during the Dialogue year. The Subgroup expressed the

desire that information about the Carpet Policy Dialogue should reflect the positive aspects of a diverse group of concerned organizations that collaborated in a voluntary framework. As such, the focus of public communications products would be on the many accomplishments of the Carpet Policy Dialogue rather than a critique of the process. The Subgroup understood the value in selecting appropriate wording to convey messages that would be clear and specific. Furthermore, the Subgroup accepted the principle that preliminary data submitted in confidence to the Carpet Policy Dialogue for deliberative discussions and draft materials of reports and other document materials would not be released for public distribution prior to the approval of the Carpet Policy Dialogue Plenary.

Finally, the Subgroup accepted the principle that participation in the Carpet Policy Dialogue, Public Communications Subgroup would not preclude any group or organization (governmental and nongovernmental) from activities which they deemed necessary and important to carry out their organization's mission to communicate with their constituency or the interested public. The Subgroup viewed the products to be developed for the Carpet Policy Dialogue as a resource to assist other organizations in developing factual information about the topics addressed during the Dialogue year.

4.2.4. Discussion Topics

As part of the scoping activities that took place during the initial Public Communications Subgroup meetings, the Subgroup referred to materials prepared by the Plenary during the convening meeting for the Carpet Policy Dialogue on August 21, 1990. This consisted of a list of questions and discussion topics prepared by the Plenary for the Public Communications Subgroup to consider in addressing its mission. The list included general questions such as: what would be the best forum/form to communicate information; how could information be communicated in a positive fashion; what is the public's need for information about TVOCs; what communication channels already exist to disseminate information; and what are the economic considerations related to communicating. Other topics included scientific and technical issues such as: what is a VOC; what is the relevance of VOC measurements; what is the role of odor and irritation; and what is the relevance of ongoing research. The handout used by the Subgroup for this discussion is included as Table 4.1.

The Subgroup reviewed items on this list and observed that many of the questions and topics were relevant to the charge set in the Federal Register. They noted that the items listed could be used to spur discussion at future meetings and guide in the preparation of the various communications products developed during the Dialogue year.

TABLE 4-1

TENTATIVE LIST OF DISCUSSION TOPICS FOR THE PUBLIC COMMUNICATIONS SUBGROUP [1]

- What information to convey?
- Message options: brochure/booklet/label/ad campaign/nothing
- What do the numbers mean?
- What is the impact of environmental factors on VOC emissions (like ventilation)?
- Identify the target audience(s).
- What is the impact of installation technology?
- What are the cost impacts?
- What is the best forum/form to communicate this information?
- Why has research been done?
- How to communicate in a positive, nonprejudicial fashion?
- What about aesthetic factors?
- How/where to get more information?
- Should there be an overall strategy for TVOC communication?
- What is the nature of VOCs - What is a VOC?
- Why do people need to know about VOCs?
- Look to other communication models that provide the public with information (e.g., fuel efficiency, construction industry).
- Relate this information to something the public knows about.
- List constituents in products.
- Identify current information and communications materials already available (e.g., advertising).

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[1] This material was prepared for discussion by the Public Communications Subgroup at a meeting held on February 27, 1991. It was developed from a list which was compiled by the Carpet Policy Dialogue Plenary on August 21, 1990.

4.3. COMMUNICATIONS PLANNING

Preparing a communication plan is a multifaceted process. The Public Communications Subgroup identified 10 steps common to developing any communications plan and addressed these steps in identifying a communications strategy for the Carpet Policy Dialogue. These steps are depicted in Figure 4.1. The following discussion highlights the deliberative considerations of the Public Communications Subgroup relevant to the communications planning process.

4.3.1. Step 1: Situation Analysis

The Subgroup identified several factors that would influence the distinctive characteristics and shape of the Carpet Policy Dialogue communications effort. These included: a) the sparsity of available information about TVOC emissions from carpet and carpet floor covering products; b) the nature of a voluntary communications effort; and c) the ability of the general public to grasp scientific concepts about TVOCs.

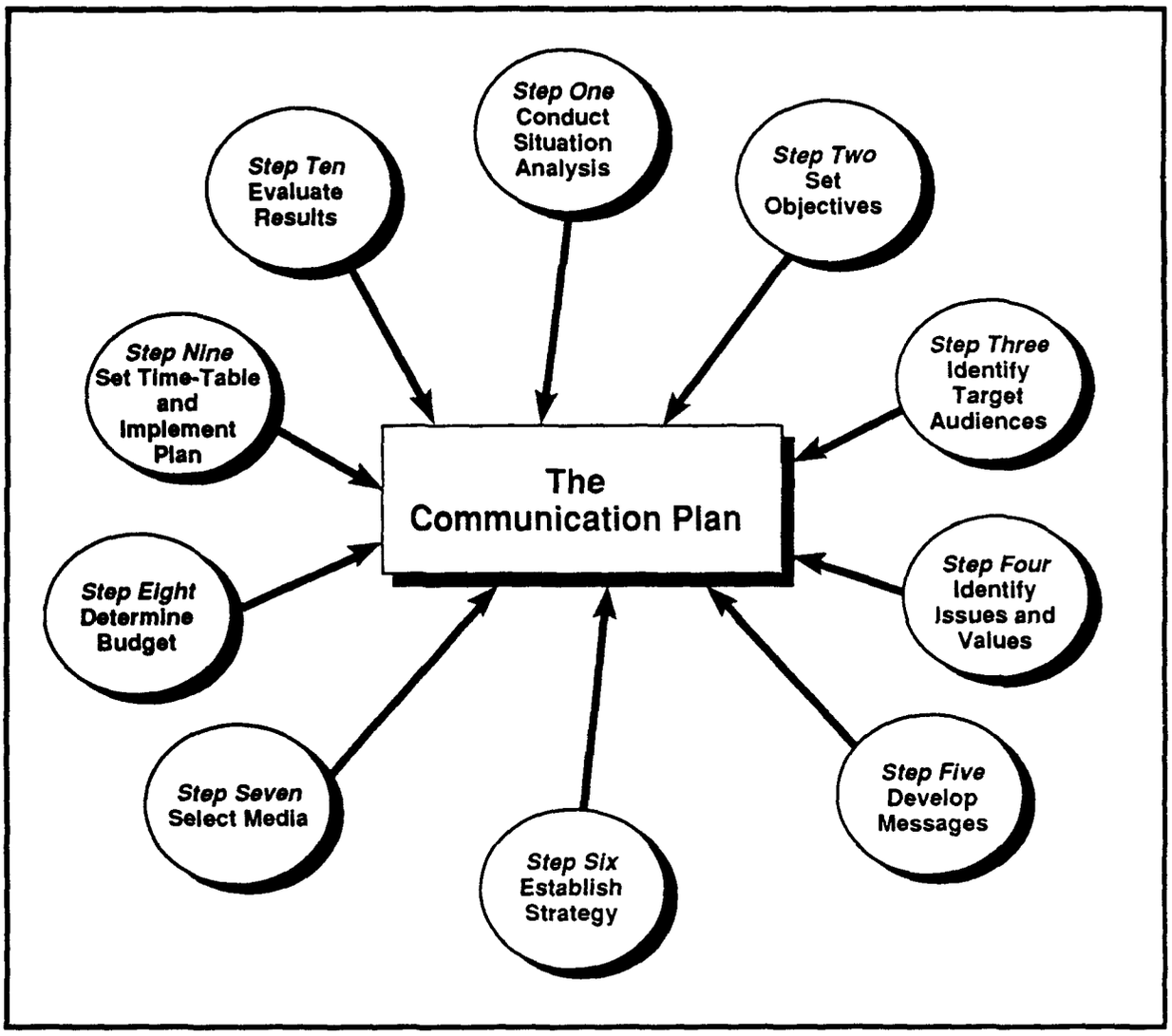
As noted previously, the Subgroup acknowledged that data about TVOC emissions from the voluntary product testing programs would not be available before the close of Carpet Policy Dialogue activities. The Subgroup viewed that preliminary data would not have sufficient merit to fill in this information gap. Therefore, development of public information messages would, of necessity, be focused on the findings and outcomes from the Product Testing and Process Engineering Subgroups.

The cost associated with development and distribution of communication products are always a limiting determinant in measuring the extent of a communications plan. This is most apparent in voluntary efforts. The Subgroup agreed to identify opportunities that encouraged voluntary involvement among Dialogue participants. In doing so, the Subgroup attempted to provide useful information developed from the Carpet Policy Dialogue to a wide variety of audiences.

There was some concern expressed among the Subgroup that the general public would have difficulty understanding the concept of, or information about TVOCs. It was determined that a better understanding about volatile chemicals might be communicated if an analogy was made with the concept of off-gassing. The point was made that even the term "volatile organic compound" carried with it an explosive connotation which could cause needless alarm in the minds of the uninformed public.

Figure 4-1

Communications Planning Process



4.3.2. Step 2: Set Objectives

The objectives set by the Subgroup paralleled the governing principles for communicating to the public. The Subgroup proposed that it communicate to the public:

- A summary of the accomplishments of the Carpet Policy Dialogue;
- An explanation of why the Carpet Policy Dialogue undertook its work;
- Facts about carpet, carpet floor covering products, and VOC emissions;
- A context for these facts and explanation without interpretation; and
- How this information was relevant to and could be used by the interested public.

4.3.3. Step 3: Identify Target Audiences

It was difficult for the Subgroup to set boundaries for the target audiences that could benefit from information developed during the Dialogue year. For example, it was clear that the consumer of carpet floor covering products would include residential and commercial consumers, and that professionals such as architects and interior designers should also be viewed as consumers. Employees of manufacturers, retailers, and installers were included in another category of individuals who could benefit from information. Still another category included health care professionals and regulatory scientists. Finally, the Subgroup also included people who inadvertently find themselves in carpeted areas. In conclusion, the Subgroup identified the target audience to include:

- The consumer of carpet floor covering for personal use;
- The consultant who recommends selection of carpet floor covering to the consumer;
- People who occupy carpeted spaces;
- People who advise the public relevant to carpet floor covering; and
- People involved in the carpet floor covering trade.

The Subgroup recognized that the technical expertise to communicate with such a diverse audience resided within various Government, trade, and public interest organizations. Furthermore, any effort to reach such a broad spectrum target audience would require a variety of communication products specifically focused to the training and interests of the audience to be addressed.

4.3.4. Step 4: Identify Issues and Concerns

The Subgroup acknowledged that although health concerns would be among the subjects that would occupy public interest, the Federal Register specifically noted that the Dialogue should "not further characterize the health effects of chemicals emitted from carpeting." The Subgroup did recognize that a public communication message which did not include factual information about the diversity of opinion on this subject would not be acceptable at this time. The Subgroup addressed these concerns from the viewpoint of improvements to indoor air quality, adequate ventilation, and public lifestyle choice, with the understanding that an educated consumer would have a better opportunity to make an informed choice.

4.3.5. Step 5: Develop Messages

Developing messages to inform the interested public about the Carpet Policy Dialogue was a collaborative effort. The governing principle for this activity was to focus on accomplishments. These were listed and incorporated into an Executive Summary. To develop a common message about the findings of the Carpet Policy Dialogue, the Subgroup took a broader view which included information about indoor air quality, carpet chemical emissions, actions that could minimize exposure following installation of new carpet floor covering, and identification of information resources. The Subgroup also acknowledged the importance of developing messages that told the interested public about the variety of voluntary product testing programs that would be set in place during the Dialogue year.

4.3.6. Step 6: Establish Strategy

The dynamic nature of the Carpet Policy Dialogue, the multitude of ongoing activities, and the special interests brought into play necessitated that communications products be multi-tiered and developed by a variety of mechanisms. The Subgroup acknowledged that communication products would include materials developed directly by the Subgroup, collaborative efforts of the Public Communications Subgroup in partnership with participating organizations at the Dialogue, or as separate communications efforts within Government, industry, and/or the public sector. The prime strategy adapted by the Subgroup was to develop factual information that could be used as a source reference describing the Carpet Policy Dialogue.

4.3.7. Step 7: Select Media/Products

The written word became the media of choice for the Carpet Policy Dialogue. As noted previously, four products were identified. These included: an Interim Progress Report, an Executive Summary, a public information brochure, and a compendium report.

4.3.8. Step 8: Determine Budget

Resource issues were considered within the voluntary framework of the Carpet Policy Dialogue. The Subgroup made every effort to prioritize activities and products on the basis of how well they would fit into a voluntary process. Primary consideration was given to the development of products such as the Compendium Report which could be distributed via the EPA TSCA Hotline and the National Technical Information Service. The Public Information Brochure was developed with the thought that it could be easily reproduced by the interested public. Some industry representatives implied that limited resources might be available to distribute the brochure to carpet retailers. The Subgroup concluded that in the end, distribution of these products would be via standard mechanisms traditionally used by Government, industry, and the public sector. Much of this would be dictated by the most expeditious and cost efficient means for distributing the materials and the nature of voluntary commitments.

4.3.9. Step 9: Set Time Table to Implement Plan

It became evident early in the public communications effort that there was an immediate need for the Carpet Policy Dialogue to communicate about the nature of its activities. This immediate need was met with the completion of the Interim Progress Report in April. The time table for developing other Dialogue products was determined by the schedule set by the Federal Register. The EPA provided resources and staff to finalize Dialogue products after the September 27, 1991, meeting. A notice of availability of the Compendium Report and the Public Information Brochure in the Federal Register marked the conclusion of this activity.

4.3.10. Step 10: Evaluate Results

The Subgroup acknowledged that a communications effort, by necessity, is an evolving process which can not always be confined to time constraints such as the Dialogue year. An effective public communications effort on a subject such as this requires assessment and reevaluation on an ongoing basis. Since the Public Communications Subgroup would be discharged of their duties at the conclusion of the Dialogue, no provision was made for follow-on activities by the Carpet Policy Dialogue. The Subgroup concluded that communication activities would include reporting information developed during the

Dialogue year only. The Public Communications Subgroup recommended to the Plenary that the EPA review the need for providing the interested public with additional information after it has had an opportunity to review data developed from the various testing programs.

4.4. PUBLIC COMMUNICATION OUTREACH PRODUCTS

Communication outreach products developed by the Subgroup were the result of cooperative efforts on the part of all participants. A list of potential products was developed during the initial meeting of the Subgroup (Table 4.2). The feasibility of developing various communications products was evaluated, and the list was prioritized.

The Subgroup learned by experience. As work commenced on the initial communications outreach products, the Subgroup identified additional opportunities for communicating. The shape of some communication outreach products evolved as materials were developed by the Subgroup. Preliminary draft documents initially conceived as fact sheets, became resource models to guide other organizations. These products gradually developed into a final format as an executive summary or a public information brochure.

Relations with the press were governed by the principles established by the Carpet Policy Dialogue Plenary at the convening meeting held on August 21, 1991. As such, the Subgroup chose not to prepare press announcements. The Subgroup acknowledged that summary materials (i.e., Executive Summary) would be useful to those individuals and organizations who bore the responsibility of communicating with the interested public. Announcements in the Federal Register, prepared by the project sponsor (EPA), which marked Carpet Policy Dialogue accomplishments were deemed appropriate.

The Subgroup determined that involvement in the preparation of a summary booklet(s) about the voluntary industry testing programs set in place during the Carpet Policy Dialogue year would not be an appropriate activity to pursue. Since the focus of such materials would be the carpet trade, the Subgroup recognized that such products would be better left to the various industries and representative organizations. Such organizations have full access to their membership and have existing mechanisms to communicate with their constituency via trade press and newsletters.

The Subgroup and the Carpet Policy Dialogue explored the feasibility of developing an annotated bibliography on the subjects of carpet and carpet floor covering products, indoor air quality, and related concerns about volatile organic compound emissions from carpet floor covering materials, and carpet floor covering product VOC emissions testing. While steps were initiated to compile such a bibliography, the Dialogue found itself ill prepared to complete this activity by the close of the Dialogue year. Nevertheless, the Dialogue Group agreed that such a bibliography would prove a useful resource for the interested public. At a meeting held on September 27, 1991, the Dialogue recommended that EPA continue this

TABLE 4-2

POTENTIAL PUBLIC COMMUNICATIONS OUTREACH PRODUCTS[1]

- Interim reports and/or memoranda to the project sponsor (EPA) that mark Carpet Policy Dialogue progress in accomplishing the objectives described in the Federal Register;
- A compendium of information received during the Dialogue year with explanation of findings, conclusions, and recommendations;
- An Executive Summary of the compendium information written in layman language for the general public;
- Summary booklet(s) focused to the carpet trade describing the voluntary industry testing programs set in place during the Carpet Policy Dialogue year;
- Public booklet/guide/brochure to provide interested consumers with information on VOC emissions and carpet products, indoor air quality, and information about carpet installation; and
- A series of press releases to mark Dialogue year milestones and highlight the various voluntary actions proposed by industry.

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[1] This table was developed from materials prepared for discussion by the Public Communications Subgroup at a meeting held on February 27, 1991.

activity and use the draft materials developed by project staff as the basis for such a bibliographic listing. They further suggested that this information could be made available from the Carpet Emissions Administrative Record and/or the proposed indoor air clearinghouse.

All products developed by the Subgroup were reviewed and approved for distribution by the Carpet Policy Dialogue Plenary. There were four outreach products developed by the Public Communications Subgroup. These included an interim progress report, an executive summary of Carpet Policy Dialogue accomplishments, a public information brochure, and a compendium of the Carpet Policy Dialogue. What follows is a description of these products which includes explanation of the considerations and deliberative actions by the Subgroup.

4.4.1. Interim Progress Report

At a meeting held on February 27, 1991, the Subgroup agreed to prepare an Interim Progress Report. In doing so, the Public Communications Subgroup acknowledged that it was timely for the Carpet Policy Dialogue to inform the interested public about the initial accomplishments taking place at the Carpet Policy Dialogue. Preparation of this report would also provide an opportunity to begin drafting materials that could be inserted into the Compendium Report at the conclusion of the Dialogue year. Furthermore, the Subgroup determined that the Interim Progress Report would serve to communicate to the project sponsor (EPA) on the progress achieved by the Carpet Policy Dialogue midway through the Dialogue year and also inform the interested public and various media about the activities of the Carpet Policy Dialogue.

The Subgroup provided guidance to the project staff in preparing the initial draft of the report. The outline of the report was to include introductory materials describing the background, implementation, structural organization, and working mechanisms of the Carpet Policy Dialogue. It would also include a description of the accomplishments to date and an overview of the activities of the Subgroups.

Participants of the Public Communications Subgroup were asked to provide project staff with a list of accomplishments and materials which they thought should be included in the Interim Progress Report. These materials were incorporated into a draft document and made available to the Subgroup for discussions at the April meeting. Comments and revisions made by the Subgroup were incorporated into a revised draft which was reviewed at the Carpet Policy Dialogue Plenary meeting on April 11, 1991.

It was necessary for project staff to request that a cut-off date be established for the inclusion of Dialogue accomplishments in the Interim Progress Report because activities of the Carpet Policy Dialogue were moving at such a rapid pace. The Plenary concurred that this was necessary in order to expedite this communications product. Therefore, it was

determined that the report would be inclusive of the activities that took place between August 21, 1990, and April 10, 1991.

Comments and revisions made at the April Carpet Policy Dialogue Plenary meeting were incorporated into a revised draft. Additional comments and revisions were made to the document at the May meetings. The Interim Progress Report was approved by the Carpet Policy Dialogue Plenary at the June meeting. The final document was ready for distribution in July and the report was transmitted to the EPA. Availability of the report was announced in the Federal Register on August 9, 1991 (FR 56 37912).

4.4.2. Executive Summary

Following the initial review of the Interim Progress Report, the Subgroup identified the need for a general summary about the work of the Dialogue. The goal set by the Subgroup was to develop a communication product that would be factually informative and deliver a complete message about the Carpet Policy Dialogue to the reader in only a few minutes time. Furthermore, the Subgroup agreed that this communication product would be a concise document more in the form of a fact sheet and specified that it should not be longer than two pages.

As such, the Subgroup agreed that it would be a useful means to inform the trade or popular press and should, therefore, be written using layman terminology. The Subgroup also identified this product as a potentially helpful document for participating organizations in the Dialogue to use as a means to inform their constituencies about the work of the Dialogue. In addition, they concurred that it might form the basis for press releases which could be written by Dialogue participating organizations.

The initial draft of this communication product was made available to the Subgroup at the May meeting. It was revised and submitted to the Carpet Policy Dialogue Plenary on May 22, 1991. Further revisions were made at that time, and the Plenary agreed that the final document would be incorporated into the Interim Progress Report as an Executive Summary. EPA Project Staff noted that the Executive Summary proved a useful document when responding to inquiries from trade press or the interested public who sought information about the progress of the Carpet Policy Dialogue.

As part of the Compendium Report assembly, the materials prepared for the Interim Progress Report were updated by the Carpet Policy Dialogue at meetings held on September 26 and 27, 1991. The revised Executive Summary is included at the beginning of this Compendium Report.

4.4.3 Public Information Brochure

At the April meeting, the Public Communication Subgroup explored the feasibility of preparing brochure-type material for distribution to the general public. The Public Communications Subgroup's initial concept for this outreach product was to develop a master resource booklet of relevant information for the general public that could be used by participating organizations of the Carpet Policy Dialogue or other groups as the basis for developing communication products for their constituencies. This might include facts, charts, diagrams, and sample text in layman language. A preliminary list of topics that might be included in this outreach product was outlined. A Brochure Working Party, consisting of a subset of Subgroup members, was formed to flesh-out the concept and determine the need for such a product.

Project staff integrated comments and submitted materials related to the development of this product for discussion at the May 21, 1991, Subgroup meeting. Information provided to the Subgroup for the situation analysis revealed that there was an immediate need for such a product. Furthermore, the Subgroup acknowledged that the absence of factual information about carpet floor covering products, volatile organic compound emissions, and indoor air quality was, by itself, a cause for potential concern and misunderstanding among the general public. Based on these discussions, the Subgroup identified five (5) topics that could provide useful information to the interested public. These included:

1. Pollution and indoor air quality;
2. Carpet floor covering products and indoor air quality;
3. What is being done to understand VOCs;
4. Steps that consumers can take; and
5. Where to get more information.

The Brochure Working Party was given charge to develop a "strawman" brochure product for discussion at the June Subgroup meeting.

Based on comments received from a review of the "strawman" draft prior to the June meeting and the discussions at that meeting, the Subgroup prepared a list of principles to govern further development of the brochure. These included:

- The level of understanding for the target audience should be set at the 6th-8th grade reading level; however, certain technical concepts may raise the reading level to the 10th grade level.

- The brochure should contain only statements that are accurate and which can be substantiated.

- The brochure should address all elements of the carpet floor covering system.

- The brochure should make some comparison of TVOC emissions from carpet floor covering products with emissions from other products.

- There may be different information needs for residential and commercial/institutional carpet consumers, and the brochure should differentiate where appropriate.

- Recommendations about ventilation and odor detection times should be consistent within the brochure.

It was at this meeting that the Subgroup set the goal to gain the approval of the Carpet Policy Dialogue Plenary and to seek "sign-on" to the brochure by participating organizations to the Dialogue. This would signal that representatives from the organizations participating in the Dialogue worked cooperatively to address indoor air quality issues and participated in the development of the brochure. In addition, "signing-on" indicated that the participating organizations reviewed the brochure and agreed to be listed as a participating organization.

The Subgroup agreed that the Public Information Brochure offered a unique opportunity for industry, labor, Government, and public interest to make a statement on this subject. Furthermore, a joint "sign-on" by these organizations would demonstrate a level of accomplishment that could only be attained by means of a voluntary cooperative effort. At the same time, the subgroup reaffirmed that this Carpet Policy Dialogue, Public Information Brochure would not preclude participating organizations from developing other materials focused to their constituent audience.

The Public Information Brochure was further revised for discussion at the July Subgroup meeting. Project staff subjected the document to analysis by various computer readability programs. This analysis formed the basis for discussions and further revisions to the document on July 30, 1991. It was at this meeting that the Subgroup refined terminology and sought to clarify the message for the broadest possible target audience. Difficult concepts, lengthy scientific phrasing, and complex words were simplified to focus the reader's attention and to provide the reader with an understanding of the information that is currently available on this subject. Sections from early drafts were completely deleted or revised, and existing text was repositioned to improve flow through the document. When this had been completed, the Subgroup recommended that the revised document be forwarded to the Carpet Policy Dialogue Plenary.

The Public Information Brochure was reviewed by the Carpet Policy Dialogue Plenary on July 31, 1991. The Plenary made further revisions to the document before it was approved in "FINAL TEXT" form. This approval permitted project staff to issue a letter to nineteen (19) organizations participating in the Dialogue seeking "sign-on" approval to be listed on the brochure.

Results from the "sign-on" process were reported at the September 26, 1991, Subgroup meeting. The majority of participating organizations attained "sign-on" status. Subsequent discussion focused on those organizations which did not attain "sign-on" approval as this provided useful feedback to the Dialogue about how the brochure could be perceived. In the true spirit of the consensus process, the Dialogue Group sought to understand barriers that precluded some organizations from "signing-on."

In some cases, there was little that could be done to bring an organization to "sign-on" status. For example, the Subgroup learned that the American Society for Testing and Materials (ASTM) had no procedural mechanism to approve or disapprove of such a document. Other organizations requested text changes because, in their opinion, some important subjects needed further clarification or a different emphasis. To its credit, the Dialogue group was able to resolve these points and, following some text revisions, sixteen (16) organizations agreed to be listed on the brochure. These organizations are listed in Table 4.3.

Brochure layout options were also discussed at the final meeting of the Public Communications Subgroup on September 26, 1991. The Subgroup considered several proposed options and set guiding principles for the final layout. These included:

1. Use of recycled paper should be encouraged;

2. Paper stock (8 1/2" x 11" preferred over 8 1/2" x 14") should be cover weight, non-glossy, and may be colored to attract reader attention;

3. Two-color typeface could be used to emphasize text;

4. The section: "Steps To Take," should be border framed, and the shading grid should attract reader attention but not interfere with user friendly duplication;

5. A 2-fold (6 panel) or 3-fold (8 panel) format should be used to allow user friendly duplication;

6. The brochure should not contain graphics;

7. The cover should emphasize the title only without graphics, and

8. EPA's sponsorship of the Dialogue should be recognized by placing an EPA logo on the cover page bottom.

TABLE 4-3

LIST OF ORGANIZATIONS THAT AGREED TO BE LISTED ON THE BROCHURE

AFSCME -- American Federation of State, County, and Municipal Employees

AFMA -- American Fiber Manufacturers Association

ALA -- American Lung Association

ATMI -- American Textile Manufacturers Institute

CRI -- Carpet and Rug Institute

CCC -- Carpet Cushion Council

FCICA -- Floor Covering Installation Contractors Association

FCAMC -- Floor Covering Adhesive Manufacturers Committee of the National Association of Floor Covering Distributors

GTRI -- Georgia Tech Research Institute

NFFE -- National Federation of Federal Employees, Local 2050

NIST -- National Institute of Standards and Technology

SBLMC -- Styrene Butadiene Latex Manufacturers Council

ASC -- The Adhesives and Sealants Council

CPSC -- U.S. Consumer Product Safety Commission

EPA -- U.S. Environmental Protection Agency

GSA -- U.S. General Services Administration

The Subgroup also discussed potential brochure distribution. EPA noted that it intends to distribute 5,000 copies of the brochure to each "sign-on" participant along with camera ready copy to permit these organizations to duplicate the brochure to meet their distribution needs. In addition, the EPA will announce the availability of the brochure in the Federal Register, distribute copies to the Regional offices, and make copies available from the TSCA Hotline and the Office of Air and Radiation, Indoor Air Division. The Consumer Product Safety Commission noted that they envisioned that the brochure would be available on request from the CPSC Office of Public Affairs, and distributed to CPSC Regional Offices. CPSC would also send copies of the brochure to State Product Safety Coordinators as well as State and local Consumer Product Protection Organizations. The Carpet and Rug Institute explained that they would encourage all carpet manufacturers, distributors, retailers, and installers to distribute the Carpet Policy Dialogue brochure. Similar distribution would be encouraged by the Carpet Cushion Council. The American Lung Association envisions distribution of the brochure to its 131 constituent and affiliate Lung Associations across the country where it will be publically available on request. Other organizations indicated a variety of distribution channels to meet the needs of their constituencies.

The text of the Carpet Policy Dialogue: Public Information Brochure entitled "Indoor Air Quality and New Carpet, What You Should Know" is included as Appendix M of this report. A copy of the brochure may be obtained by contacting the EPA.[1]

4.4.5. Compendium Report

On February 27, 1991, the Public Communications Subgroup determined that the hallmark of its public communication efforts would be a comprehensive report describing the accomplishments of the Carpet Policy Dialogue. This communication product would be a compilation of the final documents produced as a result of the Carpet Policy Dialogue. A Draft Table of Contents for this product was developed and discussed at a Subgroup meeting on April 9, 1991. The revised Draft was distributed to the Plenary on April 10th and approved.

The "Compendium Report" incorporates into one source document all materials associated with the work of the Carpet Policy Dialogue. As such, it is an assembly which includes: the consensus agreements for the industry testing programs (carpet, carpet cushion, and carpet floor covering adhesives industries), the analytical test method for measuring TVOC emissions, information about the process engineering and installation practices of

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[1] The EPA, the Carpet Policy Dialogue, and all participating organizations listed on the brochure encourage reproduction and distribution of this brochure without alteration and without permission, except for use as advertising material or product endorsement. Any such reproduction should credit those organizations listed on the brochure. The use of all or any part of the brochure in a deceptive manner or for purposes of endorsing a particular product may be subject to appropriate legal action.

carpet floor covering materials relevant to VOC emissions, and public communications products. It also includes a record of other Carpet Policy Dialogue related materials such as the Federal Register announcements, and various Memoranda of Understanding.

The Compendium Report also provides descriptive information to give perspective about the structure and framework of the Carpet Policy Dialogue. The report gives context about the scope of work for the Carpet Policy Dialogue Plenary and explains the relationships and activities of the three working Subgroups (Product Testing, Process Engineering, and Public Communications).

This report was prepared with the understanding that it would become a public document that would be available on request. It was developed so that participating organizations in the Carpet Policy Dialogue and their representatives would be able to use materials in the Compendium to communicate with their respective constituencies and publics as they choose. At the same time, the document provides an opportunity for these organizations to inform the interested public about ongoing and proposed activities with respect to carpet floor covering, TVOC emissions, and indoor air quality.

Preparation of the Compendium Report involved the coordination of several activities. This included updating materials prepared for the Interim Progress Report; compiling documents prepared during the Dialogue year; preparation of bridging materials to give context to the findings, conclusions, recommendations, and products developed by the Carpet Policy Dialogue; and finally review and assembly of the document. The modular nature of the document made it possible to insert reports prepared during the Dialogue year. For example, the introductory material (Chapter 1) was initially prepared for the Interim Progress Report, while Chapters 2, 3, and 4 are reports submitted to the Carpet Policy Dialogue which were prepared by the working Subgroups. However, because these modules repetitively referenced Dialogue products, it became necessary to integrate the appendices and their attachments within the Compendium Report. This assured a meaningful document that would be easy to follow.

A draft of the Compendium Report was made available to the Carpet Policy Dialogue for review in September 1991. Comments from this review cycle were considered during discussions of the Public Communication Subgroup on September 26, 1991. The document was also reviewed and discussed by the Carpet Policy Dialogue Plenary at a meeting held on September 27, 1991. Comments and revisions to the draft document were incorporated by project staff following these meetings. The final document was transmitted to EPA and announced in the Federal Register. Copies of the Compendium Report's Executive Summary are available from the TSCA Hotline, and the report will be available for purchase from the NTIS (PB 92-115005). The report is also filed in the TSCA Carpet Emissions Administrative Record which is available to the public for reviewing and copying.

CHAPTER 5

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List of Carpet Policy Dialogue Participants

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APPENDIX B

Federal Register, Vol. 55.
No. 79; Part VII,
Environmental Protection Agency,
Carpet Response to Citizen's
Petition; Notice

federal register

Tuesday
April 24, 1990

Part VII

Environmental Protection Agency

Carpet Response to Citizens' Petition; Notice

ENVIRONMENTAL PROTECTION AGENCY

[OPTS-211027; FRL 3739-8]

Carpet: Response to Citizens' Petition

AGENCY: *Environmental Protection* Agency (EPA).

ACTION: Response to Citizens' Petition.

SUMMARY: On January 11, 1990, the National Federation of Federal Employees (NFFE), Local 2050, petitioned EPA under section 21 of the Toxic Substances Control Act (TSCA), 15 U.S.C. 2620, to initiate rulemaking proceedings, under sections 4, 6 and 8 of TSCA, 15 U.S.C. 2603, 2605, and 2607, to reduce emissions from new carpets. EPA has decided not to initiate the specific rulemaking proceedings requested by NFFE because the Agency disagrees with the specific assertions regarding the health risk posed by carpeting and with the remedies sought.

However, EPA is concerned that volatile compounds from installation of new carpeting may significantly increase indoor air exposures to such compounds. Therefore, this notice describes the Agency's decision to initiate a series of actions designed to assess and, if necessary, reduce the public's exposure to compounds which may off-gas from carpeting.

FOR FURTHER INFORMATION CONTACT: Michael M. Stahl, Director, Environmental Assistance Division (TS-799), Office of Toxic Substances, Rm. E-543B, 401 M St., SW., Washington, DC 20460, (202) 554-1404.

SUPPLEMENTARY INFORMATION:

I. Summary of Response

EPA has found that there are insufficient data to support the conclusions and remedies requested by NFFE. The Agency, however, believes that an absence of scientific certainty does not necessarily mean an absence of risk and that efforts to better characterize carpet emissions, and potential health effects which may be associated with carpeting, as well as other indoor exposure sources, should be continued and expanded.

In addition, the Agency recognizes that new carpet may be a significant source of human exposure to low levels of volatile organic compounds (VOCs). As a matter of policy, the Agency believes it is prudent to minimize indoor human exposure to these chemicals where reasonable and that efforts on the part of manufacturers to reduce product emissions should be strongly encouraged.

In light of these findings, the Agency is taking three major initiatives. First, the Agency is formally requesting that the carpeting industry undertake a voluntary program to conduct periodic total VOC analyses on a company-by-company and product-by-product basis to provide the interested public with comparative information on total VOC emissions. Second, the Agency is inviting all interested parties to participate in a 1-year dialogue process designed to work out the details of the voluntary testing program mentioned above and to explore and, where possible, reach agreement on a variety of issues including: the sampling and analytical methods for the voluntary testing, any additional information needed, and cost-effective process changes to reduce emissions. Further, details on the dialogue process are discussed in Unit IV of this notice. Thirdly, the Agency will continue its on-going exposure reduction and research activities on indoor air quality issues generally and on the potential health effects of exposure to low level VOC mixtures, in particular.

A concurrent effort will be initiated to assess the feasibility of prospective epidemiology studies to determine the response characteristics of individuals exposed to carpet emissions.

II. Background

A. Statutory Requirements

1. *TSCA in general.* Section 21 of TSCA provides that any person may petition EPA to initiate proceedings for the issuance of rules under sections 4, 6 and 8 of TSCA.

Under section 4 EPA may issue rules to require chemical manufacturers and processors to test their chemicals. To issue a section 4 rule on a chemical, EPA must find either that activities involving the chemical may present an unreasonable risk of injury to health or the environment, or that the chemical will be produced in amounts that may cause significant or substantial human exposure or substantial environmental release. In addition, EPA must find that existing data are insufficient to determine or predict the effects of the chemical and that testing is necessary to develop that data.

Under section 6 EPA may promulgate rules to control a chemical if the Agency finds there is a reasonable basis to conclude that activities involving the chemical present or will present an unreasonable risk of injury to health or the environment.

Under section 8 EPA may issue rules to require chemical manufacturers and processors to gather, retain and report existing information, as may be reasonably required. This information includes production and use information, health and safety studies, and allegations of adverse reactions.

2. *TSCA section 21.* A section 21 petition must set forth the facts which establish the need for the rules requested. EPA is required to grant or deny the petition within 90 days. If EPA grants the petition, the Agency must promptly commence an appropriate proceeding. If EPA denies the petition, the Agency must publish its reasons in the **Federal Register**.

Within 60 days of denial, the petitioner may commence a civil action in a U.S. district court to compel the initiation of the rulemaking requested in its petition. The court must, for a petition for a new rule, provide the opportunity for the petition to be considered *de novo*.

After hearing the evidence, the court can order EPA to initiate the action requested if the petitioner has demonstrated, by a preponderance of the evidence, support for particular conclusions described in section 21. The petitioner must support different conclusions for section 4 petitions than for section 6 or 8 petitions.

In the case of a section 21 petition for a section 4 rule, the petitioner must demonstrate support for the conclusion that (1) information is insufficient to permit a reasoned evaluation of the effects of a chemical and (2) the chemical either may present an unreasonable risk or will be produced in substantial amounts and may result in significant or substantial human exposure or substantial environmental release.

In the case of a section 21 petition for a section 6 or 8 rule, the petitioner must demonstrate support for the conclusion that there is a reasonable basis that rules are "necessary" to protect against "unreasonable risk."

B. Assertions of Petitioner

NFFE petitioned EPA to initiate proceedings for a number of immediately effective rules to control exposure to the chemical substance 4-phenylcyclohexene (4-PC), an inadvertent byproduct of the manufacture of styrene-butadiene latex (SB latex) used in carpet manufacturing, as well as other chemicals emitted by new carpeting.

NFFE asserts that immediately effective rules are needed to protect against alleged adverse health effects described by NFFE as "multiple chemical sensitivity" (MCS) and "acute irritancy response" (AIR). NFFE claims

that MCS and AIR result from exposure to 4-PC emitted from SB latex in "bad" batches of carpets. The chemical 4-PC is likely produced at the initial polymerization stage of SB latex.

NFFE supports this contention by citing a surge in illness complaints among EPA employees following carpet installation in 1987–88 at the EPA headquarters building in Washington, D.C. NFFE claims that 4-PC is the single common emission product from these carpets and that similar complaints have been made by persons exposed to SB latex and not carpets. In addition, NFFE asserts that animal studies link 4-PC with adverse health effects.

NFFE maintains that this evidence provides a reasonable basis for the initiation of action under TSCA, arguing that it is not necessary to show 4-PC is the only cause of injury or to know the precise mechanism by which the adverse health effects occur.

NFFE further asserts that it might be inexpensive to reduce 4-PC levels in the initial production of SB latex or its subsequent processing. NFFE concludes that this remedy is justified on the basis of its probable low economic consequence compared to the severity of the life-altering human health effects asserted in the petition.

C. Remedies Sought

EPA is requested to initiate the following specific regulatory actions:

1. *Section 4.* NFFE requests that EPA promulgate rules to generate information elucidating the mechanism of action for 4-PC and other chemicals emitted from certain carpeting through specific testing including: (1) A case-control epidemiology study, (2) *in vitro* studies of the reactivity of 4-PC and its epoxide derivative with cellular proteins and DNA and like studies of the ability of 4-PC to affect certain enzyme levels in living cells, and (3) whole animal studies related to the *in vitro* studies on 4-PC and carpet off-gassing chemicals (effects on enzyme levels, immune system marker chemicals and neurotransmitter substances).

2. *Section 6.* NFFE requests that EPA promulgate immediately effective rules under section 6 to establish 4-PC indoor air level standards of 5 parts per trillion (ppt) to protect against MCS and 17 ppt to protect against AIR, and to require manufacturers to buy back carpets which would cause these levels to be exceeded. NFFE also requests EPA to issue an immediately effective order under section 8(b) to require manufacturers to remedy quality control procedures, notify the public of the health risks, and require the carpet buy-backs discussed above.

NFFE requests that testing be conducted to determine what levels of 4-PC in carpets would cause these indoor air level standards to be exceeded. Although NFFE characterizes this testing requirement as a rule under TSCA section 6, EPA believes that such requirement is more appropriately characterized as a rule under TSCA section 4.

3. *Section 8.* NFFE requests that EPA promulgate immediately effective rules: (1) Under section 8(a) to require manufacturers, processors and distributors to report amounts of SB latex manufactured and its uses; (2) under section 8(c) to require manufacturers to maintain and present for inspection records of allegations of adverse health effects related to exposure to 4-PC or mixtures containing 4-PC; and (3) under section 8(d) to require manufacturers to submit lists of health and safety studies on 4-PC or mixtures containing 4-PC and to submit health and safety studies on 4-PC in their possession.

4. *Other remedy requested.* NFFE requests that EPA develop and issue a "Chemical Advisory" directed to building managers regarding exposure to volatile chemicals in carpeting, particularly 4-PC, and the hazard to those persons apparently experiencing MCS. This remedy is not petitionable under TSCA.

III. Evaluation of the Petition

A. Legal Standards

Section 21, itself, does not specifically state the criteria under which EPA should decide whether to grant or deny a citizens' petition. Section 21 merely states that EPA must grant or deny within 90 days.

However, there are standards under sections 4, 6 and 8 for issuing regulations, and there are standards imposed on the court for deciding whether to order EPA to initiate rulemaking in the event of a lawsuit filed by the petitioner after denial of a section 21 petition. EPA has examined these standards, summarized in Unit II.A. of this notice, as the basis for evaluating NFFE's petition. Following is a discussion of how these standards apply to evaluation of the NFFE petition.

1. *Legal standards regarding testing rules.* With respect to NFFE's request for initiating testing rules under section 4, EPA considered the legal standards found in both section 4 and section 21. Some standards contained in these sections are essentially the same. For example, under section 4, EPA may issue a rule to require testing if it finds that data on a chemical are insufficient to evaluate its effects, and that the chemical may present an unreasonable risk of injury or is produced in substantial quantities, and either may result in significant or substantial human exposure, or may result in substantial environmental release. Section 21 allows a court to order EPA to initiate rulemaking if it makes, essentially, the same determination after a *de novo* review of the petition.

Three criteria are relevant to evaluating these standards for this petition: (1) Sufficiency of data, (2) unreasonable risk and (3) significant or substantial exposure. Decisionmaking under each of these criteria depends on the particular facts involved in any particular case and involves significant judgment on the part of the decisionmaker—EPA or a court. The unreasonable risk criterion, however, requires elaboration because it is a general standard that applies to both section 4 and section 6. This elaboration appears later in this Unit.

EPA applied another standard to its evaluation of NFFE's request for testing rules not found in section 21, but only found in section 4. Under section 4, EPA must find that testing is necessary to develop the data needed for evaluating a chemical before it may issue a testing rule. Under this requirement, EPA needs to consider such issues as whether there is a testing method that can be expected to develop useful data or whether there are other means of obtaining data without resorting to testing.

2. *Legal standards regarding control rules.* In evaluating NFFE's request for rules under section 6 to control chemicals, EPA assessed whether such rules are necessary to protect against unreasonable risk. This is the same test the court would apply under section 21. The test has two aspects. First, there must be an "unreasonable risk" of injury against which protection is needed. Second, TSCA rules must be "necessary" to protect against that risk.

EPA interprets the standard that rules are "necessary" to require consideration of whether TSCA rules are the appropriate remedy to protect against the risk described. For example, regulations under other Federal statutes, whether administered by EPA or other agencies, may be more appropriate than TSCA rules. Another consideration may be whether State or local initiatives constitute the appropriate remedy instead of Federal rules.

3. *Unreasonable risk.* Unreasonable risk is the basic regulatory standard under TSCA. It applies to rules under both section 4 and section 6, and to judicial decisions on section 21

petitions. The importance of the unreasonable risk standard to TSCA decisionmaking requires that the standard be given special explanation.

The finding of unreasonable risk is a judgment under which the decisionmaker determines that the risk of health or environmental injury from a chemical outweighs the burden to society of potential regulations. The section 4 requirement that EPA must find that a chemical "may" present an unreasonable risk requires less information on risk than the section 6 requirement to find that a chemical "will" present an unreasonable risk.

This concept is discussed in the legislative history of TSCA. The House Report notes that risk is measured by elements of probability of harm and severity of harm that may vary in relation to each other, and that the regulatory effect will be of greater significance in making an unreasonable risk determination if greater restrictions are imposed by regulation (H.R. Rep. 94-1341, 94th Cong., 2d Sess., pages 14 and 15). Thus, to impose regulations banning a chemical, for example, and thereby imposing a significant burden on society, the decisionmaker would need considerable information on toxicity and exposure. On the other hand, the decisionmaker would need less information on risk if the regulation were only a testing requirement that would not, by itself, result in the loss of benefits of the chemical to society.

In practical application, an unreasonable risk decision cannot be made considering risk alone. Rather, the probability of harm must be considered against the impacts of regulation. Thus, if exposure to a chemical is low and extremely high burdens would be incurred to achieve small incremental risk reduction, a decisionmaker might not find the risk unreasonable. On the other hand, an unreasonable risk may be found if the evidence on the risk asserted is marginal but the impact of regulation is low. Thus, the identified risk may justify the minimal costs of a testing rule or a labelling requirement, but would not justify the costs of more restrictive measures.

These considerations are especially relevant in the case of the NFFE petition.

B. Evaluation of NFFE's Assertions

EPA disagrees with NFFE that the health problems cited in the petition are likely caused by 4-PC exposure, or even that the petition identifies human disease conditions (MCS) that the medical community generally recognizes or for which there are evaluation techniques. Instead, NFFE's risk case is entirely based on the presence of 4-PC at the site of complaints about non-specific health effects.

EPA recognizes that certain individuals may have adverse reactions from exposure to indoor air contaminants. However, EPA's evaluation of 4-PC shows no evidence of such toxicity and, indeed, shows that it is an unremarkable chemical. There are no clinical studies or epidemiology data for 4-PC. Animal studies at dose levels well above those measured or expected at the EPA Headquarters do not indicate acute toxicity or skin sensitization. In addition, no credible physiological or biochemical causal mechanism has been identified to link 4-PC to the effects alleged in the petition. This evidence does not, however, entirely rule out a causal relation of 4-PC to effects on hypersensitive individuals.

NFFE has shown no definitive evidence that persons exposed to SB latex but not to carpet suffer the same complaints as people exposed only to carpet. Furthermore, 4-PC is not the only chemical found at the carpet complaint sites at EPA. Other chemicals, such as toluene, have been found at the same sites. A number of the chemicals found at these sites could produce the same non-specific symptoms that the petitioner attributes to 4-PC. It appears that some persons, NFFE included, may have alleged 4-PC as a cause of adverse effects partly because the odor of the chemical is so readily detectable. It has an extremely low odor threshold, approximately 0.5 parts per billion (ppb).

EPA does not rule out that complaints associated with the installation of carpets could be the result of the complex mixture of off-gassing chemicals, including the VOCs in carpets, padding and installation materials. The composition and concentrations of off-gassing chemicals vary between carpets. The large surface area of carpet compared to the surface areas of other room components might also be responsible for capturing and emitting of contaminants from many other sources.

C. Evaluation of NFFE's Remedies

EPA has determined that NFFE's assertions concerning 4-PC do not support its proposed remedies. The Agency's analysis follows.

1. *Section 4.* EPA has determined that the toxicity testing requested by NFFE is not justified under the legal standards of TSCA and the existing scientific evidence. There are insufficient data to reasonably determine or predict the effects of low levels of 4-PC and other chemicals that may be emitted from carpets. However, the other determinations under sections 4 and 21 cannot be made at this time.

First, EPA is not able to determine that, in the absence of sufficient data, 4-PC either may present an unreasonable risk or is emitted at levels that may cause significant exposure. EPA's evaluation of the available toxicity data, as summarized in Unit III.B. of this notice and as described in more detail in the administrative file prepared for this petition response, shows no particular concern for 4-PC. There is not even an apparent theoretical basis (structure-activity relationship or causal mechanism) that would lead to a significant concern for 4-PC. Thus, exposure to 4-PC off-gassing from carpeting does not appear to be unreasonable or significant, since it is present at such low levels. The low odor threshold of 4-PC is the only apparent reason for indicting the chemical. EPA believes this is not an appropriate reason to require special testing of this chemical.

Second, different considerations apply to the evaluation of exposure to total VOCs emitted from carpeting. The large amounts of new carpet distributed in the U.S. and the large surface area in the indoor environment lead to a concern that there may be substantial exposure to off-gassed chemicals. Thus, EPA believes that it is appropriate that companies test in order to characterize VOC emissions from carpeting products, and will require such testing under section 4 if it cannot be accomplished voluntarily. This testing will help determine if any exposure reduction measures are necessary, as more fully explained below.

Testing might be done either by carpet manufacturers or by raw material suppliers. For example, the Styrene Butadiene Latex Manufacturers Council (SBLMC), a trade association of companies that manufacture SB latex, has told EPA that its member companies have attempted 4-PC reduction over the last 2 years. The SBLMC, however, has not provided data on attempted manufacturing process changes or on levels of 4-PC in individual products. The SBLMC has told EPA that the present average level of 4-PC in SB latex is 123 parts per million (ppm). In a related matter, no information has been collected regarding the 4-PC levels in a related product, styrene-butadiene rubber latex, which is sometimes used to glue down carpets. Also, the Carpet and Rug Institute (CRI), a trade association of carpet manufacturers, has informed EPA of ongoing studies of carpet emissions. Results are expected in the next few months.

Finally, with respect to the potential adverse health effects of total carpet emissions, the studies requested by NFFE are not likely to develop the data needed. Accordingly, EPA has decided to consider whether other studies can be developed to evaluate the potential effects. The mechanistic case-control epidemiological studies requested by NFFE are not appropriate. Case-control studies look at subjects with a well defined disease compared to subjects without the disease to examine the possible similarities in exposures. If the disease is not well-defined, as with the conditions that the petitioner describes as MCS or AIR, epidemiologic studies will not clarify a disease mechanism or etiology. Studies done after the fact of disease cannot assign the presence or levels of enzymes (as the petitioner requested) to particular chemical exposures. EPA believes that it would be more useful to consider a prospective study of several populations, such as those who appear most sensitive to carpets and those who work with carpets directly.

EPA concludes that the animal studies suggested by NFFE would not be useful. NFFE claims that there may be a breakdown in the immune system, and perhaps other systems, of certain sensitive persons caused by exposure to 4-PC and other off-gassing chemicals. However, there is no adequately defined connection between the symptoms reported in humans by NFFE and its requested measurements of: (1) The binding of a chemical to cellular proteins and DNA, (2) enzyme levels, (3) immune system marker chemicals, or (4) neurotransmitter substances.

Changes in the immune system have historically not been shown to be a reliable predictor of the symptoms of concern presented in NFFE's petition. Exploratory research on broad classes of indoor air pollutants is needed to develop such predictive capability. Thus, it is appropriate for the research cost to be borne by a broader segment of society rather than by the carpet industry alone.

2. *Section 6.* Under unreasonable risk standards, EPA does not believe that the health effects evidence on 4-PC justifies immediately effective rules, requirements for indoor air levels in the low part per trillion range (well below current detection limits) or requiring buying back of carpet already installed. Such types of rules are too restrictive, given the paucity of evidence on 4-PC. EPA believes that by focusing on these types of rules for 4-PC, resources would be diverted from potentially more fruitful efforts to address indoor air pollution generally, including carpet emissions. A major problem with NFFE's requested remedies is that resources would be spent on addressing chemicals that may in fact cause no problem. In addition, NFFE's remedies may unfairly indict particular chemicals or a particular industry and could lead to undue public concern.

EPA is willing to consider, however, whether it is possible under unreasonable risk standards to develop cost-effective control steps to reduce levels of all VOCs that may be emitted from carpet, including 4-PC. A good understanding of the effects of complex mixtures, particularly in the case of sensitive individuals, may not be available for a long time. Thus, at least for the near term, further study of the health effects of complex mixtures in indoor air, should not delay efforts to address immediate concerns. EPA, therefore, believes that, until more definitive information is available, the Agency should promote reductions of chemicals emitted from carpets.

3. *Section 8.* The principal issue regarding NFFE's section 8 request is whether to institute rulemaking or obtain the information on a voluntary basis. Much of the information requested by NFFE (i.e. health and safety studies) has already been obtained from industry; industry has also informed EPA of ongoing animal studies. In addition, production data and use information on SB latex have been provided by industry.

The NFFE requested section 8(c) remedy for records retention for SB latex is already established at 40 CFR part 717. The SB latex industry has agreed to provide by May 1990 their existing records regarding adverse reactions allegations associated with SB latex as well as existing health and safety studies on SB latex. There may be little incremental benefit to issuing rules to gather information that industry will provide voluntarily and more quickly than through rulemaking. EPA will consider rules as necessary to obtain information about processing which can help identify appropriate exposure reduction measures.

4. *Chemical advisory.* EPA believes that its present and proposed information dissemination and technical assistance activities already provide an effective means to reach the public regarding health effects information. Furthermore, issuance of a Chemical Advisory is not a petitionable item under section 21.

IV. EPA's Response

The NFFE petition requested that EPA publish a number of immediately effective rules to protect the public from exposure to the compound 4-PC and mixtures containing 4-PC. EPA, however, denies this Section 21 petition because the evidence on the risk from 4-PC and other VOCs does not support the remedies requested.

The Agency, however, recognizes NFFE's concerns and would certainly agree that an absence of scientific certainty does not necessarily mean an absence of risk. In addition, the Agency recognizes that new carpeting can be a source of widespread human exposure to low levels of VOCs. As a matter of policy, the Agency believes it is prudent to minimize indoor human exposure to VOCs and other indoor air contaminants where reasonable and that efforts on the part of manufacturers to reduce product emissions should be strongly encouraged.

In light of these findings, the Agency is taking several steps. First, the Agency is formally requesting that the carpeting industry undertake a voluntary program to conduct periodic total VOC analyses on a company-by-company and product-by-product basis to provide the interested public with comparative information on total VOC emissions. Such a program, which may include labeling of carpet products for total VOC emission, would help to stimulate efforts to lower overall VOC emissions. Second, the Agency is inviting all interested parties to participate in a 1-year public dialogue process (discussed below) to initiate this program. Third, the Agency will also continue its risk management activities and research to identify possible health effects associated with complex air mixtures emitted by carpets and low level VOC exposures. These ongoing activities and planned research under the indoor air program are summarized in Unit V of this notice.

EPA's public dialogue process will continue for approximately 1 year. The Agency will invite interested members of the public to participate. EPA will seek participation by NFFE, the carpeting products industry, consumer/public interest groups, other Federal agencies, and other interested parties. The goal of this dialogue will be to characterize emissions and identify low-impact, feasible VOC controls that could be implemented in the near term, not to further characterize the health effects of chemicals emitted from carpeting.

The specific charges to the participants in the dialogue will be to:

1. Develop standard methodologies for testing carpet emissions and obtain commitments to test carpeting. The Agency will be requesting the carpet

industry to voluntarily commence appropriate periodic testing (probably on a company-by-company, product-by product basis) to quantify the total emissions of VOCs from their products to provide the interested public with comparative information on total VOC emissions from new carpets. Should an acceptable voluntary agreement not be obtained within a reasonable time, the Agency intends to propose a test rule under section 4 of TSCA to compel such testing.

2. Identify information needs for assessment of emission control feasibility, including data on carpet manufacture and installation technology and commercial activities associated with carpet installation. This data development and/or collection could be accomplished either by issuance of rules under TSCA sections 4 or 8, or by voluntary submissions.

3. Evaluate potential controls for reducing emissions, including product and/or emission standards, and labeling of carpet for VOC emissions. These could be accomplished either voluntarily or through low impact TSCA rules. Other appropriate statutes administered by either EPA or other Federal agencies will be considered, as required by section 9 of TSCA. If EPA pursues mandatory control options under TSCA, EPA will be required to make an unreasonable risk finding under section 6.

4. Identify VOC exposures which are associated with carpet installation but not necessarily from a carpet source (adhesives, floor preparation, etc.) and recommend any appropriate actions to reduce them.

A simultaneous effort will be made to assess whether prospective epidemiologic studies can be developed to determine the response characteristics of individuals exposed to carpet emissions and assess whether other health effects studies (e.g. human chamber, *in vitro*, or animal studies) should be performed as methodologies are developed and become available. A prospective epidemiology study would require identification and definition of symptoms of concern, with selection criteria including expressions of symptoms within a specified time after an exposure event. Workable test methods to measure the relevant symptoms would need to be identified. It may take as long as 1 year to determine whether appropriate epidemiology protocols can be developed. If a determination is made that protocols are feasible, EPA will require industry to develop specific test protocols and carry them out.

The administrative actions to establish the dialogue—including meetings, reports, and other pertinent information—will be described in a separate Federal Register notice to be issued by June 1, 1990.

V. EPA Indoor Air Program

The issue of carpet emissions and their contribution to adverse health effects has been treated by the Agency as part of the overall indoor air pollution problem. Prior to and independently of the petition, EPA has undertaken a risk management and research program for indoor air pollution as part of its responsibilities under Title IV of the Superfund Amendments and Reauthorization Act of 1986 (SARA). Title IV of SARA mandates a comprehensive indoor air quality research and development program by EPA to identify, characterize, and monitor sources and levels of indoor air pollutants, to develop instruments for indoor air quality data collection, and to identify high risk building types.

This program has two major elements, risk management and research, which are discussed below.

A. Risk Management

The indoor air pollution risk management program undertaken by EPA emphasizes nonregulatory programs of information dissemination, technical assistance, guidance and training to build State and local government and private sector capabilities to address indoor air quality problems. However, the Agency also believes that for identified high priority problems, regulation under available statutes, including the Toxic Substances Control Act, the Federal Insecticide, Fungicide, and Rodenticide Act, and the Safe Drinking Water Act may also be appropriate.

In an effort to disseminate available information on indoor air quality, EPA has published a number of documents on indoor air pollution and its mitigation, including a major "Report to Congress on Indoor Air Quality" (August 1989), a series of fact sheets on indoor air issues, including "Sick Buildings" and "Ventilation and Air Quality in Offices," a "Survey of Private Sector Indoor Air Quality Diagnostic and Mitigation Firms," and several publications dealing with residential indoor air issues.

EPA is currently developing guidance documents directed to specific audiences, such as architects and engineers, building owners and managers, and new home builders and buyers, on the prevention, diagnosis and mitigation of indoor air quality problems in commercial and residential structures. As an example, the guidance document for building owners and managers is designed to be used in assessment programs to identify and correct potential problems, and to manage related indoor air quality problems, through building investigations, employee relations, contracting and mitigation techniques. EPA is also exploring, through a public dialogue process, whether a consensus based credentialing system for private sector indoor air quality diagnosis and mitigation firms is feasible and desirable. In addition, a manual for physicians on the recognition, diagnosis and treatment of illnesses related to indoor air quality will be developed.

EPA is developing a general indoor air quality training program for State and local governments to help them to identify and mitigate indoor air quality problems. In addition, EPA will be developing model State programs for indoor air quality assessment and response.

B. Research

The objective of EPA's indoor air pollution research program is to gain information to reduce exposure to indoor air pollutants known to cause health risks. The first step in achieving this objective is the identification and characterization of the health risks posed by indoor exposures. Once the risks have been adequately characterized, exposure reduction techniques can then be evaluated on the basis of their practicality, cost, and effectiveness.

To characterize pollutants from off-gassing or volatilization that might occur from carpets, wall coverings, paints, and other products, EPA is conducting small chamber testing of the indoor air contribution of construction products. Levels of chemicals that would be expected indoors can then be estimated based on such emissions data, using indoor air models developed by EPA.

EPA is encouraging emissions testing by industry using consensus, verified methods. The American Society for Testing and Materials (ASTM) is currently reviewing an EPA-developed standard small-chamber test method to characterize the complex emissions from products used indoors, such as carpeting. EPA is conducting monitoring and analytical methods research that includes the development and evaluation of personal and micro-environmental monitors to measure pollutants in indoor air, including monitors for semiVOCs and polar organic compounds. This research

includes compiling these methods into a compendium of monitoring and analytical techniques for indoor pollutants, including methods for semi-VOCs and polar organic compounds. EPA is developing exposure assessment techniques for application to large buildings.

EPA is conducting research on the effects of VOC mixtures on neurobehavioral and physiologic effects on humans. EPA is developing a risk assessment methodology to evaluate the human health risks from exposure to indoor air pollution for both cancer and non-cancer endpoints.

To understand the national scope of the indoor air problem, EPA is developing baseline data. EPA is also resolving specific indoor air pollution inquiries and complaints from within EPA. As part of this effort, EPA has been developing and implementing a national Indoor Air Quality and Work Environment Study to be implemented at the EPA's Headquarters facilities, where EPA staff have expressed concerns about indoor air quality. Actions to improve indoor air quality at EPA's facilities are being taken in response to the survey results, and other information.

In addition, EPA is engaging independent experts to assist the Agency in the development of a long-range research strategy relative to MCS with the goal of producing the information necessary for establishing Federal policy on this issue.

EPA is continuing development of risk assessment information and methods for evaluating risks associated with specific sources of indoor air contamination. As part of this process, EPA is co-sponsoring a 3-day technical workshop scheduled for April 17-19, 1990, to address risk assessment methods for indoor air complex chemical mixtures, including carpeting.

VI. Administrative Record

EPA has established a public record of those documents the Agency considered in denying NFFE's petition. The record consists of documents located in the file designated by Docket Control Number, OPTS-211027, located at the TSCA Public Docket Office. This Docket is available for reviewing and copying from 8 a.m. to 4 p.m., Monday through Friday, excluding legal holidays, at the following address: Environmental Protection Agency, Rm. NE-G004, 401 M St., SW., Washington, DC 20460. The public record consists of all documents in the OPTS-211027 file and all documents cited in the documents in that file.

Dated: April 17, 1990.

William K. Reilly,

Administrator.

[FR Doc. 90-9464 Filed 4-23-90; 8.45 am]

BILLING CODE 6560-50-D

APPENDIX C

Federal Register, Vol. 55, No. 130;
Carpet Emissions Reduction;
Policy Dialogue

[OPTS-505; FRL-3816-5]

Carpet Emissions Reduction; Policy Dialogue

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of public meeting.

SUMMARY: EPA is initiating a policy dialogue as part of its efforts to gather data which will assist EPA in determining what future activity is necessary to assess total volatile organic chemical emissions from carpet and reduce the public's exposure to total compounds which may off-gas from carpeting.

DATES: The first meeting has been scheduled for August 21, 1990. The meeting will start at 8:30 a.m. and end at approximately 5 p.m.

ADDRESSES: The meeting will be held at the Holiday Inn Crown Plaza, National Airport, 300 Army Navy Drive, Arlington, VA 22202, Tel. (703) 892-4100.

FOR FURTHER INFORMATION CONTACT: Oscar Hernandez, Existing Chemical Assessment Division (TS-778), Office of Toxic Substances, Environmental Protection Agency, room E 409, 401 M Street, SW., Washington, DC 20460, Telephone: (202) 382-3560.

SUPPLEMENTARY INFORMATION:

I. Background

On January 11, 1990, the National Federation of Federal Employees (NFFE), Local 2050, petitioned EPA under section 21 of the Toxic Substances Control Act (TSCA), 15 U.S.C. 2620 to initiate rulemaking proceedings, under sections 4, 6, and 8 of TSCA, 15 U.S.C. 2603, 2605, and 2607, to reduce emissions from new carpets. EPA has decided (55 FR 17404) not to initiate the specific rulemaking proceedings requested by NFFE because the Agency disagreed with the specific assertions regarding the health risk posed by carpeting and with the remedies sought.

The Agency believes, however, that an absence of scientific certainty does not necessarily mean an absence of risk and that efforts to better characterize carpet emissions, and potential health effects which may be associated with carpeting, should be continued and expanded. In addition, the Agency recognizes that new carpeting may be a significant source of human exposure to low levels of volatile organic compounds (VOCs). As a matter of policy, the Agency believes it is prudent to minimize indoor human exposure to these chemicals where reasonable and that efforts on the part of manufacturers to reduce product emissions should be strongly encouraged.

In light of these findings, the Agency is taking three major initiatives. First, the Agency is formally requesting that the carpeting industry undertake a voluntary program to conduct periodic total VOC analyses on a company-by-company and product-by-product basis to provide the interested public with comparative information on total VOC emissions. Second, the Agency is inviting parties representing concerned interest groups to participate in a 1-year dialogue process designed to work out the details of the voluntary testing program mentioned above, and to explore and, where possible, reach agreement on a variety of issues including: The sampling and analytical methods for the voluntary testing, any additional information needed, and cost-effective process changes to reduce emissions. Third, the Agency will continue its ongoing exposure reduction and research activities on indoor air quality issues generally and on the potential health effects of exposure to low level VOC mixtures, in particular.

A separate, but concurrent effort, will be initiated to assess the feasibility of prospective epidemiology studies to determine the response characteristics of individuals exposed to carpet emissions.

II. Participants

The Agency has contracted with a private consulting firm to identify key individuals and groups who are prospective participants in the dialogue. For further information, contact the Existing Chemical Assessment Division as noted above.

Dated: July 30, 1990.

Joseph A. Carra,

Acting Director, Office of Toxic Substances.

[FR Doc. 90-18172 Filed 8-2-90; 8:45 am]

BILLING CODE 6560-50-M

APPENDIX D

Schedule of Carpet Policy Dialogue Meeings

APPENDIX D

Schedule of Carpet Policy Dialogue Meetings

MEETING SCHEDULE

8/21/90	Carpet Policy Dialogue Plenary meeting
9/6/90	Product Testing Subgroup meeting
9/25/90	Product Testing Subgroup meeting
9/26/90	Process Engineering Subgroup meeting
10/17/90	Product Testing Subgroup meeting
10/24/90	Process Engineering Subgroup, Product Testing Subgroup meeting
10/25/90	Carpet Policy Dialogue Plenary meeting
11/29/90	Carpet Policy Dialogue Plenary meeting
11/30/90	Process Engineering Subgroup, Product Testing Subgroup meeting
1/15/91	Carpet Policy Dialogue Plenary meeting
2/27-28/91	Subgroup meetings (Product Testing, Process Engineering, Public Communications)
2/28-3/1/91	Carpet Dialogue Plenary meeting
4/8-9/91	Subgroup meetings (Product Testing, Process Engineering, Public Communications)
4/9-10/91	Carpet Policy Dialogue Plenary meeting
5/20-21/91	Subgroup meetings (Product Testing, Process Engineering, Public Communications)
5/22/91	Carpet Policy Dialogue Plenary meeting
6/27-28/91	Subgroup meetings (Product Testing, Process Engineering, Public Communications)
7/29-31/91	Subgroup Meetings (Product Testing, Process Engineering, Public Communications) and Carpet Policy Dialogue Plenary meeting
9/26-27/91	Public Communications Subgroup Meeting and Carpet Policy Dialogue Plenary meeting

APPENDIX E

Test Method for Determining Total Volatile Organic Compound Emission Factors from Carpet Under Defined Test Conditions Using Small Environmental Chambers

TEST METHOD FOR DETERMINING TOTAL VOLATILE ORGANIC COMPOUND EMISSION FACTORS FROM CARPET UNDER DEFINED TEST CONDITIONS USING SMALL ENVIRONMENTAL CHAMBERS

1.0. SCOPE

1.1. The following method measures the total volatile organic compound (TVOC) emission factor from flooring materials using test conditions designed to simulate product use in residential and commercial settings. The method provides an *estimate* of TVOC that is based on the sampling and analysis procedures specified herein. These procedures may not adequately collect and/or quantify all organic compounds emitted from the carpet specimen being analyzed. The method will, however, provide data that can be used to compare emissions between different carpet products. The level of total volatile organic chemical emissions is determined by observing the TVOC concentration in a small environmental chamber under specified test conditions. The observed concentration is then related by a mathematical calculation to an emission factor, a product specific variable. The quantity of TVOC in the environmental chamber air is determined by gas chromatography or gas chromatography/mass spectrometry. The methodology is generally applicable to volatile organic compounds emanating from individual flooring materials including carpet, carpet cushions, adhesives, and subflooring. Applicability to adhesives may require procedural changes in sample preparation and analytical measurement techniques.

1.2. The "generic" standard environmental chamber practices currently described by the U.S. EPA in its document "INDOOR AIR SOURCES: USING SMALL ENVIRONMENTAL CHAMBERS TO CHARACTERIZE ORGANIC EMISSIONS FROM INDOOR MATERIALS AND PRODUCTS," EPA REPORT 600/8-89-074, and ASTM Guide D5116-90, "STANDARD GUIDE FOR SMALL-SCALE ENVIRONMENTAL CHAMBER DETERMINATIONS OF ORGANIC EMISSIONS FROM INDOOR MATERIALS/PRODUCTS," are coupled with "flooring specific" environmental chamber requirements and analytical procedures. These requirements are necessary for the study of TVOC emission factors from carpet and other flooring specific materials if acceptable accuracy and precision are to be achieved.

1.3. The methodology provides a standard means of reproducibly and accurately testing carpet and other flooring materials under controlled laboratory conditions.

1.4. This methodology, as presented, is technologically complex and requires a high degree of analytical capability and experience in environmental chamber operation, sorbent system use, and high-resolution gas chromatographic and/or mass spectrometric/gas chromatographic analysis. Individual laboratories performing this method will find it necessary to establish their own specific standard operating procedures to achieve the specific methodology criteria.

2.0. REFERENCE DOCUMENTS

2.1. ASTM Guide D5116-90 for Small Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products.

2.2. ASTM Test Method 741 for Determining Air Leakage Rates by Tracer Dilution.

2.3. ASTM D3195 Recommended Practice for Rotameter Calibration.

2.4. ASTM D1356 Definitions of Terms Related to Atmospheric Sampling and Analysis.

2.5. ASTM E355 Recommended Practice for Gas Chromatography Terms and Relationships.

2.6. ASTM Committee E-11 on Quality and Statistics, "Manual on Presentation of a Data and Control Chart Analysis, Sixth Edition."

2.7. Tichenor, "Indoor Air Sources: Using Small Environmental Chambers to Characterize Organic Emissions From Indoor Materials and Products," EPA report 600/8-89-074. This report is available to the public through the National Technical Information Service, Springfield, VA 22161.

2.8. Matthews, "Environmental Chamber Test Methodology for Organic Vapors from Solid Emission Sources," ATMOS. Env., 21, p. 321, 1987.

2.9. Tichenor, "Organic Emissions from Consumer Product and Building Materials to the Indoor Environment," J of APCA, 38, p. 264, 1988.

2.10. Black, "Environmental Chamber Methodology for the Study of VOCs Emitting from Manufactured Products," Proceeding of Indoor Air '90, Toronto, August, 1990.

2.11. CRI, "Standard for Installation of Textile Floorcovering Materials," Publication 104, The Carpet and Rug Institute, 310 Holiday Avenue, Dalton, GA 30720.

2.12. U. S. EPA, "Compendium of Methods for Determination of Toxic Organic Compounds in Ambient Air" EPA report 600/4-89/017. This report is available to the public through the National Technical Information Service, Springfield, VA 22161; PB90-116989.

2.13. Winberry et al., "Compendium of Methods for the Determination of Air Pollutants in Indoor Air" EPA report 600/4-90/010. This report is available to the public through the National Technical Information Service, Springfield, VA 22161; PB90-200288.

3.0. TERMINOLOGY

3.1. Definitions and Terms Specific to This Standard.

AIR CHANGE RATE (ACH). The ratio of the volume of air brought into the chamber hourly and the chamber volume measured in identical units (typically expressed in air changes per hour (ACH) or hr^{-1}.

EMISSION FACTOR (mg/m^2hr). A product specific factor describing the mass of chemical emitted from a product per exposed area of the product per unit time.

ENVIRONMENTAL TEST CHAMBER. A test apparatus with highly controlled operational parameters designed to provide accurate and reproducible emission factors for sources of indoor air pollutants.

LOADING RATIO (m^2/m^3). The ratio of exposed surface area of the test product and the free chamber volume, measured as m^2/m^3.

4.0. SIGNIFICANCE AND USE

4.1 The minimization of VOC emissions from interior products and processes has been suggested as a prudent step in reducing human exposures to chemical emissions.

4.2 The results of this method can be used to assist those involved with the design of new construction and building refurbishing in order to give consideration to emissions from products and interior activities.

4.3 This methodology provides a standard means of testing carpet and other flooring materials under surrogate conditions, i. e., product loadings with operational parameters and environmental conditions consistent with a product's end use.

4.4 TVOC data alone are inadequate to determine health effects. The method will, however, provide data that can be used to compare emissions between different carpet products.

4.5 The method incorporates a small environmental chamber, approximately 0.05 m^3 in size to evaluate the level of TVOC in the flooring materials over a specified duration of time. Environmental chambers larger or smaller in size may be used if acceptable correlation with the latter chamber is shown (correlation coefficient greater than 0.90 at multiple points in time ranging from the lowest obtained emission factor to the highest obtained emission factor). Conditions controlled in the method include:

4.5.1. Sample collection and packaging to preserve the product's manufactured chemical integrity;

4.5.2. Sample preparation in a presentation for individual materials and "installed systems";

4.5.3. Conditioning of the product or system prior to obtaining the test value;

4.5.4. Exposed surface area of the product being tested;

4.5.5. Environmental test chamber construction and operation;

4.5.6. Environmental test chamber temperature and moisture content;

4.5.7. Environmental test chamber air changes per hour;

4.5.8. Air circulation within the test chamber;

4.5.9. Accuracy and precision control of the chamber system;

4.5.10. Accuracy and precision of the analytical methodology; and

4.5.11. Sample archiving.

4.6. The test procedure employs a single set of experimental parameters to assess the TVOC emissions of certain carpet and associated flooring materials. Care must be exercised in the extension of the results to actual TVOC emissions under different conditions. This method provides an accurate and precise comparison of TVOC levels from different products intended for the same use.

4.7. The test method permits variance of experimental parameters to assess TVOC emissions of carpet and associated flooring materials under different usage situations. Parameters which can be independently controlled include air temperature, air moisture level and air exchange rate.

5.0. THE ENVIRONMENTAL CHAMBER

5.1. The interior volume of the environmental chamber should be approximately 0.05 m^3, unless data exist to demonstrate the adequacy of a different size as described in section 4.4 above. Surfaces shall be sufficiently chemically inert that recovery rates of a representative mixture of TVOCs including hexanol, toluene, cyclohexane and decane is greater than 95% at a mixture concentration of 40 $\mu g/m^3$ (10 $\mu g/m^3$ of each). All joints of the chamber must be permanently sealed except those absolutely necessary, e.g., the opening for loading and unloading the sample and environmental probes. These ports must have a self-sealing capacity comprised of non-VOC emitting and non-VOC adsorbing/absorbing materials.

5.2. The air within the chamber must be free of any obstructions or contamination such as fans, humidifiers or coils. The internal air must only come in contact with the inert chamber walls, the air diffusion system, which includes inlet and outlet ports and environmental measurement devices.

5.3. Internal chamber air must be well-mixed and must comply within 5% of the theoretical well-mixed model. A discussion of this evaluation is given in reference document 2.1, ASTM Guide D5116-90. It is recommended that SF_6, or an other inert gas, be used as a tracer gas to determine compliance with the theoretical curve. Another useful reference here is Method IP-4B in reference document 2.13. A known concentration and constant supply of SF_6 is introduced into the chamber, and the chamber concentration of SF_6 versus time profile is measured. The time duration of the tracer gas experiment should be comparable to that of the actual experiments with floor covering materials. Mathematically, this experimental curve should comply within a 5% relative standard deviation (RSD) of the theoretical curve. This can be accomplished by estimating the RSD of the mean of the deviation of the difference between the observed and theoretical values. An estimate of the variance is:

$$s^2 = \sum \frac{(o - t)^2}{n - 1}$$

where, o = observed value; t = theoretical value; n = number of observations. The mean of the differences would be:

$$m = \frac{\Sigma (o - t)}{n}$$

The RSD is then:

$$RSD = \frac{s}{m}$$

This mixing evaluation should be confirmed with the flooring mounting substrate in place. An empty chamber may not give a realistic representation of the air mixing within the chamber during actual testing.

5.4. Purified air must be provided as the chamber supply air. It is necessary that the supply air backgrounds be sufficiently low to achieve statistically meaningful analytical measurements at the levels anticipated. Purified air must not have a background contributing concentrations greater than 2.0 $\mu g/m^3$ of TVOC.

Supply air must be accurately and reproducibly metered to the chamber, and maintained at a rate of 1.00 ± 0.05 (precision standard deviation) air changes per hour. The accuracy of this air exchange rate must be confirmed using procedures similar to that presented in ASTM method 741 for tracer gas applications, and found to have less than 10% relative error.

5.5. Other environmental conditions must be maintained reproducibly within the ETC environment including:

Temperature at 23°C ± 1.0°C (precision standard deviation)

Relative Humidity at 50% ± 5% (precision standard deviation) (Initial variance in the chamber may be observed after loading a product as a result of 1) outside air entrance of differing humidity, and of 2) moisture contribution from the product being tested. *These variances should be recorded.)*

Acceptable accuracy levels are 5% average relative standard deviation based on twelve measurements over a 24 hour period as measured within the ETC supply air.

5.6. The chamber must be operated under slight positive pressure (less than 1 inch of water) relative to atmospheric pressure.

5.7. Sample ports must be affixed to the outlet exhaust of chamber in a manner that does not adversely affect the chamber flow. *Experience has shown that acceptable results* are obtained when the sampling protocol does not pull more than 50% of the outlet air flow.

5.8. Appropriate instrumentation must be incorporated in the test system to control and monitor airflow rates, temperature, and humidity. This instrumentation must have adequate accuracy, precision, and sensitivity to control these parameters and to document that the specified data quality objectives are met. Automated process control, monitoring, and data logging systems are recommended.

6.0. SAMPLE HANDLING

6.1. The primary intent of a well-defined sample handling procedure is to ensure preservation of the sample's chemical integrity. This process involves defined and controlled procedures encompassing sample collection, sample packaging, sample delivery to the testing facility and storage of the sample prior to testing. All of these parameters are important once the sample has been collected and until it is tested.

6.2. Sample Collection.

6.2.1. The collected sample must ensure accurate representation of the actual performance parameter being evaluated. Since the measured performance factor, in this case, is TVOC, its composition must be retained and uncontaminated during all the phases of the sample handling process. Because of the low levels of TVOC associated with carpet products, it is recommended that the carpet and associated materials be collected directly from the manufacturer's production line, and packaged immediately. This is the only way to ensure that original sample integrity is maintained.

6.2.2. In actual building usage applications, one may wish to more closely simulate the handling of the product prior to its delivery to a job site. This may be attempted if the handling procedures are known, but it may be very difficult to control. There will be no assurance that the TVOC levels and composition of the product after this type of treatment would be product

specific TVOCs. This approach is not recommended for product specific information. Contamination of the carpet and its associated products may occur by atmospheric exposure, activities and materials during this type of preparatory stage.

6.2.3 For rolled materials such as broadloom carpet and cushions, the sample should be collected as a minimum size of 2 ft. by 2 ft. This will allow for rolling of the product so that there is an internal layer from which a minimum of two samples can be collected from the internal product roll. Other products such as carpet tile should be obtained and packaged so that one internal piece is sandwiched between two outer pieces. Any other solid or liquid material, such as adhesive, should be placed from the manufacturing facility into appropriately clean and sealed metal containers, protecting it from the external atmosphere.

6.3. Sample Packaging.

It is essential to package the product with materials which will not contaminate the product nor allow VOC permeability from either the interior or exterior. Aluminized packaging (shiny side out) lined with polyethylene or Tedlar has given acceptable results with the present sampling procedure. The sample background on the packaging material, as tested according to this protocol, must have a consistent TVOC background emission factor less than 0.010 mg/m^2hr.

6.4. Product Delivery and Storage.

Once the sample is collected and packaged, it must arrive at the testing facility ASAP, with a maximum allowable delivery time of 36 hours following collection. It should then be stored in its packaged state in an environmentally controlled interior space for a maximum period of 48 hours prior to testing. The sample is to remain sealed until it is to be tested. There should not be any preliminary observation of the sample.

6.5. Product Storage.

Following testing, the product should be repackaged and stored for a 6 month time period by the testing facility. This storage should be maintained in an environmentally conditioned interior environment. The test specimen packaging must be air-tight and VOC free as required of the original packaging with a VOC background emission factor less than 0.010 mg/m^2hr.

7.0. PREPARATION OF THE PRODUCT TEST SYSTEM

7.1. A stainless steel plate may be used as the substrate for the carpet cushion material if it is tested alone. The mounting must have the ability to seal the edges of the test specimen or entire mounting block. A stainless steel tray is recommended for this. The installations and systems should be prepared according to the manufacturer's instructions and the use of CRI's Installation Guide for Commercial and Residential Structures, CRI Publications 104 and 105. The manufacturer's instructions should have priority, if available.

Other substrates such as particleboard underlayment or plywood, the most common in residential homes, or other materials, such as resilient flooring, may be used. However, these flooring systems will contribute VOCs and complicate the studies, since they too will be emitters of VOCs. A background control of their VOC emissions must be obtained so that the product test results may take the substrate contributions into account.

7.2. The flooring material must be prepared to comply with a loading ratio of 0.41 m^2/m^3. This loading is based on a standard ceiling height of 2.4 m allowing complete floor coverage with the material being tested. The flooring must be laid on the appropriate sub-flooring and tested as a complete package. The edges of the flooring system, including the sub-flooring and carpet, must be sealed or considerable error could be incurred in the analysis.

Once the appropriate system has been prepared, it should be immediately loaded into the test chamber for testing.

7.3. Installation systems of specific products may be assembled and tested, but individual-product-specific information will not be obtainable. It is simply a "whole" or complete system emission description. If the total system as well as component contributions are required information, then each component and the "whole" will have to be tested.

It is suggested that all component pieces be tested simultaneously in order to avoid aging effects on the individual component contributions to the whole.

7.4. The standard assembly for component testing will be that component installed on the sub-flooring with the edges sealed. The other floorings, as mentioned in 7.1, may be used if specified for special applications.

8.0. ENVIRONMENTAL CHAMBER TESTING PROTOCOL

The testing should be conducted in environmental chambers. These chambers must be constructed and designed to evaluate ultra-trace levels of organic compounds. Chamber test conditions must be controlled if accurate and reproducible data is to be obtained.

8.1. Procedure.

8.1.1. The test chamber shall be purged with purified air prior to loading under normal operating conditions, but without the test specimen. A chamber background test conducted on the chamber must confirm a TVOC background level less than 2.0 $\mu g/m^3$. Once that is ascertained, the chamber may be opened and loaded.

8.1.2. The test specimen is prepared immediately prior to loading, and is subsequently loaded into the chamber so that it is centered and does not interfere with the flow of the supply air.

8.1.3. The standard test chamber operating parameters are:

1.00 $\pm$ 0.05 (standard deviation) Air Changes per Hour

50 $\pm$ 5% (standard deviation) Relative Humidity (Initial variance in the chamber may be observed after loading a product as a result of 1) outside air entrance of differing humidity, and 2) moisture contribution from the product being tested. These variances should be recorded.)

23°C $\pm$ 1.0°C (standard deviation) Temperature

8.1.4. The test specimen is loaded so that the square area of the exposed surface to chamber volume ratio of 0.41 m^2/m^3 is achieved. All edges of the test specimen are carefully cut, and the specimen is placed in a tray with edges equal in height to the carpet thickness.

8.1.5. Samples are collected at points in time consistent with the study objectives (see Section 10). Several points (e.g., greater than 5, taken before the system achieves steady state) are required to define the emission profile of sources with a changing emission factor. A measurement
at a single point in time may be appropriate to compare materials with similar decay rates.

8.1.6. Prior to sample collection, the sampling lines are purged for a total of 5 times their volume. The sampling line length should be minimized to reduce potential sample loss. In addition, the sampling lines should be heated.

9.0. CHEMICAL ANALYSIS

9.1. Chamber Air Collection.

The low levels of VOCs associated with flooring materials require a significant pre-concentration of the air prior to chemical analysis. A multi-bed sorbent trap containing Carbosieve SIII, Carbotrap C, and Carbotrap (Supelco or equivalent) is recommended for this purpose. The adsorbents should be sequentially packed in an appropriate sampling tube in approximately equal amounts separated by glass wool plugs. The adsorbents selected must provide greater than 90% collection and desorption efficiencies for the majority of the chemicals present in the product emissions under the test conditions established for sample collection and analysis. Determinations of efficiency must be supported by an independent quantitation of recovered compounds, such as by interpolation of GC peak measurement into a standard curve obtained by direct injection. Any other sorbent system meeting these requirements may be used.

Allowable maximum collection volumes (V_{max}) and sample collection flow rates (Q_{max}) must be determined for each sorbent system, such that

$$V_{max} = w \times V_b/1.5$$

where V_{max} = maximum total volume in L
V_b = breakthrough volume for the least retained compound of interest in L/g
w = weight of sorbent(s) in g

and $$Q_{max} = 1000 \times V_{max}/t$$

where Q_{max} = maximum flow rate in mL/minute
V_{max} = maximum total volume in L
t = desired sampling time in minutes

For the sorbent system recommended above, the tube should be

1. Purified under an ultra-pure gas flow for a minimum of 8 hours at 275°C.

2. After purification, maintained under a constant ultra-pure gas flow until immediately before use for sampling. Storage is not recommended.

3. After sampling, immediately analyze or seal with stainless steel caps and frozen at -20°C until analysis.

4. Stored for no more than 5 days at -20°C.

Actual sorbent traps must be conditioned in the laboratory making sure that they are purified and contain no greater than 36 ng of TVOC.

Generally, sampling for carpet TVOC can be conducted from 30 mL/minute to 200 mL/minute for a total collection not recommended to exceed 20 liters. The collection volume should be optimized with the sorbent tube preparation. The sampling manifolds must maintain a constant flow rate during the entire sampling period.

Samples are introduced to the GC via a single tube thermal desorber. Samples are desorbed at 275°C for 10 minutes under a carrier gas flow of 40 mL/min. A transfer line heated to 150°C connects the desorber to the head of the GC column. Other types of desorbers may be applicable

if they meet the method accuracy, precision, and detection limit as required in Section 9.5 of the "Test Method." Desorption operating parameters may change for other desorbers.

9.2 Instrumentation.

Rotameters, or any other flow measuring devices used, are calibrated with tubes in line. Ten percent of all tubes purified are used for QC.

The TVOC analysis must be conducted by capillary gas chromatography coupled with flame ionization, mass-selective, or mass spectrometric detection. Sensitivity is comparable between mass selective detectors and the flame ionization detectors, and the compounds associated with the flooring materials respond well to both detector systems. If individual volatile compounds are to be identified, a mass spectrometer or mass-selective detector must be used as the detector. The air sample must be efficiently desorbed from the sample sorbent tube to the analytical instrumentation via a well-controlled, reproducible thermal desorption system.

Tuning and mass standardization is performed according to the manufacturer's instructions, generally using perfluorotributylamine (FC-43). This process may vary among instruments. The FC-43 is introduced directly into the ion source through a molecular leak. Instrumental parameters are automatically adjusted following the sequence below to give acceptable relative ion abundances of:

Mass	% Relative Abundance
69	100
131	>35
219	>24
502	>1

The electron multiplier is adjusted to bring within range the abundances of m/z 69, 219, and 502. The mass range scanned is 20 amu to 600 amu with an allowable scan every 0.5-1 second.

The chromatographic system is comprised of a gas chromatograph equipped with capillary columns and a flame ionization detector, mass-selective detector, or interfaced with a mass spectrometer. The thermal desorption system is interfaced with the gas chromatographic injection system. A description of chromatographic systems and their calibration and operating parameters is given in EPA's "Compendium of Methods for Determination of Toxic Organic Compounds in Ambient Air" (EPA/600/4-89/017) and "Compendium of Methods for the Determination of Air Pollutants in Indoor Air" (EPA/600/4-90/010).

Only high-resolution (capillary column) GC techniques are acceptable for application of this method. The specific column and temperature program employed is dependent on the compounds of interest. In general, a non-polar stationary phase column (e. g., SE-30, SE-54, OV-1), temperature programmed from -70°C to 250°C at 10 degrees/minute is suitable. A fused silica column 50 m in length × 0.3 mm internal diameter is recommended with a helium carrier flow of 1-2 mL/minute.

Chromatographic efficiency should be checked with the TVOC calibration mixture or perfluorotoluene to ensure an asymmetry factor between 0.5 and 2.0. The compound(s) are introduced into the chromatographic system as a "sample." The width of each peak at 10% of its height should not exceed 10 seconds for each of the compounds evaluated.

9.3. Standard Operating Procedures.

The laboratory must present Standard Operating Procedures (SOPs) for all aspects of the analytical procedures with confirmation of their compliance with the detection capability and established QC parameters. The SOP should address:

9.3.1. Assembly, calibration and operation of the sampling system;

9.3.2. Preparation, handling and storage of the sorbent collection media;

9.3.3. Description and operation of the instrumentation systems including the sampling device, sample introduction system, separation chemistry, and data system;

9.3.4. All aspects of data recording and processing; and

9.3.5. The operating procedures should be specific and be readily available to those involved in the analysis and testing. A copy of the method should be retained in the laboratory.

9.4. Quantitation of the analytical system is with a TVOC mixture representative of the types of VOCs present in the sample. The standard mixture contains equal parts by weight hexanol, toluene, cyclohexane, and decane. Data from the calibration standards are used to calculate a response factor for TVOC. Calibration levels of 200 ng, 400 ng, 600 ng, and 800 ng of each component are used for determining calibration curves. The calibration data at the end of each week are pooled to yield a response factor. A daily standard encompassing 400 ng of each component is injected to determine day-to-day precision of response factors. Calibration standards may need to be changed to cover the concentration range of the samples. The average mass response of this mixture is used for quantitation. This mixture must be introduced as a gas into the analytical system and be subjected to the same analytical processes, including sorbent collection, as the sample. The mixture (i.e., liquid or gaseous standard) should be purged from a known source onto the sorbent media. Internal usage of perfluorotoluene or bromofluorotoluene is recommended to

check instrumental system performance of the mass spectrometer. A normal alkane, not present in the sample emissions, is recommended for the flame ionization detector.

9.5. Method Accuracy and Precision.

The requirements for those representative compounds included in the TVOC mix are greater than 90% recovery (incorporating sample collection through analysis) and less than 10% relative standard deviation. Any deviations beyond these are unacceptable. The minimal quantifiable limit is 4.0 $\mu g/m^3$ which is twice the required detection limit of 2.0 $\mu g/m^3$.

9.6. Method Detection Limit.

The system detection limit is obtained from calibration standards and is defined as:

$$DL = A + 3.3\,s$$

where DL = the calculated detection limit in nanograms,
A = the intercept from a least squares calibration curve fit, and
s = the standard deviation of replicate determinations of the lowest level standard.

Experience with this method has shown that the minimal quantifiable limit is twice the detection limit or 4.0 $\mu g/m^3$ which is twice the detection limit of 2.0 $\mu g/m^3$ or 36 ng TVOC. The minimal quantifiable emission factor limit is 0.01 mg/m^2hr emission rate. Obviously, an emission rate represented by a single number is a time average for samples whose emission varies on a time scale comparable to the sampling time.

9.7. All detected mass responses corresponding to the quantifiable limit should be summed and used in the TVOC determination. Calibration is by TVOC-mixture response factor as determined from a calibration curve.

10.0. EMISSION FACTOR CALCULATIONS

10.1. Dynamic chamber testing, as described in this method, provides for the calculation of emission factors for vapor phase organic compounds. The calculation procedure depends on the behavior over time of the source being tested. For the purposes of this method, it is assumed that sources have either constant emission factors or emission factors that exhibit first-order decay over time.

10.2. For sources with constant emission rates, once the chamber concentration reached equilibrium, the emission factor is calculated as:

$$EF = C(N/L) \qquad (1)$$

where EF = emission factor, mg/m^2hr
C = chamber concentration, mg/m^3
N = chamber air exchange rate, hr^{-1}
L = product loading, m^2/m^3

10.3 For sources with an emission factor having a first-order decay, the emission factor is:

$$EF = EF_0 e^{-kt} \qquad (2)$$

where EF_0 = initial emission factor, mg/m^2hr
k = first-order decay constant, hr^{-1}
t = time, hr

EF_0 and k are determined by fitting the following equation to the chamber concentration vs. time data:

$$C = L(EF_0)(e^{-kt} - e^{-Nt})/(N-k) \qquad (3)$$

where C = chamber concentration, mg/m^3
EF_0 = initial emission factor, mg/m^2hr
e = natural log base
k = first order rate constant, h^{-1}
t = time, hr (midpoint of the sampling interval)
N = air change rate in hr^{-1}
L = product loading, m^2/m^3

10.4. If products within a given class of material exhibit similar decay characteristics, a chamber measurement at a single point in time may be used to compare emissions between individual products. The point in time (e.g., 24 hrs) should be determined by preliminary decay rate studies. Equation (1) would be used to calculate a surrogate emission factor that would be used to rank individual products. This surrogate emission factor should not be used in IAQ models to calculate indoor concentrations or to estimate exposures without recognition of the errors and uncertainty it can produce.

11.0. QUALITY CONTROL AND QUALITY ASSURANCE

11.1. A quality control/assurance plan is designed to ensure the integrity of the measured and reported data obtained during product evaluation studies. This program encompasses all facets of the measurement program from sample receipt to final review and issuance of reports.

11.2. Project Description.

A brief description of the project should include identification of the materials to be tested; how the testing is to be conducted; and, who is responsible for various project activities. The project experimental design should be described including the test temperatures, air exchange rate, and material loading; sample collection schedule, procedures, equipment, and materials; analytical system procedures and equipment.

11.3. Data Quality Objectives/Acceptance Criteria.

The QA/QC plan must be based on established data quality objectives and acceptance criteria. These will depend on the purpose of the testing and the capability of the laboratory (equipment and personnel) to conduct the test procedures. Data quality objectives shall be established for the following parameters prior to beginning the testing program:

11.3.1. Test Sample Transfer Time and Environmental Conditions.

Establish tolerable limits for the elapsed time from sample acquisition to testing under an acceptable range of specified environmental conditions.

11.3.2 Test Chamber Conditions and Test Results.

Precision and accuracy limits should be met for each of the following parameters:

PARAMETER	PRECISION	ACCURACY	COMPLETENESS #
Temperature	±1.0°C	±0.5°C	>90%
Relative Humidity	±5.0%RH	±5.0%RH	>90%
Air flow rate	±5.0%	±5.0%	>90%
Substrate area	±1.0%	–	>90%
Sample weight	±1.0%	–	>90%
Organic Concentration	±20% RSD*	–	>90%
Emission factor	±20% RSD*	–	>90%

Completeness characterizes the percentage of the planned measurements that are actually conducted.

* RSD = Relative standard deviation = (s/m)100%
where s = estimate of the standard deviation and m = mean

A common method of estimating s for a variable calculated from several measured quantities, such as EF is here is the root-mean-square approach:

$$s_F = \sqrt{\sum s_i^2 \left(\frac{\partial F}{\partial x_i}\right)^2}$$

Accuracy certifications are supplied by the manufacturers of the sensors who calibrate them against NIST-traceable primary sources. Precision measurements are obtained within the laboratory by continuous recording of the parameters. Non-compliance requires immediate correction and/or replacement of sensors. Calibrated replacements should be kept in the laboratory. Experience indicates that routine calibration and tracking of precision prevents non-compliance. See Sections 11.4-11.8 below.

11.3.3. **Record Keeping and Logs.**

Various logging requirements should be implemented for all test parameters including chamber and analytical performance. Many of these are identified in ASTM D5116-90. Additionally, personnel conducting each procedure should be so noted. Records of the devices used, date and

time of tests, and the test results should be part of the QA/QC recording process. The completeness of records indicates the care and attention given the quality control process.

11.4. Calibration.

Calibration should be frequent enough to assure performance of the system within the specified parameters. Frequency of calibration should be determined prior to the test and periodic equipment checks should be used to verify the maintenance of acceptable performance. Experience suggests that calibration of air flow, humidity, and temperature every two months gives adequate results; in fact, the manufacturers recommend six-month intervals. All calibration and verification measurements should be recorded including the time, equipment, and measurement results.

11.5. Accuracy Determinations.

Accuracy determinations require measurement of a known emission source (e.g., permeation tubes, spiked samples) or test gas. These measurements should be made prior to establishing the project data quality objectives and should be consistent with the overall project objectives. The procedures and materials used for establishing accuracy of the measurement system should be recorded.

11.6. Precision.

Precision determinations require replications sufficient to establish the systematic variation associated with a given measurement. Where multiple chambers are used as part of an experiment, duplicate samples should be used for this determination. Variation in test results from a single chamber and among chambers can be established by use of standardized sources such as permeation tubes for determining organic concentrations and calculated emission rates.

11.7. Duplicate Analysis.

No less than 10% of the samples collected, both analytical and carpet samples, should be subject to duplicate analysis. The results of such analyses should be recorded and assessed to determine the adequacy of the total system performance relative to the project objectives.

11.8. Charting.

Charting quality control data will allow visual analysis of system performance and observation of anomalistic or unacceptable deviations. This may be done by use of the Shewart Chart (reference: Shewart, W.A., 1931, Economic Control of Quality of Manufactured Products, Bell Telephone Laboratories). (Cf. "Manual on Presentation of a Data and Control Chart Analysis", 6th ed., prepared by Committee E-11 on Quality and Statistics, ASTM, 1991.

11.9. Periodic audits should be conducted by external QA personnel, i. e., not by the same person who is running the tests.

12.0. REPORT TEST RESULTS

The purpose of the test report is to provide the reader the ability to understand the conduct of the tests and to assess and interpret the results. To meet these objectives, a complete description of the test objectives, facilities and equipment, experimental design, sample

descriptions, experimental procedures, data analysis, results, discussion, and conclusion, and quality assurance/quality control program.

12.1. Test Report Contents.

The contents of the test report shall include all aspects of the test program relevant to interpretation of results. The report shall be comprehensive and inclusive rather than omitting detail, yet it should be presented as concisely as possible.

12.1.1. Testing Laboratory Identification.

Name, address, phone number, and contact person for the reported testing activity.

12.1.2. Test Objectives.

Purpose of the testing project and the intended use of the results.

12.1.3. *Facilities and Equipment.*

Describe the test chambers, clean air system, environmental measurement and control, sample collection including sorbents, analytical instrumentation, and standards generation and calibration.

12.1.4. Experimental Design.

Describe test conditions including temperature, humidity, air exchange rate, and test materials loading. Include a test matrix listing the test condition and test sample variables and their combinations in the experiment.

12.1.5. Sample Description.

Provide sample description and any given sample information, including , but not limited to, type of material, product history, etc., and sample selection process (e.g., random). For wet samples or samples applied to a substrate, describe the substrate and any measures taken to attach the sample to the substrate or seal the sample edges. Provide information on sample acquisition procedures, sample packaging, storage, transport, and handling upon arrival at the laboratory. Describe environmental conditions and duration of each phase of the process from acquisition until testing.

12.1.6. Experimental Procedures.

Describe the experimental procedures used during testing, including details of the sampling and analysis techniques and references to published methods whenever used. For wet samples or samples installed on a substrate, describe the materials used and the procedures. Describe the timing of air sample collection in relation to the placement of the test specimen in the chamber and operation of the environmental control system for the chamber. Provide the dates for testing and the duration of exposure.

12.1.7. Data Analysis.

Show or reference the methods including appropriate models or equations used to analyze the chamber data to obtain emission factors or emission rates.

12.1.8. Results.

Provide emission factors for each type of sample tested and for each environmental condition evaluated. The sampling time shall be reported as the mid-point of the sample collection. Emission factors can be provided for individual organic compounds and/or total organics. Where total organics are reported, include a description or reference of the method of quantification. Where variable rates are measured, provide a rate constant and describe the calculation method by which it is derived. Describe the accuracy and precision bounds of the test results.

12.1.9. Discussion and Conclusion.

Present the requested results. If required, discuss the relevance of the findings and provide conclusions. For example, describe the effect of temperature and/or air exchange rate on emission factors. Note any anomalies and describe data treatment to address such data.

12.1.10. Quality Assurance/Quality Control.

Describe the QA/QC objectives (see Sec. 11.2) and discuss adherence to the acceptance criteria. The discussion shall include both environmental variables and the results of chemical analyses. Provide the results of duplicate and replicate sampling, and discuss the outcome of any audits. Be both specific and concise. Describe the availability of the QA/QC plan and its storage location.

12.1.11. Reporting Format.

A sample format is attached.

ATTACHMENT

OUTLINE OF REPORT: MATERIALS EMISSIONS MEASUREMENTS

A. TESTING LABORATORY
   1. Name
   2. Phone
   3. Address
   4. Certifications

B. TEST SPECIMEN
   1. Product Identification
      a. Manufacturer
      b. Product Name
      c. Color or pattern
      d. Model Name, Style, or Numerical Designation
      e. Other Identifying Information
   2. Acquisition and Handling
      a. Date Received
      b. Test Specimen Age or Date of Manufacture
      c. Description of Packaging
      d. Storage Conditions
   3. Conditioning
   4. Preparation of Test Specimen

C. CHAMBER TEST CONDITIONS
   1. Temperature (chamber and sampling lines)
   2. Humidity
   3. Air velocity
   4. Air exchange rate
   5. Dates of testing

D. SAMPLE COLLECTION
   1. Timing and Duration
   2. Chamber Loading Ratio
   3. Collection Media
   4. Sampling Rate (i. e., sampling flow rate)
   5. Chemical identification/quantification methods and procedures

E. RESULTS
   1. Procedures Used for Identification of Compounds
   2. Emission Factors: Basis of Calculation
   3. Emission Factors for Specific Compounds
      If absence of any substance is claimed, the relevant detection limit(s)
   4. Emission Factors for Total measured organic compounds (in units of average mass response of the four standards)

F. QUALITY ASSURANCE AND QUALITY CONTROL
   1. Individual responsible for QA/QC plan preparation and oversight
   2. Identification of data quality objectives
   3. Performance of test system against data quality objectives

ATTACHMENT E-1

Annex

EPA Dialogue
Annex Draft 02
Date: 8-20-91

TEST METHOD FOR DETERMINING TOTAL VOLATILE ORGANIC COMPOUND EMISSION FACTORS FROM CARPET UNDER DEFINED TEST CONDITIONS USING SMALL ENVIRONMENTAL CHAMBERS

ANNEX

A1. Modifications For Testing of Adhesives

A1.1 SCOPE

A1.1.1 The purpose of this annex is to provide guidance to interested parties on the use of small environmental chambers for determining total volatile organic compound emission factors from adhesives that are used for the installation of carpet or carpet cushions. The methodology provided in the standard method to which this section is annexed provides the basis for measurements made for adhesives. However, some modifications of the procedures outlined in the standard method for sample handling, preparation of the product system, the environmental chamber testing protocol, chemical analysis, and emission factor calculations are required in order to obtain data that can be used to compare emissions between different adhesives products.

A1.1.2 The annex provides recommendations for procedures that can be implemented to test adhesives. The annex does not include mandatory methods for testing adhesives. Methods for testing adhesives are being developed, but their performance has not been adequately documented for the purposes of a standard method. Interested parties should develop testing protocols based on guidance provided in the standard method and this annex.
Performance of any test program using protocols developed on the basis of recommendations in this annex must be documented using appropriate test procedures. A quality control/quality assurance plan that specifies data quality objectives and acceptance criteria consistent with this standard method should be established to document the integrity of the measured and reported data obtained during testing.

A1.1.3 The user of the procedures recommended in this annex should be aware that the procedures for testing adhesives are currently under development. This annex will be subject to revision based on the results the research.

A1.2 THE ENVIRONMENTAL CHAMBER

A1.2.1 Specifications for the environmental chamber, as described in Section 5.0 of the Standard Method are appropriate for testing of adhesives.

A1.3 SAMPLE HANDLING

A1.3.1 Samples for testing may be procured from manufacturers, distributors, building sites, or retail suppliers. Samples procured for testing should be in an orginal, unopened manufacuturer's container not more than one year old, based on information on the label. The container should be insected to ensure that it has not been previously opened. If the container is suspected to be have been opened, it should be rejected for comparative testing.

A1.3.2 The user should record the following information from the container: manufacturer, product name, product code, lot number, recommended application trowel(s) and rate(s). The user should record the date and location of procurement of the product.

A1.3.3 The product should be stored in its original container at room temperature.

A1.3.4 Containers of adhesives to be tested should not be opened until immediately prior to preparation of the test specimen for placement in the chamber. If signs of physical separation of adhesives (indicated by an oily/resinous layer on the surface) are observed, the container of adhesive should be discarded. However a small amount of condensation of water on the surface does not indicate that the product cannot be tested. Adhesive should be removed from the center of the container from below the surface using a suitable tool. Procedures for removal of test specimens should ensure that the product remaining in the container does not become contaminated. Containers should be immediately closed and sealed after adhesive has been removed for the tests. Excess adhesive removed during specimen preparation should be discarded, not returned to the container. The user should document each occasion when a sample is removed from the container.

A1.4 PREPARATION OF THE PRODUCT TEST SYSTEM

A1.4.1 Although manufacturers may recommend different types of trowels for different adhesives and different product applications, a standardized method for preparation of the test system that uses one trowel size should be implemented to determine compariability and to achieve uniformity on the test specimens. The tester should record and report the mass of adhesive used and calculate and report the emission factor based on the mass of adhesive, as well as based on surface area.

A1.4.2 A stainless steel plate should be used as the substrate for the adhesive if it is to be tested alone. The size of the plate should comply with a loading ratio of 0.41 ml/lht

A1.4.3 The recommended trowel for application of the adhesive is a 1/8 X 1/8 X 3/32 Unnotched trowel held at a 45 degree angle.

A1.4.4 The recommended procedure for application of the adhesive to the plate is as follows:

1) Weigh the clean stainless steel plate.

2) Place the stainless steel plate into a holder designed such that the top suface of the plate is flush with the top surface of the sides of the holder. The surface of the sides of the holder should be smooth and should extend out from the plate a few centimeters so that the holder provides excess surface area along the edges of the plate to facilitate uniform application of adhesive onto the plate.

3) Remove sufficient adhesive from the container so that a uniform application can be made to the plate. Do not use adhesive from the top surface of the container.

4) Holding the trowel at a 45 degree angle, make one pass across the plate to spread the adhesive. Rotate the plate and holder 90 degrees and make a second pass across the plate with the trowel to insure uniform application.

5) Visually inspect the application to determine If it is uniform. If any areas of the plate are not covered with adhesive or the application is not homogenous, reject the specimen and prepare a new one.

6) Remove the plate from the holder and weigh the plate with adhesive. Record the mass of adhesive applied to the plate.

7) Place the plate in the chamber and proceed with the test.

A1.5 ENVIRONMENTAL CHAMBER TESTING PROTOCOL

A1.5.1 Standard test chamber operating p3rameters should be as specified in Section 8.1.3 of the standard method. The relative humidity of the inlet air should be held constant at 50% ± 5%. The humidity in the chamber should be recorded, at a minimum, at each time a sample Is collected.

A1.5.2 Samples should be collected at points in time corgistent with the study objectives, as described in Sections 8 and 10 of the standard method.

A1.6 CHEMICAL ANALYSIS

A1.6.1 During testing, the concentration of VOCs in the air stream from the chamber may vary substantially between intiation of the test and completion of the test. During the intial phase of tests of some adhesives, the concentrations may be sufficiently high to allow direct sampling and analysis of the air stream. During later phases of the tests, preconcentration of the VOCs in the air stream may be required prior to analysis. Sampling methods need to be determined. The effects of water vapor emitted from adhesives will be considered in developing the test method. Calculation of emission factors will be simplified by the use of a single method for sample collection at all time points because complications associated with differences In collection efficiency are precluded.

A1.6.2 Quantitation of the analytical system will be with a TVOC mixture representative of the types of VOCs in the sample. The composition of the standard mixture needs to be determined in development of the test method.

A1.7 EMISSION FACTOR CALCULATIONS

A1.7.1 As stated in the standard method, the procedure for calculation of emission factors of VOCs depends on the behavior over time of the source being tested. If the adhesive has an emission factor having a first order decay, procedures described in Section 10.0 of the method can be used. If the adhesive does not exhibit simple exponential decay emissions over time, other emission models may be required.

A1.7.2 Emission factors should be reported in both surface area and mass of product units.

APPENDIX F

Carpet and Rug Institute Consensus Statement: Testing Program for Carpet Products

CARPET POLICY DIALOGUE

CARPET AND RUG INSTITUTE CONSENSUS STATEMENT:

Testing Program for Carpet Products

February 28, 1991

PREFACE

The Carpet Dialogue Group, convened by the U.S. Environmental Protection Agency, is engaged in a one-year effort to develop consensus and voluntary commitments with respect to approaches for minimizing exposure to volatile organic compounds (VOCs) emitted by carpet and associated products of carpet flooring systems (FR: April 24, 1990 - "Carpet: Response to Citizens' Petition" p.17404-17409; and, FR: August 3, 1990 - "Carpet Emissions Reduction; Policy Dialogue" p.31640-34641).

This document conveys a consensus statement of the Carpet Dialogue Plenary Group regarding the commitment by the carpet industry, as represented by the Carpet and Rug Institute (CRI), for the voluntary development and communication of TVOC test data on carpet.

Additional statements and reports concerning other aspects of the Carpet Dialogue are anticipated.

CARPET DIALOGUE

Consensus Statement
for the
Carpet and Rug Institute:

Testing Program for Carpet Products

1.0. BACKGROUND

1.1. Charter and Charge
1.2. CRI Statement of Commitment

2.0. DEFINITIONS

2.1. Total Volatile Organic Compounds (TVOC)
2.2. Boundary of Subject Matter
2.3. Voluntary Action
2.4. Analytical Test Method

3.0. CARPET PRODUCT TESTING PROGRAM

3.1. Rationale for a Carpet Product Variability Study
3.2. Study Objectives
3.3. Scope & Structure of Study
3.3.1. Carpet product type selection criteria
3.3.2. Sample collection & analytical test method
3.3.3. Study design sampling matrix for analytical testing
3.4. Data Reporting & Evaluation
3.4.1. Statistical analysis
3.4.2. Data presentation
3.4.3. Initial program evaluation
3.4.4. Public study report on industry profile
3.5. Independent Contractors & Data Quality Standards

4.0. FOLLOW-ON ACTIVITIES

4.1. Future Activities
4.1.1. Annual industry report
4.1.2. QA product certification
4.1.3. Public communication

4.2. Information Repository
4.3. Memorandum of Understanding

Attachment F-1 Carpet Emissions Decay Study

Attachment F-2 Minority Report on Carpet Testing Agreement

CARPET AND RUG INSTITUTE
CONSENSUS STATEMENT:

Testing Program for Carpet Products

1.0. BACKGROUND

1.1. Charter and Charge

The charter for testing under the carpet dialogue process was given in the U.S. Environmental Protection Agency's Federal Register notice of April 24, 1990 in responding to the petition by the National Federation of Federal Employees (NFFE) for EPA to undertake certain actions with respect to reducing emissions from carpet (FR: April 24, 1990 - "Carpet: Response to Citizens' Petition" p.17404-17409; and FR: August 3, 1990 - "Carpet Emissions Reduction; Policy Dialogue" p.31640-34641). The Carpet Dialogue Group, convened under the auspices of the U.S. Environmental Protection Agency, is engaged in a one-year effort to develop consensus and voluntary commitments for minimizing exposure to volatile organic compounds emitted from carpet and associated products of a carpet flooring system.

This document conveys the Carpet Dialogue Group consensus statement regarding the commitment of the carpet industry as represented by the Carpet and Rug Institute (CRI) to undertake voluntary testing for total volatile organic compound (TVOC) emissions from new carpet products, establishment of a database for reporting periodic TVOC analysis for new carpet products, and communication of useful information about TVOC emissions from new carpet products. Specifically, it describes a testing program to develop data to determine a profile of TVOC measurements among a representative sample of new carpet products. Its acceptance was affirmed by the Carpet Dialogue Group meeting in plenary session on February 28, 1991.

1.2. CRI Statement of Commitment

Since there are no universally accepted air quality standards, guidelines, or regulations that are applicable to carpet, the CRI regards the dialogue and this agreement as a vehicle to accelerate the exploration and understanding of voluntary pollution prevention as one component in improving indoor air quality. CRI has committed resources to this initiative in their belief that a voluntary program will promote industry-wide improvements to improve product performance with respect to indoor air quality.

This voluntary testing program commitment by the CRI addresses issues discussed in the Federal Register notice. It provides for a CRI sponsored industry-wide profile of carpet products which would serve as a base for any future measurement of TVOC emissions from new carpet products, both with respect to industry-wide trends or company-specific quality assurance. CRI and the Carpet Dialogue Group recognize that this testing agreement is only one element in a continuing program of responsible product stewardship. The Carpet and Rug Institute has formally committed itself to a voluntary initiative aimed at improvement of indoor air quality through measures within the purview and resources of its members. The full breadth of the CRI program consists of five main parts.

(1) To generate a TVOC data base for carpet products as described in this document,

(2) To present the U.S. Environmental Protection Agency with a profile of carpet emissions derived from item (1),

(3) To generate a history of TVOC levels through ongoing, periodic monitoring, which would be available for trend analysis and could be used for remedial action,

(4) To motivate manufacturers to institute voluntarily quality assurance measures to reduce TVOC emissions through a CRI-established certification program as their contribution to better indoor air quality,

(5) To inform the general public and carpet customers of the carpet industry's quality assurance program and its results on a periodic basis.

The focus of this statement is to detail the first two items listed above. Other components of the comprehensive CRI program are mentioned briefly as future follow-on activities. It is anticipated that EPA and CRI will enter into a memorandum of understanding (MOU) which will describe procedural arrangements for implementation of the voluntary carpet testing program and follow-on activities.

2.0. DEFINITIONS

2.1. Total Volatile Organic Compounds

Total Volatile Organic Compounds (TVOC), as defined in this document, represents the sum of volatile organic compounds (VOC) that can be analyzed and measured by the specified analytical method. TVOC, is reported as an emission factor in mg/m^2hr and is a single numerical expression for the sum of VOC emissions from a test substance (carpet product). This numerical expression will be used to direct scientific efforts and to communicate useful information to the interested public.

2.2. Boundary of Test Subject

Carpets are defined as a variety of fabric products used for floor covering that are manufactured from various materials by tufting, weaving, knitting, needle punching, custom tufting, or fusion bonding. For the purpose of this voluntary test agreement the test subject is restricted to carpet products as obtained at the end of a manufacturer's carpet finishing line. Such products are referred to in this document as new carpet and the terms carpet and new carpet are synonymous.

The compositional elements used in the manufacture of carpet includes: face fiber, primary backing, latex, secondary backing, dye/colorant, and topical treatment. There are numerous materials and/or processing procedures that can be brought together to form the many combinations that comprise the full range of carpet products currently available in the marketplace.

On behalf of the carpet industry, the CRI has determined that carpet product types can be resolved into two general groupings: softback and hardback. The softback group is a broadloom carpet product comprising 94% of the total market share and produced at about 151 finishing lines. The hardback group is a tile product with a thicker backing, comprising 6% of the market share and produced at about 20 finishing lines.

2.3. Voluntary Action

This voluntary agreement to conduct TVOC emissions testing for new carpet products is undertaken by the carpet industry as part of a continuing commitment to product stewardship. The program is implemented with respect to products as produced by the manufacturer and may include industry guidelines for proper installation, maintenance and care of carpet products.

point for on-going testing and evaluation which is one of the goals of the Federal Register charter. The program will be implemented so as to preserve necessary proprietary information and establishes the basis for appropriate inter-product comparison.

2.4. Analytical Test Method

The analytical test method selected to obtain TVOC measurements for carpet products is a small chamber technique. The environmental chamber method was described by the U.S. EPA in its document "Indoor Air Sources: Using Small Environmental Chambers to Characterize Organic Emissions from Indoor Materials and Products," (EPA report 600/8-89-074). The method is an ASTM standard, "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/ Products" (ASTM D5116-90). The analytical techniques described in these documents have been further refined to measure TVOC emissions from carpet products (Appendix E: "Standard Test Method for Determining Total Volatile Organic Compound Emission Factors from Carpet Under Defined Test Conditions Using Small Environmental Chambers"). TVOC data for carpet products obtained from this standardized small chamber testing procedure may be used to compare and evaluate carpet's relative contribution to indoor air quality with TVOC data from other products.

The standard analytical method, as described in Appendix E, provides accurate TVOC measurements. The minimal quantifiable limit is 4.0 ug/m³ which is twice the detection limit of 2.0 ug/m³ or 36 ng TVOC. The TVOC concentration measured in the environmental chamber is used to calculate an emissions factor expressed as mg/m^2hr.

The emissions factor is a product-specific factor describing the mass of chemical emitted from the product per exposed area of the product per unit time. The quantifiable limit expressed as an emission rate is 0.01 mg/m^2hr. The emission rate is projected by multiplying the emissions factor by the area of carpet in a particular installation.

Emission factor data may be generated at various time intervals. At this time, based on decay curve characteristics for SBR latex carpet products, the study design calls for a single time-point measurement. Although it may be possible to project a decay curve for all types of carpets from a single point using standard modelling procedures, further information is needed regarding the decay curve characteristics for non-SBR carpet products to resolve the question of whether a single point and which single point will be most representative of product performance. This question will be evaluated by the Phase I testing component of the Carpet Testing Program through the evaluation of existing decay curve data for SBR latex-backed carpet types and the development of additional decay curve data on non-SBR latex-backed carpet types. The resolution of this question will be integrated into the finalized analytical method which is attached as Appendix E.

The analytical test method has been documented by an expert working party of the dialogue's Design/Testing Subgroup and a draft is being circulated for peer-review. The method, with peer-review revisions incorporated, will be available and has been judged by the Carpet Dialogue Group on November 29, 1990 to be an acceptable analytic tool for any industry study undertaken in 1991 under the aegis of this carpet dialogue process. This test method will be submitted to ASTM by its principal originator as the basis for a first draft proposal for ASTM balloting procedures for new techniques. Further validation by interested laboratories is expected in the course of the next two years.

3.0. Carpet Product Testing Program

The Carpet Testing Program will be organized into two distinct studies. The first will be to develop decay curve emission data on six (6) hardback carpet product types. The product types to be studied and decay

curve test details are outlined in Attachment F-1. The decay curve data established on the hardback products will be compared with the decay curve characteristics for the previous nineteen (19) SBR latex-backed carpet products evaluated by Air Quality Sciences, Inc. (AQS). A comprehensive decay curve analysis will be conducted to determine the appropriate air sampling time point, or points, to use in measuring TVOC emissions in the larger industry profile study. The second will build a data base/profile of TVOC emissions from a representative sample of carpet product types. Data from the decay curve study and the SBR latex-backed carpet profile study can be used to show an industry-wide profile of TVOC emissions for carpet products currently available in commerce.

3.1. Rationale for Carpet Product Testing

Exploratory data developed in 1990 for the CRI by the AQS led to a preliminary CRI hypothesis that there may not be significant variability across carpet products made with SBR latex. This preliminary data set did not include information about non-SBR latex carpet types. Testing under the profile study will evaluate the preliminary CRI hypothesis and further characterize the range of industry-wide product performance with respect to TVOC emission rates. The decay curve characteristics from non-SBR latex carpet product types when compared with the SBR latex-backed carpet product decay curve data will provide a basis for selecting a sampling time point(s) for use in any follow-on testing.

The data developed from these carpet product testing studies will provide the Carpet Dialogue Group, industry, regulatory agencies, and the interested public with additional information to assess whether there is sufficient variability of TVOC emissions across carpet products to warrant communication of TVOC information on individual carpet products to the interested consumer.

3.2. Study Objectives

The overall Carpet Testing Program objective is to characterize quantitatively the distribution of TVOC emissions factor performance of carpet product types currently in commerce as defined by the selected study sampling of available products. These data will also address the question of TVOC emission variability, or the lack thereof, across carpet product types.

3.3. Scope and Structure of Study

3.3.1. Carpet product type selection criteria

Three materials factors will be used to define carpet product types in commerce: face fiber, topical treatment, and backing. The latter were selected as being the most prominent materials in the construction of carpet and also having some possible relevance to product VOC emission performance. By using these materials factors as the organizing constituents in a sampling roster, the full range of carpet product types currently available in commerce can be identified for study. Inclusiveness is essential to profile the industry and permit a factorial analysis to address the question of variability across product types.

A canvas of current products shows that there are twenty-five (25) carpet product types in commerce with eight (8) SBR latex-backed carpet product types accounting for roughly 94% of the market and seventeen (17) non-SBR latex-backed carpet product types accounting for roughly 6% of the market. A few of the non-SBR backed carpet product types may be produced by only one or two mills and may, therefore, be deleted

from the final draw for reasons of low market share. It is judged that this roster comprises over 98% of carpet types produced for general and commercial commerce.

The roster of currently produced commercial products and their market shares, as determined by CRI, is summarized in Table 1. It shows the 25 product types that could be sampled.

3.3.2. Sample collection & analytical test method

The method for sample collection at the carpet mill, sample transport to the laboratory, and TVOC analysis is described in Appendix E. This method will be used throughout the Carpet Testing Program. Details of the decay curve testing study of non-SBR latex-backed carpet are described in Attachment F-1.

3.3.3. Study design sampling matrix for analytical testing

Table 2 (SBR latex-backed carpet product types) and Table 3 (non-SBR latex-backed carpet product types) show the product combinations to be sampled and the number of carpet samples from each carpet product type to be collected and analyzed by the methods described in section 3.3.2. When all data are available from both studies, the TVOC emissions factors measured at the appropriate time point(s) obtained from these samples will be analyzed as a single combined data set. Thus, a total of seventy-eight (78) samples will be statistically analyzed in the combined carpet product profile study. Specifically, fifty-four (54) samples are SBR latex-backed carpet product types and twenty-four (24) are non-SBR latex-backed carpet product types. Eighteen (18) of the non-SBR latex-backed carpet product type combinations will be initially collected for the Decay Curve Study. The appropriate air sampling time point(s) (e.g., 24 hrs) corresponding to these samples will be used in the Profile Study. The remaining six (6) samples will be collected and analyzed after the SBR latex-backed carpet samples are analyzed using the appropriate air sampling time point(s) as determined from the decay curve data set. The samples and repeat samples (i.e., samples collected on different days from the same finishing line) will be selected from the manufacturing finishing lines (about 151 for the SBR latex profile study and about 20 for the decay curve study) to permit an evaluation of line to line and day to day variability of TVOC emissions factor. In addition, this combined data set will also permit evaluation of the effects on TVOC emissions factor for fiber type, topical treatment, and backing material.

For each row (product combination) in Tables 2 and 3, the number of finishing lines indicated in the column labeled "lines" will be drawn randomly from all lines making that product combination at the time the samples for that combination are to be collected. In addition, some of these lines, chosen at random from the selected lines, will have a repeat or second sample taken on a different day. The number of lines contributing a repeat sample is given in the "repeat samples" column. For example, for the first combination in table 2 (i.e., nylon/no treatment/SBR latex), six lines will be chosen at random from all lines making this carpet product type and three of these lines, chosen at random from the six, will be sampled a second time on a different day. Since the product combinations listed in Table 3 are not widely manufactured, it may occur that only one finishing line is the sole source for a specified product combination. In this case, a second sample from the same line will be taken on a different day.

Additional quality assurance (QA/QC) samples (about 10% of the total samples tested) will be taken in accordance with standard data quality procedures of the U.S. EPA.

3.4. Data Reporting and Evaluation

The data analysis will follow the lines of the objectives defined in section 3.2.

TABLE 1.

ROSTER OF CARPET PRODUCT TYPES.[1]

	Carpet Product Types			% Market Share
	Fiber	Topical Treatment	Backing	
1	Nylon	no treatment	SBR[2] latex	
2	Nylon	soil release	SBR latex	
3	Nylon	soil/stain resist.	SBR latex	70.20
4	Nylon	no treatment	AR[3] hardback	
5	Nylon	soil release	AR hardback	0.73
6	Nylon	no treatment	Urethane foam	
7	Nylon	soil release	Urethane foam	
8	Nylon	soil/stain resist.	Urethane foam	1.70
9	Nylon	no treatment	PVC[4] hardback	
10	Nylon	soil release	PVC hardback	1.30
11	Nylon	no treatment	EVA[5] hardback	
12	Nylon	soil release	EVA hardback	0.57
13	Nylon	no treatment	Urethane hardback	
14	Nylon	soil release	Urethane hardback	0.20
15	Nylon	no treatment	Bitumen hardback	
16	Nylon	soil release	Bitumen hardback	0.10
17	Olefin	no treatment	SBR latex	
18	Olefin	soil release	SBR latex	14.90
19	Olefin	no treatment	Urethane foam	
20	Olefin	soil release	Urethane foam	0.88
21	Olefin	no treatment	Urethane hardback	
22	Olefin	soil release	Urethane hardback	0.02
23	Polyester	no treatment	SBR latex	
24	Polyester	soil release	SBR latex	8.70
25	Wool	insect resist.	SBR latex	0.70
			Total	100.00

1 The CRI has determined that products with EVA latex-backing are no longer manufactured.
2 Styrene butadiene rubber
3 Amorphous Resin
4 Polyvinyl chloride
5 Ethylene vinyl acetate

TABLE 2.

DATA BASE/PROFILE STUDY SAMPLING MATRIX OF SBR LATEX PRODUCT TYPES.

Carpet Product Types			No. of	No. of	Market	
Fiber	Topical Treatment	Backing	Sampled Lines	Repeat Samples	Share %	Total Samples
Nylon	no treatment	SBR latex	6	3		
Nylon	soil release	SBR latex	6	3		
Nylon	soil/stain res.	SBR latex	6	3	70.2	27
Olefin	no treatment	SBR latex	4	2		
Olefin	soil release	SBR latex	4	2	14.9	12
Polyester	no treatment	SBR latex	4	2		
Polyester	soil release	SBR latex	4	2	8.7	12
Wool	insect resist	SBR latex	2	1	0.7	3
	Total		36	18		54

TABLE 3.

DECAY CURVE STUDY AND ADDITIONAL PROFILE SAMPLES SAMPLING MATRIX OF NON-SBR LATEX PRODUCT TYPES.

Carpet Product Types			No. of samples		Market	Total
			Decay	Add'l	Share	No. of
Fiber	Topical Treatment	Backing	Curve	Profile	%	Samples
Nylon	no treatment	AR hardback	2	0		
Nylon	soil release	AR hardback	1	1	0.73	4
Nylon	no treatment	PVC hardback	1	1		
Nylon	soil release	PVC hardback	2	0	1.3	4
Nylon	no treatment	EVA hardback	1	1		
Nylon	soil release	EVA hardback	2	0	0.57	4
Nylon	no treatment	Urethane hrdbk	2	0		
Nylon	soil release	Urethane hrdbk	1	1	0.2	4
Nylon	no treatment	Urethane foam	1	0		
Nylon	soil release	Urethane foam	1	1		
Nylon	soil/stain res.	Urethane foam	1	0	1.7	4
Nylon	no treatment	Bitumen hrdbk	1	1		
Nylon	soil release	Bitumen hrdbk	2	0	0.1	4
	Total		18	6		24

3.4.1. Statistical analysis

A factorial analysis of the "78 point" profile study data will be performed using a standard statistical technique known as analysis of variance. This method will be used to determine the effects on TVOC of five factors: fiber type, topical treatment, backing, line to line variation, and temporal (day to day) variation within a single finishing line. The first three factors are known as "fixed" effects and analysis of these data will be used to determine the effects on TVOC emissions of different fiber types, topical treatments, and backings. The last two factors are considered "random" effects. These analyses will produce estimates of the variability in TVOC emissions due to line to line differences among manufacturing lines producing the same carpet product type, and day to day differences in the operation of a single manufacturing line. All results will be accompanied by an estimate of the statistical uncertainty (95 percent confidence limits) associated with them. These uncertainties are due to sampling or product variability, as well as measurement error.

As part of the statistical investigation of the three fixed effects, the presence of two-way interactions will be tested. An interaction between two factors means that the effects of one of the factors on TVOC emissions depends on the particular setting of the other. For example, if the effect of soil release treatment (versus no treatment) depends on the fiber type, it is stated that there is a fiber type/topical treatment interaction. If statistically significant interactions are identified in the profile data, they will be presented and discussed in the final report.

Upon receipt of the data from the testing laboratory, the data will be examined to determine the need for data transformation. Traditionally, data sets of the type anticipated from these studies often exhibit a large dynamic range (e.g., factor of 5 or more) and tend to be highly skewed. Data sets of this sort are frequently transformed to a lognormal scale for analysis purposes. This is because the effects of factors and variance of the measurements tend to be multiplicative rather than additive when the dynamic range is large. This means that the geometric means, rather than the arithmetic averages, will be estimated in the statistical modeling analysis. Regardless of any transformation of the data, the findings from the statistical analysis will be reported in the original measurement scale (TVOC emissions factor).

The analysis will include examination of the data for outliers or atypical TVOC levels. This investigation, to be conducted by CRI, will seek to determine whether the product sample was handled according to good laboratory practices or whether any abnormalities occurred during the conduct of the chemical analysis procedures. Product types which are atypical in the sense that the combination yields repeatable tvoc emissions levels which are unexpected (high or low relative to other product types) will also be investigated. The results of these investigations will be reported in the results section of the final report.

3.4.2. Data presentation

Data from the decay curve study (non-SBR latex-backed carpet product types) will be depicted graphically to show the TVOC decay curve for sample tested across the six (6) measured time points. Data will be compared with the available ninteen (19) point data set previously determined by AQS for the decay curve characteristics of SBR latex-backed carpets. An evaluation of the applicability of standard time point(s) for TVOC measurement will be made from this data presentation. Given the small market share of many of the non-SBR latex-backed carpet products and the small number of finishing lines, all hardback carpet product types will be coded to facilitate a full assessment of the data collected without identifying individual carpet product types. Sample collection will be arranged in order to allow for an assessment of the production variability within a product type.

The industry-wide profile will consist, in the first data display, of the "78" data points showing TVOC emissions factor values for each product type studied in the Carpet Testing Program (both SBR and non-SBR latex-backed product types). In the second data display, fourteen (14) data points will represent the average

value for each carpet product type studied in the Carpet Testing Program. The averaged data display will exhibit a high end, a low end, and a median for TVOC emissions from SBR latex-backed carpet products.

The distribution of data from the profile study will characterize a typical industry-wide profile of carpet product type performance: industry-wide with respect to product types in commerce and also to manufacturer sources. The distribution would be statistically analyzed to identify outliers and allow the industry to pursue them for remedial action (high emitters) or for clues to reducing emissions industry-wide (low emitters). This use of test data could provide a basis for developing further programs to meet the Carpet Dialogue's goal of creating market pressure to drive down VOC exposures from carpet systems.

Individual data from the carpet testing program will be blinded to protect the identity of individual manufacturers. This approach allows the full import of the factorial analysis to be evaluated, including the identification of "outlier" phenomena.

3.4.3. Initial program evaluation

EPA will evaluate the results of the Carpet Testing Program in terms of analytical results and conclusions, and will determine the variability and appropriate characterization of carpet product emissions factors. EPA will use this technical evaluation to determine the need for follow-on testing. This evaluation will also judge the extent to which the decay curve study, carpet profile study, and appropriate follow-on measures, if required, have met the goals and concepts of the Federal Register notice. These evaluations and assessments will be pivot points in the transition from the initial data gathering stages of the CRI five-point program (see 1.2, items 1 and 2) and the application objectives/follow-on activities of the CRI program (items 3, 4, and 5). Details of the follow-on activities are described in section 4.1 through 4.3. The specific features of the follow-on program will be determined by EPA and CRI in consultation with the Carpet Dialogue Group. Among the issues to be considered at this pivot point is whether further experimental data are necessary to address the objectives of the Federal Register notice.

3.4.4. Public study report on industry profile

CRI will provide a full report on the Carpet Testing Program including the profile monitoring study and the decay curve study to the U.S. EPA. The document will include: TVOC data for each SBR latex-backed carpet product type tested (identified by carpet product type) and non-SBR latex-backed carpet product type tested (reported as a data set unidentified by carpet product type), comparision data of carpet product decay curve characteristics with assessment of a standard TVOC measurement time point(s), uniform latex loading for SBR-containing products, statistical/ variability analysis and graphic presentation(s) of the data, discussion of the study findings, and a laboratory report on field/laboratory quality assurance aspects of the study. The report may also contain a perspective about the relative contribution from various new carpet product types to the total VOC loading in the indoor environment. The EPA will make this information available to the interested public through various mechanisms including a notice of availability in the Federal Register.

3.5. Independent Contractors and Data Quality Standards

As CRI membership comprises over 95% of U.S. carpet manufacturers, it is appropriate that CRI sponsor the study and bear full responsibility for rigid scientific constructs. CRI will obtain the necessary permission and legal clearances to permit collection of samples at its member mills in accordance with the study protocol. To assure accuracy of test results and to minimize conflict of interest, an independent laboratory will be retained to conduct product testing. The laboratory will be selected on the basis of its ability to fulfill the proposed protocol for sampling and analysis and documented assurance that testing will be conducted in

accordance with good laboratory practices and standard U.S. EPA guidance for QA/QC. The protocol will include provision for using only appropriately trained personnel hired by the laboratory to perform sample collection and transport. In addition to an experimental study protocol, there will be prepared a quality assurance project plan specific to this Carpet Testing Program which would follow OTS/EPA guidance. All QA/QC evaluation will be included in the study report as will the extent to which the results met the defined data quality objectives.

CRI intends to initiate product testing in the Spring of 1991 with a view to generating preliminary results in the Fall of 1991. The U.S. EPA would provide technical counsel as it does on other voluntary testing agreements to ensure that data quality objectives are met in the Carpet Testing Program.

It is understood by all parties to this agreement that CRI will fulfill the voluntary program commitment described herein on a cost-effective basis. CRI believes that it has committed sufficient budgetary resources to support the five-point program. However, as detailed implementation plans are developed it should be understood that modifications may be made not only on technical grounds but also to meet evolving cost estimates.

4.0. FOLLOW-ON ACTIVITIES

During the balance of the dialogue year it is the intent of CRI to work with the U.S. EPA, other experts, and the Carpet Dialogue Group along with its various working subgroups, to expedite implementation of the five point program outlined in section 1.2. CRI will continue to report to the plenary on their progress to reach these objectives.

4.1. Future Activities

To the extent that further development of subsequent phases of the CRI five-point program are dependant upon information obtained from the data base study, follow-on activities are not fully detailed in this consensus statement. They are mentioned here to describe the comprehensive nature of the CRI commitment to respond to the Federal Register notice. The selections, specific direction and features of follow-on activities will be developed in consultation between EPA and CRI.

4.1.1. Annual industry report

CRI will generate an annual, aggregate history of carpet industry TVOC product performance for at least three years. The data will be derived from company submissions under the QA product certification program described below (see 4.1.2). These data will be used to reveal trends over time relative to the overall industry-wide profile and, in future, to product types. The trend analysis will be a means to pursue problematic, "outlier product" instances and to evaluate the success of the carpet industry in reducing TVOC levels.

4.1.2. QA product certification

CRI, in consultation with EPA, will devise a program to motivate producers to institute voluntary indoor air quality assurance measures with respect to their carpet products. This program would have prescribed procedures documented in an operational manual to be developed by CRI for its members. It would, at a minimum, include the development and submission to CRI of TVOC emission rate data on product types by companies.

This information would enable the CRI to pursue the trend analysis for typical carpet products as described above and to take voluntary actions for improvement or remedy of "outlier products" with member manufacturers. CRI is prepared to publish a roster of companies which have received TVOC performance certification within a given year.

4.1.3. Public communication

CRI, in cooperation with EPA and the Carpet Dialogue Public Communications Group, will conduct a consumer information program to provide their customers with appropriate information on TVOC emissions from carpet. Depending on the conclusions to be drawn from the testing described in Section 3, this information program may include either product-by-product/company-by-company numeric information on TVOC levels or, if appropriate, more generic information from industry-sponsored product certification and annual aggregate
analyses. The consumer information program will ensure that carpet TVOC emissions are placed in an appropriate context with other indoor air pollution sources.

4.2. Information Repository

Reports on studies undertaken under the aegis of the carpet dialogue will be provided to the U.S. EPA which would maintain an on-going public file of this information in its public data docket facility. This permanent repository of information would be readily available to the interested public and serve as the reporting place for the proposed annual aggregate/trend analysis, QA product certification, and public communication products.

4.3. Memorandum of Understanding

To give shape and substance to the on-going testing program and the EPA objective to attain commitments to conduct voluntary product testing for TVOC, the CRI and the U.S. EPA, will enter into a memorandum of understanding at or before the close of the dialogue process. This MOU will incorporate basic elements of this consensus statement and other procedural arrangements common for voluntary testing agreements in OTS. The MOU will be made public through a Federal Register notice.

ATTACHMENT F-1

THE CARPET AND RUG INSTITUTE CONSENSUS STATEMENT:

Carpet Emissions Decay Study

ATTACHMENT F-1

THE CARPET AND RUG INSTITUTE
CONSENSUS STATEMENT:

Carpet Emissions Decay Study

To determine the appropriate point in time to sample carpet emissions, a study in addition to the study conducted on 19 SBR latex carpet samples will be undertaken. In this study, the data on emissions factors and their decays will be determined over a period of sufficient duration to ensure that a carpet with higher emissions at an early point in time maintains its relative ranking with respect to other carpets at later points in time.

To do this, the following elements of a study will be supplied by the Carpet and Rug Institute via a test program conducted by Air Quality Sciences. This study will be Phase I of the larger study to establish a carpet emissions profile for the industry as defined in the Consensus Statement.

1. The emissions factor data provided by Air Quality Sciences on the 19 styrene-butadiene rubber (SBR) backed carpets are provisionally accepted as having demonstrated that 24 hours may be an appropriate sampling time for determining total volatile organic compound (TVOC) emissions from this type of carpet.

2. To confirm that the relative ratings do not change among SBR backed carpet after 24 hours, Air Quality Sciences will provide TVOC data over time for each of the tests of the 19 carpets as well as data on the chamber air exchange rate and product loading (m^2/m^3).

3. To determine whether 24 hours is an appropriate sampling time for non-SBR backed carpet, additional tests of emissions factors over time will be conducted. The carpet samples selected for this additional TVOC emission testing will include six types of non-SBR backed carpet:

   a. Nylon, Foam Urethane
   b. Nylon, Urethane Hardback
   c. Nylon, AR Hardback
   d. Nylon, PVC Hardback
   e. Nylon, EVA Hardback
   f. Nylon, Bitumen Hardback

4. Carpet samples will be selected by the predominant topical treatment and collected by a mutually agreed upon neutral individual (neither CRI nor EPA). There will be three samples from each type of carpet. In those cases where there is more than one mill producing a carpet type, two samples from one mill and one sample from another mill will be collected. In the case of a single source product type, three samples will be collected on three separate days from the single source mill. Thus, TVOC emissions and their decays will be determined from a total of 18 non-SBR backed carpets. A complete replicate set of the 18 carpet samples will be retained and stored by AQS.

5. The test method employed by Air Quality Sciences will be as per Appendix 1 of the Air Quality Sciences draft report "Indoor Air Quality Evaluation of Carpet for the Carpet and Rug Institute, January 8, 1991." except as noted below:

   Chamber air samples for the measurement of TVOC concentrations will be taken by Air Quality Sciences at 6 points in time: 4 hrs; 8 hrs; 24 hrs; 48 hrs; 72 hrs; and 96 hrs. These TVOC concentrations will be reported as well as data on the chamber air exchange rate and temperature and product loading (m^2/m^3).

Limited to this decay curve study, concentrations will be determined by both the flame ionization detection and mass spectrometric detection methods in order to determine a correlation (if any) between them. TVOC data for both methods will be reported to the EPA. The mass spectrometric speciation data for each carpet sample tested in the decay curve study will be retained by Air Quality Sciences.

6. At the completion of the Phase I study, Air Quality Sciences will prepare a comprehensive report of the TVOC data. Since most of the 6 non-SBR latex-backed carpets for this study are proprietary in nature and supplied by a single source, product types will be coded to facilitate a full assessment of the data collected without identifying individual producers. Sample collection will be arranged in an order to allow for an assessment of the production variability within a production unit.

7. Bruce Tichenor will provide technical oversight to Air Quality Sciences.

8. The Carpet and Rug Institute is prepared to commence immediately with the collection and testing of these six carpet products (18 samples) as Phase I of the overall test plan referenced in the Conensus Statement for submittal to the U.S. EPA.

ATTACHMENT F-2

Minority Report on Carpet Testing Agreement

ATTACHMENT F-2

MINORITY REPORT ON CARPET TESTING AGREEMENT

This report reflects concerns of the undersigned that the testing program, as it deals with SBR-backed carpets as outlined in Draft 7 (of 2/28/91), fails to provide all the information it should to the Dialogue. By this failure, the testing program ignores Charges 2 and 3 to the Dialogue regarding information needs and assessment of possible control methods for reducing emissions from carpet. Charge 2 reads, in part:

> "Identify information needs for assessment of emission control feasibility, including data on carpet manufacture....

Charge 3 reads, in part:

> "Evaluate potential controls for reducing emissions.....

Volatile organic compounds enter the carpet installation system at many points, including several points during carpet manufacture, e.g. as spinning oils for fiber manufacture, as dye solvents/carriers, as soil- and stain resistance aids, and as components of the backing.

Clearly, if the dialogue is to take seriously its charge to evaluate potential engineering- and/or process controls for reducing emissions it must generate knowledge as to the sources of those emissions. Unless it can be shown that emissions arising from spinning oils, dye-related chemicals, soil- and stain resistance treatments and backing materials are analytically indistinguishable from one another, one must conclude that obtaining the identities of the compounds in the emissions "package" is vital for an understanding of the sources. Without an understanding of the quantitative contribution of the various sources we cannot discharge our duty to evaluate potential controls that would involve changes in the above-named elements of the carpet manufacturing process.

The analyses will be conducted under the proposed agreement using both GC/MS and FID instrumentation, so identification of the emission constituents would merely involve reference to standard libraries of eluants, and would not involve doing completely separate analytical work.

Although the test program is voluntary, the dialogue group faces a charge to evaluate potential controls. Therefore, does it make sense to consider a completely new testing program some unspecified time in the future in order to meet the evaluation charge simply because industry has declined to identify the emissions' constituents?

Further, the dialogue group's unwillingness to require speciation has not been adequately justified. While charge number 1 to the dialogue does speak to total volatile organic compound

(VoC) emissions, there is no prohibition in that charge against identifying what the constituents of that total VOC package are. one argument raised against identifying the VOCs at the plenary on March 1, viz. that identification of compounds will automatically and inevitably require the dialogue to do health risk assessment is without merit. The proponents of that argument provide no basis for that assertion.

In summary, the agreement to which this minority report is appended fails to generate data that it easily could, data that are vital to the other charges before the dialogue, data that could be obtained most cost-effectively by speciation of the emissions to be measured under the agreement, data whose gathering is not prohibited by the Federal Register notice, data that do not inevitably require the dialogue to do health risk assessment.

signed[1]: J. William Hirzy, NFFE
Katherine Cox, AFSCME
Hal Levin

[1] Signatures as of May 22, 1991

APPENDIX G

Carpet Cushion Council Consensus Statement: Testing Program for Carpet Cushions

CARPET POLICY DIALOGUE

CARPET CUSHION COUNCIL CONSENSUS STATEMENT:

Testing Program for Carpet Cushions

June 28, 1991

PREFACE

The Carpet Policy Dialogue Group, convened by the U.S. Environmental Protection Agency, is engaged in a one-year effort to develop consensus and voluntary commitments with respect to approaches for minimizing exposure to volatile organic compounds (VOCs) emitted by carpet and associated products of carpet flooring systems (FR: April 24, 1990 - "Carpet: Response to Citizens' Petition" p. 17404-17409; and, FR: August 3, 1990 - "Carpet Emissions Reduction; Policy Dialogue" p. 31640-34641).

This document conveys a consensus statement of the Carpet Policy Dialogue Plenary Group regarding the commitment by the carpet cushion industry, as represented by the Carpet Cushion Council, for the voluntary development and communication of Total Volatile Organic Compound (TVOC) emission test data on carpet cushions.

Additional statements and reports concerning other aspects of the Carpet Policy Dialogue are anticipated.

Carpet Policy Dialogue

Consensus Statement
for the
Carpet Cushion Council:

Testing Program for Carpet Cushions

Page

Preface . . . . . G-i

1.0. BACKGROUND G-1
1.1. Charter and Charge G-1
1.2. Carpet Cushion Council Statement of Commitment G-1

2.0. DEFINITIONS G-2
2.1. Total Volatile Organic Compounds (TVOC) G-2
2.2. Boundary of Test Subject G-2
2.3. Voluntary Action G-2
2.4. Test Method G-3

3.0. CARPET CUSHION TESTING PROGRAM G-4
3.1. Rationale for Carpet Cushion Product Testing G-4
3.2. Study Objectives G-4
3.3. Scope and Structure of Study G-5
3.3.1. Carpet cushion product type selection criteria G-5
3.3.2. Sample collection and test method G-5
3.3.3. Study design sampling matrix for analytical testing G-5
3.4. Data Reporting and Evaluation G-6
3.4.1. Statistical analysis G-6
3.4.2. Data presentation G-7
3.4.3. Initial program evaluation G-7
3.4.4. Public study report G-7
3.5. Independent Contractors and Data Quality Standards G-8

4.0. FOLLOW-ON ACTIVITIES G-8
4.1. Future Activities G-9
4.1.1. Industry-wide study G-9
4.1.2. Annual industry report G-9
4.1.3. QA product certification G-9
4.1.4. Public communication G-9
4.2. Information Repository G-10
4.3. Memorandum of Understanding G-10

CARPET CUSHION COUNCIL CONSENSUS STATEMENT:

Testing Program for Carpet Cushions

1.0. BACKGROUND

1.1. Charter and Charge

The charter for testing under the Carpet Policy Dialogue process was given in the U.S. Environmental Protection Agency's (EPA) Federal Register notice of April 24, 1990 in responding to the petition by the National Federation of Federal Employees (NFFE) for EPA to undertake certain actions with respect to reducing emissions from carpet (FR: April 24, 1990 - "Carpet: Response to Citizens' Petition" p. 17404-17409; and FR: August 3, 1990 - "Carpet Emissions Reduction; Policy Dialogue" p. 31640-34641). The Carpet Policy Dialogue Group, convened under the auspices of the U.S. Environmental Protection Agency, is engaged in a one-year effort to develop consensus and voluntary commitments for minimizing exposure to volatile organic compounds emitted from carpet and associated products of a carpet flooring system.

This document conveys the Carpet Policy Dialogue Group consensus statement regarding the commitment of the carpet cushion industry, as represented by the Carpet Cushion Council, to undertake voluntary testing for total volatile organic compound (TVOC) emissions from new carpet cushions, to establish a data base for reporting periodic TVOC analysis for new carpet cushion products, and to communicate useful information about TVOC emissions from new carpet cushions. Specifically, it describes a testing program to develop decay curve data on five carpet cushion product types. These data will be used to determine a testing point(s) at which TVOC measurements will be compiled among a representative sample of new carpet cushions (study to be conducted as a follow-on activity to the Dialogue process). Its acceptance was affirmed by the Carpet Policy Dialogue Group meeting in plenary session on April 10, 1991.

1.2. Carpet Cushion Council Statement of Commitment

There are no universally accepted indoor air quality standards, guidelines, or regulations that are applicable to carpet cushions. The Carpet Cushion Council regards the dialogue and this agreement as a vehicle to accelerate the exploration and understanding of voluntary pollution prevention as one component in improving indoor air quality. The Carpet Cushion Council has committed resources to this initiative in their belief that a voluntary program will promote the use of industry-wide process controls to improve product performance with respect to indoor air quality.

This voluntary testing program commitment by the Carpet Cushion Council addresses issues discussed in the Federal Register notice. It provides for a Carpet Cushion Council sponsored decay curve study of five carpet cushion product types. This study would serve as a base for any future measurement of TVOC emissions from new carpet cushions. It is anticipated that, through follow-on activities, a TVOC data base for a representative sample of carpet cushions will be generated. It is intended to provide these data to the consumer to demonstrate the carpet cushion industry's commitment to the policy of pollution prevention and improvement of indoor air quality. It is anticipated that EPA and the Carpet Cushion Council will enter into a memorandum of understanding (MOU) which will describe procedural arrangements for implementation of the voluntary Carpet Cushion Testing Program and follow-on activities.

2.0. DEFINITIONS

2.1. Total Volatile Organic Compounds (TVOC)

Total Volatile Organic Compounds (TVOC), as defined in this document, represents the sum of volatile organic compounds (VOC) that can be analyzed and measured by the specified analytical method. TVOC is reported as an emission factor in mg/m^2hr and is a single numerical expression for the sum of VOC emissions from a test substance (carpet cushion). This numerical expression will be used to direct scientific efforts and to communicate useful information to the interested public.

2.2. Boundary of Test Subject

Carpet cushions are composed of various raw materials, to a large extent, scrap materials from the manufacture of products used in other industries. The scrap materials are obtained from numerous worldwide sources and recycled for use in the manufacture of carpet cushions. As such, the chemical makeup of an individual cushion, in particular bonded and jute cushions, can vary and may be dependent on the time of the year and location of the purchase of its raw materials.

Carpet cushions are placed underneath carpet on a wall-to-wall type of installation that completely covers the surface and sides of the carpet cushion when installed. It is estimated that new carpet cushion is placed under approximately 50 percent of all new broadloom carpet sold. Vinyl non-skid rug pads and other non-skid rug pads weighing less than 14 ounces per square yard, for placement underneath area rugs, are beyond the scope of this agreement. For the purpose of this voluntary test agreement, the test subject is restricted to carpet cushions as obtained at the end of a manufacturer's finishing line. The term carpet cushion as used in this document refers to new carpet cushion as it leaves the finishing line.

On behalf of the carpet cushion industry, the Carpet Cushion Council has determined that carpet cushions can be classified into five product types: bonded, prime, rubber, synthetic and rubberized jute. These products are manufactured at a total of 75 finishing lines, representing approximately 34 companies. Bonded cushions comprise 56% of the total market share (based on square yards shipped); prime cushions constitute 33% of the market. Rubber cushions constitute 6% of the total market, while synthetic cushions represent 3% of the market. Rubberized jute cushions comprise 2% of the market. The number of finishing lines at which these five carpet cushion product types are produced will be determined by the Carpet Cushion Council and provided in the final report.

2.3. Voluntary Action

This voluntary agreement to conduct TVOC emissions testing for new carpet cushions is undertaken by the carpet cushion industry as part of a continuing commitment to product stewardship. The program is implemented with respect to products as produced by the manufacturer and may include industry guidelines for proper installation, maintenance and care.

It is understood that the agreement is not open-ended and that the commitment of the Carpet Cushion Council is the conduct of a reasonable and appropriate testing program, giving regard to cost, cost-effectiveness and other feasibility considerations. As test data are generated, this information will serve as the reference point for determining the need for additional testing and the possible need for an on-going testing program, which is one of the goals of the Federal Register charter. The program will be implemented so as to preserve

necessary proprietary information and, with future testing, establishes a base for appropriate inter-product type comparisons.

2.4. Test Method

The test method selected to obtain TVOC measurements for carpet cushions is a small chamber test. The environmental chamber method was described by the U.S. EPA in its document, "Indoor Air Sources: Using Small Environmental Chambers to Characterize Organic Emissions from Indoor Materials and Products" (EPA report 600/8-89-074). The method is based on an ASTM standard, "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/ Products" (ASTM D5116-90). The techniques described in these documents have been further refined to measure TVOC emissions from carpet flooring products (Attachment A: "Standard Test Method for Determining Total Volatile Organic Compound Emission Factors from Carpet Under Defined Test Conditions Using Small Environmental Chambers"). TVOC emissions data for carpet flooring products obtained from this standardized small chamber testing procedure may be used to compare and evaluate carpet cushion's relative contribution to indoor air quality with TVOC data from other products.

The standard method, as described in Appendix E, provides accurate TVOC measurements. The minimal quantifiable limit is 4.0 ug/m^3, which is twice the detection limit of 2.0 ug/m^3 or 36 ng TVOC. The TVOC concentration measured in the environmental chamber is used to calculate an emissions factor expressed as mg/m^{2}hr. The emissions factor is a product-specific factor describing the mass of chemical emitted from the product per exposed area of the product per unit time. The quantifiable limit for carpet cushion, expressed as an emission rate, is 0.01 mg/m^{2}hr. The emission rate is projected by multiplying the emissions factor by the area of carpet cushion in a particular installation.

Emission factor data may be generated at various time intervals. At this time, limited decay curve data exist for carpet cushions. Since it has not been determined whether the use of a single point on the decay curve is sufficient to characterize total VOC emissions from carpet cushions and whether all carpet cushion types respond similarly with respect to their decay curve characteristics, additional information regarding these properties is needed for each of the five carpet cushion types. If a single point for TVOC measurement is reasonable, then the appropriate point must also be determined. The resolution of these issues will be integrated into the finalized analytical method, which is included as Attachment A (currently in "draft" form).

The test method has been documented by an expert working party of the Dialogue's Product Testing Subgroup. A draft protocol is currently being circulated for peer review. The method, with peer review revisions incorporated, will be available directly. It has been judged by the Carpet Policy Dialogue Group on November 29, 1990 to be an acceptable analytic tool for any industry study undertaken in 1991 under the aegis of the Carpet Policy Dialogue process. This test method will be submitted to ASTM by its principal originator for ASTM balloting procedures as a new "Standard Test Method." Further validation by interested laboratories is expected over the next two years.

3.0. CARPET CUSHION TESTING PROGRAM

The Carpet Cushion Testing Program will be conducted in two phases. Fifteen samples will be collected in the combined testing program. The first phase will develop decay curve emission data on bonded and prime carpet cushion product types, representing 89% of the entire market. Three samples from each product type, or a total of six samples, will be tested. Phase II will collect corresponding information on rubber, synthetic and rubberized jute carpet cushions. A total of nine samples will be collected in Phase II. The decay curve data established for these five product types will be compared with existing data on carpet

cushion TVOC emissions, previously commissioned by the Carpet Cushion Council and the Carpet and Rug Institute. They will also be used to determine the appropriate air sampling time point, or points, to use in measuring TVOC emissions. TVOC measurements will be collected at six time points (4, 8, 24, 48, 72 and 96 hours) after placement of the carpet cushion in the small chamber. This single point(s) will be used to characterize carpet cushion TVOC emissions in a larger industry-wide study, to be conducted as a follow-on activity to the Carpet Policy Dialogue. The industry study will build a data base/profile of TVOC emissions, collected from a representative sample of carpet cushion products over time.

3.1. Rationale for Carpet Cushion Product Testing

Exploratory data on generic types of carpet cushion developed in 1990 for the Carpet Cushion Council demonstrate that TVOC emissions from carpet cushions, while different among classes, will nevertheless approximate that of carpet. It has also been shown in testing done both by the Carpet Cushion Council and by the Carpet and Rug Institute that carpet forms a barrier to emissions from carpet cushion that significantly slows down the permeation of TVOCs into an indoor area. These preliminary data sets include limited information about the characteristics of the decay curve for the various carpet cushion product types. They do not provide data on the variability of TVOC emissions from cushions of the same product type (manufactured at different finishing lines) or on the differences between average TVOC emission rates for the five carpet cushion product types. The decay curve characteristics from the five carpet cushion types will provide a basis for selecting a sampling time point(s) for use in any follow-on testing. This additional testing will characterize the range of industry-wide product performance with respect to TVOC emission rates.

The data developed from the Carpet Cushion Testing Program will provide the Carpet Policy Dialogue Group, industry, regulatory agencies, and the interested public with additional information to assess whether there is sufficient variability of TVOC emissions across carpet cushions to warrant communication of TVOC information on individual carpet cushion types to the interested consumer.

3.2. Study Objectives

The overall Carpet Cushion Testing Program objectives are to characterize the TVOC decay curve characteristics for samples from each of the five carpet cushion product types currently in commerce, and to determine the appropriate air sampling time point(s) to use in measuring TVOC emissions in future studies. At this time, the program will not provide data on the distribution of TVOC emissions across the universe of carpet cushion types.

3.3. Scope and Structure of Study

3.3.1. Carpet cushion product type selection criteria

Five carpet cushion product types (with approximate market shares based on square yards shipped in parentheses) are currently in commerce: bonded (56%), prime (33%), rubber (6%), synthetic (3%) and rubberized jute (2%).

3.3.2. Sample collection and test method

The method for sample collection at the carpet cushion mill, sample transport to the laboratory, and TVOC analysis is described in Attachment A. This method will be used throughout the Carpet Cushion Testing

Program. Samples of each product type will be randomly selected from a list of manufacturers' finishing lines, to be compiled by the Carpet Cushion Council.

3.3.3. Study design sampling matrix for analytical testing

Table 1 shows the five product types to be sampled and the number of carpet cushion samples from each carpet cushion product type to be collected and analyzed by the methods described in section 3.3.2. When all data are available from both phases, the TVOC emissions rate measured at the appropriate time point(s) obtained from these samples will be analyzed as a single data set. A total of fifteen samples (including five replicate samples) will be analyzed in the combined study. Specifically, three samples from each product type will be collected, where one sample will be collected from one finishing line and two samples will be collected from a second finishing line at different times. The samples and replicate samples (i.e., samples collected on different days from the same finishing line) will permit an evaluation of line to line and day to day variability of TVOC emission factors. In addition, this combined data set will also permit evaluation of the effects on TVOC emission factor for the five product types.

For each row (carpet cushion product type) in Table 1, the number of finishing lines will be drawn randomly from all lines making that product type at the time the samples for that type are to be collected. In addition, one of these lines, chosen at random
from the two selected lines, will have a replicate or second sample taken on a different day.

Additional quality assurance (QA/QC) samples (e.g., laboratory duplicate samples) numbering about 10% of the study samples tested will be taken in accordance with standard data quality procedures of the U.S. EPA.

Table 1. Sampling Matrix of Carpet Cushion Product Types

Carpet Cushion Product Types	No. of Sampled Lines	No. of Replicate Samples	% Market Share	Total No. of Samples
Phase I				
Bonded	2	1	56	3
Prime	2	1	33	3
Total	4	2	89	6
Phase II				
Rubber	2	1	6	3
Synthetic		2	1	33
Rubberized Jute	2	1	2	3
Total	6	3	11	9
Grand Total	10	5	100	15

3.4. Data Reporting and Evaluation

The data analysis will follow the lines of the objectives defined in section 3.2.

3.4.1. Statistical analysis

A statistical analysis of the combined study data will be performed using a technique known as analysis of variance. This method will be used to determine the effects on TVOC emissions of carpet cushion product type. Information will also be obtained on line to line variation among finishing lines producing the same carpet cushion product type and temporal (day to day) variation within a single finishing line. All results will be accompanied by an estimate of the statistical uncertainty (i.e., coefficient of variation or, if appropriate, 95 percent confidence limits) associated with them. These uncertainties are due to sampling or product variability, as well as measurement error.

Upon receipt of the data from the testing laboratory, the chemical analysis results will be examined to determine the need for data transformation. In addition to examining if a transformation is necessary, an evaluation of which type of transformation is most appropriate will be conducted. Traditionally, data sets of the type anticipated from this study often exhibit a large dynamic range (e.g., factor of 5 or more) and tend to be highly skewed. Data sets of this sort are frequently transformed to a lognormal scale for analysis purposes. This is because the effects of factors and variance of measurements tend to be multiplicative rather than additive when the dynamic range is large. This means that the geometric means, rather than the arithmetic averages, will be estimated in the statistical modeling analysis. Regardless of whether the data are transformed or not, the results of the statistical analysis will be reported in the original measurement scale (TVOC emissions factor).

The analysis will include examination of the data for outliers or atypical TVOC levels. This investigation, to be conducted by the Carpet Cushion Council, will seek to determine whether the product sample was handled according to good laboratory practices or whether any abnormalities occurred during the conduct of the manufacturing process or chemical analysis procedures. Product types which are atypical in the sense that the TVOC emission rates are repeatable but that the type yields levels which are unexpected (high or low relative to other product types) will also be investigated. The results of these investigations will be reported in the results section of the final report.

3.4.2. Data presentation

Data from the testing program will be depicted graphically to show the TVOC decay curve for each product type across the six (6) measured time points. These data will be compared with existing data sets, previously commissioned by the Carpet Cushion Council and the Carpet and Rug Institute. An evaluation of the applicability of standard time point(s) for TVOC measurement will be made from this data presentation.

In a second data display, five data points will represent the average value for each carpet cushion product type studied in the Carpet Cushion Testing Program. Individual data will be reported in an appendix to the final report. Company names will be blinded to protect the identity of individual manufacturers.

3.4.3. Initial program evaluation

The data collected in each phase of the testing program will be submitted to EPA for review as soon as each data set becomes available. Two initial evaluations of Phase I and Phase II data and an overall evaluation of the combined results will be conducted. EPA will evaluate the results of the Carpet Cushion Testing Program in terms of analytical results and conclusions, and will determine the variability and appropriate

characterization of carpet cushion product type emissions factors. EPA will use this technical evaluation to determine whether, in its view, there is a need for follow-on testing or other follow-on measures. This evaluation will also judge the extent to which the decay curve and testing data and appropriate follow-on measures, if required, have met the Federal Register charter. Among the issues to be considered is whether further experimental data are necessary to address the objectives of the Federal Register notice. Details of other follow-on activities are described in sections 4.1 through 4.3.

3.4.4. Public study report

The Carpet Cushion Council will provide a full report on the Carpet Cushion Testing Program to the U.S. EPA. The document will include: TVOC data for each carpet cushion product type tested, including the decay curve characteristics and an assessment of a standard TVOC measurement time point(s) associated with each cushion type, a description and results of the statistical/variability analysis and graphic presentation(s) of the data, discussion of the study findings, and a laboratory report on field/laboratory quality assurance aspects of the study. The report may also contain a perspective about the relative contribution from various carpet cushion types to the total VOC loading in the indoor environment. The EPA will make this information available to the interested public through various mechanisms, including a notice of availability in the Federal Register.

3.5. Independent Contractors and Data Quality Standards

The Carpet Cushion Council represents 16 carpet cushion manufacturers. It is estimated that these companies manufacture approximately 75% of all carpet cushions sold in the United States. With respect to the Carpet Cushion Testing Program, the Carpet Cushion Council will solicit the participation of all its members, as well as those carpet cushion manufacturers who are not members of the Council. The Carpet Cushion Council's goal is to achieve 95% participation of all carpet cushion manufacturers in the testing program. The Carpet Cushion Council will sponsor the testing program and will make a good faith effort to ensure that EPA guidelines for QA/QC are employed. The Carpet Cushion Council will obtain the necessary permission and legal clearances to permit collection of samples at the participating mills in accordance with the study protocol.

To assure accuracy of test results and to minimize conflict of interest, an independent laboratory will be retained to conduct product testing. The laboratory will be selected on the basis of its ability to fulfill the proposed protocol for sampling and analysis and documented assurance that testing will be conducted in accordance with good laboratory practices and standard U.S. EPA guidance for QA/QC. The protocol will include provisions for using only appropriately trained personnel hired by the laboratory to perform sample collection and transport.

In addition to an experimental study protocol, a Quality Assurance Project Plan specific to this Carpet Cushion Testing Program will be prepared following EPA Office of Toxic Substances (EPA/OTS) guidance. All QA/QC evaluations will be documented in this plan, which must be signed by representatives of the Carpet Cushion Council and EPA prior to the commencement of testing. All QA/QC results will be included in the study final report. The extent to which the results meet the defined data quality objectives of the testing program will also be addressed in the report.

The Carpet Cushion Council intends to initiate product testing in the late Summer of 1991, with a view to generating preliminary results in the Fall of 1991. Phase II will be conducted as resources can be made available, but within a one year period. The U.S. EPA will provide technical counsel, as it does on other voluntary testing agreements, to ensure that data quality objectives are met in the Carpet Cushion Testing Program.

It is understood by all parties to this agreement that the Carpet Cushion Council commitment is to conduct a cost-effective voluntary testing program. The Carpet Cushion Council believes that it has committed sufficient budgetary resources to support the two-phased program described herein. However, as detailed implementation plans are developed, it should be understood that modifications may be made not only on technical grounds, but also to reflect the limits of the Council's undertaking to conduct a cost-effective program.

4.0. FOLLOW-ON ACTIVITIES

During the balance of the dialogue year, it is the intent of the Carpet Cushion Council to work with the U.S. EPA, other experts, and the Carpet Policy Dialogue Group, along with its various working subgroups, to expedite implementation of the two-phased program outlined in section 1.2. The Carpet Cushion Council will continue to report to the Plenary on their progress to reach these objectives.

4.1. Future Activities

To the extent that further development of subsequent phases of the Carpet Cushion Council Testing Program is dependent upon information obtained from the study described in this document, follow-on activities are not fully detailed in this consensus statement. They are mentioned here to describe the comprehensive nature of the Carpet Cushion Council's commitment to respond to the Federal Register notice. The selections, specific direction and features of follow-on activities will be developed in consultation between EPA and the Carpet Cushion Council.

4.1.1. Industry-wide study

The decay curve characteristics obtained in the Carpet Cushion Testing Program will serve to identify the appropriate sampling point for TVOC measurement for the five carpet cushion types in commerce. This sampling point will be used in an industry-wide study of a representative sample of carpet cushions. This larger study will characterize a typical industry-wide profile of carpet cushion types: industry-wide with respect to product types in commerce and also to manufacturer sources. The distribution will be statistically analyzed to identify outliers and allow the industry to pursue them for remedial action or for clues to reducing TVOC emissions on an industry-wide basis. This use of test data could provide a base for developing further programs to meet the Carpet Policy Dialogue's goal of creating market pressure to drive down VOC exposures from carpet systems.

4.1.2. Annual industry report

The Carpet Cushion Council will generate an annual, aggregate history of carpet cushion industry TVOC emission product performance for at least three years. The data will be derived from the industry-wide study described in section 4.1.1. These data will be used to reveal trends over time relative to the overall industry-wide profile and, in future, to product types. The trend analysis will be a means to pursue problematic, "outlier product" instances and to evaluate the success of the carpet cushion industry in reducing TVOC levels.

4.1.3. QA product certification

The Carpet Cushion Council, in consultation with EPA, will devise a program to motivate producers to institute voluntary indoor air quality assurance measures with respect to their carpet cushion products. This

program will have prescribed procedures documented in an operational manual to be developed by the Carpet Cushion Council for its members. It will, at a minimum, include the development and submission to the Carpet Cushion Council of TVOC emission factor data on product types by companies.

This information would enable the Carpet Cushion Council to pursue the trend analysis for typical carpet cushions as described above and to take voluntary actions for improvement or remedy of "outlier products" with member manufacturers. The Carpet Cushion Council is prepared to publish a roster of companies which have received TVOC performance certification within a given year.

4.1.4. Public communication

The Carpet Cushion Council, in cooperation with EPA, will conduct a consumer information program to provide their customers with appropriate information on TVOC emissions from carpet cushions. Depending on the conclusions to be drawn from the testing described in section 3, this information program may include either product-by-product/company-by-company numeric information on TVOC levels or, if appropriate, more generic information from industry-sponsored product certification and annual aggregate analyses. The consumer information program will ensure that carpet cushion TVOC emissions are placed in an appropriate context with other indoor air pollution sources.

4.2. Information Repository

Reports on studies undertaken under the aegis of the Carpet Policy Dialogue will be provided to the U.S. EPA, which will maintain an on-going public file of this information in its public data docket facility. This permanent repository of information will be readily available to the interested public and will serve as the reporting place for the proposed annual aggregate/trend analysis and public communication products.

4.3. Memorandum of Understanding

To give shape and substance to the on-going testing program and the EPA objective to attain commitments to conduct voluntary product testing for TVOC emissions, the Carpet Cushion Council and the U.S. EPA will enter into a memorandum of understanding at or before the close of the dialogue process. This MOU will incorporate basic elements of this consensus statement and other procedural arrangements common for voluntary testing agreements in the Office of Toxic Substances. The MOU will be made public through a Federal Register notice. The document will be submitted for signature by the EPA and all participants in the Carpet Cushion Council Testing Program.

APPENDIX H

Floor Covering Adhesive Manufacturers Committee Consensus Statement: Testing Program for Carpet Installation Adhesives

CARPET POLICY DIALOGUE

FLOOR COVERING ADHESIVE MANUFACTURERS COMMITTEE CONSENSUS STATEMENT:

Testing Program for Carpet Installation Adhesives

June 28, 1991

PREFACE

The Carpet Policy Dialogue Group, convened by the U.S. Environmental Protection Agency, is engaged in a one-year effort to develop consensus and voluntary commitments with respect to approaches for minimizing exposure to volatile organic compounds (VOCs) emitted by carpet and associated products of carpet flooring systems (FR: April 24, 1990 - "Carpet: Response to Citizens' Petition" p. 17404-17409; and FR: August 3, 1990 - "Carpet Emissions Reduction; Policy Dialogue" p. 31640-34641).

This document conveys a consensus statement of the Carpet Policy Dialogue Plenary Group regarding the commitment by the carpet installation adhesives industry, as represented by the Floor Covering Adhesive Manufacturers Committee of the National Association of Floor Covering Distributors, in concert with the Adhesive and Sealant Council, Inc., for the voluntary development and communication of Total Volatile Organic Compound (TVOC) emission test data on carpet installation adhesives.

Additional statements and reports concerning other aspects of the Carpet Policy Dialogue are anticipated.

Carpet Policy Dialogue

Consensus Statement
for the
Floor Covering Adhesive Manufacturers Committee:

Testing Program for Carpet Installation Adhesives

1.0. BACKGROUND
- 1.1. Charter and Charge
- 1.2. Floor Covering Adhesive Manufacturers Committee Statement of Commitment

2.0. DEFINITIONS
- 2.1. Total Volatile Organic Compounds (TVOC)
- 2.2. Boundary of Test Subject
- 2.3. Voluntary Action
- 2.4. Test Method

3.0. CARPET INSTALLATION ADHESIVE TESTING PROGRAM
- 3.1. Rationale for Carpet Installation Adhesive Product Testing
- 3.2. Study Objectives
- 3.3. Scope and Structure of Study
  - 3.3.1. Carpet installation adhesive product type selection criteria
  - 3.3.2. Sample collection and test method
  - 3.3.3. Study design sampling matrix for methodology development
- 3.4. Data Reporting and Evaluation
  - 3.4.1. Statistical analysis
  - 3.4.2. Data presentation
  - 3.4.3. Initial program evaluation
  - 3.4.4. Public study report
- 3.5. Independent Contractors and Data Quality Standards

4.0. FOLLOW-ON ACTIVITIES
- 4.1. Future Activities
  - 4.1.1. Annual industry report
  - 4.1.2. Testing follow-up activities
  - 4.1.3. Public communication
- 4.2. Information Repository
- 4.3. Memorandum of Understanding

Attachment H-1 Test Method

FLOOR COVERING ADHESIVE MANUFACTURERS COMMITTEE CONSENSUS STATEMENT:

Testing Program for Carpet Installation Adhesives

1.0. BACKGROUND

1.1. Charter and Charge

The charter for testing under the Carpet Policy Dialogue process was given in the U.S. Environmental Protection Agency's (EPA) Federal Register notice of April 24, 1990 in responding to the petition by the National Federation of Federal Employees (NFFE) for EPA to undertake certain actions with respect to reducing emissions from carpet (FR: April 24, 1990 - "Carpet: Response to Citizens' Petition" p. 17404-17409; and FR: August 3, 1990 - "Carpet Emissions Reduction; Policy Dialogue" p. 31640-34641). The Carpet Policy Dialogue Group, convened under the auspices of the U.S. Environmental Protection Agency, is engaged in a one-year effort to develop consensus and voluntary commitments for minimizing exposure to volatile organic compounds emitted from carpet and associated products of a carpet flooring system.

This document conveys the Carpet Policy Dialogue Group consensus statement regarding the commitment of the carpet installation adhesives industry, as represented by the Floor Covering Adhesive Manufacturers Committee, to undertake voluntary testing for total volatile organic compound (TVOC) emissions from recently manufactured carpet installation adhesives, to establish a data base for reporting decay curve characteristics for carpet installation adhesive products, to provide periodic reporting of growth in usage of low VOC emission products, to encourage adhesive manufacturers to exercise due diligence in the testing of products before shipment to assure that carpet installation adhesive products meet VOC statements described on labels and to communicate useful information about TVOC emissions from carpet installation adhesives. Specifically, it describes a testing program to develop multi-time-point decay curve data on five carpet installation adhesive product classifications. The data will be used to determine a testing point(s) at which TVOC measurements could be compiled among a sample of recently manufactured carpet installation adhesives. Its acceptance, in principle, was affirmed by the Carpet Policy Dialogue Group meeting in plenary session on March 1, 1991.

1.2. Floor Covering Adhesive Manufacturers Committee Statement of Commitment

There are no universally accepted indoor air quality standards, guidelines, or regulations that are applicable to carpet installation adhesives. The Floor Covering Adhesive Manufacturers Committee regards the dialogue and this agreement as a vehicle to accelerate the exploration and understanding of voluntary pollution prevention as one component in improving indoor air quality. The Floor Covering Adhesive Manufacturers Committee has obtained commitment from 16 member companies to support this initiative in the belief that a voluntary program will promote the use of industry-wide process controls to improve product performance with respect to indoor air quality.

This voluntary testing program commitment by the Floor Covering Adhesive Manufacturers Committee addresses issues discussed in the Federal Register notice. It provides for a Floor Covering Adhesive Manufacturers Committee sponsored multi-time-point decay curve study of five carpet installation adhesive product types. This study will serve as a base for any future measurement of TVOC emissions from recently manufactured carpet installation adhesives. It is anticipated that, through annual reporting on percentage of sales by VOC classification by committee members, a data base for carpet installation adhesives will be generated. It is intended to provide these data to the consumer to demonstrate the carpet installation adhesive industry's commitment to the policy of pollution prevention and improvement of indoor air quality. It is

anticipated that EPA and the Floor Covering Adhesive Manufacturers Committee will enter into a memorandum of understanding (MOU) which will describe procedural arrangements for implementation of the voluntary Carpet Installation Adhesives Testing Program and follow-on activities.

2.0. DEFINITIONS

2.1. Total Volatile Organic Compounds (TVOC)

Total Volatile Organic Compounds (TVOC), as defined in this document, represents the sum of volatile organic compounds (VOC) that can be analyzed and measured by the specified analytical method. TVOC is reported as an emission factor in mg/m^2hr and is a single numerical expression for the sum of VOC emissions from a test substance (carpet installation adhesive). This numerical expression will be used to direct scientific efforts and to communicate useful information to the interested public.

2.2. Boundary of Test Subject

Carpet installation adhesives are formulated through a composition of several basic ingredients, combined in varying proportions depending upon the functions of the adhesive. Adhesive formulating and the choice of raw materials used is based on price, performance and environmental issues. Six functional components are generally used: vehicle (e.g., water, solvents or a combination of both), binder (e.g., latex (Styrene-Butadiene (SBR) is the major latex used) or resins (sometimes referred to as tackifiers), fillers (limestone, gypsum, sand or clay), viscosity control agents, preservatives and freeze-thaw stability agents (e.g., methanol or ethylene glycol). These raw materials are obtained from numerous sources and added to the final mixture in amounts determined by the manufacturer. Adhesive manufacturers typically offer a range of carpet installation adhesives, with good (economy), better, best (premium) and specialty products. Further, variations of adhesive formulas are needed in different geographical markets, due to variable temperature and humidity conditions.

For the purpose of this voluntary test agreement, the test subject is restricted to carpet installation adhesives as obtained directly from the distributor. The Floor Covering Adhesive Manufacturers Committee has identified that these products have a rapid turnover at the distributor. This assures a uniform test sample of recently manufactured adhesive products available to installers. Thus, the distributor represents the most appropriate site to provide test sample materials. Such products are referred to in this document as new carpet installation adhesives. The terms carpet installation adhesive, new or recently manufactured carpet installation adhesive and floor covering adhesive are synonymous.

On behalf of the carpet installation adhesives industry, the Floor Covering Adhesive Manufacturers Committee has determined that carpet installation adhesives can be classified into five product classifications: multipurpose, pressure sensitive, vinyl backed, pad cement and seam sealer. These products are manufactured by 16 member companies. Multi-purpose adhesives comprise 75% of the total carpet installation adhesive market and are produced by 16 companies at 32 plants. Pressure sensitive adhesives constitute 17% of the market and are produced at about 26 plants, representing 16 companies. Vinyl backed adhesives constitute 5% of the total market and are produced at 28 plants (17 companies). Pad cement (2% of the market) is produced at 17 plants by 12 companies. Seam sealers are produced at 15 plants (12 companies) and comprise 1% of the carpet installation adhesive market.

2.3. Voluntary Action

This voluntary agreement to conduct TVOC emissions testing for recently manufactured carpet installation adhesives is undertaken by the carpet installation adhesive industry as part of a continuing commitment to product stewardship. The program is implemented with respect to products as produced by the manufacturer and sampled at the distributor. It may include guidelines for storage and use during installation.

It is understood that the agreement will operate where reasonable and appropriate as governed by the economics of the designed testing program. As test data are generated, this information serves as the reference point for on-going testing and evaluation, which is one of the goals of the Federal Register charter. The program will be implemented so as to preserve necessary proprietary information and, with future testing, establishes a base for appropriate inter-product type comparisons.

2.4. Test Method

The test method selected to obtain TVOC measurements for carpet installation adhesives is a small chamber test. The environmental chamber method was described by the U.S. EPA in its document, "Indoor Air Sources: Using Small Environmental Chambers to Characterize Organic Emissions from Indoor Materials and Products" (EPA report 600/8-89-074). The method follows an ASTM standard, "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/ Products" (ASTM D5116-90). The techniques described in these documents have been further refined to measure TVOC emissions from carpet flooring products (Attachment A: "Standard Test Method for Determining Total Volatile Organic Compound Emission Factors from Carpet Under Defined Test Conditions Using Small Environmental Chambers"). Based on the evaluation of the results of preliminary testing, the testing procedure will be modified in an addendum to incorporate the specifics of testing carpet installation adhesives. TVOC emissions data for carpet flooring products obtained from this standardized small chamber testing procedure may be used to compare and evaluate carpet installation adhesives's relative contribution to indoor air quality with TVOC data from other products.

The standard method, which will be adapted for adhesives testing, is expected to provide accurate TVOC measurements. The minimal quantifiable limit, which is twice the detection limit, will be determined in preliminary testing. The TVOC concentration measured in the environmental chamber is used to calculate an emissions factor expressed as mg/m^2hr. The emissions factor is a product-specific factor describing the mass of chemical emitted from the product per exposed area of the product per unit time. The quantifiable limit for carpet installation adhesive, expressed as an emission rate, will also be determined in preliminary testing. The emission rate is projected by multiplying the emissions factor by the area of carpet installation adhesive in a particular installation.

Emission factor data may be generated at various time intervals. Adhesives, by their nature, emit VOCs over time as part of a setting up process. As such, TVOC emissions vary during and following carpet installation. At this time, there is limited understanding about the decay curve characteristics for carpet installation adhesives. Since it has not been determined whether the use of a single point on the curve is sufficient to characterize total VOC emissions from carpet installation adhesives and whether all carpet installation adhesive product types respond similarly with respect to their decay curve characteristics, additional information regarding these properties is needed for each of the five carpet installation adhesive product types. If a single point for TVOC measurement is reasonable, then the appropriate point must also be determined. Further, questions concerning the applicability of the standard test method described above (e.g., application rate and method of application, substrate material, frequency and duration of air sampling) were raised during technical discussions on the design of a testing program to characterize the decay curve of the various carpet installation adhesive product types. The applicability of the test method will be addressed as a preliminary component of the Carpet Installation Adhesive Testing Program. The resolution of all above described issues

will be integrated into the finalized analytical method, which is included as Attachment H-1 (currently in "draft" form).

The test method has been documented by an expert working party of the Dialogue's Product Testing Subgroup. A draft protocol is currently being circulated for peer review. The method, with peer review revisions incorporated, will be available directly. It has been judged by the Carpet Policy Dialogue Group on November 29, 1990 to be an acceptable analytic tool for any industry study undertaken in 1991 under the aegis of the Carpet Policy Dialogue process. This test method will be submitted to the ASTM by its principal originator for ASTM balloting procedures as a new "Standard Test Method." Further validation by interested laboratories is expected over the next two years.

3.0. CARPET INSTALLATION ADHESIVE TESTING PROGRAM

The Carpet Installation Adhesive Testing Program will be conducted in two phases. As described in section 2.4, a preliminary study will be conducted to establish specific testing parameters for carpet installation adhesives. The Preliminary Study will provide data to refine the test protocol for use in characterizing TVOC emissions from the multipurpose and pressure sensitive carpet installation adhesive product classifications. It will create and evaluate alternative test protocols to determine which procedures are most appropriate for use in characterizing TVOC emissions from carpet installation adhesive products. Four samples will be tested.

Following preliminary testing, Phase I will determine the TVOC decay curve characteristics for multipurpose and pressure sensitive adhesives. These adhesives represent approximately 92% of the carpet installation adhesive market. TVOC decay curves will be analytically determined on a sample(s) of each of the product classifications. A total of fifteen study samples (including five samples of the same product type manufactured by a different company) will be tested. Measurements will be taken at the number of time points determined in the Preliminary Study. This information could be used by the industry to determine the appropriate air sampling time point, or points, for follow-on activities. This single point(s) could also be used to characterize carpet installation adhesive TVOC emissions by individual companies as they test their products in a follow-on activity to the Carpet Policy Dialogue.

Phase II will include decay curve testing on vinyl backed adhesives, pad cement and seam sealers. This testing will be conducted as resources can be made available, but within a one-year period. Preliminary test method development may also be needed prior to initiating testing of these three product classifications.

3.1. Rationale for Carpet Installation Adhesive Product Testing

Most carpet installation adhesive manufacturers have been calculating VOC content using standards set by the South Coast Air Quality Management District (ASTM D3960-81 and/or ASTM D2369-87). Prior to 1990, the majority of carpet installation adhesives were at a calculated VOC of 150 g/l or higher. With the pressure of South Coast's Rule 1168, all manufacturers reformulated their products to a calculated VOC at or below the required 150 g/l limit ("Rule 1168 - Control of Volatile Organic Compound Emissions from Adhesive Application," Amended February, 1991). As of September, 1990, one manufacturer introduced a new generation carpet installation adhesive with a calculated VOC of 0 g/l. By the end of February, 1991, eight manufacturers reported they had developed solvent free low VOC emission carpet installation adhesives. At the National Association of Floor Covering Distributors Convention, held May 5-8, 1991, fourteen of the fifteen carpet installation adhesive manufacturers who had booths displayed a low VOC emission carpet installation adhesive or a line of low VOC emission products. A survey was taken in February, 1991, asking manufacturers to report on the range of calculated VOCs in the products they were making by product type -- current formulas versus new generation formulas. The responses ranged from 40 g/l to 150 g/l on current

formula lines and from 0 g/l to 20 g/l on new generation lines. However, no data on the relationship between these calculated values to TVOC emission rates from carpet installation adhesives have been established.

The data developed from the Carpet Installation Adhesive Testing Program will provide the Carpet Policy Dialogue Group, industry, regulatory agencies, and the interested public with additional information to assess TVOC decay curve emission characteristics of carpet installation adhesives. With future testing, it could be determined whether there is sufficient variability of TVOC emissions across carpet installation adhesives to warrant communication of TVOC information on individual carpet installation adhesives product classifications and grades to the interested consumer.

3.2. Study Objectives

The overall objective of the Carpet Installation Adhesive Testing Program is to characterize quantitatively the decay curve characteristics of a sample or samples from each of the five carpet installation adhesive product classifications currently in commerce. The program will indicate TVOC emissions of the five carpet installation adhesive product types currently in commerce. The program will not provide data on the distribution of TVOC emissions across the universe of carpet installation adhesive product types.

3.3. Scope and Structure of Study

3.3.1. Carpet installation adhesive product type selection criteria

Five carpet installation adhesive product classifications (approximate carpet installation adhesive market percentages are provided in parentheses) are currently in commerce: multipurpose (75%), pressure sensitive (17%), vinyl backed (5%), pad cement (2%) and seam sealer (1%).

Multipurpose carpet installation adhesives are formulated through a combination of one of two mineral spirits and VM&P (Varnish Makers and Painters) Naptha, which are used to dissolve tackifing resins. In addition, methanol and ethylene glycol are used for freeze-thaw stability, a required performance property. Because of the cost, methanol is the more commonly used anti-freeze and it is very unlikely that the two ingredients would be used in conjunction with each other. These solvents contribute 95-99% of the calculated VOCs in multipurpose carpet installation adhesives. The base solvent used in formulating multipurpose carpet installation adhesives will serve as a grouping variable for Phase I sample selection and testing. In other words, testing for multipurpose carpet installation adhesives will be based on the type of solvent and freeze-thaw additive used. Further, two grades of mineral spirits, Regular and Rule 66 (differentiated by aromatic content), are used in the industry. Samples will be collected from products manufactured with each of these mineral spirit grades. Since solvent free multipurpose carpet installation adhesives have recently been introduced to the market, these products will also be included in Phase I of the testing program.

3.3.2. Sample collection and test method

A list of all products made by each of the manufacturers participating in the testing program will be compiled by the Adhesive and Sealant Council, Inc. Random selection of samples within each product type will be made by representatives of the National Association of Floor Covering Distributors and/or The Adhesive and Sealant Council, Inc. Adhesives will be purchased directly from distributors by an independent contractor. The method of sample transport to the laboratory, and TVOC analysis is described in Attachment H-1. This method will be used throughout the Carpet Installation Adhesive Testing Program.

3.3.3. Study design sampling matrix for methodology development

Table 1 shows the five product classifications to be sampled and the number of carpet installation adhesive samples from each carpet installation adhesive product classification to be collected and analyzed by the methods described in section 3.3.2. Four samples will be used in the Preliminary Study for establishing methodology for future testing. Fifteen samples will be analyzed in the Phase I study. For five of the eight products studied in Phase I, an additional sample(s) of the similar product type manufactured by a different company will also be collected to obtain data on product variability. Selection of the five products to be additionally sampled will be determined upon evaluation of the results of preliminary testing. These additional samples are included in the fifteen samples. The number of samples to be collected in Phase II testing will be determined upon the completion and evaluation of Phase I testing.

Additional quality assurance (QA/QC) samples (e.g., laboratory duplicate samples) numbering about 10% of the samples tested will be taken in accordance with standard data quality procedures of the U.S. EPA.

3.4. Data Reporting and Evaluation

The data analysis will follow the lines of the objectives defined in section 3.2.

3.4.1. Statistical analysis

Four samples will be evaluated in the Preliminary Study to establish a sample application technique and to determine the appropriate sampling time points for use in Phase I testing. The testing laboratory will establish the reproducibility of the test protocol in accordance with accepted good analytical laboratory procedures as an inherent part of their method development.

Using the protocol established by the Preliminary Study, fifteen samples will be evaluated in Phase I (Table 1). Statistical analysis of the Phase I data will be achieved by evaluating the results of the laboratory QC samples and the additional samples collected from five of the eight product groupings. These additional samples will provide information to assess production variability within a product classification.

The analysis will include evaluation of the decay curve for each sample and the degree of correlation of each respective additional/laboratory QC sample. This analysis scheme provides the minimum data necessary for statistical evaluation.

3.4.2. Data presentation

Data from the testing program will be depicted graphically to show the TVOC decay curve for each product classification across the appropriate number (determined in the Preliminary Study) of measured time points. An evaluation of the applicability of a standard time point(s) for TVOC measurement will be made from this data presentation.

In a second data display, five data points will represent the average value for each carpet installation adhesive product classification studied in the Carpet Installation Adhesive Testing Program. Individual data will be reported in an appendix to the final report. Company names will be blinded to protect the identity of individual manufacturers.

TABLE 1.

SAMPLING MATRIX OF CARPET INSTALLATION ADHESIVE PRODUCT CLASSIFICATIONS

Carpet Installation Adhesive Product Types	No. of Sampled Products	No. of Additional Samples	Total No.of Samples
Preliminary Study			
Mineral spirits multipurpose	1	0	1
VM&P Naptha multipurpose	1	0	1
Solvent free multipurpose	1	0	1
Pressure sensitive	1	0	1
Total	4	0	4
Phase I[1]			
Multipurpose:			
Methanol/Mineral Spirits Regular	1		
Methanol/Mineral Spirits Rule 66	1		
Methanol/VM&P Naptha	1		
Ethylene Glycol/Mineral Spirits Regular	1		
Ethylene Glycol/Mineral Spirits Rule 66	1		
Ethylene Glycol/VM&P Naptha	1		
Solvent Free	2		
Pressure Sensitive	2	—	—
Total	10	5	15
Phase II (Number of Samples to be Determined)			
Vinyl Backed			
Pad Cement			
Seam Sealer			

[1] Selection of the five additional samples to be collected in Phase 1 testing will be determined upon evaluation of the results of the Preliminary Study.

3.4.3. Initial program evaluation

The data collected in each phase of the testing program will be submitted to EPA for review as soon as each data set becomes available. Thus, an initial evaluation of preliminary data, two independent evaluations of the results of Phase I and Phase II testing, and an overall evaluation on the combined results will be conducted. EPA will evaluate the results of the Carpet Installation Adhesive Testing Program in terms of analytical results and conclusions, and will determine the appropriate characterization of carpet installation adhesive product classification emissions factors. EPA will use this technical evaluation to determine the need for possible follow-on activities. This evaluation will also judge the extent to which the decay curve data collected in this testing program and appropriate follow-on measures, if required, have met the Federal Register charter. Among the issues to be considered is whether further experimental data are necessary to address the objectives of the Federal Register notice. Details of other follow-on activities are described in sections 4.1 through 4.3.

3.4.4. Public study report

The Floor Covering Adhesive Manufacturers Committee will provide a full report on the Carpet Installation Adhesive Testing Program to the U.S. EPA. The document will include: TVOC data for each carpet installation adhesive product classification tested, including the decay curve characteristics and an assessment of a standard TVOC measurement time point(s) associated with each adhesive type, a description and results of the statistical analysis and graphical presentation(s) of the data, discussion of the study findings, and a laboratory report on field/laboratory quality assurance aspects of the study. The report may also contain a perspective about the relative contribution from various carpet installation adhesive types to the total VOC loading in the indoor environment. The EPA will make this information available to the interested public through various mechanisms, including a notice of availability in the Federal Register.

3.5. Independent Contractors and Data Quality Standards

The Floor Covering Adhesive Manufacturers Committee represents 16 carpet installation adhesive manufacturers. It is estimated that these companies manufacture approximately 95% of all carpet installation adhesives sold in the United States. The Floor Covering Adhesive Manufacturers Committee will sponsor the testing program and bears full responsibility for rigid scientific constructs. The Floor Covering Adhesive Manufacturers Committee will obtain the necessary permission and legal clearances to permit collection of samples at its member's distributors, in accordance with the study protocol.

To assure accuracy of test results and to minimize conflict of interest, an independent laboratory will be retained to conduct product testing. The laboratory will be selected on the basis of its ability to fulfill the proposed protocol for sampling and analysis and documented assurance that testing will be conducted in accordance with good laboratory practices and standard U.S. EPA guidance for QA/QC. The protocol will include provisions for using only appropriately trained personnel hired by the laboratory to perform sample collection and transport.

In addition to an experimental study protocol, a Quality Assurance Project Plan specific to this Carpet Installation Adhesive Testing Program will be prepared following EPA Office of Toxic Substances (EPA/OTS) guidance. All QA/QC evaluations will be documented in this plan, which must be signed by representatives of the Floor Covering Adhesives Manufacturers Committee and EPA prior to the commencement of testing. All QA/QC results will be included in the study final report. The extent to which the results meet the defined data quality objectives of the testing program will also be addressed in the report.

The Floor Covering Adhesive Manufacturers Committee intends to initiate product testing in July, 1991, with a view to generating a report on Phase I in the Fall of 1991. The U.S. EPA will provide technical counsel, as it does on other voluntary testing agreements, to ensure that data quality objectives are met in the Carpet Installation Adhesive Testing Program.

It is understood by all parties to this agreement that the Floor Covering Adhesive Manufacturers Committee will fulfill the voluntary program commitment described herein on a cost-effective basis. The Floor Covering Adhesive Manufacturers Committee has sufficient budgetary resources to support the Preliminary Study. Funds to support Phase I and Phase II of the testing program will be solicited upon the completion and evaluation of preliminary testing. However, as detailed implementation plans are developed, it should be understood that modifications may be made not only on technical grounds, but also to meet evolving cost estimates.

4.0. FOLLOW-ON ACTIVITIES

During the balance of the dialogue year, it is the intent of the Floor Covering Adhesive Manufacturers Committee to work with the U.S. EPA, other experts, and the Carpet Policy Dialogue Group, along with its various working subgroups, to expedite implementation of the two-phased program outlined in section 1.2. The Floor Covering Adhesive Manufacturers Committee will continue to report to the Plenary on their progress to reach these objectives.

4.1. Future Activities

To the extent that further development of subsequent phases of the Floor Covering Adhesive Manufacturers Committee Testing Program is dependent upon information obtained from the study described in this document, follow-on activities are not fully detailed in this consensus statement. They are mentioned here to describe the Floor Covering Adhesive Manufacturers Committee's commitment to respond to the Federal Register notice. The selections, specific direction and features of follow-on activities will be developed in consultation between EPA and the Floor Covering Adhesive Manufacturers Committee.

4.1.1. Annual industry report

The Floor Covering Adhesive Manufacturers Committee will generate an annual, aggregate history of carpet installation adhesive industry product type sales performance for at least three years. The data will be derived from annual reporting on percentage of sales by product classification. These data will be used to reveal trends over time relative to the overall industry-wide profile and, in future, to product types. The trend analysis will evaluate the success of the carpet installation adhesive industry in reducing TVOC levels by documenting increasing sales of lower emission products.

4.1.2. Testing follow-up activities

The Floor Covering Adhesive Manufacturers Committee, in consultation with EPA, will devise a program to motivate producers to institute voluntary indoor air quality assurance measures with respect to their carpet installation adhesive products. It will, at a minimum, include the development and submission to the Floor Covering Adhesive Manufacturers Committee of TVOC emission rate data on product types by companies. This information would enable the Floor Covering Adhesive Manufacturers Committee to pursue

the trend analysis for typical carpet installation adhesives as described above and to take voluntary actions for improvement or remedy of "outlier products" with member manufacturers.

The Floor Covering Adhesive Manufacturers Committee will also conduct a study to determine if a correlation can be achieved between calculated VOCs and emission testing measurements.

4.1.3. Public communication

The Floor Covering Adhesive Manufacturers Committee, in cooperation with EPA, will conduct a consumer information program to provide their customers with appropriate information on TVOC emissions from carpet installation adhesives. Depending on the conclusions to be drawn from the testing described in section 3, this information program may include product-by-product numeric information on TVOC levels or, if appropriate, more generic information from the annual aggregate analyses. The consumer information program will ensure that carpet installation adhesive TVOC emissions are placed in an appropriate context with other indoor air pollution sources.

4.2. Information Repository

Reports on studies undertaken under the aegis of the Carpet Policy Dialogue will be provided to the U.S. EPA, which will maintain an on-going public file of this information in its public data docket facility. This permanent repository of information will be readily available to the interested public and will serve as the reporting place for the proposed annual aggregate/trend analysis and public communication products.

4.3. Memorandum of Understanding

To give shape and substance to the testing program and the EPA objective to attain commitments to conduct voluntary product testing for TVOC emissions, the Floor Covering Adhesive Manufacturers Committee and the U.S. EPA will enter into a memorandum of understanding at or before the close of the dialogue process. This MOU will incorporate basic elements of this consensus statement and other procedural arrangements common for voluntary testing agreements in the Office of Toxic Substances. The MOU will be made public through a Federal Register notice. The document will be submitted for signature by the EPA and all members of the Committee.

APPENDIX I

Memorandum of Understanding Between the Carpet and Rug Institute and the U.S. Environmental Protection Agency

MEMORANDUM OF UNDERSTANDING

between the

Carpet and Rug Institute

and the

U.S. Environmental Protection Agency

May 22, 1991

MEMORANDUM OF UNDERSTANDING

A. BACKGROUND

The EPA initiated a dialogue process in April, 1990, to undertake certain actions with respect to reducing emissions from carpet. One aspect is to develop a program for the voluntary testing of, and collection of data on, total volatile organic compound (TVOC) emissions from carpet. See "Carpet: Response to Citizens' Petition," 55 FR 17,404 (April 24, 1990) and "Carpet Emissions Reduction; Policy Dialogue," 55 FR 31,640 (August 3, 1990).

As part of the dialogue process, the Carpet Policy Dialogue Group reached a consensus agreement (February 28, 1991) on the Carpet and Rug Institute Consensus Statement: Testing Program for Carpet Products. In reaching this agreement the Carpet Dialogue Group indicated to its sponsor (EPA) that the testing program described in the Consensus Statement could provide the basis for a Memorandum of Understanding to initiate voluntary action(s) by industry in response to the charter set by EPA in the Federal Register notices. This Consensus Statement describing the testing program for carpet products with Attachments A and B is affixed (Exhibit I).

B. PURPOSE

The CRI and EPA are entering into this Memorandum of Understanding for the purpose of initiating the provisions and follow-up expectations as stated within the context of the above mentioned Carpet Dialogue Consensus Statement and for providing for the product testing and reporting of data developed from the Carpet Testing Program as outlined therein.

C. SUBSTANCE OF THE AGREEMENT

This Memorandum of Understanding formally establishes a framework in which a voluntary program response for actions described in the Federal Register notices noted above can be fulfilled. Therefore, CRI and EPA enter into the following understandings:

1. Testing and Data Development

The CRI shall take responsibility for and coordinate the testing and data development provided for in the Consensus Statement, in accordance with the procedures described within and the attachments affixed thereto, and with due consideration for the following provisions:

a. Quality Assurance

The U.S. EPA order 5360.1[1] mandates that "quality assurance is embedded in all data collection undertaken by or for the Agency." In meeting this requirement, the Office of Toxic Substances (OTS) requires the preparation of a Quality Assurance Project Plan (QAPjP) which must be submitted to and approved by EPA for use during the testing project operations outlined in the Consensus Statement. Detailed guidance is provided on the preparation of the QAPjP in the affixed document: "Office of Toxic Substances Guidance Document for the Preparation of Quality Assurance Project Plans for Industry Studies" (Exhibit II).

b. Protocol Changes

Any changes, modifications, or amendments to the testing program described within the Consensus Statement and its attachments shall be brought to the attention of EPA by CRI and documented in the record. Upon notification, both parties to this agreement shall develop an alternate approach to fulfill the needs and requirements of the Carpet Testing Program. The parties shall jointly agree on the alternate approach and a statement of such agreement shall be entered into the record.

c. Data Development

The test results will be developed into a report(s) and submitted to EPA as described in the Consensus Statement and in accordance with the provisions described below (see Data Submission).

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1 USEPA. 1984. U.S. Environmental Protection Agency. Policy and program requirements to implement the mandatory quality assurance program. Washington, DC: Office of Administration and Resource Management, USEPA. EPA Order 5360.1.

2. Confidentiality

The testing, data development, and data reporting shall be conducted in accordance with the confidentiality provisions of the Corsensus Statement and EPA shall maintain the protections afforded in such confidentiality provisions.

a. Confidential Business Information (CBI)

Information submitted to EPA under provisions of the Toxic Substances Control Act (TSCA), in support of TSCA, or as FYI under the terms of a voluntary testing agreement is subject to the provisions of Section 14 of TSCA and to EPA's Regulations on the Confidentiality of Business Information. All responses/correspondence will be placed in the OTS public files unless confidentiality is claimed in accordance with the procedures outlined in Exhibit III, entitled: "Support Information for Confidentiality Claims." Additional information about confidentiality claims can be found in 40 CFR Chapter 1, Section 2.203 et seq, and 41 FR 36902, September 1, 1976 as amended at 43 FR 40000, September 8, 1978 and 50 FR 51661, December 8, 1985. In the event that a claim for confidentiality is made on all or part of the provided information, said information will only be released by the EPA to the extent, and by means of the procedures, set forth in the cited regulations. Requests for confidentiality should be addressed to U.S. Environmental Protection Agency, Office of Toxic Substances, Document Processing Center (TS-790), 401 M Street S.W., Washington DC, 20460 (Attn: Frank Caesar, Carpet Emissions Administrative Record).

b. Data Submission

The CRI shall submit a final report on the Carpet Testing Program as described in section 3.4.4 of the Consensus Statement and in accordance with the QAPjAP. A cover letter along with two (2) copies shall be submitted for public access to the U.S. Environmental Protection Agency, Office of Toxic Substances, Information Management Office (TS-793), 401 M Street S.W., Washington DC, 20460, Attn: Lynn Marcus, Carpet Emissions Administrative Record. If the test results contain Confidential Business Information (CBI) the package must contain the cover letter, the original submitted in accordance with the Consensus Statement and two (2) copies of the

CBI study results, and three copies of a sanitized version appropriate for public access. CBI submittals shall be sent to the U.S. Environmental Protection Agency, Office of Toxic Substances, Document Control Office (TS-790), 401 M Street S.W., Washington DC, 20460, Attn: Lynn Marcus, Carpet Emissions Administrative Record.

3. Consultation and Follow-on Activities

The parties to this Memorandum of Understanding recognize that Section 3.4.3 of the Consensus Statement calls for a technical evaluation by EPA for the purpose of determining the need for follow-on testing, if required. The EPA reserves the right to assess the suitability of the test program results submitted for this evaluation to assure that EPA has met the goals and concepts of the Federal Register notice. Issues identified by EPA will be discussed as follow-on activities in joint consultation by the parties named below. Details of these matters will be worked out by consent of both parties and could be the subject of additional Memoranda of Understanding.

Elements described in Section 4 of the Consensus Statement identify certain follow-on activities proposed by CRI which would benefit by collaborative efforts undertaken by both parties to this agreement. Therefore, activities such as: 1) annual industry report, 2) quality assurance product certification, and 3) public communication, and 4) database information repository are considered useful follow-on activities. To this extent the CRI intends to pursue and report to EPA on progress in these areas.

Should CRI have technical questions about provisions of this Memorandum of Understanding, please contact Charles M. Auer, Dir. Existing Chemicals Assessment Division at (202)382-3442.

D. PLACEMENT OF RESPONSIBILITIES

Responsibility for completion of the CRI Carpet Testing Program, CRI reporting activities, EPA technical evaluation of the testing results, and inclusion of the final report into the EPA Administrative Record as described in this Memorandum of Understanding is placed with the President, Carpet and Rug Institute, and the Director, Office of Toxic Substances, EPA.

E. OTHER AGREEMENTS

Nothing in this Memorandum of Understanding precludes EPA from any other steps it deems necessary to carry out any applicable laws, regulations, or policies. These include activities listed in the U.S. Code of Federal Regulations, and the reduction of carpet emissions described in the Federal Register notices cited above. Furthermore, this Memorandum of Understanding does not preclude EPA from entering into separate agreements with individual carpet manufacturers that are presently not constituent members of the Carpet and Rug Institute. It is understood that any such separate agreements pertaining to the subject matter of this MOU will not contain provisions less stringent or contrary to those terms and conditions stipulated herein. Similarly, nothing precludes CRI from entering into similar agreements with their contractors, or constituent members for the purposes of conducting and reporting testing, or similar agreements with other regulatory Agencies.

F. NAME AND ADDRESS OF PARTIES

1. Carpet and Rug Institute
Box 2048, Holiday Avenue
Dalton, Georgia 30720

2. U.S. Environmental Protection Agency
Office of Toxic Substances
401 M Street, SW
Washington, DC 20460

G. PERIOD OF AGREEMENT

This Memorandum of Understanding is entered into by the Carpet and Rug Institute (CRI) and the U.S. Environmental Protection Agency (EPA) as of this twenty-second day of May, 1991.

For the Carpet and Rug Institute:

Ronald E. VanGelderen
President
Carpet and Rug Institute

For the Environmental Protection Agency:

Mark Greenwood
Director
Office of Toxic Substances

ATTACHMENT I-1

Federal Register: Carpet Policy Dialogue; Memorandum of Understanding: Testing Program for Carpet Products and Receipt of the Carpet Policy Dialogue Interim Progress Report

[OPTS-00108; FRL-3933-1]

Carpet Policy Dialogue; Memorandum of Understanding: Testing Program for Carpet Products and Receipt of the Carpet Policy Dialogue Interim Progress Report

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of availability.

SUMMARY: EPA has entered into a Memorandum of Understanding (MOU) with the Carpet and Rug Institute (CRI) for the purpose of initiating the provisions stated within the context of the Carpet Policy Dialogue--*Consensus* Statement: Testing Program for Carpet Products. The MOU provides for carpet product testing for total volatile organic compound emissions (TVOC) and reporting of data as outlined in the testing program. EPA has received an Interim Progress Report from the Carpet Policy Dialogue describing activities from August 21, 1990 through April 10, 1991.

DATES: The MOU was entered into on May 22, 1991.

FOR FURTHER INFORMATION CONTACT: The MOU and the Interim Progress Report are available to the public in the Carpet Emissions Administrative Record located at the TSCA Public Docket Office. This Administrative Record is available for reviewing and copying from 8 a.m. to noon and 1 p.m. to 4 p.m., Monday through Friday, excluding legal holidays at the following address: Environmental Protection Agency, rm. NE-G004, 401 M St., SW., Washington, DC 20460. Copies may be obtained from the following address: Dave Kling, Acting Director, Environmental Assistance Division (TS-799), Office of Toxic Substances, Environmental Protection Agency, 401 M St., SW., Washington, DC 20460. Telephone: (202)554-1404, TDD: (202)554-0557, or FAX (202)554-5603 (document requests only). For further information on the Carpet Policy Dialogue Project contact Richard W. Leukroth, Jr., Carpet Policy Dialogue Coordinator, Telephone: (202)382-3832.

SUPPLEMENTARY INFORMATION:

I. Background

On January 11, 1990, EPA received a petition under section 21 of the Toxic Substances Control Act (TSCA) seeking regulatory action to address carpet emissions. EPA denied the petition (55 FR 17404, April 24, 1990). In lieu of the section 21 proceedings, EPA convened the *Carpet Policy Dialogue* on August 21, 1991, and set a different mission for the group. EPA charged the dialogue to work out the details of voluntary product testing programs that report TVOC emissions that off-gas from carpet, carpet installation adhesives, and carpet cushion products. In addition, the *Carpet Policy Dialogue* was asked to explore and, where possible, reach agreement on a variety of issues including: The sampling and analytical methods for the voluntary product testing for TVOC's, any additional information needed, identification of cost-effective process changes to reduce TVOC emissions, information about carpet installation practices, and to provide the interested public with information on TVOC emissions.

The Carpet Policy Dialogue formed three working Subgroups (Product Testing, Process Engineering, and Public Communications) to respond to the EPA charter. The Carpet Policy Dialogue on TVOC emissions is a nonregulatory approach focusing on responsible care/ *product stewardship* through voluntary actions on the part of industry. It emphasizes pollution prevention, exposure reduction, and addresses the public desire for information that could lead to consumer choice. The Carpet Policy Dialogue is an example of how government, industry, public interest groups, and the scientific community can work together to resolve exposure reduction and pollution prevention issues, including those related to indoor air exposures. Proposed testing programs are developed during Subgroup discussion and submitted to the Carpet Policy Dialogue for the benefit of a consensus process of review and comment. In reaching consensus and accepting the carpet testing program, the Carpet Policy Dialogue indicates to its sponsor (EPA) that such a statement can provide the basis for a MOU to initiate voluntary action(s) in response to the charter set by EPA in the **Federal Register** notices (55 FR 17404 and 55 FR 31640).

II. Memorandum of Understanding

The EPA and CRI entered into the MOU on May 22, 1991. The MOU signed by EPA and CRI formally establishes a framework in which a voluntary program response for actions described in the Federal Register notices noted above can be fulfilled. It contains provisions initiating the Carpet Testing Program on TVOC emissions and certain follow-on activities.

A. Carpet Testing Program

Under the terms and conditions of the MOU, the CRI has voluntarily agreed to conduct product testing to determine TVOC emissions factors from samples of 25 representative carpet product types. The objectives of the Carpet Testing Program are to: (1) Study carpet emissions decay curve data, (2) characterize quantitatively the profile of TVOC emissions of carpet product types currently in commerce, and (3) address the question of TVOC emission variability, or the lack thereof, across carpet product types.

B. Participants

Placement of responsibilities for the actions described in the MOU is with the President of the Carpet and Rug Institute and the Director of EPA's Office of Toxic Substances.

III. Carpet Policy Dialogue - Interim Progress Report

In conjunction with the public outreach activities of the Carpet Policy Dialogue an Interim Progress Report was submitted to EPA. This report reviews activities and accomplishments of the Carpet Policy Dialogue from August 21, 1990 through April 10, 1991. The report is a product of the Public Communications Subgroup of the Carpet Policy Dialogue. It was reviewed and approved for submission to the EPA by the Carpet Policy Dialogue Plenary.

The report contains background information about the dialogue process, describes structural organization, and explains the nature of consensus and voluntary actions. It describes the activities of the three working Subgroups, lists both direct and indirect accomplishments attributed to the Carpet Policy Dialogue, and contains five appendices that list participants and describe Carpet Policy Dialogue products or proposed products.

It is the intent of the Carpet Policy Dialoque to update the Interim Progress Report and submit a final Compendium Report to EPA after the conclusion of their deliberations.

Dated: July 8, 1991.

Mark A. Greenwood,

Director, Office of Toxic Substances.

[FR Doc. 91-18971 Filed 8-8-91; 8:45 am]

BILLING CODE 6560-50-F

APPENDIX J

Memorandum of Understanding Between the Carpet Cushion Council and the U.S. Environmental Protection Agency

MEMORANDUM OF UNDERSTANDING

between the

Carpet Cushion Council

and the

U.S. Environmental Protection Agency

September 26, 1991

MEMORANDUM OF UNDERSTANDING

I. BACKGROUND

The Environmental Protection Agency (EPA) initiated a dialogue process in April, 1990, to undertake certain actions with respect to reducing emissions from carpet and associated products of carpet flooring systems. One part of the dialogue process is to develop a program for the voluntary testing of and collection of data on total volatile organic compound (TVOC) emissions from carpet cushions. See "Carpet: Response to Citizens' Petition," 55 FR 17,404 (April 24, 1990) and "Carpet Emissions Reduction; Policy Dialogue," 55 FR 31,640 (August 3, 1990). The objective of data collection is to provide basic information of TVOC emissions and to provide information to assess emission control feasibility.

On June 28, 1991, the Carpet Policy Dialogue Group, a group of industry, public and governmental representatives, agreed in principal to "The Carpet Cushion Council Consensus Statement: Testing Program for Carpet Cushions". In this agreement the Carpet Policy Dialogue Group indicated to its sponsor, the EPA, that the testing program described in the Carpet Cushion Consensus Statement could provide the basis for a Memorandum of Understanding to initiate voluntary action(s) by industry in response to the charter set by EPA in the above-mentioned Federal Register notices. The Carpet Cushion Council Consensus Statement describing the testing program for carpet cushion products is attached (Exhibit I).

The Carpet Policy Dialogue Group also endorsed by consensus the recommendations of the Process Engineering Subgroup to define post-dialogue Carpet Cushion Council sponsored activities that would be undertaken to understand the sources of TVOC in carpet cushion and how to reduce the magnitude of these sources. These activities are described in more detail below.

II. PURPOSE

The Carpet Cushion Council (CCC), acting on behalf of the carpet cushion industry, and EPA are entering into this Memorandum of Understanding for the purpose of initiating the provisions and follow-up expectations as stated within the context of the above mentioned {Carpet Policy Dialogue} Carpet Cushion Council Consensus Statement and for providing for the product testing and reporting of data developed from the Carpet Cushion Testing Program as outlined therein. This Memorandum of Understanding is also intended to formalize the consensus

decisions of the Carpet Policy Dialogue related to recommended post-dialogue studies intended to identify carpet cushion TVOC sources and methods of reducing their magnitude.

III. SUBSTANCE OF THE AGREEMENT

This Memorandum of Understanding (MOU) formally establishes a framework for a voluntary program to respond to actions described in the Federal Register notices mentioned above. Thus, CCC, on behalf of the carpet cushion industry, and EPA enter into the following understandings:

A. Testing and Data Development

The CCC shall take responsibility for and coordinate the testing and data development of Phase I and Phase II as provided for in the Consensus Statement, in accordance with the procedures described within and the attachments affixed thereto, and with due consideration for the following provisions:

1. Quality Assurance

The U.S. EPA order 5360.1[1] mandates that "quality assurance is embedded in all data collection undertaken by or for the Agency". In meeting this requirement, the Office of Toxic Substances (OTS) requires the preparation of a Quality Assurance Project Plan (QAPjP) which must be submitted to and approved by EPA for use during the testing project operations outlined in the Consensus Statement. Detailed guidance is provided on the preparation of the QAPjP in the attached document: "Office of Toxic Substances Guidance Document for the Preparation of Quality Assurance Project Plans for Industry Studies" (Exhibit II).

2. Protocol Changes

Any changes, modifications, or amendments to the testing program described within the Consensus Statement and its attachments shall be brought to the attention of EPA by CCC and documented in the record. Upon notification, both parties to this

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[1] USEPA. 1984. U.S. Environmental Protection Agency. Policy and program requirements to implement the mandatory quality assurance program. Washington, DC: Office of Administration and Resource Management, USEPA. EPA Order 5360.1.

agreement shall develop an alternate approach to fulfill the needs and requirements of the Carpet Cushion Testing Program. The parties shall jointly agree on the alternate approach and a statement of such agreement shall be entered into the record.

3. Data Development

The test results will be developed into report(s) and submitted to EPA as described in the Consensus Statement and in accordance with the provisions described below (see Data Submission). The CCC has committed to initiating product testing in the late Summer 1991, with a view to generating preliminary results in the Fall of 1991. Phase II will be conducted as resources can be made available, but within a one year period.

4. Testing Study Results

The CCC shall submit a final report on Phase I and Phase II testing as they become available but not longer than one year from the date of signature of this Memorandum of Understanding.

The testing, data development, and data reporting may be conducted in accordance with the confidentiality provisions of the Consensus Statement and EPA shall maintain the protections afforded in such confidentiality provisions.

a. Confidential Business Information (CBI)

Information submitted to EPA under provisions of the Toxic Substances Control Act (TSCA), in support of TSCA, or as FYI under the terms of a voluntary testing agreement is subject to the provisions of Section 14 of TSCA and to EPA's Regulations on the Confidentiality of Business Information. All responses and correspondence will be placed in the OTS public files unless confidentiality is claimed in accordance with the procedures outlined in Exhibit III, entitled: "Support Information for Confidentiality Claims." Additional information about confidentiality claims can be found in 40 CFR Chapter 1, Section 2.203 et seq, and 41 FR 36902, September 1, 1976 as amended at 43 FR 40000, September 8, 1978 and 50 FR 51661, December 8, 1985. In the event that a claim for confidentiality is made on all or part of the provided information, said information will only be released by the EPA to

the extent, and by means of the procedures, set forth in the cited regulations. Requests for confidentiality should be addressed to U.S. Environmental Protection Agency, Office of Toxic Substances, Document Processing Center (TS-790), 401 M Street S.W., Washington DC, 20460 (Attn: Frank Caesar, Carpet Emissions Administrative Record).

b. Data Submission

The CCC shall submit a final report on Phase I and Phase II of the Carpet Cushion Testing Program as described in section 3.4.4 of the Consensus Statement and in accordance with the QAPjP. A cover letter along with two (2) copies shall be submitted for public access to the U.S. Environmental Protection Agency, Office of Toxic Substances, Information Management Office (TS-793), 401 M Street S.W., Washington DC, 20460, Attn: Lynn Marcus, Carpet Emissions Administrative Record. If the test results contain Confidential Business Information (CBI) the package must contain the cover letter, the original submitted in accordance with the Consensus Statement, and two (2) copies of the CBI study results, and three copies of a sanitized version appropriate for public access. CBI submittals shall be sent to the U.S. Environmental Protection Agency, Office of Toxic Substances, Document Control Office (TS-790), 401 M Street S.W., Washington DC, 20460, Attn: Lynn Marcus, Carpet Emissions Administrative Record.

B. Carpet Cushion TVOC Source Reduction Study

1. Study Definition

The CCC shall take responsibility for and coordinate the completion of a comprehensive study which examines the manufacturing processes of each of the five types of carpet cushions. These manufacturing processes will be evaluated by task forces of carpet cushion industry technical and manufacturing personnel. Sources of carpet cushion TVOCs will be identified in the comprehensive study. Particular emphasis will be placed on summarizing information on the contributions of raw materials to carpet cushion TVOCs. Potential means by which carpet cushion TVOCs can be reduced will be

identified. The study will include, but is not limited to, an evaluation of the extent to which the following potential actions may reduce carpet cushion TVOCs in terms of TVOC reductions and cost effectiveness for each of the five carpet cushion manufacturing processes:

(1) Replacement of TVOC generating chemicals and raw materials with lower TVOC substitutes;
(2) Changes in the operating conditions, procedures and equipment of the manufacturing process;
(3) Changes in management practices related to the manufacturing processes (eg. monitoring of raw material TVOC levels);
(4) Enhancement or initiation of recycle or reuse programs which reduce TVOC sources;
(5) Improved control/treatment technologies which could lower carpet cushion TVOCs at the manufacturing site (eg. air stripping of cushions).

A listing of past actions taken by carpet cushion manufacturers that have reduced TVOC emissions from carpet cushion products can be included in the study to provide an historical perspective on this subject for this industry.

2. Study Results

The CCC shall submit a final report on the Carpet Cushion TVOC Source Reduction Study within one year of the date of signature of this Memorandum of Understanding.

a. Confidential Business Information (CBI)

Information submitted to EPA under provisions of the Toxic Substances Control Act (TSCA), in support of TSCA, or as FYI under the terms of a voluntary agreement is subject to the provisions of Section 14 of TSCA and to EPA's Regulations on the Confidentiality of Business Information. All responses and correspondences will be placed in the OTS public files unless confidentiality is claimed in accordance with the procedures outlined in Exhibit III, entitled: "Support Information for Confidentiality Claims." Additional information about confidentiality claims can be

found in 40 CFR Chapter 1, Section 2.203 et seq, and 41 FR 36902, September 1, 1976 as amended at 43 FR 40000, September 8, 1978 and 50 FR 51661, December 8, 1985. In the event that a claim for confidentiality is made on all or part of the provided information, said information will only be released by the EPA to the extent, and by means of the procedures, set forth in the cited regulations. Requests for confidentiality should be addressed to U.S. Environmental Protection Agency, Office of Toxic Substances, Document Processing Center (TS-790), 401 M Street S.W., Washington DC, 20460 (Attn: Frank Caesar, Carpet Emissions Administrative Record).

b. Study Submission

A cover letter along with two (2) copies shall be submitted for public access to the U.S. Environmental Protection Agency, Office of Toxic Substances, Information Management Office (TS-793), 401 M Street S.W., Washington DC, 20460, Attn: Lynn Marcus, Carpet Emissions Administrative Record. If the study contains Confidential Business Information (CBI) the package must contain the cover letter, the original and two (2) copies of the CBI study results, and three copies of a sanitized version appropriate for public access. CBI submittals shall be sent to the U.S. Environmental Protection Agency, Office of Toxic Substances, Document Control Office (TS-790), 401 M Street S.W., Washington DC, 20460, Attn: Lynn Marcus, Carpet Emissions Administrative Record.

C. Consultation and Follow-on Activities

1) Carpet Cushion Testing Program

The parties to this Memorandum of Understanding recognize that Section 3.4.3 of the Carpet Cushion Council Consensus Statement calls for a technical evaluation of Phase I and Phase II data by EPA for the purpose of determining the need for follow-on testing, if required. The EPA reserves the right to assess the suitability of the test program results submitted for this evaluation to assure that EPA has met the goals and concepts of the Federal Register notice. Issues identified by EPA will be discussed as follow-on activities in joint consultation by

the parties named below or their representatives. Details of these matters will be worked out by consent of both parties and could be the subject of additional Memoranda of Understanding.

Elements described in Section 4 of the Consensus Statement identify follow-on activities proposed by CCC that would benefit by collaborative efforts undertaken by both parties to this agreement. Therefore, activities such as: 1) the industry-wide study, 2) the annual industry report, 3) the quality assurance product certification program, 4) public communication, and 5) the database information repository are considered useful follow-on activities. To this extent the CCC intends to pursue and report to EPA on progress in these areas.

2) Carpet Cushion TVOC Source Reduction Study

In order to insure efficient consultation and cooperation of the organizations' participating in this MOU, the Carpet Cushion Council will within two months of signing the MOU, submit to EPA a workplan describing how the Carpet Cushions TVOC Source Reduction Study will be developed. The workplan will identify:

(1) the individuals developing the study and their qualifications;
(2) What issues the study will address;
(3) A draft table of contents of the study; and
(4) A schedule for completing the study.

EPA will respond to CCC with comments on the workplan. If needed, the workplan will be revised accordingly to accommodate the interests of CCC and EPA.

Should CCC have technical questions about provisions of this Memorandum of Understanding, please contact the Director of the Existing Chemicals Assessment Division, Charles M. Auer, at (202)382-3442.

IV. PLACEMENT OF RESPONSIBILITIES

Responsibility for completion of the CCC Carpet Cushion Testing Program, CCC reporting activities, EPA technical evaluation of the testing results, Carpet Cushion TVOC Source Reduction Study, and inclusion of the final reports into the EPA Administrative Record as described in this Memorandum of Understanding is placed with the Executive Director, Carpet Cushion Council, and the Director, Office of Toxic Substances, EPA.

V. OTHER AGREEMENTS

Nothing in this Memorandum of Understanding precludes EPA from any other steps it deems necessary to carry out any applicable laws, regulations, or policies. These include activities listed in the U.S. Code of Federal Regulations, and the reduction of carpet emissions described in the Federal Register notices cited above. Furthermore, this Memorandum of Understanding does not preclude EPA from entering into separate agreements with individual carpet cushion manufacturers that are not participating in the Carpet Cushion Council TVOC Testing Program referenced in III. C. above and are not cosignatories to this MOU. It is understood that any such separate agreements pertaining to the subject matter of this MOU will not contain provisions less stringent or contrary to those terms and conditions stipulated herein. Similarly, nothing precludes CCC from entering into similar agreements with their contractors, or constituent members for the purposes of conducting and reporting testing, or similar agreements with other regulatory Agencies.

VI. NAME AND ADDRESS OF PARTIES

A. Carpet Cushion Council
P.O. Box 546
Riverside, CT 06878

B. U.S. Environmental Protection Agency
Office of Toxic Substances
401 M Street, SW
Washington, DC 20460

VII. PERIOD OF AGREEMENT

This Memorandum of Understanding is entered into by the Carpet Cushion Council (CCC) and the U.S. Environmental Protection Agency (EPA) as of this twenty-sixth day of September, 1991.

Carpet Cushion Industry Manufacturing Companies:

Bonda Foam Company
Water Valley, MS 38965
Sterling Allen

Chris Craft Industrial Products, Inc.
Waterford, NY 12188
John Uchmanovicz

Crain Industries
Fort Smith, AR 72906
Michael A. Ricciardi

Custom Coating, Inc.
Dalton, GA 30720
Donald A. Irwin, Sr.

Dixie Manufacturing Company
Norfolk, VA 23510
John S. Mitchell

Dura Undercushions, Ltd
Montreal, Quebec CANADA H4T 1M1
David Beal

E.R. Carpenter Co. Inc.
Richmond, VA 23261
Ronald A. Hingst

Fairmont Corporation
Chicago, IL 60609
Gerald A. Bader

Flexible Foam Products Co.
Spencerville, OH 45887
Richard Whitling

Foamex, L.P.
Eddystone, PA 19022
Robert J. Hay

Foss Manufacturing, Inc.
Hampton, NH 03842
Brian D. Jeffrey

Future Foam, Inc.
Council Bluffs, IA 51503
Robert A. Heller

General Felt Industries, Inc.
Philadelphia, PA 19137
Michael V. Rivera

General Foam Corporation
Paramus, NJ 07652
Jack Meyerhardt

Great Western Carpet Cushion Co.
Orange, CA 92665
Vincent A. Bonaddio

G.S. Industries, Inc.
Newton, NC 28658
G.M. Solmaz

Hi Life Products Inc.
Chino, CA 91708
Peter Maxwell

Hickory Springs Mfg. Company
Hickory, NC 28603
Harold W. Allison

Hobbs Bonded Fibers
Lynchburg, VA 24503
Stephen L. Hooten

MPI, a Leggett & Platt Company
Fort Worth, TX 76113
Larry R. Heppe

Milliken-Sommer
Simpsonville, SC 29681
Scott E. Dempsey

National Foam Cushion Mfg. Co.
North Richland Hills, TX 76182
John Darby

No-Mur Corporation, Inc.
Jacksonville, FL 32216
Charles Mussallem III

North Carolina Foam Co.
Mt. Airy, NC 27030
J.C. Barnhardt, Jr.

Olympic Products
Greensboro, NC 27406
Larry R. Barnes

PermaFirm Pad Company
Los Angeles, CA 90013
Burton Sunkin

Reliance Upholstery Supply Co. Inc.
Gardena, CA 90248
Frank H. Huttner

Scottdel, Inc.
Swanton, OH 43558
Ernest H. Schorsch

Shaw Industries, Inc.
Dalton, GA 30722-2128
W.M. Sims, Jr.

Southwest Carpet Pad Co
Carson, CA 90746
Charles W. Morgan

Sponge Cushion, Inc.
Morris, IL 60450
Frank J. Raus

Waterville TG Inc.
Mississauga, Ontario L4W 1P1 CAN
Jean A. Aubin

Woodbridge Foam Fabricating, Inc
Chattanooga, TN 37401
Ronald A. Lessa

For the Carpet Cushion Council:

William H. Oler
Executive Director

For the Environmental Protection Agency:

Mark A. Greenwood
Director
Office of Toxic Substances

ATTACHMENT J-1

Federal Register: Carpet Policy Dialogue: Memorandum of Understanding: Testing Program for Carpet Cushion Products

[OPTS-00114; FRL-4004-3]

Carpet Policy Dialogue; Memorandum of Understanding: Testing Program for Carpet Cushion Products

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of availability.

SUMMARY: EPA has entered into a Memorandum of Understanding (MOU) with the Carpet Cushion Council (CCC) acting on behalf of the carpet cushion industry for the purpose of initiating the provisions stated within the context of the Carpet Policy Dialogue - Consensus Statement: Testing Program for Carpet Cushion Products. The MOU provides for carpet cushion product testing for total volatile organic compound emissions (TVOC) and reporting of data as outlined in the testing program.

DATES: The MOU was entered into on September 26, 1991.

FOR FURTHER INFORMATION CONTACT: Dave Kling, Acting Director, Environmental Assistance Division (TS-799), Office of Toxic Substances, Environmental Protection Agency, 401 M St., SW., Washington, DC 20460. Telephone: (202) 554-1404, TDD: (202) 554-0557, or FAX (202) 554-5603 (document requests only). For information on the Carpet Policy Dialogue Project contact Richard W. Leukroth, Jr., Carpet Policy Dialogue Coordinator, Telephone: (202) 260-3832. Copies of the MOU may be obtained from the Environmental Assistance Division at the address listed above.

SUPPLEMENTARY INFORMATION:

I. Background

The Carpet Policy Dialogue (August 21, 1990 to September 27, 1991) was part of the Agency's response to a petition under section 21 of TSCA (55 FR 17404; 55 FR 31640). EPA charged the dialogue to work out the details of voluntary product testing programs that report TVOC's that emit from carpet, carpet installation adhesives, and carpet cushion products. In addition, the Carpet Policy Dialogue was asked to explore and, where possible, reach agreement on a variety of issues including: the sampling and analytical methods for the voluntary product testing for TVOC's, any additional information needed, identification of cost-effective process changes to reduce TVOC emissions, information about carpet installation practices, and to provide the interested public with information on TVOC emissions. The Carpet Policy Dialogue formed three working Subgroups (Product Testing, Process Engineering, and Public Communications) to respond to the EPA charter.

The Carpet Policy Dialogue on TVOC emissions was a nonregulatory approach focusing on product stewardship through voluntary actions on the part of industry. It emphasized exposure reduction (pollution prevention), and addressed the public desire for information that could lead to consumer choice. The Carpet Policy Dialogue exemplified how government, industry, public interest groups, and the scientific community can work together to resolve exposure reduction and pollution prevention issues, including those related to indoor air exposures. Proposed testing programs were developed during Subgroup discussion and submitted to the Carpet Policy Dialogue for the benefit of a consensus process of review and comment. In reaching consensus and accepting the carpet cushion testing program, the Carpet Policy Dialogue indicated to its sponsor (EPA) that such a statement can provide the basis for a memorandum of understanding to initiate voluntary action(s) in response to the charter set by EPA in the **Federal Register** notices (55 FR 17404 and 55 FR 31640).

II. Memorandum of Understanding

The EPA and CCC entered into the MOU on September 26, 1991. The MOU signed by EPA and CCC formally establishes a framework in which a voluntary program response for actions described in the **Federal Register** notices noted above can be fulfilled. It contains provisions initiating the Carpet Cushion Testing Program on TVOC emissions and certain follow-on activities.

A. Carpet Cushion Testing Program

Under the terms and conditions of the MOU, the CCC has voluntarily agreed to conduct product testing to determine TVOC emissions factors for the five product types currently available in commerce over the next 3 years. The objectives of the Carpet Cushion Testing Program are to: (1) Study carpet cushion emissions decay characteristics, (2) address the question of TVOC emission variability, or the lack thereof, across

carpet cushion product types, and (3) determine the time point(s) for measuring TVOC emissions from the five product types. Results from this testing will be used in finalizing the design of a follow-on industry-wide study of a representative sample of carpet cushion products.

B. Participants

Placement of responsibilities for the actions described in the MOU is with the Executive Director, Carpet Cushion Council and the Director, Office of Toxic Substances, EPA.

III. Administrative Record

The MOU is available to the public in the Carpet Emissions Administrative Record. This Administrative Record is available for reviewing and copying in the TSCA Public Docket Office from 8 a.m. to noon and 1 p.m. to 4 p.m., Monday through Friday, excluding legal holidays. The TSCA Public Docket Office is located at EPA Headquarters, Rm. NE-G004, 401 M St., SW., Washington, DC 20460.

Dated: November 25, 1991.

Mark A. Greenwood,

Director, Office of Toxic Substances.

[FR Doc. 91-28825 Filed 11-29-91; 8:45 am]

BILLING CODE 6560-50-F

APPENDIX K

Memorandum of Understanding Between the Floor Covering Adhesive Manufacturers Committee and the U.S. Environmental Protection Agency

MEMORANDUM OF UNDERSTANDING

between the

Floor Covering Adhesive Manufacturers Committee

and the

U.S. Environmental Protection Agency

September 26, 1991

MEMORANDUM OF UNDERSTANDING

A. BACKGROUND

The Environmental Protection Agency (EPA) initiated a dialogue process in April, 1990, to undertake certain actions with respect to reducing emissions from carpet and associated products of carpet flooring systems. One aspect is to develop a program for the voluntary testing of, and collection of data on, total volatile organic compound (TVOC) emissions from carpet installation adhesives. See "Carpet: Response to Citizens' Petition," 55 FR 17,404 (April 24, 1990) and "Carpet Emissions Reduction; Policy Dialogue," 55 FR 31,640 (August 3, 1990).

As part of the dialogue process, the Carpet Policy Dialogue Group reached a consensus agreement (June 28, 1991) on the Floor Covering Adhesive Manufacturers Committee Consensus Statement: Testing Program for Floor Covering Adhesives. In reaching this agreement the Carpet Policy Dialogue Group indicated to its sponsor (EPA) that the testing program described in the Consensus Statement could provide the basis for a Memorandum of Understanding to initiate voluntary action(s) by industry in response to the charter set by EPA in the Federal Register notices. This Consensus Statement describing the testing program for carpet installation adhesives is affixed (Exhibit I).

B. PURPOSE

The Floor Covering Adhesive Manufacturers (FCAMC) and EPA are entering into this Memorandum of Understanding for the purpose of initiating the provisions and follow-up expectations as stated within the context of the above mentioned Carpet Policy Dialogue Consensus Statement and for providing for the product testing and reporting of data developed from the Carpet Installation Adhesive Testing Program as outlined therein.

C. SUBSTANCE OF THE AGREEMENT

This Memorandum of Understanding formally establishes a framework in which a voluntary program response for actions described in the Federal Register notices noted above can be fulfilled. Therefore, FCAMC and EPA enter into the following understandings:

1. Preliminary Studies/Testing and Data Development

The FCAMC shall take responsibility for and coordinate the testing and data development provided for in the Consensus Statement, in accordance with the procedures described within and the attachments affixed thereto, and with due consideration for the following provisions:

a. Quality Assurance

The U.S. EPA order 5360.1[1] mandates that "quality assurance is embedded in all data collection undertaken by or for the Agency." In meeting this requirement, the Office of Toxic Substances (OTS) requires the preparation of a Quality Assurance Project Plan (QAPjP) which must be submitted to and approved by EPA for use during the testing project operations outlined in the Consensus Statement. Detailed guidance is provided on the preparation of the QAPjP in the affixed document: "Office of Toxic Substances Guidance Document for the Preparation of Quality Assurance Project Plans for Industry Studies" (Exhibit II).

b. Protocol Changes

Any changes, modifications, or amendments to the testing program described within the Consensus Statement and its attachments shall be brought to the attention of EPA by FCAMC and documented in the record. Upon notification, both parties to this agreement shall develop an alternate approach to fulfill the needs and requirements of the Floor Covering Adhesives Testing Program. The parties shall jointly agree on the alternate approach and a statement of such agreement shall be entered into the record.

c. Data Development

The test results will be developed into a report(s) and submitted to EPA as described in the Consensus Statement and in accordance with the provisions described below (see Data Submission). The FCAMC has committed to initiating product

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[1] USEPA. 1984. U.S. Environmental Protection Agency. Policy and program requirements to implement the mandatory quality assurance program. Washington, DC: Office of Administration and Resource Management, USEPA. EPA Order 5360.1.

testing in July, 1991, with a view to generating a report on Phase I in the fall of 1991. Phase II will be conducted as resources can be made available, but within a year period from the date of this MOU. Upon completion of EPA's review of Phase I test results, EPA and FCMAC will jointly determine the number and allocation of samples to be included in Phase II testing. The agreed upon procedures for Phase II testing shall be documented as an addendum to this MOU and be placed in the Carpet Admissions Administrative Record.

2. Confidentiality

The testing, data development, and data reporting shall be conducted in accordance with the confidentiality provisions of the Consensus Statement and EPA shall maintain the protections afforded in such confidentiality provisions.

a. Confidential Business Information (CBI)

Information submitted to EPA under provisions of the Toxic Substances Control Act (TSCA), in support of TSCA, or as FYI under the terms of a voluntary testing agreement is subject to the provisions of Section 14 of TSCA and to EPA's Regulations on the Confidentiality of Business Information. All responses/correspondence will be placed in the OTS public files unless confidentiality is claimed in accordance with the procedures outlined in Exhibit III, entitled: "Support Information for Confidentiality Claims." Additional information about confidentiality claims can be found in 40 CFR Chapter 1, Section 2.203 et seq, and 41 FR 36902, September 1, 1976 as amended at 43 FR 40000, September 8, 1978 and 50 FR 51661, December 8, 1985. In the event that a claim for confidentiality is made on all or part of the provided information, said information will only be released by the EPA to the extent, and by means of the procedures, set forth in the cited regulations. Requests for confidentiality should be addressed to U.S. Environmental Protection Agency, Office of Toxic Substances, Document Processing Center (TS-790), 401 M Street S.W., Washington DC, 20460 (Attn: Frank Caesar, Carpet Emissions Administrative Record).

b. Data Submission

The data collected in each phase of the testing

program will be submitted to EPA for review as soon as each data set becomes available. Thus, an initial evaluation of preliminary data, two detailed evaluations of the results of Phase I and Phase II testing, and an overall evaluation on the combined results will be conducted.

The FCAMC shall submit a final report on the Carpet Installation Adhesives Testing Program as described in section 3.4.4 of the Consensus Statement and in accordance with the QAPjP. A cover letter along with two (2) copies shall be submitted for public access to the U.S. Environmental Protection Agency, Office of Toxic Substances, Information Management Office (TS-793), 401 M Street S.W., Washington DC, 20460, Attn: Lynn Marcus, Carpet Emissions Administrative Record. If the test results contain Confidential Business Information (CBI) the package must contain the cover letter, the original submitted in accordance with the Consensus Statement and two (2) copies of the CBI study results, and three copies of a sanitized version appropriate for public access. CBI submittals shall be sent to the U.S. Environmental Protection Agency, Office of Toxic Substances, Document Control Office (TS-790), 401 M Street S.W., Washington DC, 20460, Attn: Lynn Marcus, Carpet Emissions Administrative Record.

3. Consultation and Follow-on Activities

The parties to this Memorandum of Understanding recognize that Section 3.4.3 of the Consensus Statement calls for technical evaluations by EPA of the results of the preliminary testing, Phase I and Phase II, and ultimately an overall evaluation for the purpose of determining the need for follow-on testing, if required. The EPA reserves the right to assess the suitability of the test program results submitted for each of these evaluations to assure that EPA has met the goals and concepts of the Federal Register notice. Issues identified by EPA will be discussed as follow-on activities in joint consultation by the parties named below. Details of these matters will be worked out by consent of both parties and could be the subject of additional Memoranda of Understanding.

Elements described in Section 4 of the Consensus Statement identify certain follow-on activities proposed by FCAMC which would benefit by collaborative efforts undertaken by both parties to this agreement. Therefore, activities such as: 1) annual industry report, 2) testing

follow-up activities including development of TVOC emission rate data on product types by company and study to determine if a correlation can be achieved between calculated VOCs and emissions testing measurements, 3) public communication, and 4) database information repository are considered useful follow-on activities including development of TVOC emission rate data on product types by company and study to determine if a correlation can be achieved between calculated VOCs and emission testing measurements. To this extent the FCAMC intends to pursue and report to EPA on progress in these areas.

Should FCAMC have technical questions about provisions of this Memorandum of Understanding, please contact the Director of the Existing Chemicals Assessment Division, Charles M. Auer, at (202)382-3442.

D. PLACEMENT OF RESPONSIBILITIES

Responsibility for completion of the FCAMC Floor Covering Adhesives Testing Program, FCAMC reporting activities, EPA technical evaluation of the testing results, and inclusion of the final report into the EPA Administrative Record as described in this Memorandum of Understanding is placed with the Chairperson, Floor Covering Adhesive Manufacturers Committee, and the Director, Office of Toxic Substances, EPA.

E. OTHER AGREEMENTS

Nothing in this Memorandum of Understanding precludes EPA from any other steps it deems necessary to carry out any applicable laws, regulations, or policies. These include activities listed in the U.S. Code of Federal Regulations, and the reduction of carpet emissions described in the Federal Register notices cited above. Furthermore, this Memorandum of Understanding does not preclude EPA from entering into separate agreements with individual floor covering adhesives manufacturers that are presently not constituent members of the Floor Covering Adhesive Manufacturers Committee. It is understood that any such separate agreements pertaining to the subject matter of this MOU will not contain provisions less stringent or contrary to those terms and conditions stipulated herein. Similarly, nothing precludes FCAMC from entering into similar agreements with their contractors, or constituent members for the purposes of conducting and reporting testing, or similar agreements with other regulatory Agencies.

F. NAME AND ADDRESS OF PARTIES

1. Floor Covering Adhesive Manufacturers Committee
National Association of Floor Covering Distributors
85 W. Algonquin Road, Suite 375
Arlington Heights, Illinois 60005

2. U.S. Environmental Protection Agency
Office of Toxic Substances
401 M Street, SW
Washington, DC 20460

G. PERIOD OF AGREEMENT

This Memorandum of Understanding is entered into by the Floor Covering Adhesive Manufacturers Committee (FCAMC) and the U.S. Environmental Protection Agency (EPA) as of this twenty-sixth day of September, 1991.

Floor Covering Adhesive Manufacturers Committee Producer Member Companies:

Adh. Ind. Mfgr. Co.
Cerritos, CA 90702

Advanced Adh. Tech.
Dalton, GA 30711-1887

Capitol Adh. Inc.
Dalton, GA 30722

Chicago Adh. Products Co.
Chicago, IL 60629

DAP Inc.
Dayton, Ohio 45401-0277

Macklanburg-Duncan
Oklahoma City, OK 73125

Para-Chem Southern Inc.
Simpsonville, SC 29681

Roberts Consolidated Ind.
City of Industry, CA 91749

Superbond, Inc.
Philadelphia, PA 19134

W.F. Taylor Co. Inc.
Santa Fe Springs, CA 90670

MAPEI USA
Elk Grove Village, IL 60007

Tennessee Adh. & Chem.
Mt. Juliet, TN 37122

W.W. Henry Company
Huntington Park, CA 90255

XL Corporation
Calhoun, GA 30701

TEC, Inc.
Palatine, IL 60867

Gibson Homans - Bogart Div.
Baltimore, MD 21237

For the Floor Covering Adhesive Manufacturers Committee:

Kenneth E. Knudtzon
Chairperson

For the Environmental Protection Agency:

Mark A. Greenwood
Director
Office of Toxic Substances

ATTACHMENT K-1

Federal Register: Carpet Policy Dialogue;
Memorandum of Understanding: Testing Program
for Carpet Installation Adhesives

[OPTS-00115; FRL-4004-4]

Carpet Policy Dialogue; Memorandum of Understanding: Testing Program for Carpet Installation Adhesives

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of availability.

SUMMARY: EPA has entered into a Memorandum of Understanding (MOU) with the Floor Covering Adhesive Manufacturers Committee (FCAMC), of the National Association of Floor Covering Distributors for the purpose of initiating the provisions stated within the context of the Carpet Policy Dialogue - Consensus Statement: Testing Program for Carpet Installation Adhesives. The MOU provides for test method development, decay curve testing, carpet installation adhesive product testing for total volatile organic compound emissions (TVOC), and reporting of data as outlined in the testing program.

DATES: The MOU was entered into on September 26, 1991.

FOR FURTHER INFORMATION CONTACT: Dave Kling, Acting Director, Environmental Assistance Division (TS-799), Office of Toxic Substances, U.S. Environmental Protection Agency, 401 M St., SW., Washington, DC 20460. Telephone: (202) 554-1404, TDD: (202) 554-0557, or FAX (202) 554-5603 (*document requests only*). For information on the Carpet Policy Dialogue Project contact Richard W. Leukroth, Jr., Carpet Policy Dialogue Coordinator, Telephone: (202) 260-3832. Copies of the MOU may be obtained from the Environmental Assistance Division listed at the address above.

SUPPLEMENTARY INFORMATION:

I. Background

The Carpet Policy Dialogue (August 21, 1990 to September 27, 1991) was part of the Agency's response to a petition under section 21 of TSCA (55 FR 17404; 55 FR 31640). EPA charged the dialogue to work out the details of voluntary product testing programs that report TVOC's that emit from carpet, carpet installation adhesives, and carpet cushion products. In addition, the Carpet Policy Dialogue was asked to explore and, where possible, reach agreement on a variety of issues including: the sampling and analytical methods for the voluntary product testing for TVOC's, any additional information needed, identification of cost-effective process changes to reduce TVOC emissions, information about carpet installation practices, and to provide the interested public with information on TVOC emissions. The Carpet Policy Dialogue formed three working Subgroups (Product Testing, Process Engineering, and Public Communications) to respond to the EPA charter.

The Carpet Policy Dialogue on TVOC emissions was a nonregulatory approach focusing on product stewardship through voluntary actions on the part of industry. It emphasized exposure reduction (pollution prevention), and addressed the public desire for information that could lead to consumer choice. The Carpet Policy Dialogue exemplified how government, industry, public interest groups, and the scientific community can work together to resolve exposure reduction and pollution prevention issues, including those related to indoor air exposures. Proposed testing programs were developed during Subgroup discussion and submitted to the Carpet Policy Dialogue for the benefit of a consensus process of review and comment. In reaching consensus and accepting the carpet installation adhesive testing program, the Carpet Policy Dialogue indicated to its sponsor (EPA) that such a statement can provide the basis for a memorandum of understanding to initiate voluntary action(s) in response to the charter set by EPA in the Federal Register notices (55 FR 17404 and 55 FR 31640).

II. Memorandum of Understanding

The EPA and FCAMC entered into the MOU on September 26, 1991. The MOU signed by EPA and FCAMC formally establishes a framework in which a voluntary program response for actions described in the Federal Register notices noted above can be fulfilled. It contains provisions initiating the Carpet Adhesive Testing Program on TVOC emissions and certain follow-on activities.

A. Carpet Adhesive Testing Program

Under the terms and conditions of the MOU, the FCAMC has voluntarily agreed to develop an analytical test method for measuring TVOC emissions from adhesive products, conduct decay curve testing to determine the time point(s) for measuring TVOC emissions from the selected test procedure, and conduct product testing to determine TVOC emissions factors for five adhesive product types currently available in commerce over the next 2 years. The objectives of the Carpet Adhesive Testing Program are to: (1) Study carpet adhesive emissions decay characteristics, and (2) characterize quantitatively the distribution of TVOC emissions factor performance of the carpet adhesive product types currently in commerce.

B. Participants

Placement of responsibilities for the actions described in the MOU is with the Chairperson, Floor Covering Adhesive Manufacturers Committee of the National Association of Floor Covering Distributors and the Director, Office of Toxic Substances, EPA.

III. Administrative Record

The MOU is available to the public in the Carpet Emissions Administrative Record. This Administrative Record is available for reviewing and copying in the TSCA Public Docket Office from 8 a.m. to noon and 1 p.m. to 4 p.m., Monday through Friday, excluding legal holidays. The TSCA Public Docket Office is located at EPA Headquarters, Rm. NE–G004, 401 M St., SW., Washington, DC 20460.

Dated: November 25, 1991.

Mark A. Greenwood,

Director, Office of Toxic Substances.

[FR Doc. 91–28924 Filed 11–25–91; 8:45 am]

BILLING CODE 6560–50–F

APPENDIX L

Memorandum of Understanding Between the Styrene Butadiene Latex Manufacturers' Council and the U.S. Environmental Protection Agency

MEMORANDUM OF UNDERSTANDING

BETWEEN THE

STYRENE BUTADIENE LATEX MANUFACTURERS COUNCIL

AND THE

U. S. ENVIRONMENTAL PROTECTION AGENCY

SEPTEMBER 26, 1991

MEMORANDUM OF UNDERSTANDING

A. BACKGROUND

The EPA initiated a dialogue process in April 1990, to undertake certain actions with respect to reducing emissions from carpet. One aspect is to develop a program for the voluntary collection of data on emissions from carpet. See "Carpet: Response to Citizens' Petition, "55 Fed. Reg. 17,404 (April 24, 1990) and "Carpet Emissions Reduction; Policy Dialogue, "55 Fed. Reg. 31,640 (August 3, 1990). As part of the dialogue process, the Carpet Policy Dialogue Group reached a consensus agreement on May 23, 1991, concerning the Styrene Butadiene Latex Manufacturers Council's (SBLMC) voluntary offer to provide data on the levels of 4-phenylcyclohexene (4-PC) in styrene butadiene latex sold for carpet backing applications.

This Memorandum of Understanding will record voluntary actions by SBLMC in response to the charter set by EPA in the Federal Register notices.

B. PURPOSE

The SBLMC and EPA are entering into this Memorandum of Understanding for the purpose of stating the provisions of the voluntary agreement within the context of the above mentioned Carpet Policy Dialogue and for providing for the public reporting of company quality assurance data.

C. SUBSTANCES OF THE AGREEMENT

This Memorandum of Understanding formally establishes a framework in which a voluntary program response to the Federal

Register notices noted above can be undertaken. Therefore, SBLMC and EPA enter into the following understandings:

1. 4-PC Reporting

a. SBLMC members, acting through SBLMC, will provide data from their ongoing quality analysis programs that will report the company-by-company weighted average of 4-PC in styrene butadiene latex sold for carpet backing applications for the last quarter of 1991 and the last quarter of 1992. Individual company average 4-PC measurements used as input to the weighting calculation as well as the weighting calculation methodology will be reported. All 4-PC measurements will be made, as has been the case in the past SBLMC-sponsored 4-PC survey, by the analytical method, "Quantitation of 4-Phenylcyclohexene in Styrene-Butadiene Latex by Capillary Gas Chromatography" described in Attachment I; or equivalent method.

b. SBLMC will provide information regarding the quality control practices applied to generate 4-PC data. General comparisons will be made between actual laboratory practices used and provisions of TSCA Good Laboratory Practice Standards as stated in 40 CFR Part 792, FR Vol. 54, No. 158, August 17, 1989). 4-PC data will be reported to EPA through SBLMC in non-confidential form but with individual company identifiers blinded to protect confidentiality. The data will be reported, as it becomes available, for a total number of two reports submitted under the terms of this Memorandum of Understanding. Newly

reported data will be compared to data previously submitted to EPA and the Carpet Policy Dialogue. The reported data will also be displayed by updating the graph titled, "4-PCH Reduction History" shown in Attachment II.

c. SBLMC will assess the styrene butadiene latex 4-PC data developed in the ongoing quality analysis programs noted above to determine the feasibility of utilizing the information to develop future quality control activities. This activity is voluntarily undertaken in the absence of scientific evidence linking adverse health effects and the levels emitted by new carpet. SBLMC will provide its assessment to EPA on or before ~~the expiration of this Memorandum of Understanding.~~ JULY 1, 1993 RGA

d. EPA shall make the reports publicly available via the Carpet Emissions Administrative Record.

2. Reporting Requirements

The SBLMC shall submit the data reports and other communications noted above as described in this paragraph. A cover letter along with two-(2) copies of each report shall be submitted for public access to the U.S. Environmental Protection Agency, Office of Toxic Substances, Information Management Office (TS-793), 401 M Street, S.W., Washington, D.C. 20460, Attn: Lynn Marcus, Carpet Emissions Administrative Record.

D. PLACEMENT OF RESPONSIBILITIES

Responsibility for completion of the SBLMC 4-PC data submission activity, as described in this Memorandum of Understanding, is placed with the Chairman of SBLMC, and the Director, Office of Toxic Substances, EPA.

E. OTHER AGREEMENTS

Nothing in this Memorandum of Understanding precludes EPA from any other steps it deems necessary to carry out any applicable laws, regulations, or policies. These include activities listed in the U.S. Code of Federal Regulations, and the reduction of carpet emissions described in the Federal Register notices cited above. Furthermore, this Memorandum of Understanding does not preclude EPA from entering into separate agreements with individual latex manufacturers that are presently not constituent members of the SBLMC. It is understood that any such separate agreements pertaining to the subject matter of this Memorandum of Understanding will not contain provisions less stringent or contrary to those terms and conditions, stipulated herein. Similarly, nothing precludes SBLMC from entering into similar agreements with any contractors, or constituent members for the purposes of conducting and reporting testing, or similar agreements with other regulatory agencies.

F. NAME AND ADDRESS OF PARTIES

Styrene Butadiene Latex Manufacturers Council
1815 H Street, N.W.
Washington, D.C. 20006-3604

U.S. Environmental Protection Agency
Office of Toxic Substances
401 M Street, S.W.
Washington, D.C. 20460

G. PERIOD OF AGREEMENT

This Memorandum of Understanding is entered into by the SBLMC and the U.S. Environmental Protection Agency (EPA) as of this 26th DAY of September, 1991 and shall expire upon completion of reporting as described in paragraph C.1 above.

For the Styrene Butadiene latex Manufacturers Council:

Randall G. Arnott
Styrene Butadiene Latex
Manufacturers Council

For the Environmental Protection Agency:

Mark A. Greenwood
Director
Office of Toxic Substances

Attachment L-1

Quantitation of 4-Phenylcyclohexene in Styrene-Butadiene Latex

ATTACHMENT I

SBLMC

Styrene Butadiene Latex Manufacturers Council

1330 Connecticut Avenue, N.W., #300, Washington, D.C. 20036-1702
(202) 659-0060 • TELECOPIER (202) 659-1699

ANALYTICAL METHOD

QUANTITATION OF 4-PHENYLCYCLOHEXENE IN STYRENE-BUTADIENE LATEX BY CAPILLARY GAS CHROMATOGRAPHY

This method has been developed by the Analytical Committee of the Styrene Butadiene Latex Manufacturers Council (SBLMC) to provide a standard reference method for the detection of 4-phenylcyclohexene in carboxylated styrene-butadiene latices. The method has been validated and is available to any interested person. Further information on the method or on the validation can be obtained from the Styrene Butadiene Latex Manufacturers Council, Suite 300, 1330 Connecticut Avenue, N.W., Washington, D.C. 20036 (202/659-0060).

INTRODUCTION

4-Phenylcyclohexene (4-PCH), a co-dimer of 1,3-butadiene and styrene, has been associated with the odor in some styrene-butadiene (SB) based backings in carpets. The Analytical Committee of SBLMC developed this method in order to provide uniformly acceptable data for the level of 4-PCH in carboxylated styrene-butadiene (XSB) latices. The concentration of 4-PCH is reported on the basis of the total latex with a normalized solids content of 50%.

1. SCOPE

1.1 This method is applicable for the determination of 4-PCH in XSB latex produced for carpet backing applications.

1.2 This method was validated over a range of 94-2830 ppm 4-PCH (wt/wt latex solids).

2. REFERENCED DOCUMENTS

2.1 ASTM Standards:
D4483 Practice for Rubber-Determining Precision for Test Method Standards, Annual Book of ASTM Standards, Vol. 09.01 and 09.02

D1417 Standard Methods of Testing-Rubber Latices--Synthetic, Annual Book of ASTM Standards, Vol. 09.01

3. SUMMARY OF METHOD

3.1 4-Phenylcyclohexene is preferentially extracted from the XSB latex into an organic phase using a n-heptane/0.5M ammonium sulfate liquid-liquid extraction system.

3.2 An aliquout of the organic phase is analyzed using capillary gas chromatography.

3.3 An internal standard methodology is employed for making the quantitative calculations.

4. SIGNIFICANCE AND USE

4.1 Quantitation of 4-PCH in the XSB latex will help in further studies.

4.2 This method allows for the quantitation of 4-PCH with a relative standard deviation ($\sigma/\bar{X}$) of 1.4% determined at a level of 960 ppm (wt/wt latex solids).

5. APPARATUS

5.1 Gas Chromatograph - This instrument should be equipped with a flame ionization detector and have the capability to accept a wide-bore fused silica capillary column. A detector make-up gas is required.

5.2 Fused Silica Capillary Column, DB-5 (95% Dimethyl-(5%)-diphenyl-polysiloxane), 30M x 0.53mm ID with 1.5 micron film thickness, J&W Scientific, cat. no. 125-5032

5.3 Data Recording Device - A strip chart recorder, recording integrator, or computer based data system is suitable.

5.4 Mechanical shaker, (Eberbach shaker at high speed, 280 excursions per minute, or equivalent to provide for a minimum 92% (4-PCH) recovery in spiked latex samples)

5.5 Centrifuge, capable of 2000 rpm

5. APPARATUS (cont'd)

5.6 Balance, analytical, 0.1 mg readability, Mettler AE163, or equivalent

5.7 Aluminum weighing dish, diameter, 2 3/8"; depth, 5/8". These dishes should be pre-cleaned with suitable organic solvent, to eliminate processing oils, and dried in a vacumm oven before their use in the procedure.

5.8 Volumetric Flasks, 25, 250 mL

5.9 Vials, screw cap, size No.2, 2 3/4 (25 mL capacity)

6. REAGENTS AND MATERIALS

6.1 Purity of Reagents - Use solvents especially purified for high-pressure liquid chromatography work in this procedure. Use other grades only after ascertaining that the reagent is free of interferences.

6.2 Observe all health and safety recommendations of the chemical manufacturers when using their products.

6.3 Dodecane, 99.7%, Wiley Organics cat. no. 2269.55, or equivalent

6.4 4-Phenylcyclohexene, 98%, Wiley Organics cat. no. 7803.00, or equivalent

6.5 n-Heptane, B&J Brand, American Scientific Products cat. no. 210-4*DK, or equivalent

6.6 Ammonium Sulfate ((NH4)2SO4), American Scientific Products cat. no. 3512-500*NY, or equivalent

6.7 Water, triple distilled, Distillata, or equivalent

6.8 Ammonium Sulfate Solution (66 g/L) - Dissolve 66 g of ammonium sulfate ((NH4)2SO4) in water and dilute to 1 L.

7. PROCEDURE

7.1 Calibration:

7.1.1 Tare (to the nearest 0.1 mg) a 25 mL volumetric flask containing 10 mL n-heptane.

7.1.2 Weigh (to the nearest 0.1 mg) into the 25 mL volumetric flask 8 +/- 2 mg dodecane and 10 +/- 2 mg 4-phenylcyclohexene. Dilute to mark with n-heptane. Denote this solution as the 'Master Calibration'.

7. PROCEDURE (cont'd)

7.1.3 Pipet a 1 mL aliquout of the 'Master Calibration' into a clean 25 mL volumetric flask and dilute to mark with n-heptane. Denote this solution as the 'Working Calibration'.

7.1.4 Chromatograph a 1 microliter aliquot of the 'Working Calibration' under the conditions as outlined in TABLE 1. Analyze in triplicate or until a stable response factor is obtained.

7.1.5 Calculate an internal response factor for 4-PCH as per 8.1.1.

7.2 Preparation of Internal Standard Solution:

7.2.1 Tare (to the nearest 0.1 mg) a 25 mL volumetric flask containing 10 mL n-heptane.

7.2.2 Weigh (to the nearest 0.1 mg) into the 25 mL volumetric flask 8 +/- 1 mg dodecane. Dilute to mark with n-heptane. Denote this solution as the 'Internal Standard Solution'.

7.3 Sample Preparation and Analysis:

7.3.1 Tare (to the nearest 0.1 mg) a clean vial.

7.3.2 Weigh (to the nearest 0.1 mg) into the clean tared vial, 500 +/- 20 mg of the XSB latex sample.

7.3.3 Add 10 mL of the 0.5M ammonium sulfate solution.

7.3.4 Pipet 1 mL of the Internal Standard Solution into the sample vial.

7.3.5 Add 9 mL of n-heptane to the vial.

7.3.6 Cap vial and place on a mechanical shaker set at high speed (280 excursions per minute) for 30 minutes.

7.3.7 Remove vial from shaker, placing it in a centrifuge for 15 minutes at 2000 rpm.

7.3.8 Remove the vial from the centrifuge taking care not to intermix the separated layers.

7.3.9 Quantitatively remove the n-heptane layer (top) from the solution and place in a clean vial.

7.3.10 Add 10 mL of n-heptane to the original sample vial (aqueous phase) and repeat for a second time the procedure from 7.3.6 eventually combining the second n-heptane extraction layer with the first.

7. PROCEDURE (cont'd)

7.3.11 Chromatograph a 1 microliter aliquot of the combined n-heptane layers under the conditions outlined in TABLE 1.

7.3.12 Perform calculations as per 8.2.1.

7.4 Total Solids Determination:

7.4.1 Allow latex to cool to room temperature, if at an elevated temperature. Weigh two samples of latex of approximately 1 g each to the nearest 0.1 mg in tared, aluminum weighing dishes.

7.4.2 Add 1 mL of distilled water as a drying aid to each dish. Mix the latex and drying aid together by gently swirling the dish.

7.4.3 Dry the samples for 45 minutes in a vacumm oven at a temperature of 125°C, maintaining the pressure at less than 20.5 kPa (6 in. Hg). Drying time begins when door is closed. Vacumm shall be pulled over a 5 minute minimum period to prevent splattering or loss of sample.

7.4.4 Remove the samples from the oven, cool the dish and contents to room temperature in a desiccator, and weigh them to the nearest 0.1 mg.

7.4.5 Calculation - Calculate the percentage of total solids in the latex as follows:

$$\text{Total Latex Solids, \%} = \frac{(C-A) \times 100}{(B-A)}$$

where A = Weight of the weighing dish, g

B = Weight of the dish plus the original sample, g

C = Weight of the dish plus the dried sample, g

8. CALCULATIONS

8.1 Calibration:

8.1.1 Calculate an internal response factor (versus dodecane) for 4-phenylcyclohexene:

$$RF = \frac{A(std) \times W(c)}{A(c) \times W(std)}$$

where RF = Internal response factor for 4-PCH

W(c) = Weight (milligrams) of 4-PCH corrected for purity

A(c) = Peak area for 4-PCH

W(std) = Weight (milligrams) of dodecane (internal standard) corrected for purity

A(std) = Peak area for dodecane

8.2 Sample:

8.2.1 Calculate the parts per million (mg/kg) level of 4-PCH based on the total latex normalized to a 50% solids content:

$$\text{4-PCH, ppm} = \frac{A(sp) \times RF \times W(std) \times 1000 \times 0.5}{A(std) \times W(sp) \times 0.919 \times TS}$$

where RF = Internal response factor for 4-PCH

W(std) = Weight (milligrams) of dodecane (internal standard) corrected for purity

A(std) = Peak area for dodecane

W(sp) = Weight (grams) of XSB latex (sample)

A(sp) = Peak area for 4-PCH

TS = Total Solids determination obtained from 7.4.5, expressed as a fraction

0.919 = Experimentally determined recovery (4-PCH)

0.5 = Factor used to normalize the total latex to a 50% solids content

9. REPORT

9.1 Parts per million (mg/kg) 4-phenylcyclohexene based on the total latex normalized to a 50% solids content.

10. PRECISION AND BIAS

10.1 Precision statements have been prepared in accordance with Practice D4483. Refer to Practice D4483 for definitions of terminology and other statistical calculation details.

10.2 A Type I (interlaboratory) precision was evaluated. Two materials of identical matrix containing different levels of the test component were used in the interlaboratory program. Testing was conducted in five laboratories. A test result is the average value, as specified by this test method, obtained from two or more determinations of the component level in question.

10.3 The results of the precision calculations for repeatability and reproducibility are given in TABLE 2, in ascending order of the material level, for each of the materials evaluated.

10.4 BIAS - By definition, bias is a measure of the systematic error that contributes to the difference between the mean value of the test result population and an accepted reference or true value. There may be one or more bias elements that contribute to the systematic error.

10.5 A recovery study is a measure of one bias element associated with the efficiency of the sample preparation procedure (extraction, dilutions, etc.).

10.6 Material 2 was a test unit prepared by doping Material 1 with 460 mg/kg 4-phenylcyclohexene. Mean values for 4-phenylcyclohexene were determined for the two test units. The bias element is calculated from the equation:

$$\text{BIAS} = \frac{(\text{reference value}) - (\text{difference of the means})}{\text{reference value}}$$

where the reference value is the amount of 4-phenylcyclohexene used to dope Material 2. Expressed in percent terms, the bias associated with sample preparation in this method is 8.1%.

TABLE I

Gas Chromatographic Parameters

COLUMN:	
Column type:	fused silica capillary
Dimensions:	30 m x 0.53 mm I.D.
Liquid phase:	DB-5 (95% Dimethyl-(5%)-diphenyl-polysiloxane)
Film thickness:	1.5 micron
INSTRUMENT CONDITIONS:	
Injection mode:	direct injection
Carrier Gas:	helium
Linear flow velocity:	38 cm/sec (@ 75°C)
Make-up gas:	helium, @ 26 mL/min
Oven temperature profile:	programmed
Initial temperature:	75°C
Intial time:	1 min
Program rate:	12°C/min
Final temperature:	200°C
Final time:	5 min
Injection temperature:	275°C
FID temperature:	275°C

TABLE II

TYPE I - Precision

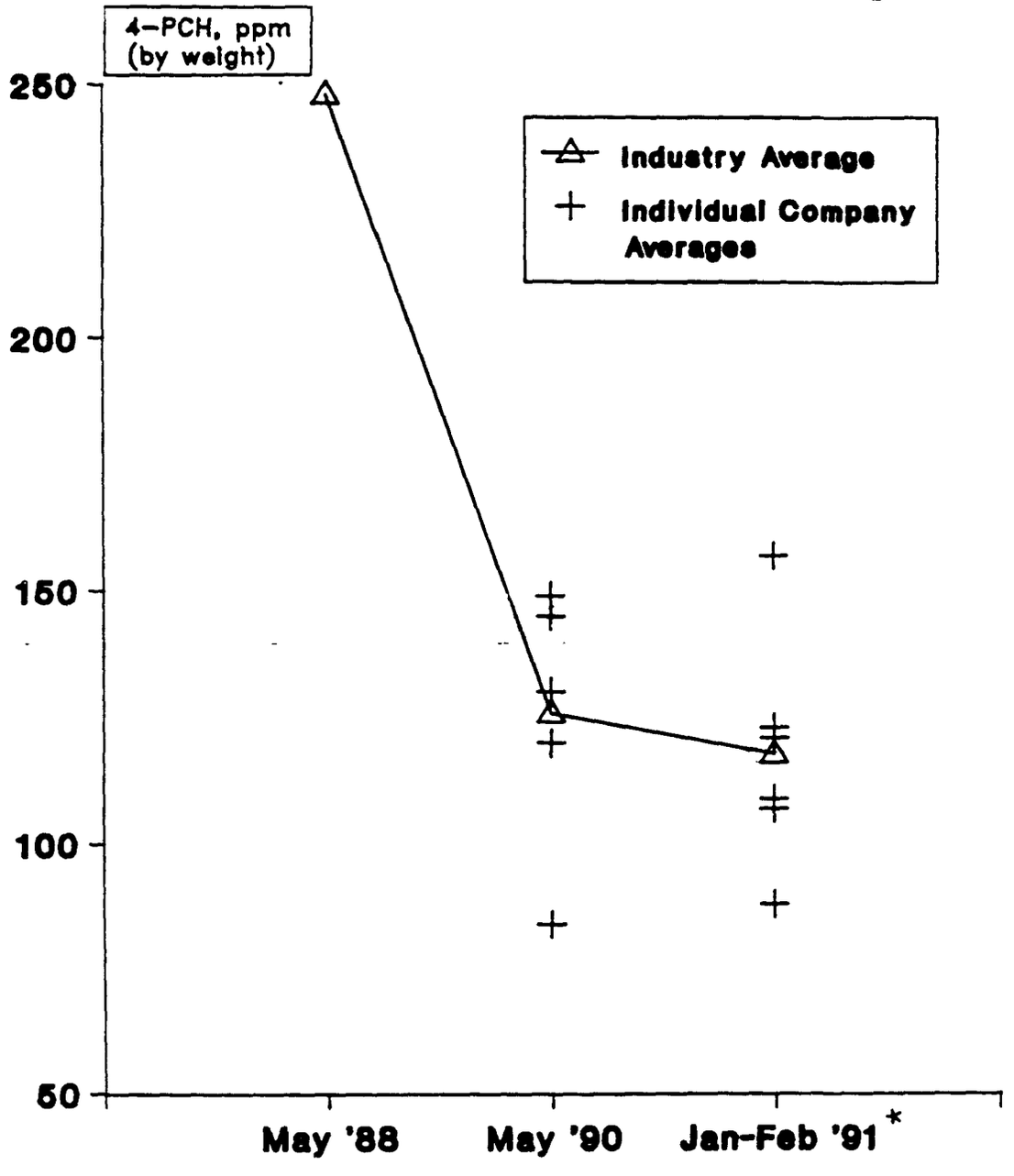
(4-Phenylcyclohexene, wt/wt latex solids)

NOTE:
sr = within laboratory standard deviation
r = repeatability (in measurement units)
(r) = repeatability (in percent)
sR = between laboratory standard deviation
R = reproducibility (in measurement units)
(R) = reproducibility (in percent)

Material	Mean Value, mg/kg	Within Laboratories			Between Laboratories		
		sr	r	(r)	sR	R	(R)
1	165	2.6	7.4	4.5	12.5	35.3	21.4
2	963	13.6	38.6	4.0	45.9	130.0	13.5

ATTACHMENT II

4-PCH Reduction History



Styrene Butadiene Latex Manufacturers Council
May 1991

*Company-by-company weighted average data include 320 individual measurements representing approximately 94% of Jan.-Feb. 1991 shipments to the carpet trade. This represents an average 50% reduction since 1988.

ATTACHMENT L-2

Federal Register: Carpet Policy Dialogue; Memorandum of Understanding: SBLMC Reporting Program for 4-PC

[OPTS-00113; FRL-4004-2]

Carpet Policy Dialogue; Memorandum of Understanding: SBLMC Reporting Program for 4-PC

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of availability.

SUMMARY: EPA has entered into a Memorandum of Understanding (MOU) with the Styrene Butadiene Latex Manufacturers Council (SBLMC) for the purpose of initiating the provisions stated within the context of recommendations from the Carpet Policy Dialogue. The MOU provides for the public reporting of company quality assurance data on 4-phenylcyclohexene (4-PC), and a feasibility assessment for future quality control activities.

DATES: The MOU was entered into on September 26, 1991.

FOR FURTHER INFORMATION CONTACT: Dave Kling, Acting Director, Environmental Assistance Division (TS-798), Office of Toxic Substances, Environmental Protection Agency, 401 M St., SW., Washington, DC 20460. Telephone: (202) 554-1404, TDD: (202) 554-0557, or FAX (202) 554-5603 (document requests only). For information on the Carpet Policy Dialogue Project contact Richard W. Leukroth, Jr., Carpet Policy Dialogue Coordinator, Telephone: (202) 260-3832. Copies of the MOU may be obtained from the Environmental Assistance Division at the address listed above.

SUPPLEMENTARY INFORMATION:

I. Background

The Carpet Policy Dialogue (August 21, 1990 to September 27, 1991) was part of the Agency's response to a petition under section 21 of TSCA (55 FR 17404; 55 FR 31640). EPA charged the dialogue to work out the details of voluntary product testing programs that report TVOC's that emit from carpet, carpet installation adhesives, and carpet cushion products. In addition, the Carpet Policy Dialogue was asked to explore and, where possible, reach agreement on a variety of issues including: the sampling and analytical methods for the voluntary product testing for TVOC's, any additional information needed, identification of cost-effective process changes to reduce TVOC emissions, information about carpet installation practices, and to provide the interested public with information on TVOC emissions. The Carpet Policy Dialogue formed three working Subgroups (Product Testing, Process Engineering, and Public Communications) to respond to the EPA charter.

The Carpet Policy Dialogue on TVOC emissions was a nonregulatory approach focusing on product stewardship through voluntary actions on the part of industry. It emphasized exposure reduction (pollution prevention), and addressed the public desire for information that could lead to consumer choice. The Carpet Policy Dialogue exemplified how government, industry, public interest groups, and the scientific community can work together to resolve exposure reduction and pollution prevention issues, including those related to indoor air exposures. Recommendations developed during Subgroup discussion were submitted to the Carpet Policy Dialogue for the benefit of a consensus process of review and comment. In reaching consensus and accepting the SBLMC 4-PC company quality assurance reporting program, the Carpet Policy Dialogue indicated to its sponsor (EPA) that such a recommendation can provide the basis for a memorandum of understanding to initiate voluntary action(s) in response to the charter set by EPA in the Federal Register notices (55 FR 17404 and 55 FR 31640).

II. Memorandum of Understanding

The EPA and SBLMC entered into the MOU on September 26, 1991. The MOU signed by EPA and SBLMC formally establishes a framework in which a voluntary program response for actions described in the Federal Register notices noted above can be fulfilled. It contains provisions describing the 4-PC company quality assurance reporting program and certain follow-on activities.

A. SBLMC Quality Assurance Reporting Program for 4-PC

Under the terms and conditions of the MOU, the SBLMC has voluntarily agreed to report data from their ongoing quality analysis programs. The SBLMC will report the company-by-company weighted average of 4-PC in styrene butadiene latex sold for carpet backing applications for the last quarter of 1991 and the last quarter of 1992. The individual company average 4-PC measurements used as input to the weighting calculations as well as the weighting calculation methodology will be reported.

In addition, the SBLMC has agreed to assess the styrene butadiene latex 4-PC data developed from ongoing quality analysis programs noted above to determine the feasibility of utilizing the information to develop future quality control activities. SBLMC will provide a report to EPA on its assessment of the feasibility on or before July 1, 1993. The report will be submitted to the EPA and entered into the Carpet Emissions Administrative Record.

B. Participants

Placement of responsibilities for the actions described in the MOU is with the Chairperson, Styrene Butadiene Latex Manufacturers Council and the Director, Office of Toxic Substances, EPA.

III. Administrative Record

The MOU is available to the public in the Carpet Emissions Administrative Record. This Administrative Record is available for reviewing and copying in the TSCA Public Docket Office from 8 a.m. to noon and 1 p.m. to 4 p.m., Monday through Friday, excluding legal holidays. The TSCA Public Docket Office is located at EPA Headquarters, Rm. NE-G004, 401 M St., SW., Washington, DC 20460.

Dated: November 25, 1991.

Mark A. Greenwood,

Director, Office of Toxic Substances.

[FR Doc. 91-28828 Filed 11-29-91; 8:45 am]

BILLING CODE 6560-50-F

APPENDIX M

FINAL TEXT DRAFT[1]
of
Public Information Brochure:
"Indoor Air Quality and New Carpet, What You Should Know"

[1] This material was approved by the Carpet Policy Dialogue on September 27, 1991. Further changes to this text may be needed to accomodate brochure layout considerations, conform with government policy regarding disclaimer statements, or for other similar reasons. The views of the sixteen "sign-on" organizations listed in the last section of the brochure will be considered in completing the final product. Not all changes were available at the time when this report went to press. A copy of the final brochure product will be available from: TSCA Assistance Information Service (TS-799), United States Environmental Protection Agency 401 M St., S.W., Washington, DC 20460. Telephone (202)554-1404.

PUBLIC INFORMATION BROCHURE:

"INDOOR AIR QUALITY AND NEW CARPET, WHAT YOU SHOULD KNOW"

Past efforts to clean the air focused on pollution outdoors rather than indoors. Since many Americans spend most of their time inside buildings, there has been a growing concern about indoor air quality.

Sources of indoor air pollution range from dust, mold, and mildew to chemical emissions from common household products, appliances, furnishings, and building materials. Poor ventilation (lack of fresh air) allows pollutants to build up indoors. Polluted indoor air may cause some people to become ill.

Indoor air pollution at low levels is difficult to study. For most chemicals, research has not yet found whether low levels are likely to cause health problems. It is impossible to keep homes and other buildings free of all pollutants. However, it makes good sense to try to reduce exposure to pollutants, while enjoying the benefits of the many products that add to the overall quality of life.

As concern over indoor air pollution has grown, some questions have been raised about the relationship between carpet products and indoor air quality. The following are answers to some of the most frequently asked questions:

What is new carpet's role in indoor air quality?

Like many other household products, new carpet can be a low-level source of chemicals that are emitted into the air. These chemical emissions, also called volatile organic compounds (VOCs), contribute to the total level of pollutants in a building.

It is important to remember that carpet is part of a total floor covering system that may include the cushion and installation adhesives. The cushion and adhesives are also sources of emissions. Manufacturers of floor covering products are working to reduce emissions from their products.

How do the emissions from carpet compare to emissions from other products?

Emissions from new carpet and cushions tend to be lower than emissions from many other construction and renovation materials. The emissions from adhesives used to install carpets can vary. New low-emitting adhesives are available that can greatly reduce emissions from new carpet installations.

New carpet is usually installed during home or office decoration, building construction, or renovation. Interior decorating usually includes the use of new materials such as wall treatments (painting, wallpapering, paneling), floor covering (carpet, vinyl, wood, ceramic), window covering (fabric, wood, plastic), and furniture. Any or all of these materials may produce chemical emissions and odors.

Should I be concerned about chemical emissions from new carpet?

Limited research to date has found no link between adverse health effects and the levels of chemicals emitted by new carpet.

Some people report allergy- or flu-like symptoms that they believe are caused by newly installed carpet, however, such symptoms could be attributed to other sources.

When new carpet is installed, it may produce an odor. All odors are caused by chemicals - even food or flower odors. However, some people are more sensitive to odors than others. The presence of an odor following installation of new carpet does not mean there is a problem. While it may be unpleasant to some individuals, most people are not bothered by new carpet odor.

What can I do to reduce my exposure?

The presence of some pollutants in buildings is unavoidable. However, increasing the amount of fresh air in the home or office may reduce exposure to pollutants. The Carpet and Rug Institute (CRI), a trade association, recommends that the ventilation system in public and commercial buildings be operated at maximum outdoor air flow before, during, and for 48-72 hours after the new carpet installation. In homes, leave doors and windows open, if possible, and use fans to increase the flow of outdoor air. It is important to provide adequate ventilation to maintain good indoor air quality.

To reduce exposure in homes, residents may wish to leave during the installation of new carpet. In the office, ask building managers to consider installing new carpet when the area is not in use.

STEPS TO TAKE.....

You should:

- Plan ahead.
- Ask your carpet retailer for information on emissions from carpet.
- Ask for low-emitting adhesives, if adhesives are needed.
- Be sure the retailer requires the installer to follow Carpet and Rug Institute installation guidelines.
- Be sure the ventilation system is in proper working order before installation begins.
- Open doors and windows, if possible, during and after installation. Consider using window fans, room air conditioning units, or other means to exhaust emissions outdoors.
- Operate the ventilation system with maximum outdoor air during and after installation for 48 to 72 hours.
- Consider leaving the premises during and immediately after carpet installation. You may wish to schedule the installation when most family members will be out of the house.
- Contact your carpet retailer if objectionable odors persist.
- Follow the manufacturer's instructions for proper carpet maintenance.

These key points, listed above, apply to carpet installations in all types of buildings. If you have questions about carpet, contact your retailer, building manager, or other responsible person.

Where can I get more information?

Individual manufacturers often provide brochures and other materials to help consumers better understand and take care of their new purchases. Government agencies, industry associations, and consumer groups are useful resources for more information on indoor air quality. You may wish to write or call these organizations for more information:

U.S. Environmental Protection Agency
TSCA Assistance Information Service (TS-799)
401 M Street, S.W.
Washington, DC 20460
(202)554-1404

U.S. Consumer Product Safety Commission
Washington, DC 20207
1-800-638-2772

American Lung Association
1726 M Street, N.W., Suite 902
Washington, DC 20036
(202)785-3355

Carpet and Rug Institute
Box 2048, 310 Holiday Avenue
Dalton, GA 30720
(404)278-3176

Carpet Cushion Council
P.O. Box 546
Riverside, CT 06878
(203)637-1312

Floor Covering Adhesive
Manufacturers Committee of
the National Association of Floor Covering
Distributors
401 North Michigan Avenue
Chicago, IL 60611
(312)644-6610

Floor Covering Installation
Contractors Association
P.O. Box 948
Dalton, GA 30722
(404)226-5488

National Federation of
Federal Employees, Local 2050
P.O. Box 76082
Washington, DC 20012
(202)862-4400

Your local carpet retailer:

[Place for retailer/distributor to stamp address and telephone number]

Note: *The organizations listed above have not reviewed or approved all the information and documents that may be provided by other organizations. The views or opinions expressed by organizations listed on this brochure may not necessarily reflect the opinions of EPA, other Federal agencies, or other organizations that collaborated in preparing this brochure. Listing an organization (Federal or non-federal) should not be construed as any endorsement by any organization.*

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Representatives from the following organizations have been working cooperatively to address indoor air quality issues and have participated in the development of this brochure.

American Federation of State, County, and Municipal Employees
American Fiber Manufacturers Association
American Lung Association
American Textile Manufacturers Institute
Carpet and Rug Institute
Carpet Cushion Council
Floor Covering Installation Contractors Association
Floor Covering Adhesive Manufacturers Committee of the
National Association of Floor Covering Distributors
Georgia Tech Research Institute
National Federation of Federal Employees, Local 2050
National Institute of Standards and Technology
Styrene Butadiene Latex Manufacturers Council
The Adhesive and Sealants Council, Inc.
U.S. Consumer Product Safety Commission
U.S. Environmental Protection Agency
U.S. General Services Administration

APPENDIX N

FINAL REPORT

Investigating the Impact of Various Cure Parameters on the Release of 4-Phenylcyclohexene (4-PCH) from Carpet Backed with Compounds Based on Carboxylated SBR Latex

FINAL REPORT

INVESTIGATING THE IMPACT OF VARIOUS CURE PARAMETERS ON THE RELEASE OF 4-PHENYLCYCLOHEXENE (4-PCH) FROM CARPET BACKED WITH COMPOUNDS BASED ON CARBOXYLATED SBR LATEX

January 17, 1990

Submitted to:

Mr. Alan Rautio
Styrene Butadiene Latex
Manufacturer's Council

Prepared by:

Dr. Mark Van Ert
Director: Occupational
Safety & Health Program

ACKNOWLEDGMENTS

This University of Arizona research project was supported in its entirety by funding from the Styrene Butadiene Latex Manufacturer's Council (SBLMC). Special thanks go to Mr. Charles Oxley of BASF Corporation for his participation as project chairman and for his professional assistance during the course of this study, to Mr. John Bogdany and his staff at GENCORP Polymer Products for assisting our research team in the development of skills essential to the preparation of carboxylated SBR latex-backed carpet, to Mr. Dennis Moldovan and Dr. Anoop Krishen of Goodyear Tire and Rubber Company, Mr. Kerwin Kolinek of GENCORP Polymer Products and, certainly, to the other members of the Council for their professional insights during the design and implementation of the project. The administrative assistance of Mr. Alan Rautio, Executive Director of the SBLMC, in expediting the development of the project is also greatly appreciated.

Dr. David Stumpf, Research Associate for the project, and Ms. Mary Flynt, Graduate Research Student, deserve special mention for their very able assistance in the completion of this research endeavor.

FINAL REPORT

FOR

INVESTIGATING THE IMPACT OF VARIOUS CURE PARAMETERS ON THE RELEASE OF 4-PHENYLCYCLOHEXENE (4-PCH) FROM CARPET BACKED WITH COMPOUNDS BASED ON CARBOXYLATED SBR LATEX

INTRODUCTION

Previous research at the University of Arizona has demonstrated 4-phenylcyclohexene (4-PCH) to be an odorous emission from certain batches of carpet.[1] The source of this chemical was determined to be the SBR latex employed in the backing of the carpet. Recent work by *Demer*,[2] revealed a trend in the reduction of 4-PCH in SBR latex as a function of cure time. The actual relationship between 4-PCH emissions from a representative compounded latex similar to that employed in the manufacture of carpet was not examined in that study. As a result, a comprehensive study was initiated to investigate the relationship between 4-PCH release from latex-backed carpet and specific cure parameters.

The following set of variables was controlled during test trials to objectively characterize the parameters affecting the release of 4-PCH from carpet samples freshly coated with SBR latex formulations:

1. Cure time
2. Cure temperature
3. Air exchange rate

Other dependent factors that were considered during the course of the curing procedure to determine their

relationship to 4-PCH release from the carpet samples included:

1. Humidity within the cure oven, and
2. Moisture content of carpet samples

METHODS AND MATERIALS

Preparation of Carpet Test Samples

The effect of specific cure parameters on the level of 4-PCH in carpet samples containing SBR latex required special considerations in experimental design. A primary consideration was evaluating the release or decay of 4-PCH in the actual carpet matrix. Consistent with recommendations provided by SBLMC advisors, both carpet type and backing were standardized prior to evaluating 4-PCH release. The representative carpet standard was a 26 oz. nylon 6:6 pile Saxony with a 3.2 oz. polypropylene backing. The carpet and secondary backing samples were provided by member companies of the Carpet and Rug Institute (CRI) Committee. Blended latexes representing two levels of 4-PCH content, were compounded as described below and employed to adhere the secondary backing to the carpet samples.

A member (SBLMC) laboratory developed the two latex composites by blending latexes from six producers. These two latex blends (i.e. latex A or B) were then compounded by the University of Arizona research team to contain 450 parts

Georgia Marble filler. Other ingredients added included a thickener and froth aid. The final carboxylated latex compound was frothed to approximately 800 grams per quart and applied at 26 oz./sq. yd. application weight. A SBLMC member assisted the University of Arizona research group in reviewing carpet samples prepared during preliminary compounding and coating tests specified in appropriate test methods (i.e. DTSC-TM 1000, 1003, and 1004). Data sheets detailing the preparation of carpet latex were compiled for each run to insure conformance with quality control parameters. A standard operating procedure describing latex preparation and application is presented in Appendix I.

A ten square inch carpet area on a 12 square inch piece of carpet was coated with a carboxylated SBR latex compound and then divided into four 5 square inch carpet pieces. These square carpet swatches were then introduced into a Fisher, Model 496, atmosphere controlled forced air curing oven set at one of three cure temperatures (225, 250, or 275° F). One of the four carpet sample swatches was removed at a designated cure time interval (10, 20, 40, or 60 min.). Five 0.5 square inch carpet pieces were cut along a diagonal from each test swatch to evaluate remaining 4-PCH and variation in latex applications. All test runs were duplicated to obtain an appreciation of the variation in each test parameter.

Two air exchange rates, zero and three air exchanges per minute, were also selected to assess the influence of this test parameter on 4-PCH release from the carpet. An air

exchange rate of three (3) per minute accounted for a 45 ± 5 linear foot per minute (lfm) velocity over the surface of the carpet.

To evaluate the release of moisture from the carpet swatches during specific cure cycles (cure temperature vs. cure time), carpet swatches were weighed with a Mettler Model H31AR Precision Balance prior to and following a cure cycle. Five-0.5 square inch samples were then prepared for 4-PCH analysis.

Analytical Equipment

Samples were analyzed using a HP 5890A gas chromatograph using a flame ionization detector. The analytical column was an HP-17 (OV-17), 10 meter, megabore column. Nitrogen carrier gas flow was 10 ml/min. (65 kPa) at 140 C column temperature. Injector temperature was 190 C, detector temperature was 250 C.

Detector output was connected to a Jones Chromatography Limited, JCL 6000 chromatography data system and collected and stored as individual files.

Sample Preparation

The carpet sample size selected for analysis was approximately 0.5 square inch with sample weight being recorded as the parameter for comparison. The carpet sample

was placed in a 16 ml screw top vial, 4-6 mls of carbon disulfide containing a 1-PCH internal standard added, capped with a teflon-faced septa cap and left to equilibrate for 15 minutes. Previous experiments demonstrated that this was sufficient equilibration time for over 95% of the 4-PCH to equilibrate with the solution. Carbon disulfide was chosen for its relatively low background FID signal as well as the high solubility of 4-PCH.

One microliter sample volumes were injected into the gas chromatograph. If the 4-PCH content was above 24 nmoles/ml, the sample had additional carbon disulfide added to bring the concentration below 24 nmoles/ml. This was due to the earlier observation that above 31 nmoles/ml concentration, dissolution of the 4-PCH was not complete.

Standard Curve

The 4-PCH standard curve was prepared using authentic 4-PCH in carbon disulfide. The curve was made so that microliter injections of the standard represented 0.64, 1.35, 3.16, 6.32, 12.6 and 25.2 picomoles per microliter (nanomoles per ml). Our lower level of detection was thus 101 ng/ml carbon disulfide.

Carpet and Oven Temperature Measurement

Carpet and oven temperatures were measured using two Omega TAC-80 T Thermocouple to Millivolt Converters attached to a Type T thermocouple and measured using a Micronta Digital Voltmeter.

RESULTS AND DISCUSSION

4-PCH Content of Composite Latexes

The raw latex composites employed in the study, namely A and B, were found to contain approximately 700 ppm (w/w)* and 250 ppm (w/w) 4-PCH, respectively. The 0.5 square inch carpet samples coated with compounded latex contained approximately 60 ppm+ or 20 ppm 4-PCH, depending on the latex employed, that is, latex A or B. Due to the slight variation in the 4-PCH content noted during the preparation of individual batches of compounded latex, all data reflecting the impact of various cure parameters on the release of 4-PCH are reported as a percentage of the absolute amount of 4-PCH remaining in a latex coated carpet sample for the individual test run.

---

* w/w means weight 4-PCH/dry weight of latex

+ weight of 4-PCH/dry weight of 0.5 sq. in. carpet sample

Effect of Oven Temperature on 4-PCH Release

The impact of oven temperature on 4-PCH release was evaluated at three temperatures, 225°F, 250°F, and 275°F for carpet backings coated with either compounded latex A or B.

The data presented in Table I and Figure 1 illustrates the temperature dependent decay of 4-PCH over time for carpet treated with latex A. The decay of 4-PCH is presented as percent 4-PCH remaining as a function of time at designated oven temperature settings. Following an initial lag in 4-PCH release during the first five minutes of the cure cycle, the rate of decay of 4-PCH is enhanced as the oven temperature settings were increased from 225°F to 275°F. The decay rate is greatest over the first twenty minutes of cure, with the exception of the 225°F cure study, and then, decreases to a minimum at 40 minutes.

A review of the 4-PCH decay profile for carpet coated with latex B revealed an almost identical pattern to that seen for latex A (see Table II, Figure 2). An initial lag on 4-PCH release is again noted over the first five minutes of cure followed by a temperature dependent release of 4-PCH.

At 275°F over 50% of the 4-PCH in latex A & B coated carpets is released within ten minutes, whereas only 10% is released at 225°F over the same time period. Although these experimental data cannot be directly extrapolated to actual cure conditions in industrial situations, the data are quite suggestive that higher cure temperatures would have a

significant impact on the release of 4-PCH from carpet backings comprised of carboxylated SBR latex. The data would also suggest that higher temperatures could be critical when circumstances dictate shorter oven cure times.

A review of Figures 1 and 2 also indicate that the percent removal of 4-PCH from carpet backed with both composite latexes (A & B) is nearly identical. This observation suggests that a partitioning process is occurring between the carpet matrix and oven air. If this partitioning phenomenon is correct, other factors such as air velocity may well influence the rate at which 4-PCH is released from carboxylated SBR latex.

The data presented in Figures 1 and 2 were collected at an air exchange rate of three air exchanges per minute. This rate was selected on the basis of preliminary studies which demonstrated no difference between 100% recirculated air (no air exchange) and a relatively high exchange rate of three per minute. Further, the latter air exchange rate did not adversely influence the maintenance of oven temperature.

Actual Carpet Temperatures vs 4-PCH Release

In addition to oven temperature measurements, an Omega TAC-80T thermocouple was inserted into the carpet tuft next to the backing to monitor the change in carpet temperature over the course of the sixty minute cure cycle. The data detailed in Tables IIIa, IIIb, and IIIc and plotted in

Figures 3a, 3b, and 3c describe the change in carpet temperature and 4-PCH decay following placement of carpet swatches in the curing oven at a preset oven temperature. Initial studies of carpet coated with latex A revealed that the carpet reached final oven temperatures, 225°F, 250°F, or 275°F, after approximately 20 minutes. At all preset oven temperatures, the rate of 4-PCH release demonstrated an increase at a carpet temperature of approximately 175°F, suggesting that this temperature level may be required to induce a relatively constant initial rate of decay. As described previously, however, higher 4-PCH decay rates were noted at higher oven temperatures.

Since carpet temperature was not expected to be influenced by the type of latex employed to coat the carpet backing, the aforementioned set of experiments was not repeated in its entirety for latex B. Rather, carpet temperature change was evaluated only at 225°F. As shown in Table IIId (Figure 3d), the rise in carpet temperature oven time for latex B was essentially identical to that obtained using latex A.

Relationship Between Carpet Moisture Loss and 4-PCH Release

The loss of moisture from carpet samples treated with latexes A and B was essentially the same at all oven temperatures tested (see Tables IVa-IVd and Figures 4a-4d). Latex A treated carpet was evaluated at all three oven cure

temperatures (225°F, 250°F, and 275°F). Latex B treated carpet was tested at 225°F to validate an expected moisture loss pattern. Interestingly, at all oven temperatures tested, the maximum moisture loss occurred at 10 minutes, reflecting a total loss of approximately 10% of the initial carpet weight. Although the data in Figure 4a indicates an increased decay rate of 4-PCH beginning at the same time carpet moisture has been eliminated (that is, after 10 minutes), the data in the remaining figures (4b-4d) suggest that an increased 4-PCH decay rate begins earlier, at approximately five minutes, when approximately 50% of the available carpet moisture has dissipated. It is difficult to state then that moisture directly influences the rate of 4-PCH release. Rather, the preponderance of the data (Figures 4b-4d) indicate that both moisture and 4-PCH are evolved as temperature increases. As described earlier, a temperature of 175°F may be required to initiate a relatively significant and constant rate of 4-PCH decay.

Effect of Increased Air Velocity on the Release of 4-PCH

Although not part of the original experimental design, a preliminary study to investigate the effect of high velocity air (ca. 1500 linear feet per minute, lfm) on the release of 4-PCH from carpet coated with freshly compounded latex (that is, latex A) was conducted at 225°F. During the cure cycle, a relatively uniform air stream of 1500 lfm was focused

perpendicularly onto the tufted surface of a 5 inch square piece of carpet. In previous experiments, the highest air velocity over the surface of the carpet was approximately 45 lfm which occurred automatically at 3 air exchanges per minute.

The results of this study (see Figure 5) demonstrated a 4-PCH decay rate significantly greater than that determined for the control carpet sample which was not exposed to forced air. The carpet sample exposed to the 1500 lfm released approximately 90% of the available 4-PCH in 10 minutes, whereas the unexposed sample released less than 30% over the same time period. It is also noteworthy that after only five minutes, which represented the initial lag period in 4-PCH release in this and previous experimental runs at 225°F to 275°F, that approximately 50% of the 4-PCH had already been released from the carpet sample exposed to the 1500 lfm air velocity. This data is further suggestive that a partitioning process is critical to the release of 4-PCH from carpet and that this process is also enhanced by increased air velocity over the carpet.

SUMMARY

The impact of various cure parameters including cure temperature, cure time, carpet moisture, and air exchange rate on the release of 4-phenylcyclohexene (4-PCH) was evaluated with carpet backed with carboxylated SBR latex .

Higher oven cure temperatures were clearly demonstrated to be a strong driving force in the removal of 4-PCH from carpet backed with two representative composite latexes containing a low and high 4-PCH level. Observations that the percent removal of 4-PCH remains relatively uniform with both latex composites (high and low) suggests that a partitioning process takes place between the latex-carpet source and oven air.

Initial studies to evaluate the impact of high velocity air on the release of 4-PCH indicate that this parameter may have a pronounced effect in reducing 4-PCH in carpet and, therefore, deserves further study.

Since all data represent laboratory findings, any correlation with commercial practice remains to be established.

Table I

Effect of Oven Temperature on 4-PCH Release
(Latex A, 3 air exchanges/minute)*

	% 4-PCH Remaining		
Time (minutes)	225 F	250 F	275 F
0	100	100	100
5	98	96	94
10	84	71	41
20	57	22	16
40	7	1.4	0.2
60	0	0	0

* n = 6, standard deviation less then 15%

Figure 1
Effect of Oven Temperature on 4-PCH Release
(Latex A, 3 air exchanges/minute)

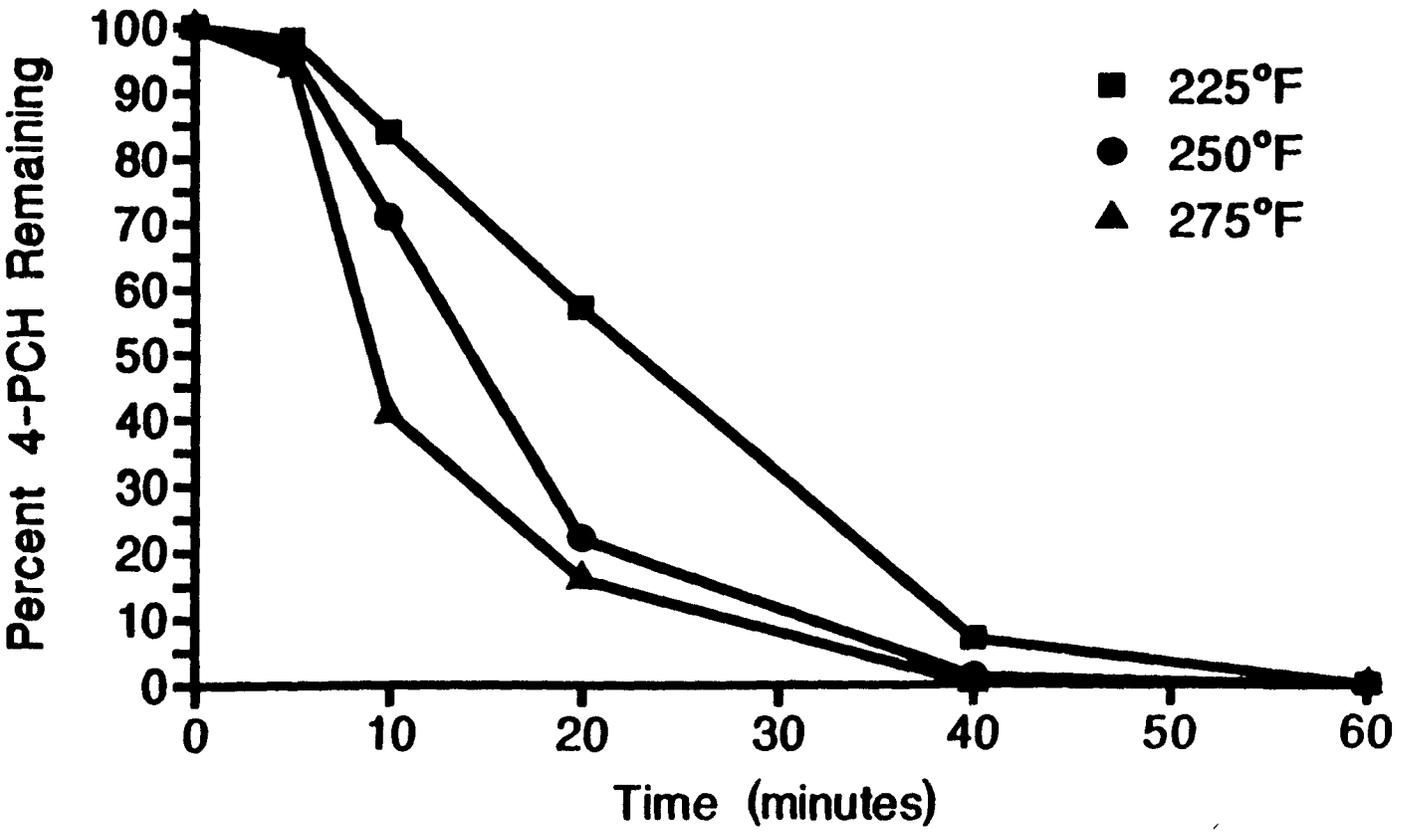


Table II

Effect of Oven Temperature on 4-PCH Release
(Latex B, 3 air exchanges/minute)*

Time (minutes)	225 F	250 F	275F
0	100	100	100
5	95	100	96
10	80	70	45
20	58	25	19
40	13	1	0
60	0	0	0

* n = 6, standard deviation less then 15%

Figure 2
Effect of Oven Temperature on 4-PCH Release
(Latex B, 3 air exchanges/minute)

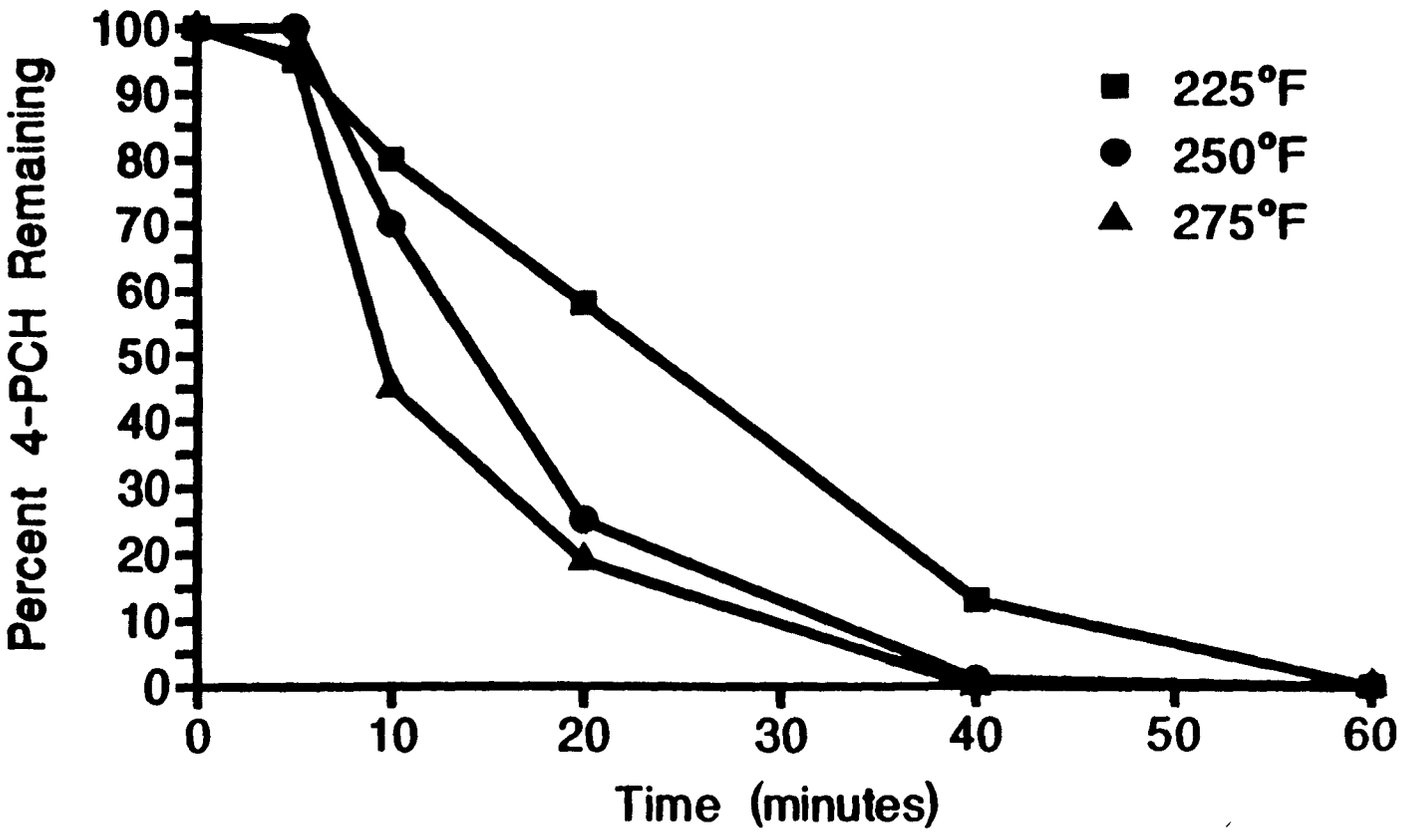


Table IIIa

Effect of 225 F Carpet Temperature on 4-PCH Release
(Latex A, 3 air exchanges/minute)*

Time (minutes)	Carpet Temperature F	% 4-PCH Remaining
0	91	100
5	137	97
10	173	96
20	225	60
40	225	9
60	225	0

* n = 6, standard deviation less then 15%

Figure 3a
Effect of Carpet Temperature on 4-PCH Release, 225°F Final Temperature (Latex A, 3 air exchanges/minute)

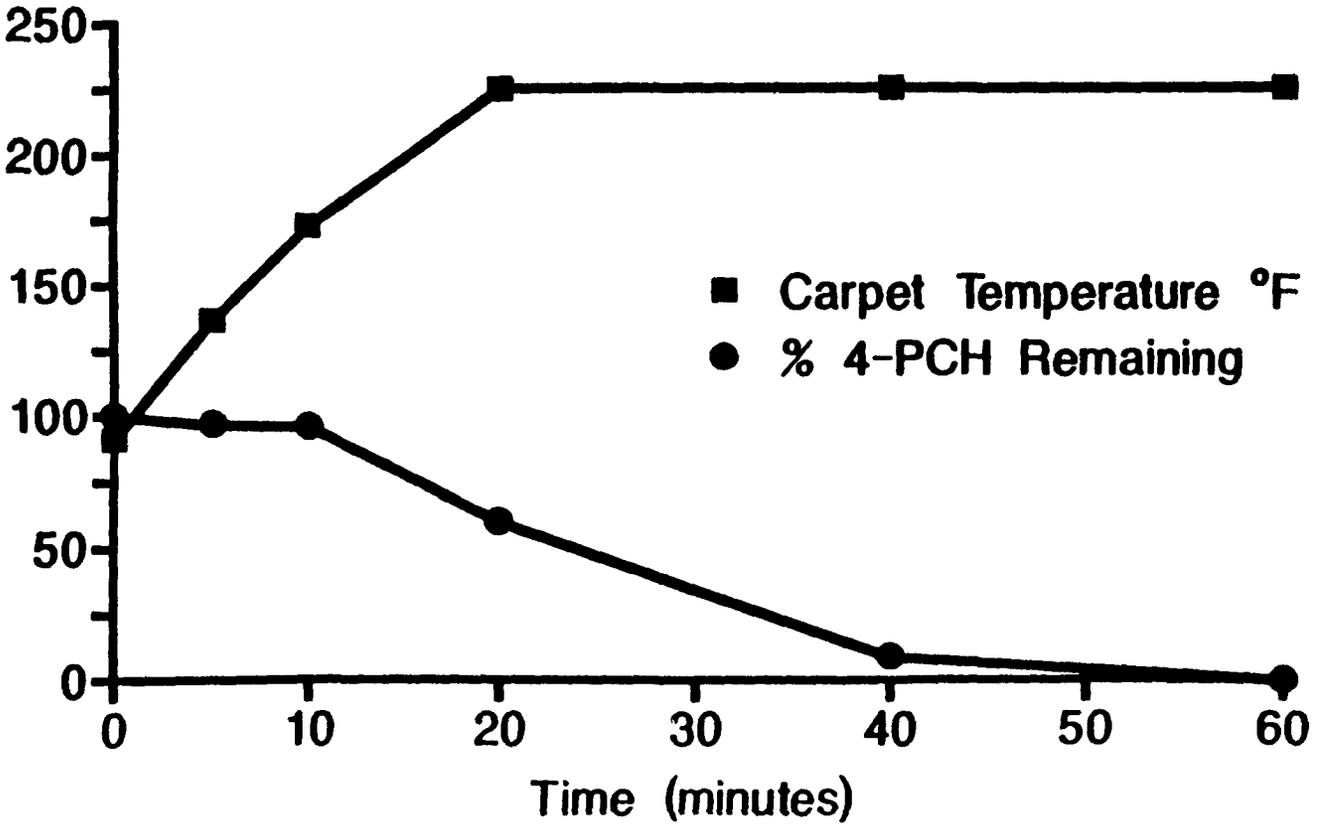


Table IIIb

Effect of 250 F Carpet Temperature on 4-PCH Release
(Latex A, 3 air exchanges/minute)*

Time (minutes)	Carpet Temperature F	% 4-PCH Remaining
0	90	100
5	178	98
10	208	74
20	246	22
40	250	1
60	250	0

* n = 6, standard deviation less then 15%

Figure 3b
Effect of Carpet Temperature on 4-PCH Release, 250°F Final Temperature
(Latex A, 3 air exchanges/minute)

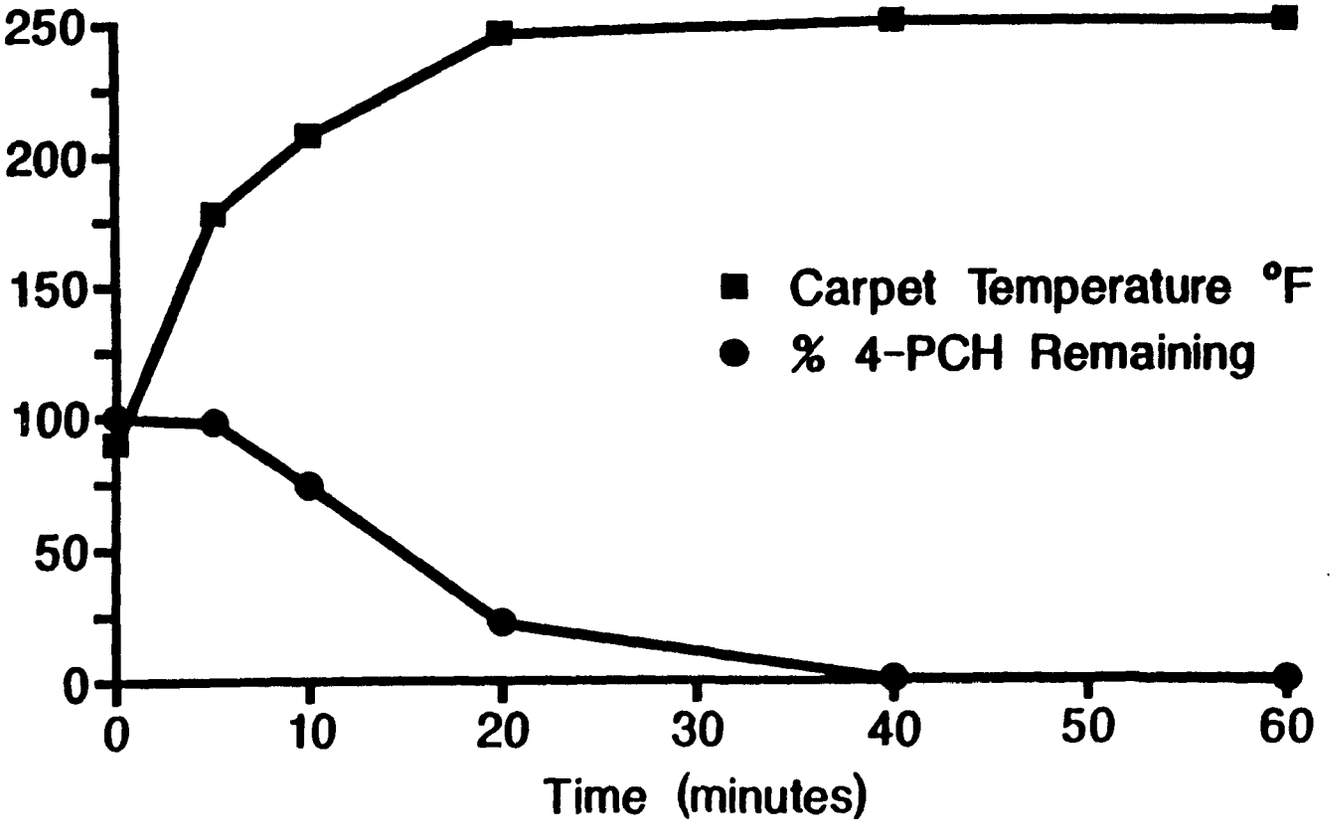


Table IIIc

Effect of 275 F Carpet Temperature on 4-PCH Release
(Latex A, 3 air exchanges/minute)

Time (minutes)	Carpet Temperature F	% 4-PCH Remaining
0	90	100
5	168	86
10	179	40
20	254	17
40	267	0
60	267	0

* n = 6, standard deviation is less then 15%

Figure 3c
Effect of Carpet Temperature on 4-PCH Release, 275°F Final Temperature
(Latex A, 3 air exchanges/minute)

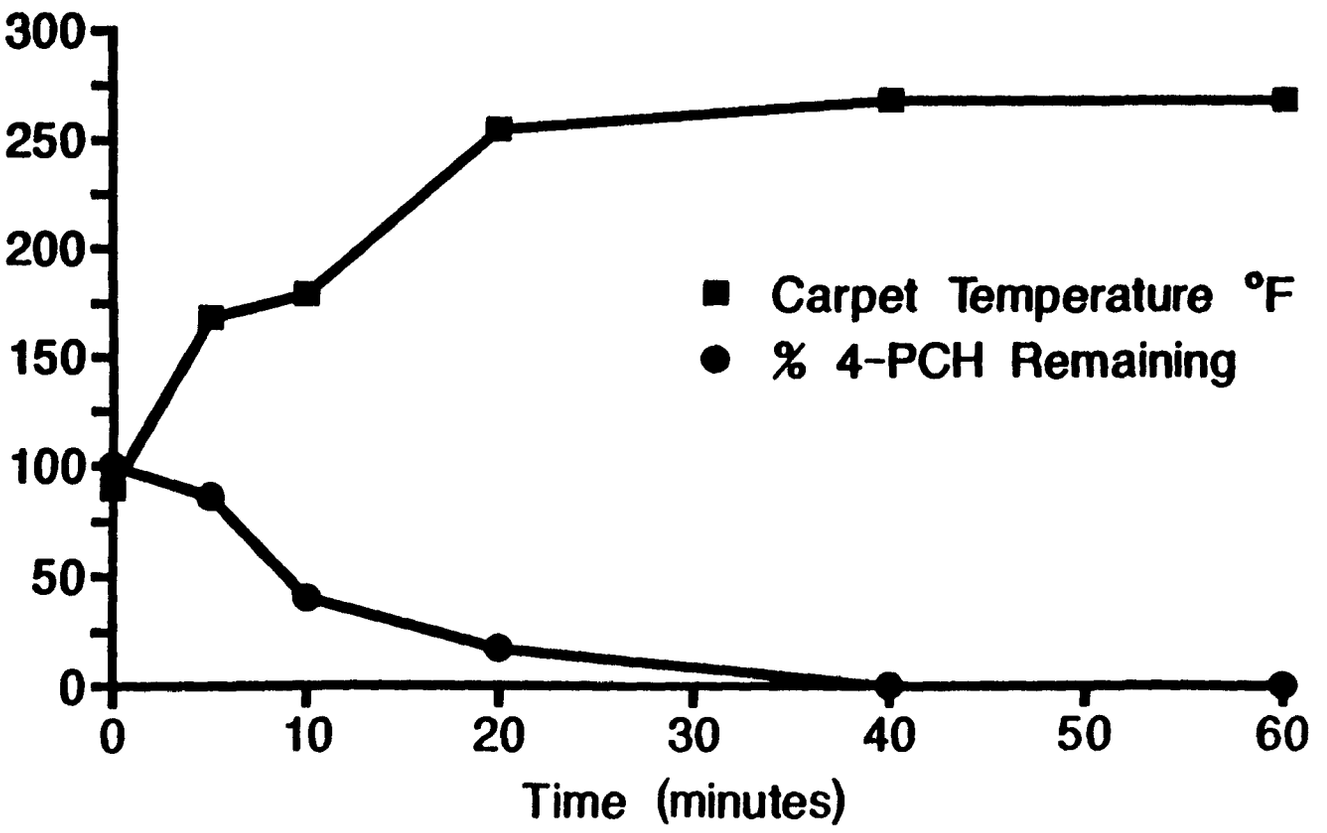


Table IIId

Effect of 225 F Carpet Temperature on 4-PCH Release
(Latex B, 3 air exchanges/minute)*

Time (minutes)	Carpet Temperature F	%4-PCH Remaining
0	100	100
5	139	98
10	190	96
20	225	62
40	225	15
60	225	1

* n = 6, standard deviation less than 15%

Figure 3d
Effect of Carpet Temperature on 4-PCH Release, 225°F Final Temperature (Latex B, 3 air exchanges/minute)

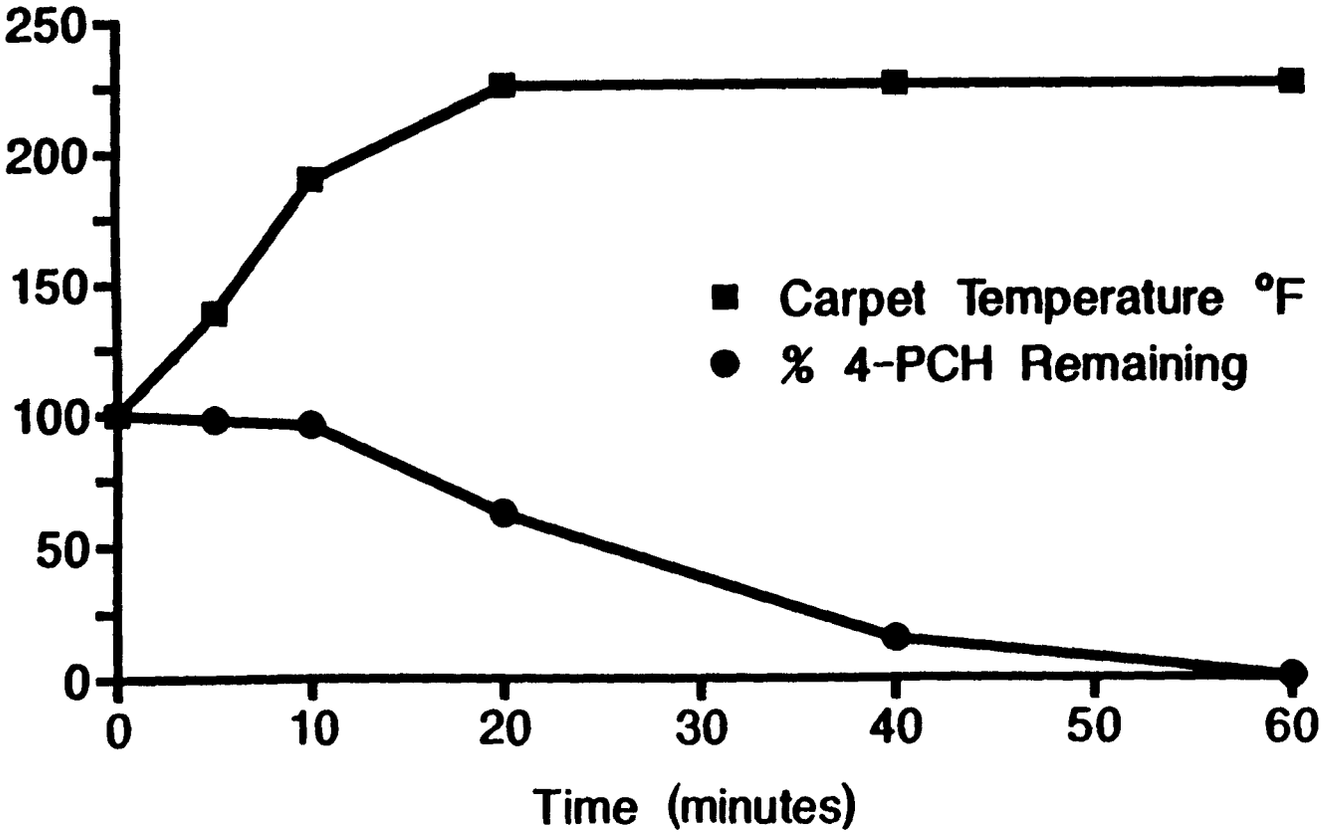


Table IVa

Relationship Between Carpet Moisture Loss and 4-PCH Release, 225 F
(Latex A, 3 air exchanges/minute)*

Time (minutes)	% Starting Weight	% 4-PCH Remaining
0	100	100
5	94	97
10	91	94
20	90	60
40	90	9
60	90	1

* n = 6, standard deviation less than 15%

Figure 4a
Relationship Between Carpet Moisture Loss and 4-PCH Release, 225°F Final Temperature (Latex A, 3 air exchanges/minute)

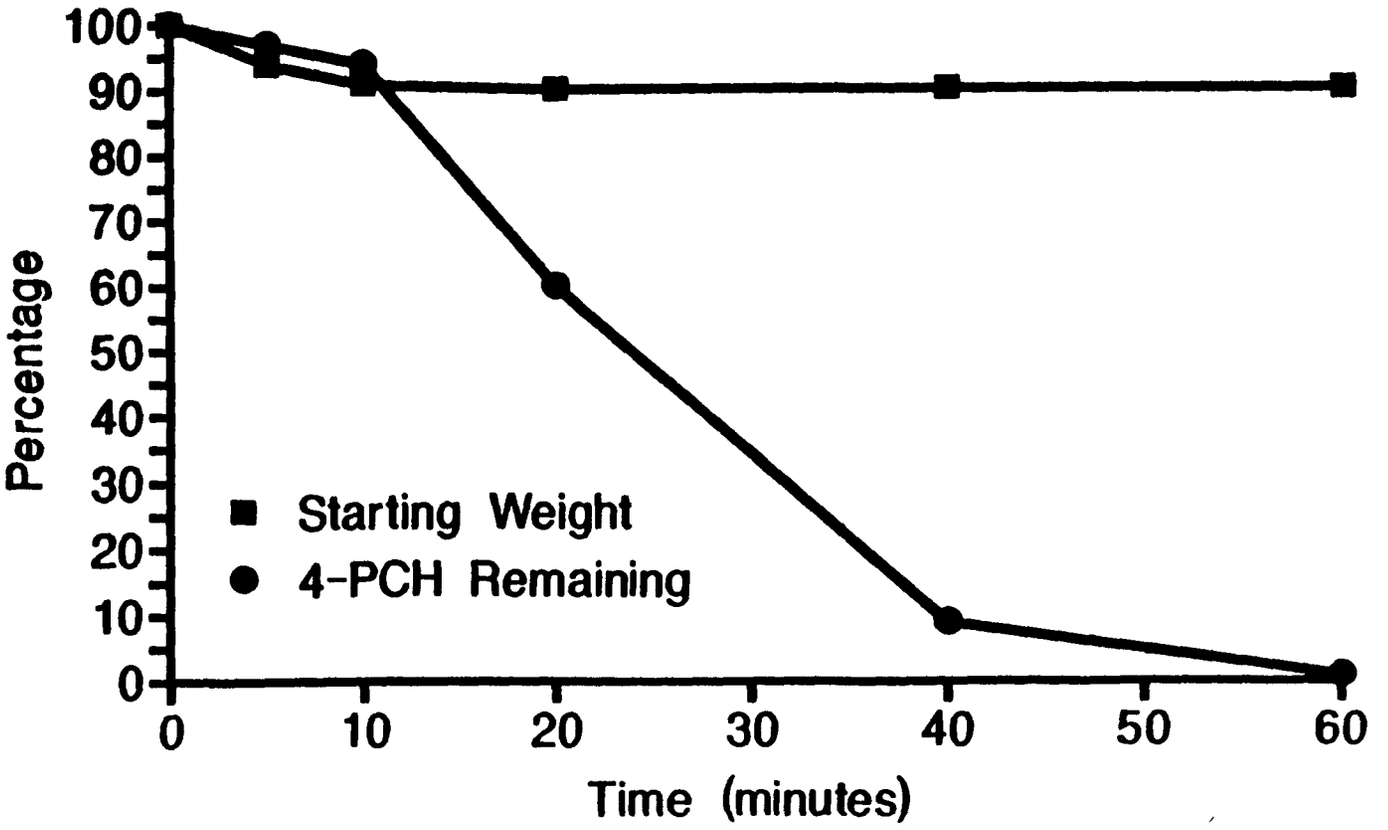


Table IVb

Relationship Between Carpet Moisture Loss and 4-PCH Release, 250 F
(Latex A, 3 air exchanges/minute)

Time (minutes)	% Starting Weight	% 4-PCH Remaining
0	100	100
5	94	98
10	90	74
20	90	22
40	90	1
60	90	0

* n = 6, standard deviation less than 15%

Figure 4b
Relationship Between Carpet Moisture Loss and 4-PCH Release, 250°F Final Temperature (Latex A, 3 air exchanges/minute)

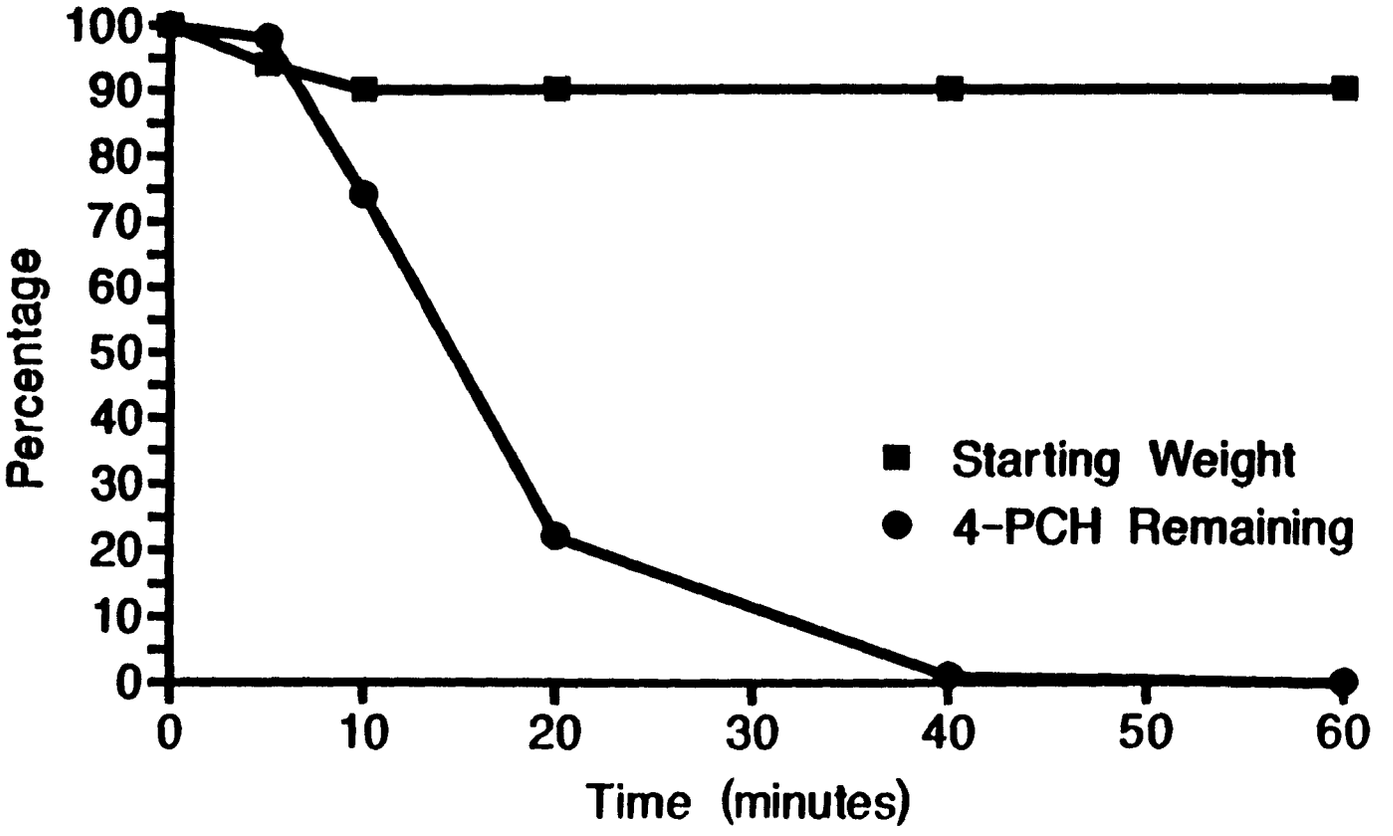


Table IVc

Relationship Between Carpet Moisture Loss and 4-PCH Release, 275 F
(Latex A, 3 air exchanges/minute)

Time (minutes)	% Starting Weight	% 4-PCH Remaining
0	100	100
5	94	86
10	90	40
20	90	17
40	90	0.2
60	90	0

* n = 6, standard deviation less than 15%

Figure 4c
Relationship Between Carpet Moisture Loss and 4-PCH Release, 275°F Final Temperature (Latex A, 3 air exchanges/minute)

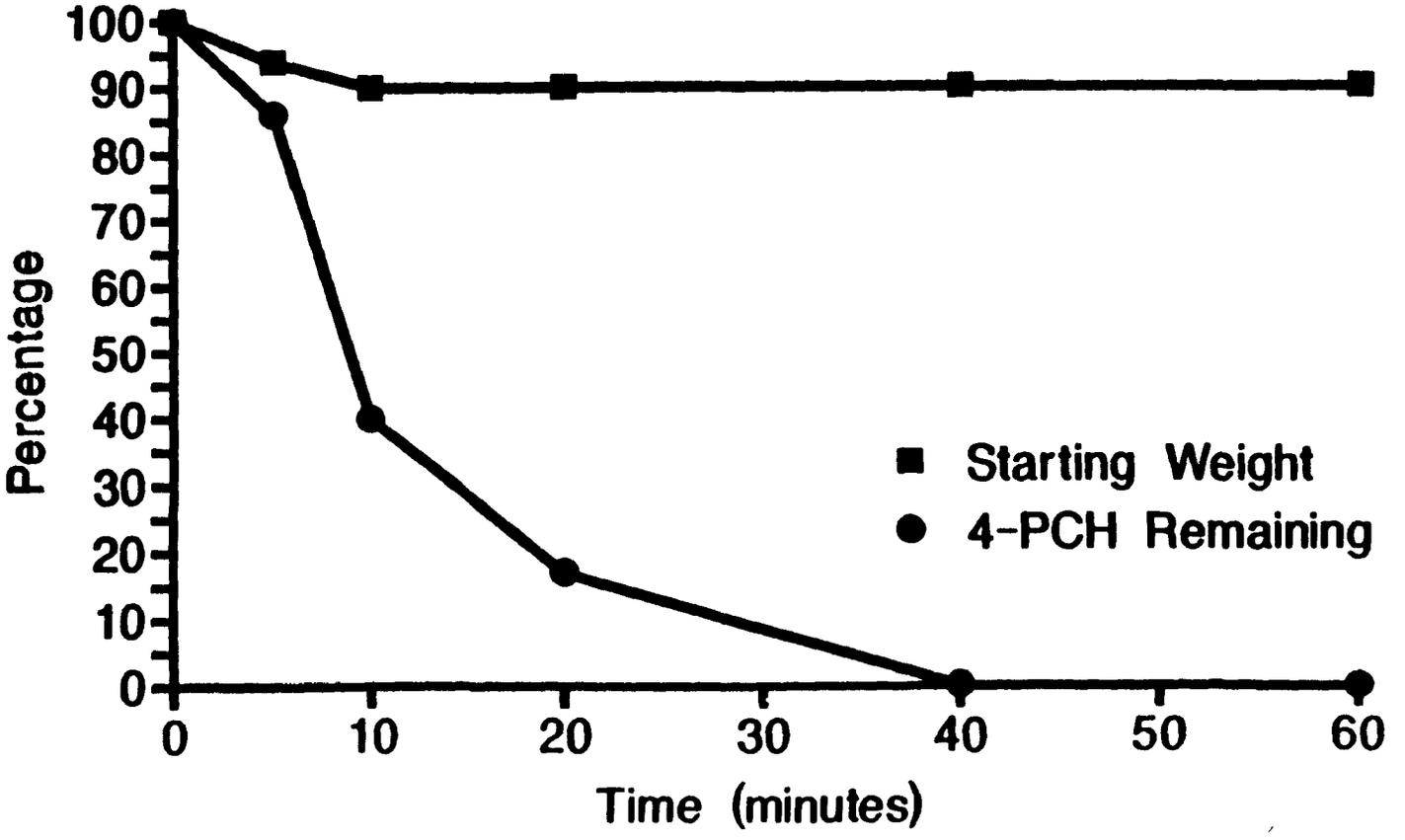


Table IVd

Relationship Between Carpet Moisture Loss and 4-PCH Release, 225 F
(Latex B, 3 air exchanges/minute)

Time (minutes)	% Starting Weight	% 4-PCH Remaining
0	100	100
5	98	98
10	91	81
20	90	61
40	90	11
60	90	1

* n = 6, standard deviation less than 15%
&

Figure 4d
Relationship Between Carpet Moisture Loss and 4-PCH Release, 225°F Final Temperature (Latex B, 3 air exchanges/minute)

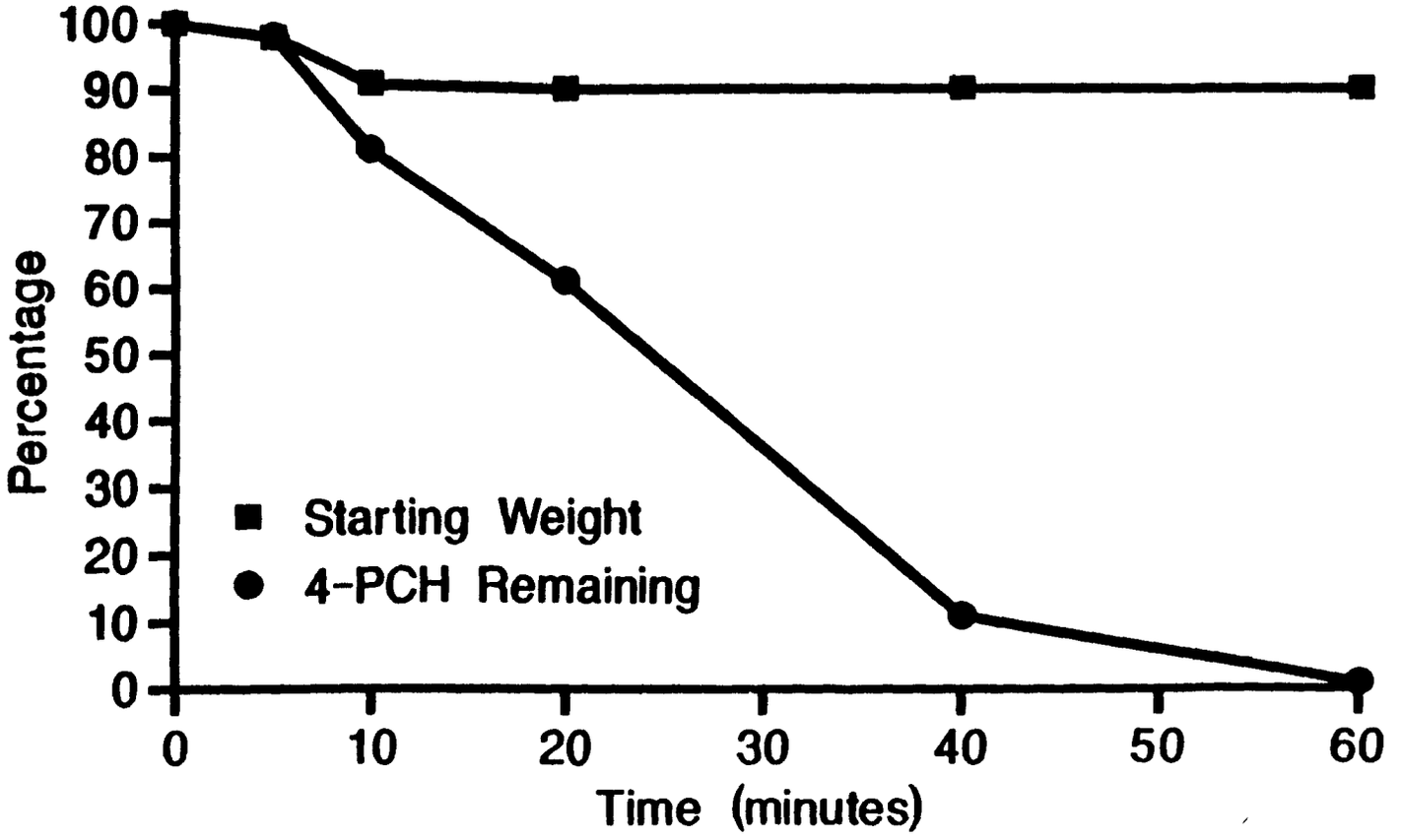
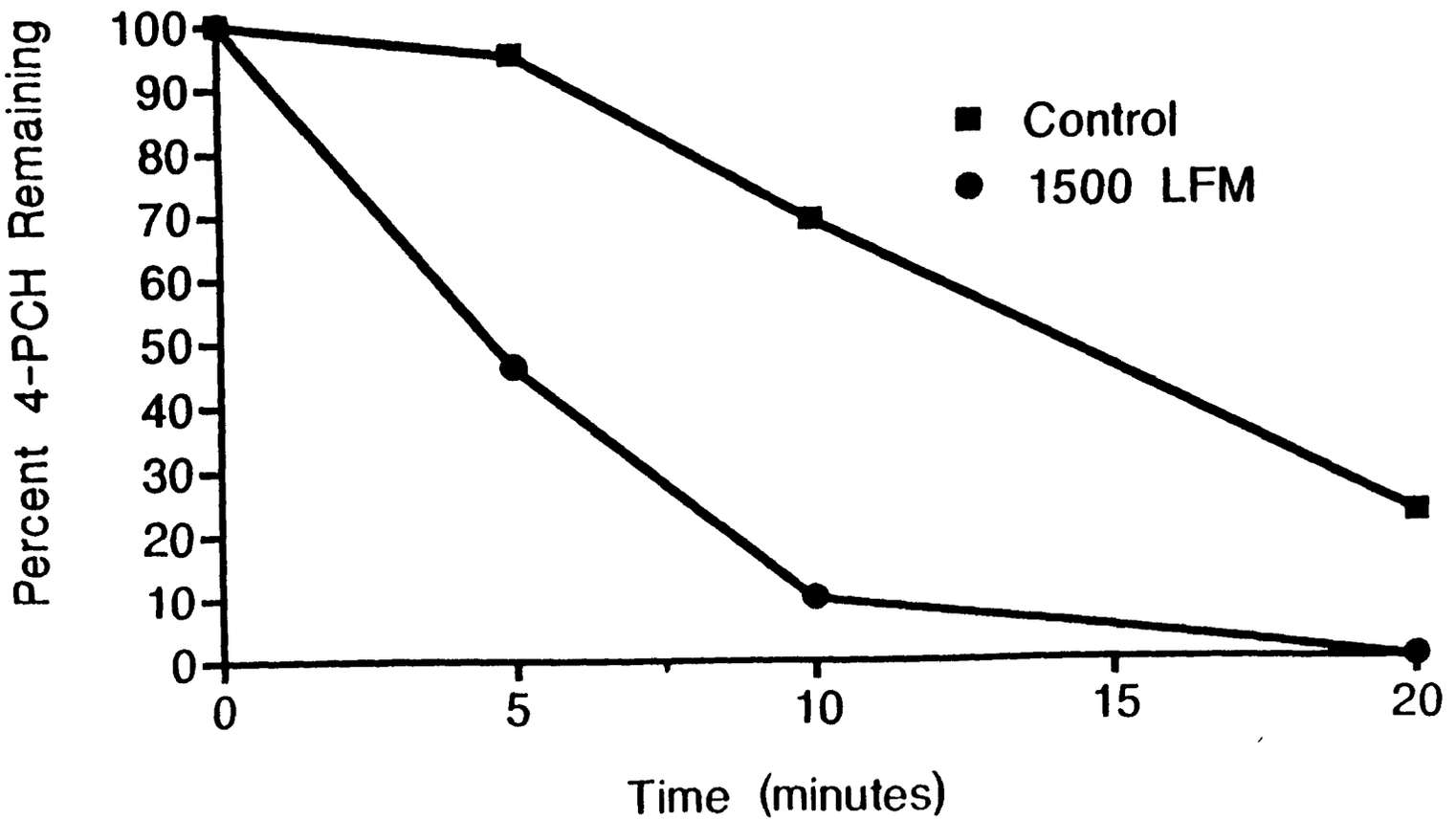


Figure 5
Relationship between Carpet 4-PCH Release and Linear Air Velocity 225°F (Latex A, 3 air exchanges/minute)



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1. Van Ert MD, Clayton JW, Crabb CL, Walsh DW: Identification and Characterization of 4-Phenylcyclohexene - An Emission Product from New Carpeting. Presented at the 1987 Am Ind Hyg Conference, Montreal, Canada, June 1, 1987.

2. Demer, Frank R: The Impact of Various Cure Parameters on the Release of 4-Phenylcyclohexene From Carboxylated Styrene Butadiene Rubber Latex. M.S. Thesis, Univ. of Arizona, Dept. of Pharm. & Tox. 1989.

APPENDIX I

PREPARATION OF CARPET BACKED WITH STYRENE-BUTADIENE RUBBER LATEX

10/30/89

1.0 INTRODUCTION

1.1 Purpose of the Standard Operating Procedure

The purpose of this SOP is to define the methodology for the preparation of styrene-butadiene rubber latex backed carpet.

1.2 Sources of the Method

1.2.1 VCR tape recorded at GENCORP laboratory.

1.2.2 Research Proposal for Investigating the Impact of Various Cure Parameters on the Release of 4-Phenylcyclohexene from Styrene-Butadiene Rubber Latex by Frank R. Demer.

1.3 References

1.3.1 VCR tape recorded at GENCORP laboratory.

1.3.2 Research Proposal for Investigating the Impact of Various Cure Parameters on the Release of 4-Phenylcyclohexene from Styrene-Butadiene Rubber Latex by Frank R. Demer.

1.4 Principles of the Method

1.4.1 Carpet made by standard procedures applicable to industry.

1.4.2 Samples prepared for gas chromatography analysis for 4-PCH content.

2.0 APPLICABILITY

This method shall be used for the preparation of standardized carpet samples for use in further research.

3.0 DEFINITIONS

(a) 4-PCH = 4-phenylcyclohexene
(b) 1-PCH = 1-phenylcyclohexene
(c) SBR = styrene-butadiene rubber
(d) SBLMC = Styrene Butadiene Latex Manufacturer's Council
(e) Filler = Whiting 200D, calcium carbonate (Georgia Marble)
(f) Frothing agent = Southern Chemical 391
(g) Thickener = Paragum 165
(h) Carpet = 26 oz. nylon 6:6 pile Saxony
(i) Secondary backing = Amoco 3.2 oz. polypropylene
(j) GC = gas chromatography

4.0 RESPONSIBILITIES

4.1 The Project Director will be responsible for the determination and implementation of appropriate laboratory procedures.

4.2 The Internal Quality Assurance Officer will be responsible for insuring the proper conduct of these procedures, and for periodically reviewing their performance.

4.3 The Laboratory Technician will be responsible for the preparation of carpet samples and the analyses of those samples according to the procedures specified in this SOP.

5.0 EQUIPMENT

5.1 Materials

(a) 26 oz. nylon 6:6 pile Saxony
(b) Secondary backing
(c) 10" x 10" carpet frames
(d) 3/4" metal latex roller
(e) 1 1/2" metal carpet roller
(f) Pyrex Desiccator
(g) Desiccant
(h) 16 ml. reaction vessels
(i) Reaction vessel septa, caps
(j) Hamilton Series 700 10ul syringes
(k) 32 oz. plastic cups with lids
(l) 20 oz. plastic cups
(m) 10 oz. plastic cups
(n) 3.2 oz. plastic cups
(o) Oxford repipettor
(p) rubber spatula
(q) 10" by 10" plexiglass square pattern

5.2 Instrumentation

(a) Brookfield Portable Viscosity Meter; Model RVT
(b) Sartorius Series U Balance; Model U6100D or equivalent
(c) Fisher Isotemp Oven; Model 496
(d) Lightning Variable Speed Mixer; Model DS3004 or equivalent
(e) Kitchen Aid 10 Speed Commercial Mixer; Model Ultra Power, 10 speed
(f) Computing Integrator (JCL6000 or equivalent)
(g) Hewlett Packard Gas Chromatograph 5890A
(h) Hewlett Packard Integrator 3390A
(i) T Thermocouple and Millivolt Converter, OMEGA Engineering, Inc.
(j) Millivolt Voltmeter (digital)

5.3 Reagents

(a) Carbon Disulfide, reagent grade
(b) Gas Cylinders for GC
(c) Latexes A & B
(d) DD Water
(e) Whiting 200D Georgia Marble filler
(f) SCT 391 Froth Aid
(g) Paragum 165 thickener
(h) 4-PCH standard, 1-PCH standard

6.0 STANDARD OPERATING PROCEDURE

6.1 Prior preparations

6.1.1 Glassware

(a) Prior to analysis, clean all glassware used to prepare standards, and all reaction vessels, caps, and septa with an approved laboratory cleaning solution.

(b) Rinse all cleaned glassware 3 times with double-distilled water.

6.1.2 1-PCH Internal Standard

(a) Low Sensitivity Standard - add 7.5 ul of 1-PCH standard to 500 ml of carbon disulfide, to give a 1-PCH concentration of 94.13 nmol/ml. Store refrigerated in brown bottle.

(b) High Sensitivity Standard - add 1.8 ul of 1-PCH standard to 500 ml of carbon disulfide, to give a 1-PCH concentration of 22.6 nmol/ml. Store refrigerated in brown bottle.

6.1.3 4-PCH Standard Solutions

6.1.3.1 Prepare stock 4-PCH standard solution by adding 4 ul of pure 4-PCH to 4 ml carbon disulfide to make a stock standard solution of 6351 nmols/ml.

6.1.3.2 Use the 1-PCH internal standard solution and the 4-PCH stock standard solution to prepare working 4-PCH standard solutions.

(a) 1.57 nmoles 4-PCH/ml working standard solution prepared by mixing 0.50 ul of stock standard 4-PCH to 2 ml internal standard solution (6.1

(b) 3.15 nmoles 4-PCH/ml standard solution prepared by mixing 1.00 ul of 4-PCH to 2 ml internal standard solution.

(c) 9.45 nmoles 4-PCH/ml standard solution prepared by mixing 3.00 ul of 4-PCH to 2 ml internal standard solution.

(d) 15.75 nmoles 4-PCH/ml standard solution prepared by mixing 5.00 ul of 4-PCH to 2 ml internal standard solution.

(e) 22.05 nmoles 4-PCH/ml standard solution prepared by mixing 7.00 ul of 4-PCH to 2 ml internal standard solution.

(f) 31.50 nmoles 4-PCH/ml standard solution prepared by mixing 10.00 ul of 4-PCH to 2 ml internal standard solution.

6.2 Preparation of SBR Latex

6.2.1 Mix latex thoroughly and weigh out appropriate amount into tared 32 oz. cup (See Appendix A).

6.2.2 Add appropriate amount of DD water (See Appendix A).

6.2.3 Mix thoroughly with the Lightning Mixer at 500 rpm for 2 minutes.

6.2.4 Add appropriate amount of calcium carbonate filler slowly while mixing at 700 rpm (See Appendix A). Continue mixing for 5 more minutes to completely wet filler.

6.2.5 Tare 32 oz. cup again and add appropriate amount of froth aid (See Appendix A).

6.2.6 Mix at 900 rpm for 30 seconds.

6.2.7 Tare 32 oz. cup again and add appropriate amount of thickener (See Appendix A).

6.2.8 Mix at 900 rpm for 5 minutes.

6.2.9 Check viscosity with the Brookfield Viscosity Meter.

6.2.9.1 Attach #5 spindle to viscosity meter and set speed on 20 rpm.

6.2.9.2 Fill 10 oz. tared cup about half full with latex mixture.

6.2.9.3 Place cup under meter and lower spindle until the top of the latex mixture just reached the notch around the spindle.

6.2.9.4 Turn viscosity meter on and allow to run for 1 minute, or until reading stabilizes. If longer than 2 minutes, check setting.

6.2.9.5 Record number on viscosity dial and multiply by factor from conversion table supplied by Brookfield (200) to get viscosity reading in centipoises.

6.2.10 Add latex mixture to 10 oz. tared cup until the weight in the cup is 500 grams.

6.2.11 Scrape latex mixture out of cup and into stainless steel bowl of Kitchen Aid mixer.

6.2.12 Whip mixture with wire whip at highest speed for appropriate time, then at lowest speed for 1 minute (See Appendix A).

6.2.13 Fill 3.2 oz tared cup with frothed latex mixture, tapping cup gently to remove air bubbles.

6.2.13.1 Weigh the latex mixture in the tared cup.

6.2.13 (continued)

6.2.13.2 Multiply amount by 9.7 (in the case of this 3.2 oz. cup) to get weight of frothed latex mixture per quart.

6.2.14 If the mixture weighs 800 grams/quart (± 25 grams), continue to 6.2.15.

6.2.14.1 If the mixture weighs less than 775 grams, continue to 6.2.15, check viscosity. If within range continue.

6.2.14.2 If the mixture weighs more than 825 grams, froth for 5 seconds more at high speed, then 1 minute more at lowest speed.

6.2.14.3 Repeat step 6.2.13.

6.2.14.4 If the mixture weighs 800 grams/quart (± 25 grams), continue to 6.2.15.

6.2.14.5 If the mixture still weighs more than 825 grams, keep repeating step 6.2.14.1 and 6.2.14.2 until it reaches 800 grams/quart (± 25 grams).

6.2.14.6 If the mixture now weighs less than 775 grams/quart, continue to 6.2.15.

6.2.15 Check the viscosity of the latex mixture.

6.2.15.1 Attach the #6 spindle to the viscosity meter.

6.2.15.2 Place the 3.2 oz cup filled with the frothed latex mixture under the meter and lower spindle until the notch just meets the top of the latex mixture.

6.2.15.3 Allow the meter to run at 20 rpm for 30 seconds.

6.2.15.4 Record the number from the meter dial and multiply by number from chart (500) to get viscosity in centipoises.

6.2.15.5 If the viscosity is between 20,000 and 27,000 centipoises, the procedure may be continued and latex used in the preparation of the carpet. If the viscosity is not between these limits, the latex mixture must be discarded and a new batch prepared, starting from 6.2.

6.3 Applying the latex mixture to the carpet

6.3.1 Mark a 10" by 10" square in black indelible Sharpie marker on the back of a 12" by 12" piece of carpet, using the plexiglass pattern.

6.3.2 Attach carpet to carpet frame by stretching and impaling the marked carpet on top of the nails, tuft side down, aligning the nails along the top and bottom of the square marked on the carpet back, and centering the marked sides so they are equidistant on each side of the nails. (The extra piece of wood that makes up the carpet frame should be in place between the two rows of nails, underneath the carpet sample.)

6.3.3 Place the 1/2" roller on top of the carpet, between the two rows of nails, flush against the top nails.

6.3.4 Weigh the tared 3.2 oz. cup filled with the frothed latex mixture, and remove latex until the cup contains 71 grams of latex mixture. Record exact amount of latex mixture in cup.

6.3.5 Spread the latex mixture evenly along the bar, on the carpet, on the side of the bar opposite to the nails. Record weight of latex mixture left in cup, and determine exact amount applied to carpet.

6.3.6 Grasp bar, placing thumbnails just below bar, thumbs touching carpet, on vertical black lines.

6.3.7 Drag bar toward you, applying no pressure to the bar other than its own weight, keeping thumbnails along black line, so that the latex mixture does not go outside of the black lines, and is applied onto the carpet.

6.3.8 When bar is within 1" of nails at bottom, spin bar such that latex mixture is carried upward and around until it is on side of bar opposite to nails, and bar is flush against bottom nails. Spread excess latex mixture evenly along bar.

6.3.9 Push bar away from you, toward top nails, using index fingernails to keep latex mixture within black vertical lines, and again applying no pressure to the bar other than its own weight.

6.3.10 When bar reaches within 1" of top nails, spin bar again, carrying latex mixture upward and around until it is on side of bar opposite to nails, and bar is flush against top nails. Spread excess latex mixture evenly along bar.

6.3.11 Continue until no excess latex mixture remains on bar (1 or 2 times more if necessary).

6.3.12 Place 12" by 12" piece of carpet backing, fuzzy side down, so that one side is just below top set of nails, and sides are even with sides of carpet.

6.3.13 Gently press down carpet backing and attach evenly to bottom nails.

6.3.14 Using heavy, 1 1/2" bar, roll the 10" by 10" square from the bottom nails up to top nails.

6.3.14 (continued)

6.3.14.1 The first roll should have no pressure applied, other than weight of bar.

6.3.14.2 The second roll should have slight pressure applied to the bar.

6.3.14.3 The third roll should have no pressure applied, other than weight of bar.

6.3.15 Carefully remove the completed carpet piece from the frame. Trim along the black lines, producing a 10" by 10" piece.

6.3.16 The standardized piece of carpet has been now been prepared, and may be used as desired in the experiment.

7.0 RECORDS

7.1 Data Collected by this Procedure

7.1.1 Data Sheets

7.1.1.1 Data Sheets are prepared for both Latex A and Latex B, with the recipe (appropriate amounts) for each type of latex written on the appropriate sheet (see Appendix A).

7.1.1.2 Each sheet also has blank spaces so that the actual amount used can be recorded. There are also spaces to record viscosity data, and weights determined throughout the process.

7.1.1.3 All information pertaining to the preparation of this batch of latex should be recorded on this sheet, and the sheet dated.

7.2 Location/Placement of Record Forms

7.2.1 Each day's data sheet should be placed in a manila folder, marked with the name of the experiment and the date, and kept in the file cabinet. The gas chromatograph data and all computer data using this batch of carpet will also be kept in this same file.

ATTACHMENT N-1

Preparation of Carpet Backed with Styrene-Butadiene Rubber Latex

Appendix A

Note that the two data forms are different, one is for Latex A and one is for Latex B.

Latex Compounding Data Sheet*

Date ____

Latex A

	Dry	Wet	_____ Factor/Batch
Latex	100.00	187.00	_____
Water	--	20.00	_____
Whiting 200D	450.00	450.00	_____
SCT 391 Frothaid	2.00	5.71	_____
Paragum 165	1.21	9.3	_____
Compound Solids	82%		
Initial Viscosity	_____		_____
Froth			
time (sec)			_____
cup weight (per quart)			_____
Viscosity			_____
Total Weight			_____

* Adapted from GENCORP Polymer Products, Dalton, GA

Latex Compounding Data Sheet*

Date _____

Latex B

	Dry	Wet	_____ Factor/Batch
Latex	100.00	185.00	_____
Water	--	26.00	_____
Whiting 200D	450.00	450.00	_____
SCT 391 Frothaid	2.00	5.71	_____
Paragum 165	0.75	5.80	_____
Compound Solids	82%		
Initial Viscosity	_____		_____
Froth			
time (sec)			_____
cup weight (per quart)			_____
Viscosity			_____
Total Weight			_____

* Adapted from GENCORP Polymer Products, Dalton, GA

APPENDIX O

Effects of Selected Process Parameters On Emission Rates of TVOC From Carpet

Effects of Selected Process Parameters On Emission Rates of TVOC From Carpet

N. C. Hawkins (The DOW Chemical Company)
J. A. LoMenzo (Ciba-Geigy Corporation)
A. E. Luedtke (E.I. Du Pont De Nemours & Co., Inc.)
C. R. Mitchell (Shaw Industries, Inc.)

ABSTRACT

A study with the objective of evaluating VOC as a function of process variables has been completed. The focus was on four factors associated with application of the secondary backing to the carpet (finishing). A statistically designed experiment provided derivation of reasonable models relating TVOC to these process variables. It was noted that the actual range of TVOC encountered at 24 hours was not particularly wide considering the test design. In addition, the emission rates for all samples dropped to relatively low levels in 24 hours. This is consistent with data obtained in other studies. Finally, the results of the study do not indicate much opportunity for major reductions in TVOC levels via these process variables.

January 1991

Effects of Selected Process Parameters on Emission Rates of TVOC From Carpet

This study was undertaken in an effort to develop an understanding of the effects of manufacturing process variables on VOC emission rates from carpet. The project was sponsored by four companies - Shaw Industries, Ciba-Geigy, Dow Chemical, and Du Pont. The significant feature of this particular group is that it consists of a carpet mill and three suppliers of many of the raw materials needed for making a carpet; i.e., a dye manufacturer, latex producer, and a fiber producer.

The study employed an experimental design methodology which required the controlled manufacture of test items (carpets). The items were defined around a few key process variables and fit into a statistical design framework.

The first step toward the design of the experiment involved discussion of all the conceivable variations possible in the manufacture of a carpet. These ranged from fiber type to dyeing processes to finishing steps. Over 100 variables were identified.

In order to have a manageable test design, it was necessary to reduce the number of variables. This was accomplished by applying the collective understanding of the study participants to their respective products and processes. The net result was the identification of four process variables around the finishing line - the last processing steps the carpet undergoes before wrapping.

The four variables studied were latex type, latex loading (coating weight per unit area of carpet), oven make up air, and oven residence time. Latex types were selected due to known composition differences. Oven make up air and oven residence time were studied because of their anticipated impact on the curing of the latex.

The actual experiment was based upon a two level factorial design (Figure 1). The process conditions (levels) were selected at high and low extremes. Center points were also included in this study and were chosen at or near normal operating conditions - these were replicated. The design, therefore, called for a total of 20 test items.

In this study the extremes were chosen as near the edge of manufacturing operability as possible without producing defective carpet. The extremes for residence time were set at +/- 25% of normal operating conditions - at shorter times not all of the items could be cured and at longer times the risk of affecting the coloration of the carpet was increased. The low for make up air was near the minimum necessary to adequately remove water vapor from the oven, while the high was just below the point of blowing out the natural gas burners. The latex loading varied from +/-10% of the normal coating weight used for a carpet. This variation was selected because the lower weights did not provide a viable carpet (i.e., inadequate adhesion of the secondary backing). At higher latex loadings, some of the test items could not be cured at the extremes of other process variables.

There is one additional note relative to the test carpets representing center points. It was opted to run these items at the "high" for make-up air. The normal setting used in day to day operations was found to be fairly close to the high extreme used in the test.

The test carpet and process line used in the study are characterized as typical. The substrate for this experiment represents a commonly used carpet design and construction - Nylon-66 fiber, beige color, cut pile, treated with stain and soil resist agents, and polypropylene primary and secondary backings. The process line is

an older line; ca. 20 years old. It has been upgraded over the years with current technology, so the performance should be similar to the majority of finishing lines in use.

The actual manufacture of the items was in a random fashion, with the exception of latex type (see Table 1). It was necessary to block the items on latex type due to the practical limitations of trying to make rapid latex batch changes on a commercial carpet line. The experiment was conducted on two separate days. Each sample set was manufactured from a single batch of latex.

Careful consideration was given to when and how the samples for emissions testing were collected. After each process change required in the design, 1,000 linear feet of carpet were run through the finishing line to allow adequate time for the system to stabilize. At the end of the 1,000 ft, two 2' by 12' samples, representing the full width of the carpet, were immediately collected. These were wrapped in layers of polyethylene, aluminum foil, and polyethylene. One test sample was retained by the carpet mill, and the other was delivered to Air Quality Sciences, Inc. (AQS) for analysis.

The actual emission rate data was obtained via small environmental chambers. The conditions of the acquisition are typical of those currently used for carpet - 0.42 m^2/m^2 loading factor, 25 deg. C., 50% RH, and 1 ACH. VOC were trapped on an adsorbent over two hour intervals starting at 1 hour and at 24 hours after introduction into the chamber. The qualitative and quantitative analysis was via GC/MS using the protocol developed by AQS. The raw TVOC rate data is reported in Table 2 at 1 hour and 24 hours in mg/m^2h.

Noted in the raw data was that sample #5 and sample #6 have considerably higher one hour emission rates than the rest of the samples. Recall that #6 is one of the center points and has a replicate #10. AQS performed a duplicate analysis of sample #6 and obtained a TVOC emission rate more consistent with the other samples. A third analysis was conducted on the sample of #6 retained by the carpet mill - this also provided a TVOC value which was more consistent with the rest of the data. The high values for #5 and #6 were found to be the result of an unusually high 2-butoxyethanol contribution to TVOC.

It is not clear why 2-butoxyethanol was so prevalent in these two samples. Subsequent analysis did determine that 2-butoxyethanol was in one of the products used by the carpet mill to formulate the latexes before application. Nonetheless, it is difficult to argue that the high levels observed in samples #5 and #6 were a result of the manufacturing process. For example, 1) both #5 and #6 were a result of the manufacturing process. For example, 1) both #5 and #6 were manufactured from the same latex batch as the other eight items in this set; 2) 2-butoxyethanol was not seen in anywhere near the same levels in the one hour emission rates for the other samples; 3) replicate analysis of #6 did not reveal high levels of 2-butoxyethanol; 4) the 24 hour emission rates for #5 & #6 are reasonable (2-butoxyethanol is a very minor component); 5) the boiling point of 2-butoxyethanol is 171°C, so it seems unlikely that the levels seen in #5 & #6 could drop to comparable levels to the rest of the samples in only 24 hours; and 6) the precautions taken in handling and storage of these samples make it unlikely that large quantities of 2-butoxyethanol could have been lost on standing.

Two key observations can be made from the raw data. The first is the significant drop in emission rate from one hour to 24 hours - 0.779 mg/m^2h to 0.071 mg/m^2h (averages) or about 90%. The 24 hour mark may be closer to the emission rate most consumers will first encounter after installation of a carpet. Also, the collection process - tightly enclosed samples taken immediately off the finishing range - is anticipated to provide a worst case emission profile. The second observation is relative to the narrow range of the 24 hour rates. In this particular experiment the difference between high and low 24 hour emission rates was 0.175 mg/m^2h, despite running the manufacturing processes as near to the limits of operability as feasible.

Although some simple observations can be made from the raw data, the primary value of an experimental design comes from statistical analysis. The modeling for this study was via multiple regression analysis, which treated TVOC as the outcome variable. The predictor variables were oven residence time, oven make up air, latex "coating weight", and latex type. This approach also provides the opportunity to evaluate

interactions between the variables (cross terms); i.e., whether they may be interacting synergistically or antagonistically.

The models shown in Table 3 illustrate the outcome of the regression analysis. TVOC is shown as a function of the significant (alpha = 0.05) process variables and cross terms. Reported with the models are R^2 values. R^2 is a reflection of the goodness of fit of the data to the model. An R^2 of 1.0 signifies a perfect fit and an R^2 of 0.0 reflects no relationship between the chosen variables.

The R^2 values for the one hour and 24 hour models were 0.58 and 0.77 respectively. This indicates that the models account for a fair amount of the variance in the data set. The important predictor variables are make up air and oven residence time. Cross terms with make up air and oven residence time also stand out as important. [Note, the one hour data for sample #6 was treated as an outlier and not used in the one hour model.]

Another way of representing relationships is through the use of contour plots. Figure 2 illustrates the response of TVOC to make up air and oven residence time. Note, that the normal operating range for residence time and make-up air for this process line lies in the upper half of center on the plot. Also recall, the extremes on the plot are approaching the limits of operability. Thus, the data indicates there is relatively little opportunity to significantly reduce TVOC on this finishing line with these process variables without increasing the risk to final product attributes.

The broader application of the previous statement to other process lines would, of course, be speculative. Nonetheless, it is important to consider three points: 1) the process line employed in the study is typical of equipment available to the trade; 2) carpet manufacturers are using products from a relatively small number of suppliers; and 3) despite the physical differences in various process lines, they are set up to take the carpet to a similar endpoint - ie., a cured latex (primarily removal of water). Hence, product TVOC differences between finishing lines would not be predicted to be great.

In summary, a study has been completed with the objective of evaluating VOC as a function of process variables. The focus was on four factors, all associated with the finishing line. A statistically designed format provided derivation of reasonable models relating TVOC to these process factors. It was noted that the actual range of TVOC encountered at 24 hours was not particularly wide considering the test design. In addition, the emission rates for all samples dropped to relatively low levels in 24 hours. This is consistent with data obtained in other studies. Finally, the results of the study do not indicate much opportunity for major reductions in TVOC levels via these process variables.

FIGURE 1

Experimental Design

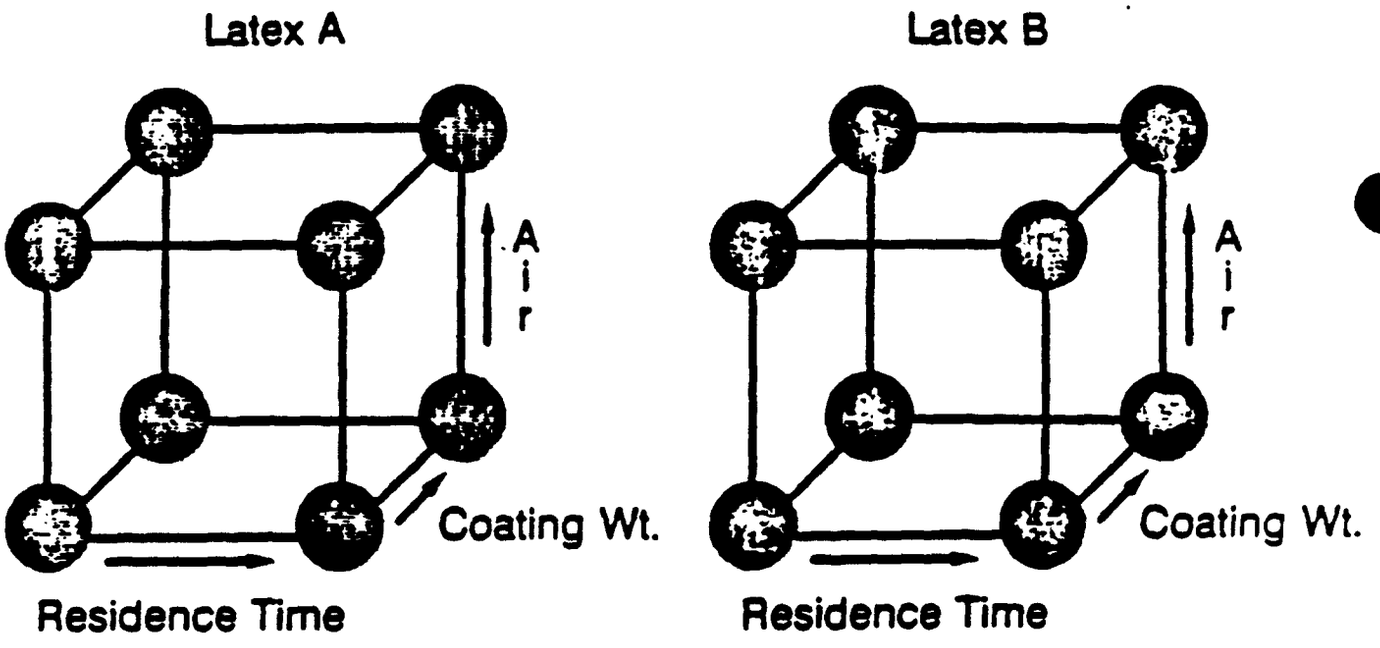


TABLE 1

ACTUAL STUDY DESIGN USED IN EXPERIMENT

Sample Number	Res. Time	Latex Level	Make Up Air	Latex Type
1	Low	Low	Low	A
2	High	Low	High	A
3	Low	Low	High	A
4	Low	High	High	A
5	Low	High	Low	A
6	Middle	Middle	High	A
7	High	High	Low	A
8	High	High	High	A
9	High	Low	Low	A
10	Middle	Middle	High	A
11	High	High	High	B
12	Low	Low	High	B
13	Middle	Middle	High	B
14	Low	High	High	B
15	High	Low	Low	B
16	High	High	Low	B
17	Middle	Middle	High	B
18	Low	Low	Low	B
19	Low	High	Low	B
20	High	Low	High	B

TABLE 2

RAW EMISSION RATE DATA
mg/m^2 h

SAMPLE	1 HOUR	24 HOUR	% REDUCTION
1	0.804	0.070	91
2	0.236	0.014	94
3	0.500	0.093	81
4	0.481	0.063	87
5	1.980	0.188	91
6	3.040*	0.071	97
7	0.302	0.056	81
8	0.350	0.063	82
9	0.288	0.061	79
10	0.156	0.027	83
11	0.343	0.053	85
12	0.693	0.111	84
13	0.397	0.067	83
14	0.386	0.069	82
15	0.693	0.085	88
16	0.881	0.088	90
17	0.973	0.088	91
18	1.200	0.168	86
19	1.190	0.162	86
20	0.690	0.050	93
Ave.	0.779	0.071	
Std. Dev.	0.687	0.042	

*Replicate analyses of #6 provided TVOC values of 0.638 & 0.227 mg/m^2h

TABLE 3

FITTED REGRESSION MODELS

ONE HOUR RATES

$$TVOC = 0.695 - 0.222(AIR) - 0.215(RES.\ TIME) + 0.161(AIR)(RES.TIME)^{*}$$

$$R^2 = 0.58$$

24 HOUR RATES

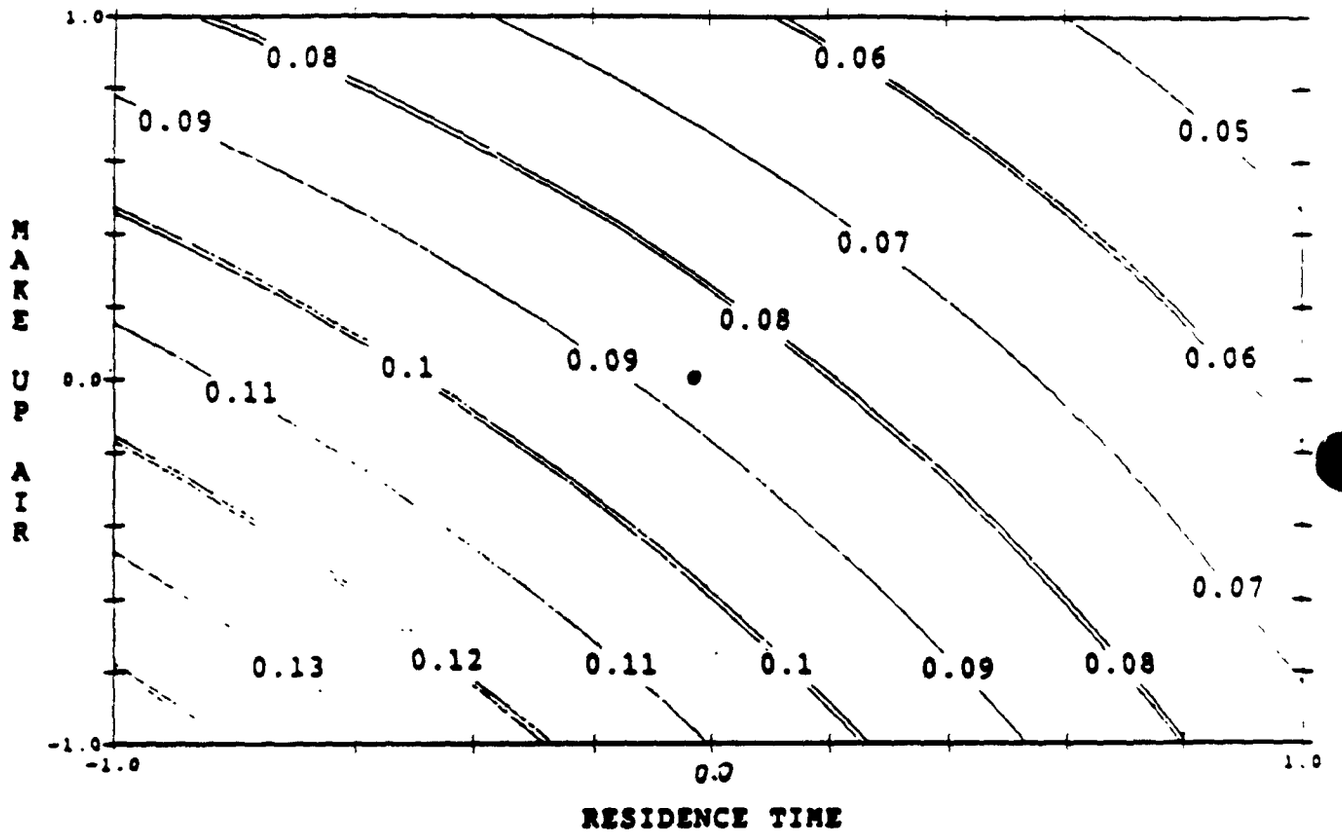
$$TVOC = 0.087 - 0.023(AIR) - 0.028\ (RES.\ TIME) - 0.012(LATEX) + 0.015(AIR)(LEVEL)(RES.\ TIME)$$

$$R^2 = 0.77$$

* Cross term was close to Alpha = 0.05 significance level

FIGURE 2

TVOC RESPONSE TO OVEN RESIDENCE TIME & "AIR" AT 24 HOURS



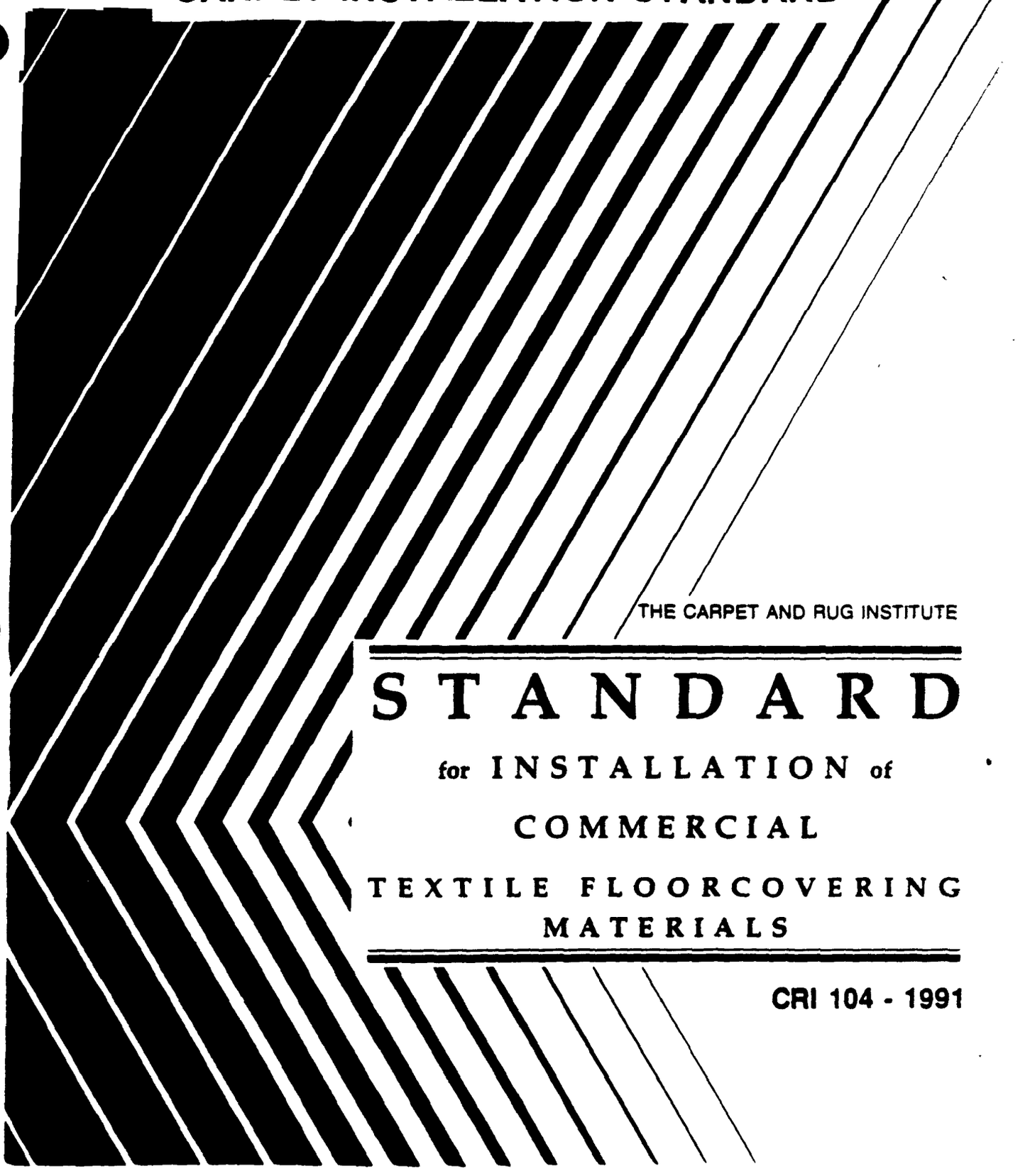
UNITS = mg/m2h; STD DEV. OF REGRESSION = 0.030

APPENDIX P

CRI Commercial Carpet Installation Standard

COMMERCIAL

CARPET INSTALLATION STANDARD



THE CARPET AND RUG INSTITUTE

STANDARD

for INSTALLATION of

COMMERCIAL

TEXTILE FLOORCOVERING

MATERIALS

CRI 104 - 1991

COMMERCIAL CARPET INSTALLATION STANDARD

CRI 104 - 1991

STANDARD FOR
INSTALLATION OF COMMERCIAL TEXTILE FLOORCOVERING MATERIALS
1991

ISBN # 0-89275-010-3

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Table of Contents

Page

Notice . . . . . P-ii

Forward . . . . . P-iii

Section

1. Scope P-1
2. Applicable Documents P-1
3. Definitions of Terms P-1
4. Tools and Materials P-4
5. Storage and Handling P-4
6. Site Conditions P-5
7. Planning and Layout P-7
8. Direct Glue-Down P-8
9. Double Glue-Down P-10
10. Attached Cushion P-12
11. Stretch-in Utilizing Tackless Strip P-13
12. Carpet on Stairs P-16
13. Carpet Modules (Tiles) P-17
14. Installation of Outdoor Carpet and Synthetic Turf P-18
15. Protection of Installation P-20

Tables

I. Tools P-21
II. Materials P-22
III. Adhesives P-23
IV. Trowel Size P-24
V. Tackless Strip P-25

Figure

1. Tufted, Stretch Diagram P-27
2. Wilton or Velvet, Stretch Diagram P-28
3. Axminster, Stretch Diagram P-29

CRI Publications P-30

NOTICE

The Carpet and Rug Institute assumes no responsibility and accepts no liability for the application of the principles or techniques contained in this standard. Specifying authorities have the responsibility of reviewing all applicable federal, state and local statutes, ordinances, and regulations.

FOREWORD

This publication, a voluntary minimum standard for the installation of commercial textile floorcoverings, is based on reliable installation principles and procedures developed through practical experience, research, and information obtained from carpet manufacturers, retailers, installers, end users, testing laboratories, and others with specialized experience in the field.

This publication does not include carpet performance characteristics. Users are urged to review appropriate publications developed by the Carpet and Rug Institute for guidance in selecting and specifying carpet.

For standards applicable to the installation of residential carpet, please refer to the Carpet and Rug Institute publication CRI 105, "Standard Reference Guide for Installation of Residential Textile Floorcovering Materials."

CRI STANDARD 104

STANDARD PRACTICE FOR INSTALLATION OF COMMERCIAL TEXTILE FLOORCOVERING MATERIALS

1. SCOPE

1.1 This standard covers the installation of textile floorcovering materials over subfloor and the preparation of the subfloor prior to installation.

1.2 This standard covers the installation of all textile floorcovering materials for all methods of manufacture including carpet modules.

1.3 This standard establishes industry minimum installation procedures. These procedures shall not be decreased.

1.4 This standard may be changed only by specific recommendations from the manufacturer of the products to be installed.

2. APPLICABLE DOCUMENTS

2.1 Standard for Installation of Residential Textile Floorcovering Materials - CRI 105 - The Carpet and Rug Institute

2.2 Carpet Specifier's Handbook - The Carpet and Rug Institute

2.3 How to Specify Commercial Carpet Installation - The Carpet and Rug Institute

2.4 Areas of Responsibility - The Carpet and Rug Institute

3. DEFINITIONS OF TERMS

Adhesive, n. - A substance which dries to a film capable of holding materials together by surface attachment.

Alkali, n. - A soluble substance with basic properties and having a pH of more than 7.

Attached Cushion, n. - Cushion material permanently bonded to the back of carpet and rugs by the manufacturer. Often made of synthetic rubber foam or polyurethane foam.

Axminster Carpet, n. - Carpet woven on Axminster loom by which pile tufts are individually inserted from varied colored yarns arranged on wide spools. This process makes it possible to produce carpet and rugs of complex designs with many colors, such as Oriental design rugs.

Baseboard, n. - A board skirting the lower edge of a wall, covering the joint of the wall and the adjoining floor.

Birdcage, n. - Common term used to describe the end of a stair rail where the banisters are curved in a spiral to form a newel post.

Bullnose, n. - Common term used for step return.

Carpet Cushion, n. - A term used to describe any kind of material placed under carpet to provide resiliency, support and noise absorption when walked upon. Also referred to as carpet lining, padding or underlay, although "carpet cushion" is the preferred industry term.

Carpet Modules, n. - Carpet packaged as squares, generally 18 inches by 18 inches (457 x 457 mm) with or without attached cushion backing. Also referred to as "carpet tiles."

Custom Carpet, n. - A carpet or rug manufactured in a special size, shape, color, design, or width through a number of tufted or woven manufacturing processes.

Double Glue-Down, n. - An installation method whereby the carpet cushion is first adhered to the floor with an adhesive, and the carpet is then adhered to the cushion by an adhesive.

Glue-Down, n. - An installation method whereby the carpet is adhered to the floor with an adhesive.

Gully, n. - The distance between tackless strip and the wall. It should always be slightly less than the thickness of the carpet.

Knee-Kicker, n. - An installation tool designed to position loose carpet and move it onto the tackless strip. The leading edge of the kicker should be on the surface of the carpet and on the tackless strip to hook and force carpet backing onto the pins of the strip. To absorb the pressure shock on the knee, the kicker's "butt pad" is made of sponge rubber. (NOTE: With the exception of stair installation, knee-kickers should only be used for positioning and hooking the carpet onto the tackless strip and not for stretching carpet. A power stretcher should always be used for stretching carpet during installation; see below.)

Knitted Carpet, n. - Carpet produced in a fabric formation process comprising interlacing yarns in a series of connected loops by the use of needles. As in weaving, pile and backing are produced simultaneously. Multiple sets of needles interlace pile, backing, and stitching yarns in one operation.

Molding, n. - A wooden or plastic strip, either quarter round or shoe molding, attached to the bottom of a baseboard or wall to cover the joint between wall and floor.

Open-Time, n. - Elapsed time during which an applied adhesive will still bond to the carpet.

Power Stretcher, n. - A carpet installation tool used to stretch carpet for installation on tackless strip. It consists of a pinned plate which grips the carpet, tubular extensions, a padded end which is used to brace against an opposing wall or other structure, and a lever system that multiplies the installer's applied stretching force.

Quarter-Round, n. - Wooden or plastic molding with a cross section comprising a 90° arc of a circle. It is used as joints between walls and floors, or between larger moldings

and floors.

Restretch, v. - Term used to describe stretching carpet after original tackless installation to remove wrinkles, bubbles, or to correct loose fit.

Riser, n. - The upright part of a step between two stair treads.

Seam, n. : In a carpet installation, the line formed by joining the edge of two pieces of carpet by the use of various seaming tapes, hand sewing or other techniques

Seam Adhesive, n. - A specifically formulated adhesive for securing cut edges of carpet to be seamed. Specialized products are necessary for either direct glue-down attached cushion, or stretch-in over a cushion installation. Its use will help prevent raveling and delamination at seam edges.

Seaming Tape, n. - Fabric tape used for joining two sections of carpet. "Hot melt" tape is precoated with a thermoplastic adhesive. For other tapes, the adhesives are applied separately.

Secondary Backing, n. - Woven or nonwoven fabric reinforcement laminated to the back of tufted carpet usually with an adhesive to enhance dimensional stability, strength stretch resistance, and ease of handling.

Selvage (Selvedge), n. - The factory-finished edge of a carpet.

Set-Up Time, n. - The required drying time whereby adhesive will no longer transfer whenever pressure sensitive or contact cements are used.

Shoe Molding, n. - Wood or plastic strip with one corner edge rounded slightly It is used to conceal joints between walls and floors, or between larger moldings and floors.

Stretch-in, n. - Installation procedure for installing carpet over separate cushion using a tackless strip.

Tackless Strip, n. - Wood or metal strips fastened to the floor near the walls of a room containing either two or three rows of pins angled toward the walls on which the carpet backing is stretched onto and secured in a stretch-in installation.

Textile Floorcovering Material, n. - General description used for carpet, rugs, etc.

Threshold, n. - The raised board beneath a door, also known as a "door sill" or "saddle "

100% Transfer, n. - The full coverage/transfer of the carpet floor adhesive into the carpet backing, including the recesses of the carpet back, while maintaining full coverage of the floor.

Tread, n. - The horizontal part of a stair and that part which is walked on.

Tufted Carpet, n. - Carpet manufactured by the tufting process, a method by which pile yarns are inserted into a primary backing fabric by a row of eyed needles.

Unitary Carpet, n. - Carpet used for glue-down installations which has an application of high quality backcoating latex to increase tuft bind performance properties without the addition of a secondary backing.

Velvet Carpet, n. - Carpet woven on a velvet loom. Velvet carpet is typically cut pile or level loop in solid or tweed colorings, though textured and patterned effects are possible.

Vinyl Plasticizer, n. - A substance incorporated into vinyl to increase its flexibility, workabili-

ty, or distensibility (capable of being extended).

Wilton Carpet, n. - Carpet woven on a loom with a Jacquard mechanism which uti[illegible] a series of punched cards to select pile height and yarn color. The Wilton loom c[illegible] produce carpet with complex multicolor patterns and highly textured pile surfaces of multilevel cut and looped yarns.

Woven Carpet, n. - Carpet produced on a loom through a weaving process by which the lengthwise (warp) yarns and widthwise (weft or filling) yarns are interlaced to form the fabric. Carpet weaves — such as Wilton, Axminster and velvet — are complex, often involving several sets of warp and filling yarns for the pile and backing

4. TOOLS AND MATERIALS

4.1 Carpet shall be installed using the tools and accessories listed in Table I

4.2 Materials shall be selected from the list in Table II.

4.3 Adhesive shall be used as recommended by the carpet manufacturer or adhesive manufacturer. Common types are listed in Table III.

4.4 General guidelines for trowel notch selection are listed in Table IV.

4.5 When specified, the tackless strip shall be selected from the list in Table V

5. STORAGE AND HANDLING

Environmental conditions prior to and immediately after installation shall meet the following criteria to assure a "relaxed" carpet, preventing glue-down or stretch-in problems.

5.1 Storage - Carpet shall be stored in flat bins to prevent pile crush. Temporary storage shall be in flat bins with a maximum height not to exceed three rolls.

5.2 Handling - Carpet shall be transported on flat dollies equipped with carpet cradles Fork lifts shall be equipped with booms. Bending or folding of individual carpet rolls is not recommended. However, if it is absolutely necessary for delivery purposes, under no circumstances should the carpet be left bent or folded for longer than 4 hours.

5.3 Conditions - The carpet and adhesive shall be conditioned on site in a heated dry space at a minimum temperature of 65° F (18° C) and a relative humidity between 10% and 65% for at least 48 hours before installation. These conditions shall be maintained night and day during installation and for at least 72 hours after completion.

6. SITE CONDITIONS

6.1 **Floor Preparation** - Each subfloor shall be inspected to determine the special care required to make it a suitable foundation for carpet.

6.1.1 **Concrete** - New concrete shall be cured, clean and dry. It shall be free of curing or parting agents that interfere with the bonding of the adhesive. The owner or general contractor must submit to the flooring contractor a report on the percentage of moisture in the slab. The moisture content shall not exceed a hygrometer reading of 65%.[1]

Whenever a powdery surface is encountered, a sealer compatible with the adhesive shall be used to provide a suitable surface for the glue-down installation when specified.

Patching of cracks and depressions shall be made with a compatible latex patching compound. Do not exceed manufacturer's recommendation for patch thickness. Large patched areas must be sealed.

Old concrete must be clean, dry, and free of paint, dirt, adhesive, oils and other contaminants.

6.1.2 **Wood** - Wood subfloors should have a minimum 18-inch (457 mm) air space underneath with cross ventilation. Plywood, hardwood, and particleboard used as subflooring must be a flooring grade installed to the manufacturer's specifications. Joints shall be filled and rough areas sanded smooth. Old wood shall be checked for soundness, and any loose boards shall be renailed. Rough and uneven areas shall be sanded smooth and sealed.

Oil contaminated floors must be covered with a suitable underlayment such as hardboard, plywood, or particle board installed according to the Hardwood Plywood Manufacturers Association or the Particleboard Manufacturers Association recommendations.

The suitability of a painted wood surface can be checked by gluing down a two-foot square of carpet. If the adhesion bond is strong, and the paint does not pull up with the carpet after 72 hours, the carpet can be installed. Glossy surfaces are to be roughened prior to installation.

Sanded and new floors shall be coated with a compatible sealer to provide a good surface for glue-down.

---

[1] To determine the presence of excessive moisture on-site, place a hygrometer on the floor near an inside wall, cover with a sheet of clear plastic film about two feet (610 mm) square, and seal with duct tape. A rough estimate may be obtained in 15 to 30 minutes; 24 hours is needed for an accurate check. Various locations in the area should be tested.

Moisture test on slabs below 55°F (13°C) are inaccurate because moisture migration is retarded by low temperatures.

6.1.3 **Metal** - Metal floors must be level and cleaned of grease, oil, dirt, and rust

6.1.4 **Vinyl and Linoleum** - Carpet must not be glued down directly over existi sheet vinyl

Direct glue-down over tiles and other types of previously installed resilient flooring is feasible under certain conditions; however, tests must be performed to determine if the vinyl plasticizers will migrate into the carpet adhesive and loosen the bond.

6.1.5 **Terrazzo, Ceramic, Marble, Epoxy and Slate** - All of these materials represent nonporous surfaces. If a nonporous backed carpet is glued down over these surfaces, strict attention must be given to the "open time recommendations.

6.1.6 **Radiant Heat** - Heat must be lowered before the installation to prevent floor adhesive from "setting" too fast. When affixing tackless strips in stretch-in installations, care must be taken not to nail into the pipe or conduit.

6.1.7 **Sealers** - The use of sealers on floor surfaces is generally not necessary except for sanded, dusty, porous, and acoustical surfaces. Sealing cannot overcome moisture conditions and must not be used for that purpose. When used, sealers must be thin and fast drying. They should be compatible with adhesives, which should be applied only after sealer is dry.

6.2 **Moisture in Concrete Subfloors** - At least 90-120 days are to be allowed fo concrete slab to cure and reach an acceptable dryness. Appearance alone is not a reliable test. In order to prevent glue-down and adhesive breakdown problems due to moisture and alkali, the general contractor or owner shall be responsible for providing written moisture and alkali test results relating to the concrete slab prior to the installation. A pH range of 5-9 is satisfactory; however, 10 or greater requires corrective measures.[2] This can be accomplished by applying an acid etch consisting of 10 parts water to 1 part of muriatic acid, and rinsing twice with clear water. In some cases, a 30% mixture of vinegar and water may be used to reduce alkalinity

In case "gypcrete," lightweight, or acoustical concrete is used, check the manufacturer's recommendations for the proper sealer to be used before carpet is installed.

6.3 **Temperature and Humidity** - Ideally, carpet shall be installed when the temperature is between 65° F and 95° F (18° C and 35° C) and the relative humidity is between 10% and 65% and, if installing over concrete, the slab temperature should not be less than 65° F (18° C).

---

[2] The pH on the surface of the concrete can be determined by slightly wetting the floor and applying pH test paper.

6.4 **Relax Carpet** - Whenever possible and conditions permit, all carpet shall be unrolled, relaxed, and allowed to ventilate with the induction of fresh air

6.5 **Environmental Conditions** - Fresh air ventilation during installation shall be maintained by opening windows and doors, by utilizing exhaust fans, and by operating the ventilation fan system at full capacity. When conditions warrant, fresh air ventilation shall be maintained after installation for 48-72 hours at normal room temperatures by operating the ventilation fan system at full capacity and by opening windows and doors if possible. This will help eliminate the existence of any lingering odors.

6.6 **Carpet over Carpet** - Carpet shall not be installed over existing carpet.

7. PLANNING AND LAYOUT

All facets of the installation are to be coordinated. A scale drawing of the area to be carpeted is required to determine yardages, yardage per dye lot, edge treatments, cushions, adhesives, moldings, and other accessories and to identify proper location of seams.

On new construction, architectural drawings shall be provided that define the entire carpet area with space names or numbers and a finish schedule of styles, patterns, colors, and installation methods. On existing structures, new measurements and shop drawings shall be made.

7.1 **Shop Drawings and Layout** - The carpet shop drawing shall contain the following information:

7.1.1 Name of the job, owner, and installation company. On new construction, the name of the general contractor and architectural firm shall be listed.

7.1.2 Building address

7.1.3 Date of drawing

7.1.4 Scale

7.1.5 Floor number and location in building

7.1.6 Compass direction on each sheet

7.1.7 Drawing for each area to be carpeted

7.1.8 Type of floor for each area

7.1.9 Type of installation for each area

7.1.10 Quantities of carpet needed for each area, including roll length requirements

7.1.11 Notations where dye lot changes will occur

7.1.12 Excess material in each area and how it will be used

7.1.13 Seam layout of each area

7.1.14 Carpet pile direction for each area

7.1.15 Name of manufacturer, quality, and color of carpet for each area

7.1.16 Large scale drawings showing treatment of step areas or other detail work

7.1.17 Location and type of all edge moldings

7.1.18 Type of base in each area

7.2 **Seams** - Seams shall be kept to a minimum. The seams shall be positioned so that where possible:

A. The seams run the length of the area.
B. Main traffic runs along rather than across the seam.
C. Incident light does not strike across the seam.
D. The seams are away from areas subject to pivoting traffic.
E. Seams are not perpendicular to doorway openings.

7.3 **Pile Direction** - Where two or more pieces of the same carpet are adjacent, the pile direction shall be the same as in other areas unless otherwise specified. Ideally, pile direction shall be toward the entrance, but other factors such as pattern, aesthetics and economic use of material may also be considered.

INSTALLATION

8. **DIRECT GLUE-DOWN**
Direct glue-down adheres carpet to subfloors.

8.1 **Preparation** - The floor is to be dry and free from contaminants which will prevent good adhesion. Surfaces shall be vacuumed and thoroughly cleaned before application of the adhesive.

8.2 **Layout** - Cut the carpet to the proper length and spread out in the area where it is to be installed. The carpet shall be cut three to four inches longer than the area measurement. Where applicable, also allow for pattern repeat. Align all breadths, or sections, of carpet in their proper position and trim the seams.

Whenever possible, carpet should be spread in the room 24 hours prior to actual installation, with room temperature between 65° F and 95° F (18° C and 35° C) Before spreading adhesive, seam edges must be trimmed using the appropriate seam cutting tools according to the manufacturer's recommendations.

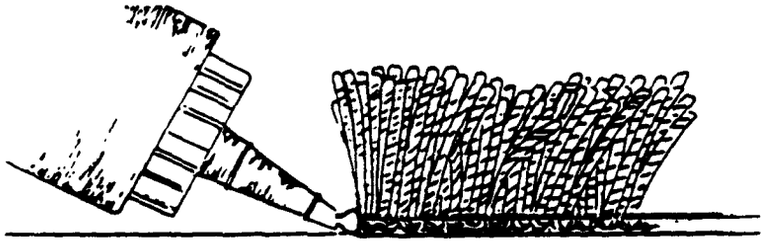
8.3 Trowel Notch Size and Adhesive

8.3.1 Select the appropriate adhesive and trowel notching recommended by the carpet manufacturer and/or adhesive supplier, or refer to the list shown in Table IV as a minimum. A 100% transfer of the floor adhesive into the carpet backing while maintaining full coverage of the floor must be obtained.

8.3.2 The floor adhesive shall be spread uniformly over the subfloor with the specified trowel. After sufficient open time, the carpet should be pressed into the adhesive and rolled with the appropriate roller.

WARNING - Lack of adhesion caused either by a lower quality adhesive or wrong trowel selection is the number one cause of installation failure. A 100% transfer of floor adhesive into the carpet backing, including the recesses of the carpet back, while maintaining full coverage of the floor must be attained.

8.4 Seaming - To prevent fraying and raveling at the seams, a 1/8-inch (3.2 mm) continuous bead of seam adhesive should be applied to the base of the first edge where the face yarn enters the backing. (See diagram below.) This will seal the first edge as well as the second when the edges are butted together to form the seam.



8.4.1 Woven carpet - All cut seam edges on woven carpet must be secured with a latex seam adhesive immediately following seam trimming.

8.4.2 Unprotected edges - All unprotected edges must be protected with an appropriate seam adhesive.

8.5 Rolling - Rolling shall be performed with the lightest roller which will achieve 100%

transfer of the floor adhesive into the carpet back. Refer to manufacturer's recommendation for roller weight. Normally, do not exceed 75 pounds (34 kg)

8.5.1 **Jute or Synthetic Secondary Backing** - Tufted carpet with jute or synthetic secondary backing should be pressed down into the adhesive bed using a section of carpet core or a roller. Roll in both directions but do not over roll.

8.5.2 **Unitary and Woven** - Unitary (single back) carpet and woven carpet must be rolled a second time about 3-12 hours after initial rolling to make sure a strong bond is established.

8.6 **Trimming** - The wall trimmer shall be adjusted to trim the excess carpet flush to the wall.

9. DOUBLE GLUE-DOWN

Site and environmental conditions for double glue-down should be the same as for direct glue-down. In this type of installation, a separate cushion is adhered to the floor and the carpet is glued to the cushion using the same methods utilized for direct glue-down. NOTE: As significant differences exist in various carpet cushions, consult with the manufacturers of the cushion, carpet, and adhesives for their recommendations in this type of installation.

9.1 **Preparation** - The floor is to be dry and free from contaminants which will prevent good adhesion. Surfaces shall be vacuumed and thoroughly cleaned before applying the adhesive.

9.2 **Adhesives and Trowel Notch Sizes** - Select the appropriate adhesive and trowel notch size recommended by the manufacturers of the carpet, cushion, and adhesive. If recommendations are not available, refer to the general guidelines in Table IV. Roller or spray applications may be used upon recommendations of the carpet manufacturer and/or adhesive supplier.

For application of cushion to floor, a pressure sensitive adhesive is recommended to facilitate easy removal of cushion at end of use. Other premium adhesives may be used, but removal of cushion from the floor will be more difficult.

For application of carpet to cushion, a consideration in the selection of the trowel notch size is the coarseness of the carpet backing. It is important that the trowel notch be large enough to apply a continuous thin film of adhesive for 100% transfer into the backing while maintaining full coverage of the cushion. Woven and unitary backed carpet require full penetration of the adhesive into the valleys or depressions between tuft rows. A premium adhesive is recommended.

9.3 Layout Cushion - After the floor is prepared, the layout and cutting of the cushion should be completed. Cushion should be installed in the longest continuous lengths possible with consideration given to the traffic pattern and seam placement of the carpet. Cushion seams should not be directly under carpet seams, but located at right angles or offset at least 6 inches (152 mm) from the carpet seams.

Cushion seams must be butted without compression leaving no gaps. Place cushion flush with all walls, trimming for net fit. Fold back the cushion and apply adhesive to the floor.

9.4 Layout Carpet - Cut the carpet to the proper length and spread out in the area to be carpeted. The carpet should be cut 3-4 inches (76-101 mm) longer than the area measurement. Where applicable, allow for pattern repeat. Carpet seams should be at a right angle to cushion seams or offset at least 6 inches (152 mm) to either side. Align all carpet breadths to their proper position and trim seams.

The adhesive shall be spread uniformly over the cushion surface with the specified trowel. After sufficient open time, the carpet is to be pressed into the adhesive and rolled with the appropriate roller.

9.5 Seaming - To prevent fraying and raveling at the seams, a 1/8-inch (3.2 mm) continuous bead of seam adhesive should be applied to the base of the first edge where the face yarn enters the backing. This will seal the first edge as well as the second when the edges are butted together to form the seam.

Sewn seams or hot melt seams may be used. If hot melt tape is used, it must be non-silicone treated, and the edges of paper beyond the netting removed. The carpet manufacturer's recommendations should be followed if available.

9.6 Rolling - Rolling shall be performed as follows:

9.6.1 Jute or Synthetic Secondary Backing - Tufted carpet with jute or synthetic secondary backing should be pressed into the adhesive bed with a two-foot section of carpet roll core, a stiff broom, or by using a roller weighing 35-50 pounds (16-23 kg). Roll in both directions, but do not over roll.

9.6.2 Woven Carpet - Woven carpet should be pressed into the adhesive using a two-foot section of carpet roll core or a stiff broom, followed by rolling with a roller weighing up to 50 pounds (23 kg) to press the carpet firmly into the adhesive.

9.6.3 Unitary Back - To make certain a strong bond is established, tufted unitary back must be rolled a second time about 3-12 hours after the initial rolling with a roller weighing up to 75 pounds (34 kg).

10. ATTACHED CUSHION

Carpet with cushion material permanently bonded to the back of the carpet by the manufacturer. It is often made with attachment of synthetic rubber foam or polyurethane 'cam

10.1 *Conditions*

10.1.1 For site, handling, and environmental conditions as well as floor preparation refer to Sections 5 and 6.

10.2 Carpet Layout

10.2.1 Refer to Section 8.2 (Direct Glue-Down).

10.3 Adhesives

10.3.1 Consult the carpet manufacturer for recommendations for floor and seam adhesives.

10.3.2 When specific adhesive recommendations are not available, refer to Table III

10.3.3 Trowel notch size - refer to Table IV.

10.3.4 Open time of adhesive is required. Use tacky method of installation. The applied adhesive must develop legs or tack prior to laying the carpet into the adhesive. Open time will vary dependent upon environmental conditions

10.3.5 IMPORTANT: Sufficient adhesive application must provide a 100% coverage of the floor and carpet back when installed.

10.4 Installation - Dry lay the carpet area making sure the carpet lays flat and the pile runs in the same direction. Rough cut the carpet in at walls and around columns. Using a cushion back cutter, trim seams according to the manufacturer's recommendation. To eliminate possible height variation at the seam areas, a sufficient amount of the factory or selvage edge must be trimmed. Check for any height variation at the seam and adjust if necessary by shimming. Then carefully fold back both breadths of carpet, being careful not to shift the carpet. Using recommended adhesives and properly notched trowel, spread adhesive in a uniform manner. Keep trowel clean and properly notched. Check proper open time of the adhesive, allowing the adhesive to develop legs or tack before installing carpet. Lay the first breadth into the adhesive and smooth out using a section of the carpet core. Seal the seam edge using a recommended seam adhesive by applying a 1/8-inch (3.2 mm) continuous bead at the point where the yarn enters the primary backing.

Lay the other side into the adhesive, butting the second carpet edge tightly against the first edge. Do not allow the seams to peak. Eliminate any trapped air or buckles by smoothing out the carpet with a section of the carpet core or a lightweight roller

Clean any excessive seam adhesive from seam area using a recommended cleaner and white cloth. Do not flood seam with cleaning solvent. Check the seam and clip any loose tufts with nap shears. For cut piles, make sure the yarn is not trapped in the seam.

10.5 Carpet on Stairs

10.5.1 Stair nosing must be rounded 3/4 to 1 inch (19 to 25 mm) to allow carpet contact with the nosing.

10.5.2 For straight stairs with a nosing, carpet should be installed with one piece covering both tread and nosing and a separate piece covering the riser. For straight stairs without a nosing, cut carpet to be installed in one piece over the tread and riser.

10.5.3 Measure and cut carpet accordingly.

10.5.4 Apply a 3-inch (76 mm) band of contact cement to the nosing, under the nosing, and on the stair tread. Apply contact adhesive to the corresponding areas on the back of the pre-cut carpet for both the tread and riser.

10.5.5 Use carpet manufacturer's recommended floor adhesive and apply to remaining areas of the tread and riser.

10.5.6 Allow adhesives to set properly before positioning carpet.

10.6 Protection of Installation

10.6.1 Refer to Section 15.

10.6.2 Maintain minimum traffic for a 24-hour period to allow adhesive to properly cure.

10.6.3 Temporarily use plywood or hardboard to protect the installation if roller traffic is required prior to 72 hours of cure time of the adhesive.

11. STRETCH-IN UTILIZING TACKLESS STRIP

This method requires fastening the carpet under tension on tackless strip around the perimeter of the area to be carpeted. A separate cushion shall be used. (See Section 6 regarding site conditions.)

11.1 Selection of Separate Cushion - Contact the carpet manufacturer to obtain cushion requirements in order to prevent problems resultant from improper cushion selection and the possible voiding of applicable warranties. Choice of cushion which is

inappropriate for the end use application of the carpet may result in accelerated loss of appearance retention, wrinkling, buckling, and the separation of the carpet backing or seams. **Cushion thickness should not exceed 3/8-inch (9.5 mm).**

11.2 **Layout and Material** - Carpet is to be laid out with consideration to traffic patterns and seam placement. Where possible on large commercial installations, it is recommended that carpet be spread and allowed to condition for 24 hours prior to installation.

All materials shall be on the job site prior to the beginning of the installation to assure uniformity of the application.

11.3 **Tackless Strip** - Tackless strip applications are to be matched to each specific use in accordance with Table V. **NOTE:** Standard and pre-nailed wood tackless strips should be a minimum of one inch (25 mm) wide and 1/4-inch (6.4 mm) thick. Commercial or architectural strip with three rows of pins is to be used when dimensions exceed 30 feet (9.1 m).

11.3.1 **Installation of Tackless Strip** -

A. Full length pieces of tackless strip shall be spread around the wall perimeter with pins pointing toward the wall.
B. The proper gully shall be slightly less than thickness of the carpet, but not to exceed 3/8-inch (9.5 mm).
C. The tackless strip shall be cut to proper lengths to maintain the same gully, regardless of the shape of the wall.
D. The tackless strip shall be securely fastened to maintain the proper stretch provided by power stretching. Two nails (fastening points) are required for the smallest pieces of tackless strip.
E. Carpet shall NOT be stapled to the tackless strip.
F. Avoid placing tackless strip across door openings or door sills where possible.

11.4 **Installation of Separate Cushion** - Cushion is to be installed in the longest continuous lengths possible. The cushion seams should not be installed directly under carpet seams. Generally, they should be placed at right angles to the carpet seams. When this is not practical, shift the cushion so that seams are at least 6 inches (152 mm) to one side of the carpet seams.

11.4.1 **Cushion Installed Wall-to-Wall** - Cushion shall be securely fastened to the subfloor with staples or nonflammable cushion adhesive around the perimeter of the installation. Seams shall be secured with staples or nonflammable cushion adhesive. However, tape — such as duct tape — shall be used for seams on rubber cushion. These procedures are required to pre-

vent shifting of the cushion during and after the carpet installation

Foam or sponge cushion with a waffle design should be installed with the **smooth side up.**

Foam cushion seams are to be covered with vinyl covered fabric tape, such as duct tape, or secured with adhesives. Staples or adhesives are to be applied approximately 6 inches (152 mm) within the perimeter edges all around.

11.4.2 **Cushion Installed Loose** - Felt cushion seams are to be sewn with stitches not more than one inch (25 mm) apart and at least one inch from the seam edges.

Foam cushion seams are to be covered with vinyl covered fabric tape or duct tape. Eight-inch to ten-inch (203 to 254 mm) strips of tape are to be placed at right angles to the seam at 18-inch (457 mm) intervals. Tape is to be applied to full length of seam.

11.5 **Layout and Cutting** - Following the seaming diagram, cut sufficient length of carpet that will cover the entire area. Where pattern matches are involved, an extra repeat must be allowed on each cut for the match, plus an extra 3 inches (75 mm) on each cut for trimming.

Trim all edges that are to be used for seaming at least one inch (25 mm) on each side. **NOTE:** The selvage of some woven carpet must not be trimmed. The manufacturer's recommendations should be followed.

11.6 **Edge Securing** - Once the edges are trimmed, an appropriate seam adhesive must be applied to both trimmed edges. Allow the seam adhesive to dry thoroughly before seaming. Improperly sealed edges can lead to seam delamination or loss of face yarns with unsightly results.

11.7 **Seaming** - The choice of seaming method is dictated by the type of carpet backing and carpet construction.

11.7.1 **Hot Melt Tape** - A fabric seaming tape precoated with a thermoplastic adhesive is centered beneath the seam. Heat from an electric iron melts the adhesive, laminating the carpet backing to the tape. A grooved iron is recommended for better penetration of the adhesive. Proper iron temperature is essential, with special care taken for carpet with synthetic backing or synthetic pile yarns. Always run the iron in the smooth direction of the pile. The maximum recommended heat setting is 2½. A heat shield for the iron is required. A metal surface should not be used to weight the seam behind

the iron, as metal traps the heat. **Wood should be used for this purpose.**

Premium tape with high tensile strength and sufficient adhesive on the woven scrim is recommended. **NOTE:** To minimize elevating and peaking, a 6-inch (152 mm) wide tape should be used.

Pre-stretch the carpet in the seam direction before making the seam.

11.7.2 **Tape and Latex** - The seaming tape shall be centered directly under the seam. Latex seaming adhesive is applied to the tape. The seam shall be allowed to dry at least 8 hours before stretching.

11.7.3 **Hand Sewing** - Hand sewing shall be an overcast stitch placed not more than ½-inch (13 mm) apart and no less than ½-inch (13 mm) from the edge of the carpet. It is recommended that a latex coating and tape be applied over the stitching. Hand sewing is recommended for all Wilton and most other woven carpet.

11.7.4 **Electrical Tape** - For electrically conductive tapes, follow the manufacturer s recommendations.

11.8 **Power Stretching** - Following seaming, carpet must be power stretched and firmly hooked onto the tackless strip at the starting walls and on the tackless strips in the surrounding area. **The use of power stretchers is mandatory.**

Before power stretching, make certain that hot melt tape seams are cool to the touch.

A four-way stretch is to be used (See Figures 1-3).

Follow the carpet manufacturer's recommendations for the method and amount of stretch to be applied. When recommendations are not available, tufted carpet with a jute secondary back should be stretched "drum tight." Tufted carpet with a synthetic secondary back should be stretched 1%-1½% in width and length.

Refer to Figures 2 and 3 for woven carpets.

A wall trimmer shall be used to trim the carpet along walls and abutments. The trimmer shall be adjusted to leave sufficient excess carpet to tuck into the gullies.

12. CARPET ON STAIRS

Stair carpet should be installed as follows:

12.1 **Preparation** - Stair nosing should be rounded 3/4-1 inch (19 to 25 mm) to prevent sharp stair edges from cutting the carpet and/or cushion.

12.2 **Stretch-In Installation** - Tackless strip is to be installed on each tread and riser.

Pins on the step point toward the riser. Pins on the risers point down to the step The gully between the strips is slightly less than double the carpet thickness. Tackless strips and cushion are about 1 1/2-inch (38 mm) less than the carpet width to allow for a turn under on each side of the stairs. Some stairs require tackless strip on the sides to maintain the proper tension.

Using a knee-kicker, or "stair stretcher," stretch the carpet tightly over each step The carpet should be secured to each tackless strip and driven into the gully with a stair tool at the junction of the tread and riser. Curved or sloped areas shall have the carpet tailored to fit the tread and riser without wrinkles and with the edges neatly finished.

12.3 **Glue-Down Installation on Stairs** - Carpet is to be tightly secured to treads and risers using a proper adhesive. A separate piece of carpet shall be used for each step with riser, except on steps without nosing. Carpet should be installed with the pile direction in the length of the stair.

13. CARPET MODULES (TILES)

The carpet manufacturer's recommendations are to be followed. If not available, the following procedure is to be used.

13.1 **Measuring** - Determine the center of the room using standard tile layout methods using grid lines where possible.

13.2 **Method of Installation** - Determine the starting point. Snap a chalk line across the room in both directions through the center to divide the room into four squared sections. On both sides of each chalk line, apply a strip of adhesive at least nine inches (228 mm) wide using a twist-textured paint roller or a 1/16-inch (1.6 mm) V-notch trowel. When the adhesive is dry or tacky, begin installing each section in a pyramid fashion starting from the center and working outward.

Additional modules within the quadrant are to be installed using the "stair step" technique. In this technique, the tiled area grows steadily away from the center of the room. It does not grow along either of the chalk lines but, rather, along an imaginary diagonal line between them. The installation continues to grow from the center to the corner of the room, finishing the entire quadrant before starting the next quadrant.

13.3 **Joints** - Modules in the completed installation must be snugly jointed together. Continually check that modules are being placed together with correct firmness.

To check for correct snugness, measure the distance along ten installed modules.

The gain in each 10 modules should be ¼-inch (6.4 mm). Example: Ten 18 inches by 18 inches (457 x 457 mm) modules should measure 180¼ inches (4578 m when properly installed. When placing modules, brush the face pile back from the tile edge and "tip" the module into place in order to prevent pile yarns from becoming entrapped in the joint.

13.4 **Control Grid** - Throughout the installation, a control grid should be installed at regular 15-foot (4.57 m) intervals to keep the modules from shifting. A control grid consists of a row of modules anchored in place with the same adhesive used to align the center line adhesive. Adhesive must always be placed around the perimeter of the area. All cut modules should be installed over adhesive.

NOTE: Where wheel traffic will be present, the entire area must be installed with adhesive.

14. INSTALLATION OF OUTDOOR CARPET AND SYNTHETIC TURF

Outdoor carpet installations offer conditions quite different from those encountered indoors. Both carpet and adhesive are subjected to extremes of weather and traffic, and installation surfaces will be much more varied and often uneven.

14.1 **Carpet Selection** - The carpet to be installed outdoors should be of the construction and type of synthetic face yarns and backing recommended for outdoor u

14.2 **Site Conditions** - All installation surfaces must be clean, dry, sound, cured, smooth as possible, and with adequate drainage.

14.2.1 **Concrete** - Concrete surfaces must be clean, dry and free from alkali. They must be cured for a minimum of 60 days, or longer, dependent upon weather conditions. All wax must be removed, and painted surfaces should be sanded thoroughly and cleaned before installation.

14.2.2 **Wood** - Painted wood surfaces should be sanded and sealed with an appropriate outdoor sealer. Slotted wood surfaces should be covered with an outdoor grade plywood and sealed. Waxed or oiled wood surfaces present special problems which will require resurfacing.

14.2.3 **Metal** - Metal surfaces must be cleaned of grease, oil, dirt, and rust. Painted metal surfaces must be rough-sanded with loose paint removed.

14.2.4 **Terrazzo, Ceramic, Marble, Epoxy** - These surfaces must be clean and dry with all wax finishes removed.

14.2.5 **Slate and Brick** - These surfaces may be too rough and uneven for most outdoor installations and may require refinishing and leveling before

installation.

14.2.6 **Asphalt** - Asphalt must be clean, dry, free from excessive oil and grease, and in good condition. New asphalt must be cured for at least 30 days, or longer, dependent upon weather conditions. Old asphalt may require resurfacing before installing carpet.

14.2.7 **Swimming Pools** - Regardless of the surface encountered, indoor swimming pools must be drained and dry before installing outdoor carpet. Outdoor pools must not be used during installation. Any fungus or algae must be removed from the surfaces to be covered.

14.3 **Backing Materials** - The type of backing materials involved is very crucial in the installation of outdoor carpet. Outdoor carpet backings can be classified into one of the following types:

A. Fibers - Polypropylene, woven and nonwoven.
B. Vinyl - Unitary or foam. (Requires special adhesive.)
C. Urethane - Unitary or foam, smooth or patterned.
D. Latex Rubber - Smooth, foam waffle, or diamond shape.

CAUTION: Use of the correct adhesive will greatly determine the success of an outdoor installation. Where the backing material is unknown, or if doubt exists, contact the carpet manufacturer for a positive identification.

14.4 **Adhesives** - Adhesive selection is very important. Recommended adhesives for outdoor installations are as follows:

A. Solvent Based - Preferred for outdoor installations as they can be applied over a wide range of weather conditions and are generally more water resistant.
CAUTION: Some contain flammable solvents and should only be used outdoors..
B. Latex (Water) Based - Latex adhesive must be of premium quality. Avoid application under damp, humid, or extreme cold or hot conditions. Surface of substrate must be compatible with liquid adhesive.
CAUTION: Always follow the manufacturer's installation procedures.

14.5 **Layout** - All outdoor carpet must be unrolled and allowed to relax at least one hour before installation. Ideally, this should take place when the temperature is between 55° F and 95° F (12.7° C and 35° C), and the relative humidity is between 10% and 65%.

The carpet should be pre-cut for the area to be covered, allowing for any required trimming. Seams should be kept to a minimum and run with the traffic pattern whenever possible. Knee-kickers may be used to position the carpet prop-

erly, but should be used with caution.

Where seams are required, be certain that the pile lay runs in the same direction

14.6 **Edge Seaming** - A bead of seam adhesive must be applied to **all** seam edges of the outdoor carpet, as well as **all** exposed edges.

14.7 **Rolling** - Generally, outdoor carpet will require rolling after installation. The size and weight of the roller to be used should be specified by either the carpet or adhesive manufacturer.

14.8 **Finishing** - All seams should be brushed, and protruding pile tufts should be trimmed. Excess adhesive must be removed with a suitable solvent recommended by the adhesive manufacturer. The final installation must be cleaned and ready for use.

NOTE: For indoor installation of outdoor carpet, follow the procedures outlined in Section 8, except where outdoor conditions may also exist — such as indoor swimming pools, health spas, and indoor-outdoor patios.

NOTE: The installation of artificial turf on athletic fields is a highly specialized area and is outside the scope of this standard. Consult the manufacturer for specific installation instructions.

15. PROTECTION OF INSTALLATION

If required to protect the finished floorcovering from dirt or paint, or if additional work is to be done after the installation, cover it with a non-staining building material paper.

Plastic sheeting should not be used over glue-down or tackless installations as it may trap moisture or retard curing of the adhesive.

Ideally, temperatures of indoor carpeted areas should never fall below 50° F (10° C) regardless of the age of the installation.

TABLE I

TOOLS

A. **Tape Measures**
   1. 25-ft. (7 6 m) Retractable
   2. 50-ft. (15.2 m) Metallic
   3. 100-ft. (30.5 m) Metallic

B. **Straight Edges**
   1. 1-Rigid
   2. 1-Flexible

C. **Chalk Line and White Chalk (Only)**

D. **Knives and Cutters**
   1. Utility Knife
   2. Carpet Knife
   3. Slotted Razor Blade
   4. Loop Pile Cutter
   5. Wall Trimmer - Conventional
   6. Wall Trimmer - Cushion Back
   7. Carpet Shears
   8. Nap Shears
   9. Electric Rotary Knife
   10. Hacksaw
   11. Tin Snips
   12. Tackless Strip Cutter

E. **Hammers and Mallets**
   1. Carpenters
   2. Tack
   3. Rubber Mallet
   4. Electric Stapler
   5. Hammer Tacker

F. **Screwdrivers**
   1. Phillips
   2. Standard

G. **Trowels**

H. **Files**
   1. Triangular
   2. Flat

I. **Rollers**
   1. 35 lb. (16 kilograms)
   2. 50 lb. (23 kilograms)
   3. 75 lb. (34 kilograms)

J. **Power Stretcher**

K. **Knee Kicker**

L. **Miscellaneous**
   1. Base Shoe Lifter
   2. Drive Down Bar
   3. Stair Tool
   4. Awl
   5. Nail Set
   6. Sharpening Stone
   7. Carpet Spreader
   8. Pliers
   9. 3-in. (76 mm) Hot Melt Seaming Iron and Shield
   10. 6-in. (152 mm) Hot Melt Seaming Iron and Shield
   11. Extension Cord and Adapter
   12. Plastic Squeeze Bottle
   13. Hammer Drill
   14. Metal Miter Box
   15. Hygrometer
   16. pH Paper
   17. Carpet Tractor
   18. Wood Weight to follow Hot Melt Seaming Iron
   19. Door Pin Remover
   20. First Aid Supplies
   21. Stay Nails
   22. Carpenters Square
   23. Pencil and Note Pad
   24. Chalk Stick
   25. Marking Pen
   26. Thimble, curved
   27. Needle and Thread
   28. Putty or Coloring Sticks for touchup of wood
   29. Vacuum Cleaner

TABLE II

MATERIALS

A. **Metal and Vinyl Moldings**
   1. Binder Bars
   2. Cap Molding
   3. Stair Nosing
   4. Accent Molding
   5. Metal Clamp-Down Binder Bar
   6. Access Panel Molding
   7. Combo Metal

B. **Seaming Tape**
   1. Latex
   2. Hot Melt

C. **Tackless Strip**
   1. Standard - no anchoring nails
   2. Pre-nailed wood
   3. Pre-nailed concrete
   4. Acoustical
   5. Commercial or Architectural

TABLE III

ADHESIVES

1. Latex
2. Vinyl Back Carpet Adhesive
3. Carpet Seam Adhesive
4. Carpet Seaming Latex
5. Contact Cement
6. Urethane Carpet Cushion Adhesive
7. Seam Sealer

TABLE IV

TROWEL SIZE - MINIMUM GUIDELINES

Direct Glue-Down

Carpet Backing	Adhesive Type	Trowel Size width x spacing x depth in inches*	Notch Shape
Jute	Latex	3/32 x 3/32 x 3/32 1/8 x 1/8 x 3/32	V or U
Rubber (foam & sponge)	Latex		
Urethane Cushion	Latex		
Jute/Vinyl	Vinyl		
Vinyl-foam	Vinyl		
Vinyl-slab	Vinyl		
Vinyl-coated	Vinyl		
Synthetic	Latex	1/8 x 1/16 x 1/8 1/8 x 1/8 x 3/32	V or U
Unitary	Latex	1/8 x 1/16 x 1/8 1/8 x 1/8 x 3/16	V or U
Woven	Latex	1/8 x 1/16 x 1/8 1/8 x 1/8 x 3/16	V or U
Hot Melt	Latex	3/32 x 3/32 x 3/32 1/8 x 1/8 x 3/16	V or U

Double Glue-Down

Between floor & cushion			
- smooth floor	Latex	1/16 x 1/32 x 1/32	U
- porous floor	Latex	1/16 x 1/16 x 1/16	U
Between cushion & carpet			
- smooth back carpet	Latex	1/8 x 1/8 x 3/32	U
		1/8 x 1/16 x 1/8	U
- rough back carpet	Latex	1/8 x 1/8 x 3/16	U

Notes: The above guidelines should only be used when specific recommendations are not available from the carpet manufacturer and/or the adhesive supplier. Rough, porous concrete surfaces and heavily textured carpet backs may require a trowel with deeper notches than listed above. A 100% transfer of floor adhesive to both floor and carpet must be achieved.

*To convert trowel dimensions to metric:

1/32" = 0.8mm
1/16" = 1.6mm
3/32" = 2.4mm
1/8 " = 3.2mm
3/16" = 4.8mm

TABLE V

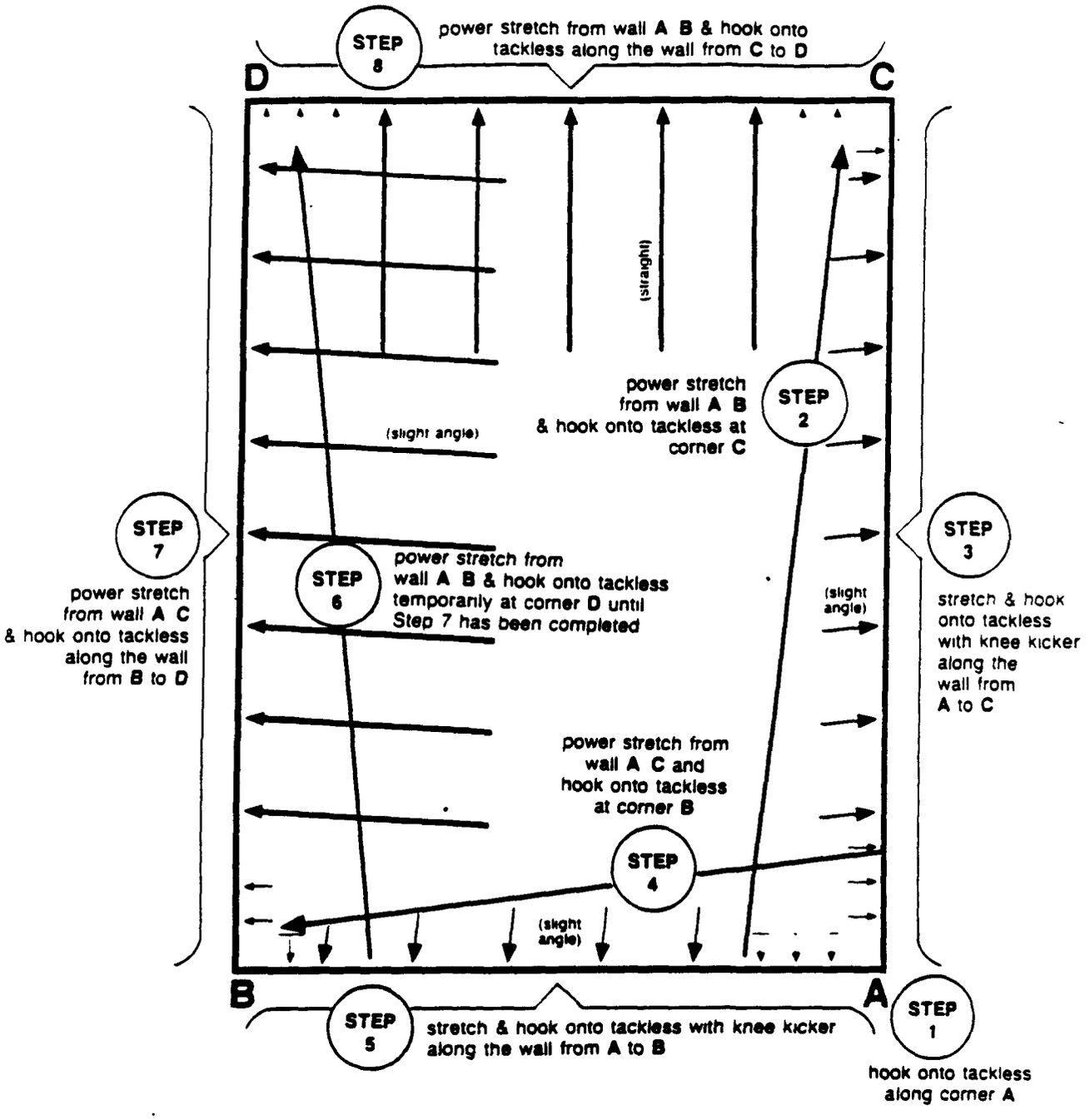
TACKLESS STRIP

Type Tackless	Application
Standard	Use on wood, concrete and other hard surface floors
Pre-nailed (wood)	Use on wood subfloors
Pre-nailed (concrete)	Use on concrete
Acoustical	Use on lightweight aggregate concrete flooring that has been designed for absorbing sound
Commercial or Architectural	Use when dimensions exceed 30 feet (9.1 m)

FIGURE 1

TUFTED

Amount of Stretch as per the Carpet Manufacturer's Recommendation
In Absence of Carpet Manufacturer's Recommendation, Use Diagram Below

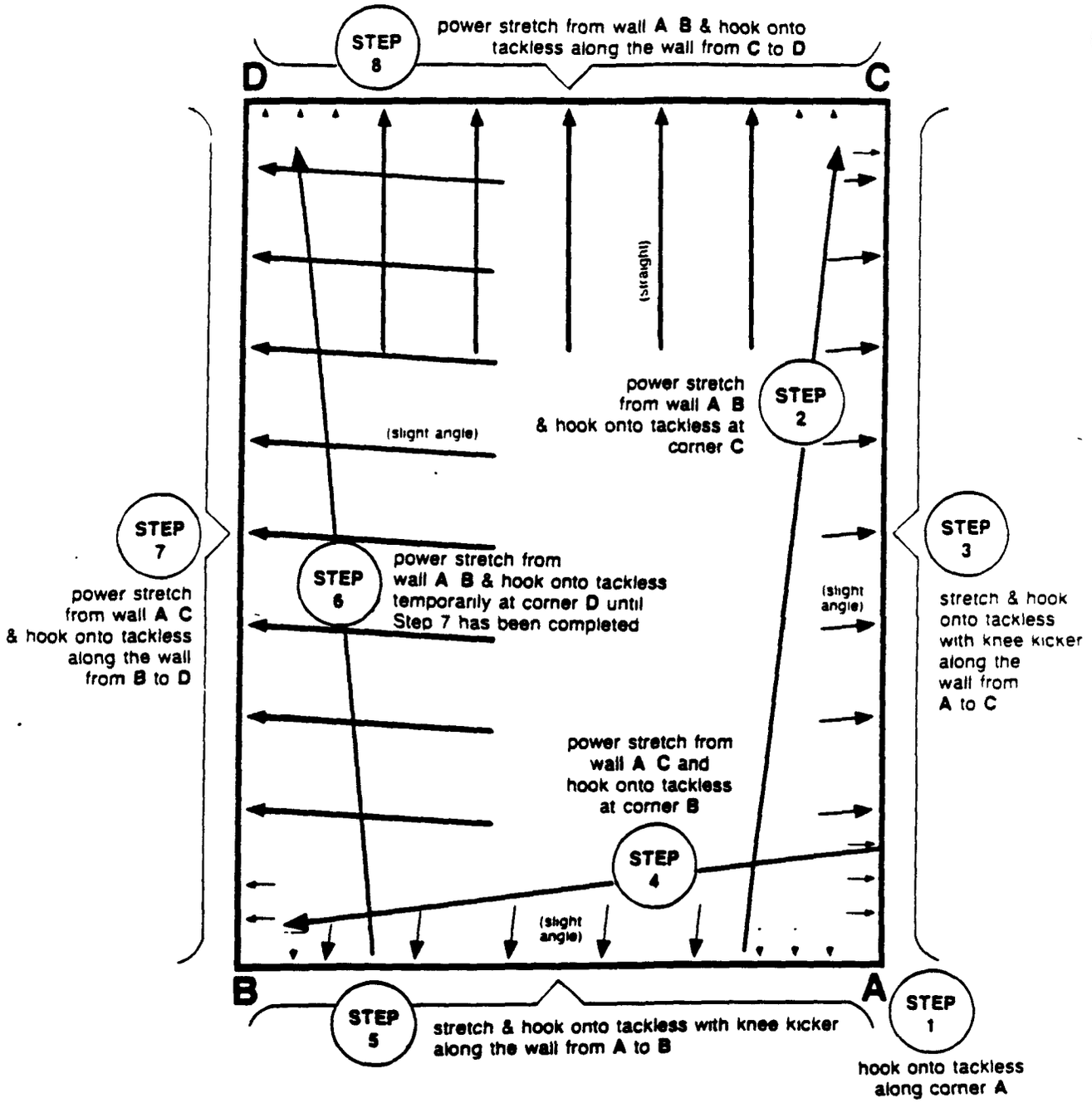


STRETCH:	Length	Width
Jute Secondary Backing:	"drum tight"	"drum tight"
Synthetic Secondary Backing:	1% - 1½%	1% - 1½%

FIGURE 2

WILTON OR VELVET

Amount of Stretch as per the Carpet Manufacturer's Recommendation
In Absence of Carpet Manufacturer's Recommendation, Use Diagram Below

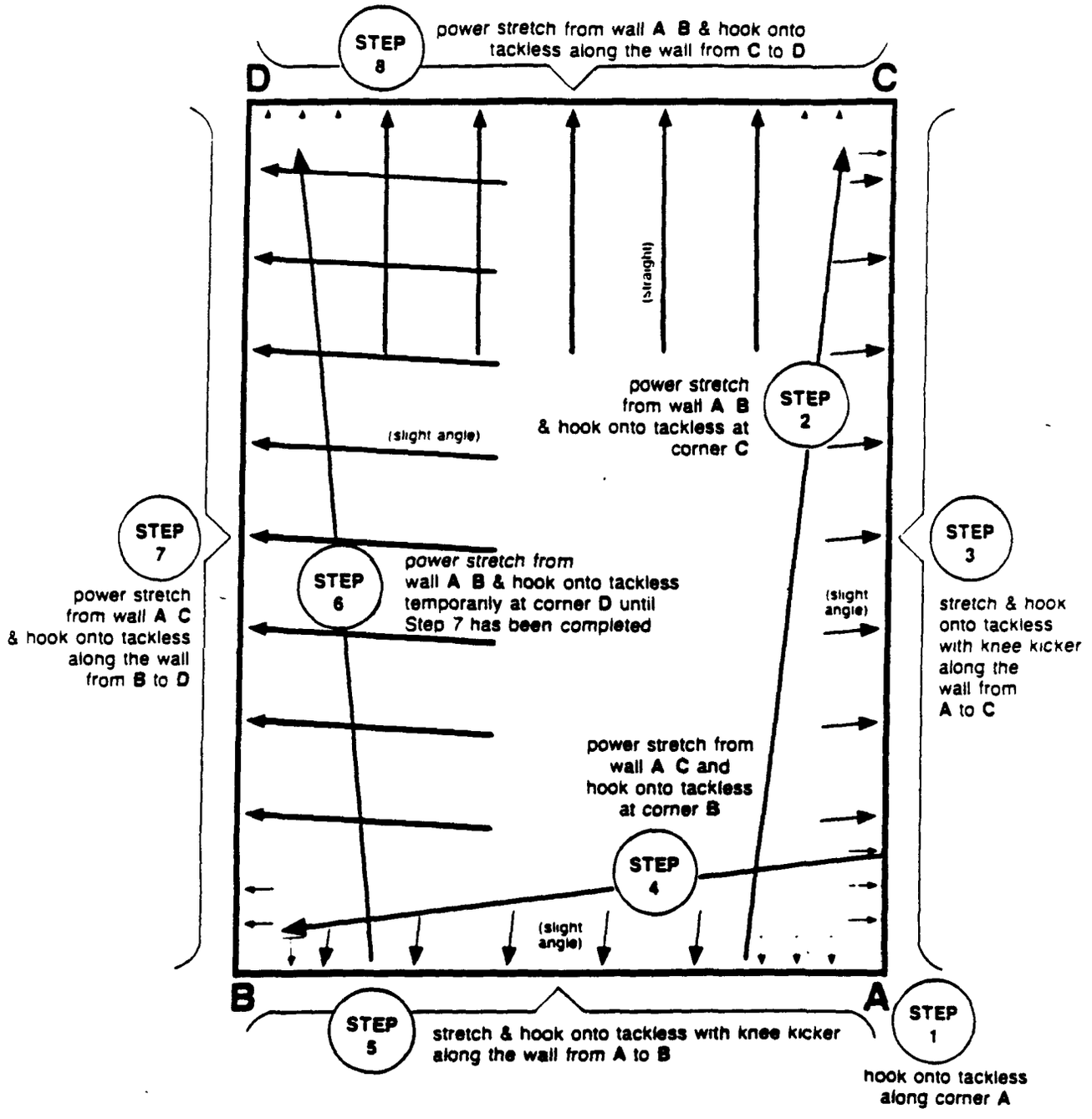


STRETCH:	Length	Width
Wilton:	equal stretch in length and width (drum tight)	equal stretch in length and width (drum tight)
Velvet:	snug	more stretch in width than length

FIGURE 3

AXMINSTER

Amount of Stretch as per the Carpet Manufacturer's Recommendation
In Absence of Carpet Manufacturer's Recommendation, Use Diagram Below



STRETCH: **Length** tight **Width** snug

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Aimed at residential, commercial and industrial end users and maintenance personnel, this booklet identifies common chemical substances and describes the type of damage that they can cause to carpets and what might be done to correct a problem.

COMMERCIAL CARPET MAINTENANCE MANUAL

Written to assist facility managers, maintenance supervisors and others who buy, sell, specify, or are responsible for commercial carpet maintenance, this book is designed to build awareness of performance characteristics of carpet. It offers recommendations that will assist in developing a maintenance plan that is tailored to the commercially carpeted environment.

CRI MEMBERSHIP DIRECTORY

A complete listing of manufacturer and associate members of the Carpet and Rug Institute, this directory includes key personnel addresses, telephone numbers of home and branch offices and warehouses, products, and services. Also listed are CRI officers, directors, and staff.

DIRECTORY OF CARPET STYLE NAMES

This industry registry of current carpet style names, including those trademark registered, is designed to assist manufacturers, distributors, and others involved in the process of naming carpet in avoiding the duplication of style names. Names are listed alphabetically and by manufacturer.

ECONOMY OF CARPET

A reprint of Chapter #7 of the CRI Carpet Specifier's Handbook, this study provides substantial data verifying the significant cost savings when using carpet. Specific comparative data outlines cost of materials and installation, service-life experience, and maintenance of carpet and hard surface floors.

FLAMMABILITY TESTING FOR CARPET

As a guide to flammability testing prepared by the National Bureau of Standards, it contains descriptions of the Pill, Tunnel, Chamber, Flooring Radiant Panel tests, and critical radiant flux. This booklet is designed to provide answers to questions posed by specifiers, architects, facilities managers, and end users.

HOW TO CHOOSE YOUR CARPET AND RUGS

Prepared especially for consumers, but suitable for anyone involved in the selection of carpet, this buying guide includes tips on how to get the best buy for the money, what constitutes quality, information on construction, color, texture, and fiber choice, and more. This is an excellent retailer handout.

HOW TO SPECIFY COMMERCIAL CARPET INSTALLATION

The specifier, facilities manager, architect, and installer will find this booklet helpful. It is a guide to writing specifications, stretch-in installation, selecting cushion, and other information necessary for a satisfactory installation.

INDUSTRY REVIEW

This book is a statistical recommending a seven year summary of industry shipments in square yard volume and dollar value, including tufted, woven, and other types of carpet. It includes total carpet and rug fiber shipments, room export, country of origin and destination, and other important data.

SQUARE FEET, SQUARE METERS, SQUARE YARDS COMPUTATION TABLE

To help calculate the amount of carpet needed for a specific area, this book gives the number of square feet, yards, or meters in a standard width. Included are charts for exact computations in 9 feet, 12 feet, and 15 feet widths.

STANDARD FOR INSTALLATION OF COMMERCIAL TEXTILE FLOORCOVERING MATERIALS, CRI 104

A definitive industry minimum installation standard, this book is a detailed outline of technique, procedure, and terminology used in specification writing, planning, layout, and installation. Information includes topics such as accepted tools and materials, floor preparation, installation in special areas, diagrams and charts. This book is especially well suited for specification writers and building owners.

STANDARD REFERENCE GUIDE FOR INSTALLATION OF RESIDENTIAL TEXTILE FLOORCOVERING MATERIALS, CRI 105

A definitive industry minimum installation standard based on reliable principles and procedures, the book provides installers and retailers with technique, principles, and workmanship standards for residential installation of floor covering. Information includes such topics as tools and materials, floor preparation, installation in special areas, diagrams and charts. Also included is a consumer expectation guide to prepare occupants and purchasers of carpet for the installation process. It is an excellent guide for retailers.

VALUE THROUGH TECHNOLOGY

This is a series of four video cassettes describing the carpet manufacturing process and is suitable for educational seminars. Included in the series are:

Tape #1 Carpet Fibers and Yarns
Tape #2 Carpet Construction and Textures
Tape #3 Carpet Dyeing and Finishing
Tape #4 Overview

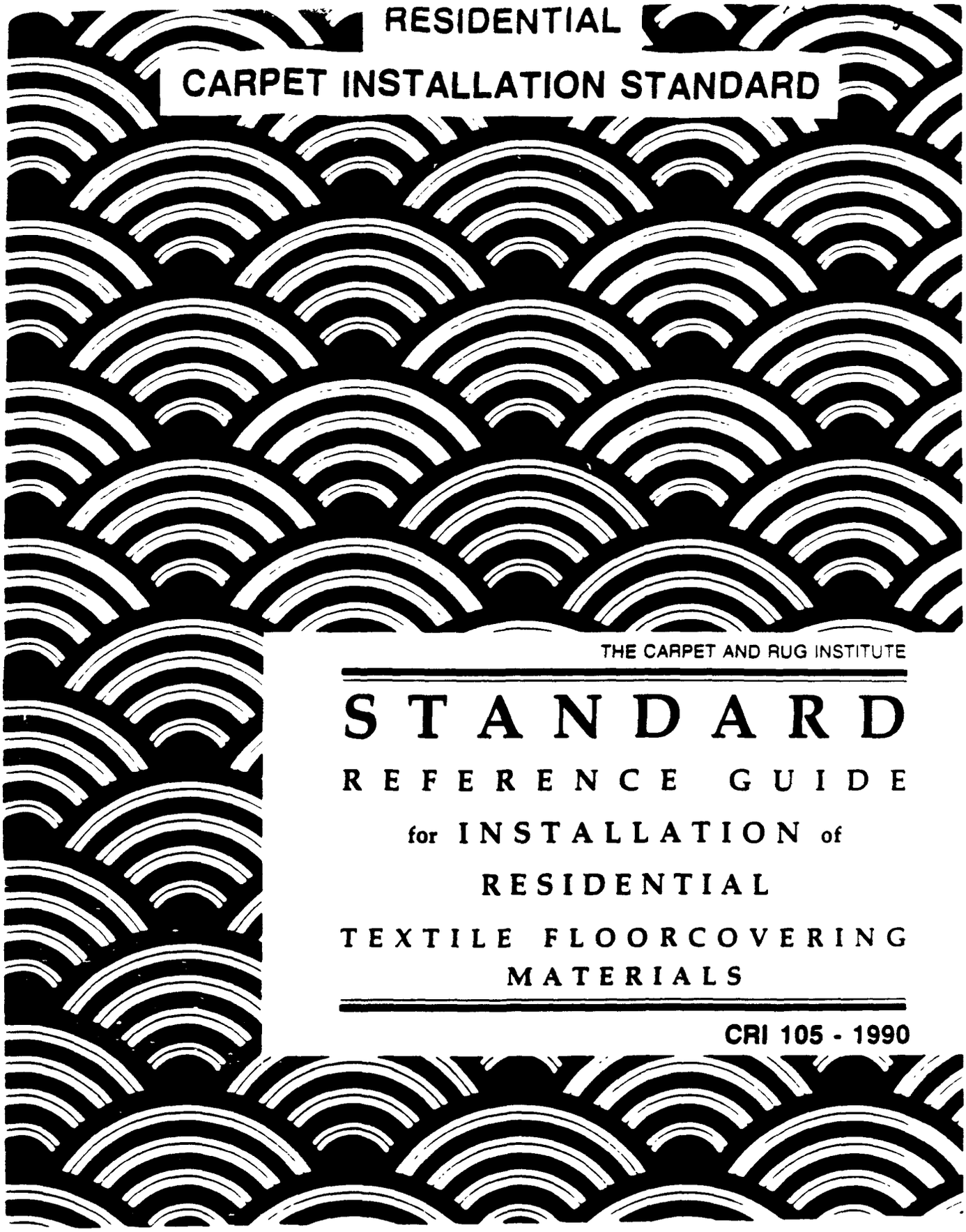
Prices available upon request.
For more information, contact CRI's Publications Department at 404 278-0232.

APPENDIX Q

CRI Residential Carpet Installation Standard

RESIDENTIAL

CARPET INSTALLATION STANDARD



THE CARPET AND RUG INSTITUTE

STANDARD

REFERENCE GUIDE for INSTALLATION of RESIDENTIAL TEXTILE FLOORCOVERING MATERIALS

CRI 105 - 1990

RESIDENTIAL CARPET INSTALLATION STANDARD

STANDARD REFERENCE GUIDE FOR INSTALLATION OF RESIDENTIAL TEXTILE FLOORCOVERING MATERIALS

First Edition

The Carpet and Rug Institute

ISBN #0-89275-030-8

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Table of Contents

Page

Forward . . . . . Q-iii

Introduction . . . . . Q-iv

Consumer Check List for the Installation of Carpet . . . . . Q-v

Good Consumer Relations . . . . . Q-vii

Standard Reference Guide for Installation of Residential Carpet

1. Scope Q-1
2. Specific Reference Applicable to the Standard Reference Guide Q-1
3. Tools and Materials Q-1
4. Handling Q-1
5. Site Conditions Q-1
6. Environmental Conditions Q-2
7. Measuring Q-2
8. Planning Q-2
9. Layout Q-2
10. Customer Sign-Off Q-2
11. Carpet Over Cushion Q-3
12. Carpet on Stairs Q-3
13. Direct Glue-Down of Carpet Q-4
14. Double Glue-Down of Carpet Q-4
15. Attached Cushion Carpet' Q-4
16. Outdoor Carpet and Synthetic Turf Q-4
17. Protection of the Installation Q-4
18. Customer Acceptance Q-5

Specific Reference Section in Support of the Standard Reference Guide

1. Scope Q-9
2. Applicable Documents Q-9
3. Tools and Materials Q-9
4. Handling Q-10
5. Site Conditions Q-10
6. Environmental Conditions Q-12
7. Measuring Q-12
8. Planning Q-12
9. Layout Q-13
10. Customer Sign-Off Q-15
11. Stretch-in Utilizing Tackless Strip Q-15
12. Carpet on Stairs Q-18
13. Direct Glue-Down of Carpet Q-19
14. Double Glue-Down of Carpet Q-20
15. Attached Cushion Carpet' Q-21
16. Installation of Outdoor Carpet and Synthetic Turf Q-22
17. Protection of the Installation Q-24
18. Customer Acceptance Q-24
19. Definitions of Terms Q-25

Page

Tables

I. Tools Q-28
II. Materials Q-29
III. Adhesives Q-30
IV. Trowel Size Q-31
V. Tackless Strip Q-32
VI. Seaming Q-33
VII. Stretch Q-34
VIII. Residential Q-35

Figure

1. . . . . Q-36
2. . . . . Q-37
3. Tufted, Stretch Diagram Q-38
4. Wilton or Velvet, Stretch Diagram Q-39
5. Axminster, Stretch Diagram Q-40
6. Knitted, Stretch Diagram Q-41

Special Acknowledgements Q-42

FOREWORD

This publication, entitled . . . CRI-105, **STANDARD REFERENCE GUIDE FOR INSTALLATION OF RESIDENTIAL TEXTILE FLOORCOVERING MATERIALS**, is a voluntary standard. It is based on reliable installation principles and procedures developed through practical experience, research and information obtained from manufacturers, retailers, installers, end users, testing laboratories and others with applicable expertise.

Installation techniques, principles and workmanship requirements apply similarly to all types of applications. However, this publication differs in emphasis and target audience. It is directed toward the installation of carpet intended for residential or equal use such as homes, apartments, condominiums, etc. As such, it stresses current products and installation methods commonly used in these locations.

The Standard Reference Guide is contained within the special yellow pages (11 - 17) **of this publication.**

It provides the installer and retailer with a specific and practical set of standards. While these are voluntary standards, they do represent a consensus as to the very minimum of acceptable requirements for a satisfactory installation and cover residential applications normally encountered. Anyone who chooses to represent or request conformity to the CRI installation standards shall conform to each of these minimum standards.

A **Specific Reference Section** is provided to assist the installer and retailer with detailed requirements in support of the minimum Standard Reference Guide pertaining to varying conditions and applications.

CRI-105 does not include carpet performance characteristics. Users are urged to review appropriate publications developed by The Carpet and Rug Institute for guidance in selecting and specifying carpet.

NOTE: For standards applicable to the installation of **commercial** carpet and carpet modules, please refer to CRI-104, the **Standard for Installation of Commercial Textile Floorcovering Materials.**

INTRODUCTION

This publication is unique in its content.

It contains the CRI-105 **Standard** Reference Guide and a **Specific** Reference Section in support of the Standard Reference Guide.

It also includes a section listing expectations from and by the consumer entitled "**Consumer Check List**" and a section of expectations from and by the installer entitled "**Good Customer Relations.**"

Installers are urged to study and understand both sections. This will help the installer prepare for questions from the customer and prevent being caught unaware.

It is recommended that retailers discuss the "Consumer Check List" with the consumer prior to the job. This will help the customer understand what can be reasonably expected and which services may incur additional costs.

These two sections are intended to provide a better understanding between the consumer and the installer. Assumptions and false expectations can be avoided by creating a clear understanding before the job begins, which will result in consumer satisfaction . . the ultimate objective.

CONSUMER CHECK LIST
FOR THE INSTALLATION OF CARPET

The installation of carpet is the most important function to be performed once you have selected your carpet and its intended use. There are a number of things you can do and should know which can help you obtain an installation job to your satisfaction and needs.

A sketch . . . it would be helpful to make a rough sketch with approximate measurements of the area(s) where carpet will be installed. Try to locate all windows, doors, closets and unusual angles. However, you should ask the retailer or the installation company to make accurate measurements for actual installation purposes.

Seams . . . be sure there is agreement between you and the dealer as to the location of all seams that may be required before the job starts. Usually, seams are best laid toward the primary natural light source. Visibility of the seams will vary with the type of carpet purchased. Please understand that most carpet seams cannot be guaranteed to be invisible.

Carpet size . . . be sure there is an exact understanding of the total amount of carpet required for each and every location. Most carpet is made in standard widths. Please understand that there is a good chance for some small overages due to corners, room sizing, etc. This is normal.

Cushion . . . be sure to have the appropriate type of cushion (underlayment or padding) laid to serve your specific needs. It may differ from room to room. There are many different types of cushion available. Be sure to discuss those at the time you purchase your carpet.

Moving furniture . . . do you plan to move your own furniture out of the room, or do you expect the installers to move the furniture for you? There may be an extra charge involved. You may wish to move cherished or fragile items yourself.

Appliances . . . in the event appliances require a utility disconnect (water, gas, etc.), local code requirements and disconnect/reconnect arrangements are to be determined in advance.

Removal of existing carpet . . . before any work commences, discuss who is expected to remove the existing carpet and cushion and if the cost of that task is included. Be sure to advise the installers whether or not you wish to keep that carpet or have it taken away.

Installation date . . . agree on an installation date and obtain a rough approximation of the amount of time required to complete the job. Have an alternate date in mind in case the carpet cannot be installed on your preferred date.

Stretching of the carpet . . . all carpet should be power stretched. Tautness of the carpet is essential to assure a good, long lasting installation. It will also enhance the performance of your carpet and prevent wrinkling or buckling.

Leftovers . . . advise the installers if you wish to keep smaller, leftover pieces of carpet or if you wish to have the scraps taken away.

Vacuum . . . arrangements for the vacuuming of the newly installed carpet should be made in advance. Vacuuming may involve an extra charge.

Guarantee/Warranty . . . it is important that there is an understanding of the guarantee/warranty; what is covered/not covered; and the procedure if a service call is required. Find out what can be reasonably expected.

Ventilation . . . as with most new products, new carpet may initially have a slight odor. This is normal. Adhesives or hot melt seaming tapes used to install the carpet may have a slight odor while they are curing. Existing carpet or cushion, while being removed, may create an odor.

All removal or installation processes are best handled under optimum fresh air ventilation conditions. During installation, be sure that windows and doors are open, conditions permitting. Ideally, the heating/air conditioning/ventilation system should be operating at normal room temperature with maximum fan speed.

If you, a member of your family, or other occupants are sensitive to certain odors, you may wish to be absent during installation. After the installation has been completed, you may wish to ventilate the premises with fresh air by opening windows and doors and operating the ventilation system at normal room temperature with fan speed at maximum capacity for at least 48-72 hours. This will help eliminate the existence of any lingering odors.

GOOD CUSTOMER RELATIONS

Customer satisfaction is the ultimate objective. Observing the following rules will enable a carpet installer to avoid callbacks, avoid costly claims, and earn the respect and goodwill of the customer. The carpet installer is the last person with whom the customer has any cc act. The customer has the right to expect professionalism and a quality nstallation. A good impression is a lasting impression.

Before the job . . . review the plans and installation requirements of the job and resolve any questions before going to the job site. Make sure your tool box has everything you might need for the installation. Be sure to have a sketch of the area(s) where the carpet will be installed showing the location of all seams, edge molding, etc.

Double check before going to the job to see that you have the correct carpet, cushion and supplies as ordered/purchased by the customer and that the quantity is sufficient to complete the job.

Be on time . . . always be on time. If you are detained for any reason at all, be sure to call the customer and determine if it is still convenient or if another day and time should be scheduled.

Be neat . . . always have a neat appearance.

Respect the customer . . . always respect a customer's home. You are there to add function and beauty to the environment. You are there because the customer has asked for your services as a professional installer of carpet.

Be courteous . . . be courteous and friendly to everyone. Maintain a professional decorum. Do not talk about your personal problems with the customers.

If you smoke, first ask permission. Many people do not smoke. Please respect the customer's wishes. A good indication is the availability or lack of ashtrays in a home.

Always ask permission to use the bathroom and be sure to leave it in the same condition you found it. If you have any trash, be sure to ask permission for its disposal and where it should be placed.

Always obtain the customer's approval before using the phone.

Be professional . . . instruct your helpers and fellow workers not to argue in the presence of the customer about the work and how it should be done.

Do not try to be a "salesperson" on the job. Something you say could create a problem

Avoid answering the customer's questions about the quality of the carpet or cushion. Do not volunteer information about any of the products. Instead, suggest that the customer call the store for that kind of information.

Should you see or suspect a manufacturing defect, immediately contact the retailer who sold the carpet for directions.

If you run into an unexpected installation problem on the job, talk it over with your customer so that he/she will know beforehand what you plan to do to resolve it and why you are doing it. If there are additional costs involved, be sure the customer is asked to call the store.

If you should accidentally make a mistake in the installation, or damage the carpet, repair it immediately.

If a change in the time schedule, or possibly other inconveniences, should be necessary, be sure to discuss this with the customer.

Never discuss with the customer how difficult the carpet may be to install.

Make sure the job is done right and that you are proud of your workmanship and that of your co-workers.

Things to do . . . if you are asked to move furniture, do it carefully and make sure the customer knows that you are being careful and can see your caution. If you are asked to move appliances such as stoves and refrigerators connected to gas or water lines, be sure to have the customer arrange the utility disconnect in advance.

The estimator/measurer should initially check and list existing damage; i.e., chipped paint, scratched walls, chipped or scratched furniture, worn wallpaper, etc. Upon arrival at the customer's home, the installer should recheck. Discuss their existence before and after the job with the customer. If customer is not present, a list should be kept.

If removal of existing shoe moldings has not been addressed by the store, then the installer shall contact the dealer for direction.

Confirm with the customer the location of seams as indicated on the drawing agreed to in advance by the customer and the dealer. If necessary, explain why they are located there. Most locations require seaming toward the primary natural light source with some

notable exceptions such as high traffic areas, doors, etc. If the initially agreed upon seam locations appear to be unacceptable to the customer, call the store. Customer understanding and approval of seam locations are essential to customer satisfaction.

Find out from the customer if you are expected to remove the existing carpet and cushion or if the customer wishes to keep them.

Ask the customer if they would like to keep the smaller pieces of carpet (if any).

If the carpet arrives at the customer's place rolled up or wrapped in plastic containers be sure to unwrap these rolls outside, allowing them to breathe and relax before taking them to the area where they are to be installed.

Be sure that the room is adequately ventilated while you are working. Windows and doors should be opened. The ventilation system should operate at full fan speed. Utilize plenty of fresh air.

Carpet, cushion and adhesives used for seaming and/or installation often have a slight odor while they are curing. This is normal. However, if the customer expresses a sensitivity to these odors, be sure to recommend that the windows be kept open and that the ventilation system continue to operate at full fan speed for at least 48-72 hours after the installation has been completed. Settings of the heating/air conditioning system should be left at normal room temperature levels. This will help eliminate the existence of any lingering odors.

Arrangements for the vacuuming of the newly installed carpet should be made in advance. There may be an extra charge for this service. Leaving the carpet vacuumed after the job has been completed leaves a good impression of the product and a finished look to the job.

Upon completion . . . do not leave the job until you have cleaned the work area. A tidy area leaves a good impression and enhances the beauty and quality of your installation.

Check over the completed job before leaving and ask yourself the questions: Would you be proud and satisfied to have this in your home? Would you put your name on this installation?

Finally, invite the customer to join you and inspect the completed installation.

STANDARD REFERENCE GUIDE
FOR INSTALLATION OF RESIDENTIAL CARPET

STANDARD REFERENCE GUIDE
FOR INSTALLATION OF RESIDENTIAL CARPET

1. Scope of this Standard Reference Guide (See Section 1, p. 21)
   1.1 This guide covers the installation of residential carpet.
   1.2 This guide covers the preparation of the subfloor.
   1.3 This guide establishes minimum installation procedures. These procedures shall not be decreased.
   1.4 This guide may be changed only by specific recommendations from the manufacturer of the products to be installed.

2. **Specific Reference** applicable to this Standard Reference Guide (pp. 19 - 39)
   2.1 The "Standard Reference Guide for the Installation of Residential Carpet - Specific Reference Section" is applicable to this minimum Standard Reference Guide if more detail is desired or in the event of varying conditions and/or applications.

3. **Tools and Materials** (See Section 3, p. 21)
   3.1 Carpet shall be installed using the tools listed in Table I.
   3.2 Use of a power stretcher is mandatory on all wall-to-wall installations.
   3.3 Materials shall be selected from the list in Table II.
   3.4 Adhesives shall be used as recommended by the carpet manufacturer or adhesive manufacturer but not less than in Table III.
   3.5 Whenever possible, the carpet, cushion and adhesives should be conditioned to site conditions prior to installation.

4. **Handling** (See Section 4, p. 22)
   4.1 Do not bend or fold rolls of carpet unless it is necessary for delivery purposes. Carpet rolls shall be unfolded upon arrival at the job. Carpet shall not be left bent or folded.
   4.2 Storage at the job site shall be dry and secured.

5. **Site Conditions** (See Section 5, pp. 22 - 24)
   5.1 Every subfloor shall be properly prepared. Concrete, wood or other flooring each has its own preparation requirements as per Specific Reference Section 5.
   5.2 Check and correct subfloor ridges and other unevenness which could be reflected by the finished installation.
   5.3 Carpet shall not be installed over existing carpet.
   5.4 Cushion shall not be installed over existing cushion.
   5.5 Whenever possible and conditions permit, all carpet shall be unrolled, relaxed and allowed to ventilate with the induction of fresh air.

6. **Environmental Conditions** (See Section 6, p. 24)
   6.1 Fresh air ventilation during installation shall be maintained by opening windows and doors, by utilizing exhaust fans and by operating the ventilation fan system at full capacity.
   6.2 When conditions warrant, fresh air ventilation shall be maintained after installation for 48-72 hours at normal room temperatures by operating the ventilation fan system at full capacity and by opening windows and doors if possible. This will help eliminate or minimize the existence of any lingering odors.

7. **Measuring** (See Section 7, p. 24)
   7.1 Each room shall be measured before installation to ensure efficient use of carpet and proper location of jogs, projections, openings, hearths, closets, stairs and door swings.

8. **Planning** (See Section 8, pp. 24 - 25)
   8.1 Determine responsibility for moving of furniture before and after installation.
   8.2 Determine responsibility (customer or installer) for having door height adjusted (if necessary) for proper clearance.
   8.3 Determine disposition of excess carpet (keep or remove).
   8.4 Determine disposal of scraps (customer or installer).
   8.5 Obtain number of stair steps and size of the treads and risers (width, height, length).
   8.6 Determine location and type of edge moldings and transitions.
   8.7 Determine type of base.
   8.8 Determine seam location and direction.
   8.9 Determine correct seaming tape for application (See Table VI.)

9. **Layout** (See Section 9, pp. 25 - 27)
   9.1 Seams should be placed toward the primary natural light source, whenever possible. If not possible, seams are to be kept out of heavy traffic areas or placed where they can be covered by furniture.
   9.2 Carpet pile shall run in the same direction and toward the entrance unless specified otherwise.
   9.3 Dye lots of carpet shall be matched or sequenced.
   9.4 A 3-inch minimum overage is required for each cut of carpet unless the pattern repeat demands otherwise.

10. **Customer Sign-Off** (See Section 10, p. 27)
   10.1 Obtain customer agreement on seam locations prior to installation.
   10.2 Obtain customer agreement on quarter turning of carpet prior to installation.

INSTALLATION

11. **Carpet Over Cushion** (See Section 11, pp. 27 - 30)
    - 11.1 Separate cushion used shall be in accordance with the carpet manufacturer's recommendation. (See Table VIII)
    - 11.2 Separate cushion shall be securely fastened to the subfloor with smooth side up or in accordance with manufacturer's recommendation.
    - 11.3 Separate cushion seams shall be perpendicular to carpet seams or offset by at least 6 inches.
    - 11.4 Tackless strips shall be not less than 1 inch wide and 1/4-inch thick. (See Table V for correct application.)
    - 11.5 Tackless strips are to be fastened around the perimeter of the room with a gully slightly less than the thickness of the carpet from the wall but not to exceed 3/8-inch
    - 11.6 Do not place tackless strips across door openings or door sills except where there is a threshold.
    - 11.7 Carpet shall not be stapled to the tackless strip.
    - 11.8 Before seaming, carpet should be power stretched at seam line. (Hot melt tape does not stretch.)
    - 11.9 Carpet must be fastened under tension on tackless strips around the perimeter of the room over separate cushion.
    - 11.10 Trim all edges used for seaming at least one inch on each side. NOTE: Selvage of some woven carpet must not be trimmed.
    - 11.11 Trimmed seam edges should be sealed with an appropriate seam sealer.
    - 11.12 Seaming method is dictated by the type of carpet backing and carpet construction in accordance with Table VI.
    - 11.13 After seaming, the carpet must be properly stretched with the edges hooked to the tackless strips of the starting and surrounding walls with a power stretcher (See Figures 3-6 for appropriate stretching diagrams). Use of a power stretcher is mandatory.
    - 11.14 Amount of stretch is per manufacturer's recommendation or Table VII.
    - 11.15 Wall trimmers shall be adjusted to leave sufficient excess carpet to tuck into gullies.

12. **Carpet on Stairs** (See Section 12, pp. 30 - 31)
    - 12.1 Stair nosing should be rounded at a radius of 3/4-inch - 1 inch.
    - 12.2 Tackless strips shall be secured on each tread and riser. Pins on steps point toward riser. Pins on risers point down toward tread.
    - 12.3 Gullies between the tackless strips are to be slightly less than double the carpet thickness.
    - 12.4 Tackless strips and cushion shall be cut 1 1/2-inch less than the width of the carpet to allow for turn under each side of the stairs. Some stairs require tackless strips on the sides to maintain proper tension.
    - 12.5 Carpet shall be secured to each tackless strip using a knee kicker or stair

stretcher and driven into the gully with a stair tool at the junction of the tread and riser.

12.6 Curved or sloped areas shall have the carpet tailored to fit the tread and riser without wrinkles and with the edges neatly finished.

13. Direct Glue-Down of Carpet (See Section 13, pp. 31 - 32)

13.1 This method is not widely used in residential applications but is an acceptable method for installing carpet on concrete or plywood subfloors, stairs and basements.

13.2 Floor preparation, layout specifics, use of adhesives and tools, edging, seaming, trimming and rolling require special techniques as per Specific Reference Section 13 of the Standard Reference Guide.

13.3 Site conditions shall be met in accordance with Section 5 of the Standard Reference Guide.

14. Double Glue-Down of Carpet (See Section 14, pp. 32 - 33)

14.1 This method is not widely used in residential applications but can be used as recommended by the manufacturer with special minimum requirements as per Specific Reference Section 14 of the Standard Reference Guide.

15. Attached Cushion Carpet (See Section 15, pp. 33 - 34)

15.1 Carpet with attached cushion shall be installed in strict accordance with the manufacturer's recommendation. Dye lot checks, floor preparations, layout specifics, use of adhesives and tools, edging, seaming, trimming and rolling require special techniques and cautions per Specific Reference Section 15 of the Standard Reference Guide.

15.2 Site conditions shall be met in accordance with Specific Reference Section 5 of the Standard Reference Guide.

16. Outdoor Carpet and Synthetic Turf (See Section 16, pp. 34 - 36)

16.1 Outdoor carpet installation conditions differ significantly from those encountered indoors. Carpet and adhesives must meet extreme weather, temperature, surface, traffic and differing use conditions.

16.2 Use only products specified by manufacturers for outdoor applications.

16.3 Surface preparation, layout, use of adhesives and tools, edging, seaming, rolling and finishing require special techniques as per Specific Reference Section 16 of the Standard Reference Guide.

17. Protection of the Installation (See Section 17, p. 36)

17.1 If protection of the carpet is required immediately after installation, cover the affected area with a non-staining building paper. Caution: Do not use plastic sheeting on any installation as it may trap moisture, retard curing of the adhesive or prevent the ventilation process.

18. Customer Acceptance (See Section 18, p. 36)

18.1 Upon completion of the job, the customer shall be asked to sign a job completion ticket.

SPECIFIC REFERENCE SECTION

in support of the

STANDARD REFERENCE GUIDE
FOR INSTALLATION OF RESIDENTIAL CARPET

STANDARD REFERENCE GUIDE
FOR INSTALLATION OF RESIDENTIAL CARPET

SPECIFIC REFERENCE SECTION

1. SCOPE

This standard covers the installation of residential carpet in a home, apartment, boat trailer or other type residence and the preparation of the subfloor over which it will be installed.

This standard establishes minimum installation procedures. These procedures shall not be decreased.

This standard may be changed only by specific recommendations from the manufacturer of the products to be installed.

2. APPLICABLE DOCUMENTS

Standard for Installation of Commercial Textile Floorcovering Materials - CRI-104 - Carpet and Rug Institute

Carpet Specifier's Handbook - Carpet and Rug Institute

How to Specify Commercial Carpet Installation - Carpet and Rug Institute

Areas of Responsibility - Carpet and Rug Institute

Carpet Installation Training Manual (Student's Guide) - Floor Covering Installation Training Council

Carpet Installation Training Manual (Instructor's Guide) - Floor Covering Installation Training Council

3. TOOLS AND MATERIALS

Carpet shall be installed using the tools listed in Table I.

Use of a power stretcher is mandatory on all wall-to-wall installations.

Materials shall be selected from the list in Table II.

Adhesives shall be used as recommended by the carpet manufacturer or adhesive manufacturer but not less than in Table III.

Whenever possible, the carpet, cushion and adhesive should be stored in a heated and dry place.

Whenever possible, the carpet should be stored under environmental conditions which closely approximate ideal installation temperatures and conditions at the job site. This will allow the carpet to be "relaxed" and prevent problems in both stretch-in and glue-down installations.

Carpet shall be stored in flat bins to help prevent pile crush. Temporary storage shall be in flat bins with a height not to exceed three rolls.

4. HANDLING

It is preferable that carpet be transported on flat dollies equipped with carpet cradles Fork lifts shall be equipped with booms. Bending and folding of individual carpet rolls is not recommended unless absolutely necessary for delivery purposes. The carpet shall not be left bent or folded. The bottom side must have a protective covering Storage at the job site shall be dry and secured.

5. SITE CONDITIONS

Temperature and Humidity - Ideally, carpet shall be installed when the temperature s between 65° and 95° F and the relative humidity is between 10% and 65% and. f installing over concrete, the slab's temperature should not be less than 65° F

Floor Preparation - Every subfloor shall be inspected to determine what special care may be required to make it a suitable foundation for carpet, as follows:

Carpet over Carpet - Carpet shall not be installed over existing carpet.

Cushion over Cushion - Cushion shall not be installed over existing cushion.

Radiant Heat Ducts - Heat must be lowered before installation to prevent adhesive from "setting" too quickly. When affixing tackless strip in stretch-in installations. take care not to drive nails into conduits or pipes.

Sealers - The use of sealers on floor surfaces is generally not necessary except for sanded, dusty, porous and acoustical surfaces. Sealing cannot overcome high moisture conditions and must not be used for that purpose. When used, sealers must be thin and fast-drying. They should be compatible with adhesives, which should be applied only after sealer is dry.

Concrete - New concrete shall be cured, cleaned and dry. It shall be free of curing or parting agents that interfere with the bonding of the adhesive. The builder or general contractor of the building should be asked by the installer for a report on the slab's moisture percentage. The moisture content shall not exceed 65%.

To determine the existence of excessive moisture on-site, place a hygrometer in several areas of the floor near an inside wall and cover with a sheet of clear plastic film about 2 feet (61 cm) square and seal with duct tape. A rough estimate may be obtained within 30 minutes, though 24 hours is needed for an accurate check. (NOTE: Moisture test kits are available.)

Moisture tests on slabs below 55° F (13° C) are inaccurate as moisture migration

is retarded by low temperature

Whenever a powdery surface is encountered, a sealer shall be used, compatible with the adhesive, to provide a suitable surface for a glue-down installation where specified.

Moisture in Concrete Subfloors - Whenever possible, at least 90-120 days are to be allowed for a concrete slab subfloor to cure and reach acceptable dryness. Appearance alone is not a reliable test. The builder or general contractor involved shall be asked for moisture and alkali test results on the concrete slab prior to the installation. This is necessary to prevent adhesive breakdown problems due to moisture or alkali. A pH range of 5-9 is satisfactory. But 10 or more requires corrective measures. This can be accomplished by applying an acid rinse consisting of 10 parts water to 1 part muriatic acid, and rinsing twice with clear water. In some cases, a 30% mixture of vinegar and water may be used to reduce alkalinity.

pH on the surface of the concrete can be determined by slightly wetting the floor and applying pH test paper.

In case "Gypcrete" lightweight or acoustical concrete is used, check the manufacturer's recommendations for the proper sealer to be used before the carpet is installed.

Wood - Wood subfloors should have a minimum 18-inch air space underneath with cross ventilation. Plywood, hardwood and particle board used as the subflooring must be of a flooring grade installed to the manufacturer's specifications. Old wood shall be checked for soundness, and any loose boards shall be renailed. Joints and rough and uneven areas shall be smoothed and sealed.

Oil contaminated floors must be covered with a suitable subfloor such as plywood or particle board installed according to Hardwood Plywood Manufacturers Association or Particle Board Manufacturers Association recommendations.

The suitability of a painted wood surface for a glue-down installation can be checked by gluing down a 2-foot square of carpet. If the adhesive's bond is strong, and the paint does not pull up with the carpet after 72 hours, the carpet can be installed. Glossy surfaces are to be roughened prior to installation.

Sanded and new floors shall be coated with a compatible sealer to provide a good surface for glue-down.

Metal - Metal floors must be cleaned of grease, oil, dirt and rust and the surface leveled

Terrazo, Ceramic, Marble, Epoxy and Slate - All of these materials represent nonporous surfaces. If a carpet with a nonporous back is glued down over these surfaces, strict attention must be given to the "open time" recommendations

6. ENVIRONMENTAL CONDITIONS

Fresh air ventilation during installation shall be maintained by opening windows and doors, by utilizing exhaust fans and by operating the ventilation fan system at full capacity

When conditions warrant, fresh air ventilation shall be maintained after installation for 48-72 hours at normal room temperatures by operating the ventilation fan system at full capacity and by opening windows and doors if possible. This will help eliminate the existence of any lingering odors.

7. MEASURING

All facets of the installation should be coordinated. A correct measurement is essential before any carpet can be planned, estimated or completed.

Measuring - Exact length and width measurements shall be made with a steel tape of every area to be carpeted.

Measurements should include jogs, projections, openings, hearths, closets, stairs and door swings.

Short measures should be checked to make certain they add up to the total measures or dimensions.

Estimating Yardage - After measurements have been completed, yardage should be estimated with a minimum of waste. Use the scaled plan to lay out cuts and fillers and excess carpet from each area. For patterned carpet, allow sufficient yardage for pattern match. Determine yardage and seams by width of carpet available. For example, if carpet to be used is 12 feet wide, scale 12 feet on the plan for all areas to be carpeted, allowing 3-inch overage on each net cut. (See Figures 1 and 2)

8. PLANNING

If agreed upon decisions are made by the consumer, carpet dealer and installer prior to installation, many problems and customer dissatisfaction can be overcome. The customer should be a part of the planning stage.

Prior to the arrival of the installation crew, there should be agreement as to who will move the furniture. This agreement should take into consideration the large pieces of furniture, such as waterbeds, hutches, refrigerators, pianos, etc., as well as small items, such as lamps, end tables, etc. It is important to know who will be responsible for moving breakable and valuable items from on and around the furniture.

In the event appliances require a utility disconnect (water, gas, etc.), local code requirements and disconnect/reconnect arrangements are to be determined in advance by the customer.

If this is the first time carpet is installed or a higher pile is to be used, the doors may not have sufficient clearance to swing freely over the carpet. Arrangements need to be made as to who will be responsible for cutting the doors.

Arrangements need to be made in advance as to who will remove and dispose of the old carpet and cushion.

The customer should be allowed to have a choice of the type of metal or vinyl molding to be used.

The customer should be shown the proposed layout which contains all of the seams. The location of the seams should be explained and an agreement obtained before any work starts.

If a piece of carpet is to be given a quarter turn, the customer should be informed and a written agreement obtained.

The customer should be made aware of carpet scraps and allowed to decide what should be done with them.

9. LAYOUT

A scale drawing of the areas to be carpeted is required to determine yardages, yardage per dye lot, edge treatments, cushions, adhesives, moldings, other accessories and to identify proper location of seams.

For new homes and apartment buildings, architectural drawings shall be provided that indicate the areas to be carpeted with room designations or apartment numbers plus a finished schedule of carpet styles, patterns, colors and installation methods to be used for each area. For existing buildings, new measurements and shop drawings shall be made.

Shop Drawings and Layout - The carpet shop drawing shall contain the following information:

Name of the owner of the home or apartment and the installation company On new construction, the names, addresses and telephone numbers of the general contractor, architect and interior designer shall also be listed

Address and telephone number of the customer (end-user).

For homes or apartments, the floor number and location in building, marking room names -- L.R., D.R., M.B.R., Hall, Ent., etc.

Date of drawing.

Scale drawing of carpet layout to be approved by end user.

Scale drawing for each area to be carpeted.

Location, swing and clearances of all doors.

Type of floor for each area on which carpet is to be installed (with notation as to what type of old carpet or floorcovering is currently installed and who will be responsible for removal).

Type of installation to be used for each area.

Quantities of carpet needed for each area, including roll length requirements.

A cut list should accompany the diagram to avoid misunderstandings.

Notations where dye lot changes will occur.

Excess material in each area and how it will be used.

Seam layout of each area.

Carpet pile direction for each area.

Name of manufacturer, quantity and color of carpet for each area.

Location and type of all edge moldings.

Type of base in each area.

Location of door openings requiring edging.

Stairs - Stairs should be shown on the plan in proper scale and location, indicating the number of steps, dimensions of treads and risers and width of steps

Seams - Seams shall be kept to a minimum, positioned where possible so that
A. Main traffic runs along, rather than across, the seam.
B. Incident light does not strike across the seam.
C. The seams are away from areas subject to pivoting traffic.
D. Seams are not perpendicular to doorway openings.

Pile Direction - Where two or more pieces of the same carpet are adjacent, the pile direction shall run the same as in other areas of the room, unless otherwise specified. Ideally, pile direction shall be toward the entrance, but other factors such as pattern, aesthetics and economic use of material may also be considered. Pile direction on stairs should be illustrated.

10. CUSTOMER SIGN-OFF

The customer or end user should be shown a copy of the completed shop drawing, signing off to indicate approval.

INSTALLATION

11. STRETCH-IN UTILIZING TACKLESS STRIP

Using this method requires fastening the carpet under tension on tackless strip around the perimeter of the area to be carpeted. A separate cushion shall be used. (See Section 5 regarding Site Conditions.)

Layout and Material - Carpet is to be laid out with consideration to traffic patterns and seam placement. All materials shall be on the job site prior to the beginning of the installation to assure uniformity of the application.

Tackless Strip - Tackless strip applications are to be matched to each specific use in accordance with Table V. (NOTE: Standard and pre-nailed wood should be a minimum of 1 inch wide and 1/4-inch thick.) Architectural strip with three rows of pins is to be used for carpet with heavily-latexed backs, most wovens and certain "Berber" type carpet with knobby backs, or rooms exceeding 30 feet.

Installation of Tackless Strip -

A. Full length pieces of tackless strip shall be spread around the wall perimeter with pins pointing toward the wall.
B. The proper gully shall be slightly less than thickness of the carpet, but not to exceed 3/8-inch.
C. The tackless strip shall be cut to proper lengths to maintain the same gully regardless of the shape of the wall.
D. The tackless strip shall be securely fastened to maintain the proper stretch provided by power stretching. Two nails or fastening points are required for the smallest pieces of tackless strip.
E. Carpet shall NOT be stapled to the tackless strip.
F. Avoid placing tackless strip across door openings or door sills where possible.

Installation of Separate Cushion - The selection of separate cushion shall be in accordance with the carpet manufacturer's recommendation.

Contact the carpet manufacturer to obtain his cushion requirements in order to prevent problems resultant from improper cushion selection and the possible voiding of applicable warranties. Choice of cushion which is inappropriate for the end use application of the carpet may result in accelerated loss of appearance retention, wrinkling, buckling, and the separation of the carpet backing or seams.

Cushion thickness should not exceed 7/16-inch.

Cushion is to be installed in the longest continuous lengths possible. The cushion seams should not be installed directly under the carpet seams. Generally, they should be placed at right angles to the carpet seams. When this is not practical, shift the cushion so that seams are at least 6 inches to one side of the carpet seams.

Cushion Installed Wall-to-Wall - Cushion shall be securely fastened to the subfloor with staples or nonflammable cushion adhesive around the perimeter of the installation. Seams shall be secured with staples or nonflammable cushion adhesive. However, tape – such as duct tape – shall be used for seams on rubber cushions. These procedures are required to prevent shifting of the cushion during and after the installation.

Foam or sponge cushion with a waffle design should be installed with the smooth side up.

Vinyl-covered fabric tape such as duct tape, or adhesives, shall be used for seams on foam cushion. Staples or adhesives are to be applied 1 - 6 inches

within the perimeter edges all around.

Layout and Cutting - Following the seaming diagram, cut sufficient length of carpet that will cover the entire area. Where pattern matches are involved, an extra repeat must be allowed on each cut for the match, plus extra carpet (3 inches) on each cut for trimming.

Trim all edges that are to be used for seaming at least 1 inch on each side (NOTE: The selvage of some woven carpet must not be trimmed. The manufacturer's recommendations should be followed.)

Edge Securing - Trimmed seam edges should be sealed with an appropriate seam sealer. Unsealed seams can lead to seam delamination of tufted carpet or loss of face yarns with unsightly results.

Seaming - The choice of seaming method is dictated by the type of carpet backing and carpet construction.

Hot Melt Tape - A fabric seaming tape precoated with a thermoplastic adhesive is centered beneath the seam. Heat from an electric iron melts the adhesive, laminating the carpet backing to the tape. A grooved iron is recommended for better penetration of the adhesive. Proper iron temperature is essential, with special care taken for carpet with synthetic backing or synthetic pile yarns. Always run the iron in the smooth direction of the pile. The maximum recommended heat setting is "2 1/2". A heat shield for the iron is required. A metal surface should not be used to weight the seam behind the iron, as metal traps the heat. **Wood should be used for this purpose.**

A premium tape with high tensile strength and sufficient adhesive on the woven scrim is recommended. NOTE: To minimize elevating and peaking, a 6-inch wide tape should be used.

Pre-stretch the carpet in the seam areas before making the seam.

Tape and Latex - The seaming tape shall be centered directly under the seam. Latex seaming adhesive is applied to the tape. The seam shall be allowed to dry at least 8 hours before stretching.

Hand Sewing - Hand sewing shall be an overcast stitch placed not more than 1/2-inch apart and no less than 1/2-inch from the edge of the carpet. It is recommended that a latex coating and tape be applied over the stitching. Hand sewing is recommended for all Wilton and most woven carpet.

Electrical Tape - For electrically conductive tapes, follow the manufacturers recommendations.

Power Stretching - Following seaming, carpet must be power stretched and firmly hooked to the tackless strip at the starting walls and on the tackless strips in the surrounding area. **The use of power stretchers is mandatory.**

Before power stretching, make certain that hot melt tape seams are cool to the touch.

A four-way stretch is to be used (See Figures 3-6).

Follow the carpet manufacturer's recommendations for the method and amount of stretch to be used. When recommendations are not available, tufted carpet with jute secondary back should be stretched "drum-tight." Tufted carpet with synthetic secondary back should be stretched 1% to 1-1/2% in width and length

Some woven carpet, such as velvet, does not stretch in the length, while other woven carpet, such as an Axminster, has no stretch in the width. Where there is no stretch, the carpet should be power stretched "snug" in these directions.

A wall trimmer shall be used to trim the carpet along walls and abutments. The trimmer shall be adjusted to leave sufficient excess carpet to tuck into the gullies.

12. CARPET ON STAIRS

Stair carpet should be installed as follows:

Preparation - Stair nosing should be rounded 3/4-inch to 1 inch to prevent sharp stair edges from cutting the carpet and/or cushion.

Stretch-In Installation - Tackless strip is to be installed on each tread and riser. Pins on the step point toward the riser. Pins on the risers point down to the step. The gully between the strips is slightly less than double the carpet thickness. Tackless strips and cushion are about 1 1/2-inch less than the carpet width to allow for a turn under on each side of the stairs. Some stairs require tackless strip on the sides to maintain the proper tension.

Using a knee kicker, or "stair stretcher," stretch the carpet tightly over each step. The carpet should be secured to each tackless strip and driven into the gully with a stair tool at the junction of the tread and riser. Curved or sloped areas shall have the carpet tailored to fit the tread and riser without wrinkles and with the

edges neatly finished.

Glue-Down Installation on Stairs - Carpet is to be tightly secured to treads and risers using a proper adhesive. A separate piece of carpet shall be used for each step with riser, except on steps without nosing. Carpet should be installed with the pile direction in the length of the stair.

13. DIRECT GLUE-DOWN

Direct glue-down adheres carpet to subfloors by use of nonflammable adhesives. The edges of the carpet are butted together to form seams. Though direct glue-down is not widely used in residential installations, it is an acceptable method for installing certain types of carpet on concrete, plywood or particle board subfloors in basements, gamerooms and other areas of a home. Some fire retardant treated plywood (pressure salt treated) will produce adhesive deterioration.

Preparation - The floor is to be dry and free from contaminants which will prevent good adhesion. Surfaces shall be vacuumed and thoroughly cleaned before application of the adhesive. (Refer to Section 5 on Floor Preparation.)

Whenever possible, before installation, the carpet and adhesive should be acclimated to a room temperature of between 65° and 95° F. Before spreading the adhesive, all seam edges must be trimmed, using seam-cutting tools recommended by the carpet manufacturer.

Layout - Cut the carpet to the proper length and spread out in the area where it is to be installed. The carpet shall be cut 3 inches longer than the area measurement. Where applicable, also allow for pattern repeat. Align all breadths, or sections of carpet, in their proper position and trim the seams.

Trowel Notch Size and Adhesive - Select the appropriate adhesive and trowel notching recommended by the carpet manufacturer, or refer to the list shown in Table IV as a minimum. A 100% adhesive coverage of the carpet backing surface must be obtained.

The floor adhesive shall be spread uniformly over the subfloor with the specified trowel. After sufficient open time, the carpet is to be pressed into the adhesive and rolled with appropriate roller.

Edge Seaming - Apply a bead of seam adhesive to the first edge to seal the seams and prevent fraying and raveling. Edges are butted to form seams. The seam adhesive is to be applied along the trimmed edge where the face yarn enters the

backing.

Rolling - Rolling shall be performed as follows:

Jute or Synthetic Secondary Backing - Tufted carpet with jute or synthetic secondary backing should be pressed into the adhesive bed with a 2-foot section of carpet core or by using a roller weighing not more than 50 pounds. Roll in both directions thoroughly, but do not over roll.

Unitary Back - Unitary (single back) carpet and woven carpet must be rolled a second time with a 35 - 50 pound roller a minimum of 3-1/2 hours after initial rolling to make certain a strong bond is established.

Trimming - The wall trimmer shall be adjusted to net trim the excess carpet to the wall.

14. DOUBLE GLUE-DOWN

Site and environmental conditions for double glue-down should be the same as for direct glue-down (Refer to Sections 5 & 6). But, in this type of installation a separate cushion is adhered to the floor, and the carpet is glued to the cushion using the same methods utilized for direct glue-down. NOTE: As significant differences exist in various carpet cushions, consult with the manufacturers of the cushion, carpet and adhesives for their recommendations in this type of installation.

Preparation - The floor is to be dry and free from contaminants which will prevent good adhesion. Surfaces shall be vacuumed and thoroughly cleaned before applying the adhesive.

Trowel Notch Sizes and Adhesives for Double Glue-Down Installations - Select the appropriate adhesives and trowel notch sizes recommended by the manufacturers of the carpet, cushion and your adhesive suppliers. The trowel notch size should be sufficient to apply a continuous thin film of adhesive to the floor for glue-down of the cushion. It should also be of the proper size and shape to assure full coverage of the adhesive into the carpet back for a proper glue-down of the carpet to the cushion. A premium adhesive is recommended.

Woven and unitary backed carpet requires full penetration of the adhesive into the "valley," between the tuft rows on the back.

Layout-Cushion - After the floor is prepared, the layout and cutting of the cushion should be completed. Cushion should be installed in the longest continuous lengths possible with consideration given to the traffic pattern and seam placement of

the carpet. Cushion seams should not be directly under the carpet seams but located at right angles or offset at least 6 inches from the carpet seam

Cushion seams must be tightly butted, leaving no gaps Place cushion flush with walls, trimming for net fit. Fold back the cushion and begin applying adhesive to the floor

Layout-Carpet - Cut the carpet to the proper length and spread out in the area to be carpeted. The carpet shall be cut 3 inches longer than the area measurement Where applicable, also allow for pattern repeat. Carpet seams should be at a right angle to the cushion seam or offset at least 6 inches to either side. Align all carpet breadths to their proper position and trim the seams. Select the appropriate adhesive and trowel notching from the list shown in Tables III and IV

The adhesive shall be spread uniformly over the cushion surface with the specified trowel. After sufficient open time, the carpet is to be pressed into the adhesive and rolled with the appropriate roller. **WARNING:** Lack of adhesion caused either by a low quality adhesive or wrong trowel selection is the number one cause of failures in glue-down and double glue-down installations.

Edge Seaming - Edges are to be butted to form seams. A bead of seam adhesive is to be applied to the edges of the carpet to seal the seams and prevent fraying and raveling. The seam adhesive should be applied along the trimmed edge where the face yarn enters the backing. Sewn seams or hot melt seams may also be used. If hot melt tape is used, it should be non-silicone treated, and the edges of paper beyond the netting should be removed, or the manufacturer's recommendation should be followed.

Rolling - Rolling shall be performed as follows:

Jute or Synthetic Secondary Backing - Tufted carpet with jute or synthetic secondary backing should be pressed down into the adhesive bed with a 2-foot section of carpet core or by using a roller weighing 35 - 50 pounds. Roll in both directions, but do not over roll.

Unitary Back - Unitary back or woven carpet must be rolled a second time with a 35 - 50 pound roller about 3-1/2 hours after initial rolling to make certain a strong bond is established.

15. ATTACHED CUSHION

Site Conditions and Floor Preparation - See Section 5.

Adhesives - Use only adhesives recommended by the carpet or adhesive manufacturers Use the tacky adhesive method for installing attached cushions. Caution: Vinyl backed carpet requires special floor and seam adhesives.

Installation - Check dye lots. If there is more than one dye lot, determine best breaking point. DO NOT MIX DYE LOTS. Lay out carpet by overlapping the edges and making sure the carpet with the attached cushion lays flat and the pile runs in the same direction. Rough cut carpet in at walls and columns. Cut seams according to manufacturer's recommendation. Check for height differences at the seam and correct if necessary. Carefully fold back both breadths of carpet, being careful not to shift the carpet. Using recommended adhesives and proper notched trowel, spread adhesive in a uniform manner. Keep trowel clean and properly notched. Check proper open time of the adhesive, allowing the adhesive to develop legs or tack before installing carpet. Lay the first breadth into the adhesive and smooth out using back of broom or section of carpet core. Attached cushion carpet shall be rolled as per the manufacturer's recommendation. Seal the seam edge using recommended seam adhesive Lay the other side into the adhesive, butting the second edge tightly against the first edge. DO NOT LET SEAMS PEAK. Press the second carpet into the adhesive pushing away from the seam, working out any trapped air. Clean excess adhesive from seam using recommended cleaner and white cloth. DO NOT FLOOD SEAM WITH CLEANING SOLVENT. Check the seam and clip any loose tufts with nap shears. For cut piles, make sure the yarn is not buried in the seam.

16. INSTALLATION OF OUTDOOR CARPET AND SYNTHETIC TURF

Outdoor carpet installations offer conditions quite different from those encountered indoors. Both carpet and adhesive are subjected to extremes of weather and traffic. and installation surfaces will be much more varied and often uneven.

Carpet Type - The carpet to be installed outdoors should be of the construction and type of synthetic face and backing yarns recommended for outdoor use.

Site Conditions - All installation surfaces must be clean, dry, sound, cured, smooth as possible and with adequate drainage.

Concrete - Concrete surfaces must be clean, dry and free from alkali. They must be cured for a minimum of 60 days and longer, if necessary, according to weather conditions. All wax must be removed, and painted surfaces should be sanded thoroughly and cleaned before installation.

Wood - Painted wood surfaces should be sanded and sealed with an appropriate outdoor sealer. Slotted wood surfaces should be covered with marine grade

plywood and sealed. Waxed or oiled wood surfaces present special problems which will require resurfacing.

Metal - Metal surfaces must be cleaned of grease, oil, dirt and rust. Painted metal surfaces must be rough-sanded with loose paint removed.

Terrazo, Ceramic, Marble, Epoxy - These surfaces must be clean and dry with all wax finishes removed.

Slate and Brick - These surfaces may be too rough and uneven for most outdoor installations and may require refinishing and leveling before installation

Asphalt - Asphalt must be clean, dry and free from excessive oil and grease and in good condition. New asphalt must be cured for at least 30 days, or longer dependent upon weather conditions. Old asphalt may require resurfacing before installing carpet.

Swimming Pools - Regardless of the surface encountered, indoor swimming pools must be drained and dry before installing outdoor carpet. Outdoor pools must not be used during installation. Any fungus or algae must be removed from the surfaces to be covered.

Backing Materials - The type of backing materials involved is very crucial in the installation of outdoor carpet. Outdoor carpet backings can be classified into one of the following types:

A. Fibers - Polypropylene, woven and nonwoven.
B. Vinyl - Unitary or foam. (Requires special adhesive.)
C. Urethane - Unitary or foam, smooth or patterned.
D. Latex Rubber - Smooth, foam waffle and diamond shape.

CAUTION: Use of the correct adhesive will greatly determine the success of an outdoor installation. Where the backing material is unknown, or if doubt exists, contact the carpet manufacturer for a positive identification.

Adhesives - Adhesive selection is very important. Recommended adhesives for outdoor installations are as follows:

A. Solvent Based - Preferred for outdoor installations as they can be applied over a wide range of weather conditions and are generally more water-resistant. **CAUTION:** Some contain flammable solvents and should only be used outdoors.
B. Latex (Water) Based - If used, must be of premium quality. Avoid using under damp, humid or extreme cold or hot conditions. Surface of substrate must be compatible with liquid adhesive.

CAUTION: Always follow the manufacturer's recommended installation procedures.

Layout - All outdoor carpet must be unrolled and allowed to relax at least one hour before installation. Ideally, this should take place when the temperature is between 55° and 95° F. and the relative humidity is between 10% and 65%.

The carpet should be pre-cut for the area to be covered, allowing for any required trimming. Seams should be kept to a minimum and run with the traffic pattern whenever possible. Knee kickers may be used to position the carpet properly but should be used with caution.

Where seams are required, be certain the pile lay runs in the same direction.

Edge Seaming - A bead of seam adhesive must be applied to **all** seam edges of the outdoor carpet, as well as **all** exposed edges.

Rolling - Generally, outdoor carpet will require rolling after installation. The size and weight of the roller to be used should be specified by either the carpet or adhesive manufacturer.

Finishing - All seams should be brushed, and protruding pile tufts should be trimmed. Excess adhesive must be removed with a suitable solvent recommended by the adhesive manufacturer. The final installation must be cleaned and ready for use.

NOTE: For indoor installation of outdoor carpet, follow the procedures outlined in Section 11, except where outdoor conditions may also exist - such as indoor swimming pools, health spas and indoor-outdoor patios.

17. PROTECTION OF THE INSTALLATION

If required to protect the finished floorcovering from dirt or paint, or if additional work is to be done after the installation, cover it with a non-staining building material paper.

Plastic sheeting should not be used over glue-down or tackless installations as it may trap moisture or retard curing of the adhesive.

Ideally, temperatures of indoor carpeted areas should never fall below 50° F (10° C) regardless of the age of the installation.

18. CUSTOMER ACCEPTANCE

Upon completion of the job, the customer shall be asked to sign a job completion ticket.

19. DEFINITIONS OF TERMS

Alkali, n. - A soluble substance with basic properties and having a pH of more than 7

Attached Cushion, n. - Cushion material permanently bonded to the back of carpet and rugs by the manufacturer. Often made of synthetic rubber foam or polyurethane foam

Axminster Carpet, n. - Carpet woven on a special Axminster loom by which pile tufts are individually inserted from varied colored yarns arranged on wide spools. This process makes it possible to produce carpet and rugs of complex designs with many colors, such as Oriental design rugs.

Baseboard, n. - A board skirting the lower edge of a wall, covering the joint of the wall and the adjoining floor.

Birdcage, n. - Common term used to describe the end of a stair rail where the banisters are curved in a spiral to form a newel post.

Bullnose, n. - Common term used for step return.

Carpet Cushion, n. - A term used to describe any kind of material placed under carpet to provide additional softness, support and noise absorption when walked upon. Also referred to as carpet lining, padding or underlay, although "carpet cushion" is the preferred industry term.

Custom Tufted Carpet, n. - A carpet or rug manufactured in a special size, shape, color, design or width through a number of manufacturing processes.

Double Glue-Down, n. - An installation method whereby the carpet cushion is first adhered to a substrate, or a floor, with an adhesive, and the carpet is then adhered to the cushion by an adhesive.

Glue-Down, n. - An installation method whereby the carpet is adhered to a substrate, or a floor, with an adhesive.

Gully, n. - The distance between tackless strip and the wall. It should always be slightly less than the thickness of the carpet.

Knee-Kicker, n. - An installation tool designed to position loose carpet and move it onto tackless strip. The leading edge of the kicker should be on the surface of the carpet and on the tackless strip to hook and force carpet backing onto the pins of the strip. To absorb the pressure shock on the knee, the kicker's "butt pad" is made of sponge rubber. (NOTE: Knee-kickers should only be used for the attachment of carpet to the tackless strip and not for stretching carpet. A power- stretcher should always be used for stretching carpet during installation; see below.)

Open-Time, n. - Elapsed time during which an applied adhesive will still bond to the carpet.

Power Stretcher, n. - A carpet installation tool used to stretch carpet for installation on tackless strip. It consists of a pinned plate which grips the carpet, tubular extensions, a padded end which is used to brace against an opposing wall or other structure, and a lever system that multiplies the installer's applied stretching force.

Quarter-Round, n. - Wooden or plastic molding with a cross section comprising a 90°

arc of a circle. It is used as joints between walls and floors, or between larger moldings and floors.

Restretch, v. - Term used to describe stretching carpet after original tackless installation to remove wrinkles or bubbles or to correct loose fit.

Riser, n. - The upright part of a step between two stair treads.

Seam, n. - In carpet installation, the line formed by the joining of the edges of two pieces of carpet by use of various seaming tapes, hand sewing or other techniques.

Seam Adhesive, n. - A specifically formulated adhesive compound for securing cut edges of carpet to be seamed. Its use will help prevent raveling and delamination at seam edges.

Seaming Tapes, n. - Fabric tapes used for joining two sections of carpet. "Hot melt" tapes are precoated with a thermoplastic adhesive. For other tapes, the adhesives are applied separately.

Secondary Backing, n. - In tufted carpet, a second backing fabric is laminated to the primary backing for body, dimensional stability and ease of handling. Most primary backing fabrics today are made of synthetic fibers; secondary backings are made of synthetic or jute fibers.

Selvage (Selvedge), n. - The factory-finished edge of a carpet.

Set-Up Time, n. - The elapsed time during which an applied adhesive will be fully "cured" or dried.

Stretch-In, n. - A term describing the procedure for installing carpet using tackless strip.

Tackless Strip, n. - Wood or metal strips fastened to the floor near the walls of a room containing either two or three rows of pins angled toward the walls on which the carpet backing is secured in a "stretch-in" installation.

Textile Floorcovering Material, n. - General description used for carpet, rugs, etc.

Threshold, n. - The raised board beneath a door, also known as a "door sill" or "saddle."

100% Transfer, v. - The full coverage/transfer of the carpet floor adhesive into the carpet backing, including the recesses of the rough carpet back.

Tread, n. - *The horizontal part of a stair.*

Tufted Carpet, n. - Carpet manufactured by the tufting process, a method by which the pile yarns are inserted into a primary backing fabric by a row of eyed needles. Tufting accounts for a large percentage of the carpet produced in the U. S. today, especially those for residential use.

Unitary Carpet, n. - Type of carpet used for glue-down installations which has an application of high quality latex to increase tuft bind performance properties without the addition of a secondary scrim backing.

Velvet Carpet, n. - Carpet woven on a loom similar to a Wilton, but lacking the Jacquard mechanism. Velvet carpet is typically cut pile or level loop in solid or tweed colorings, though textured and patterned effects are possible.

Vinyl Plasticizer, n. - A substance incorporated into vinyl to increase its flexibility workability or distensibility (capable of being extended).

Wilton Carpet, n. - Carpet woven on a loom with a Jacquard mechanism which utilizes a series of punched cards to select pile height and yarn color. The Wilton loom can produce carpet with complex multicolor patterns and highly-textured pile surfaces of multilevel cut and looped yarns.

Woven Carpet, n. - Carpet produced on a loom through a weaving process by which the lengthwise (warp) yarns and widthwise (weft or filling) yarns are interlaced to form the fabric. Carpet weaves -- such as Wilton, Axminster and velvet -- are complex, often involving several sets of warp and filling yarns for the pile and backing.

TABLE I

TOOLS

A. **Tape Measure**
   1. 25-ft. Retractable

B **Straight Edges**
   1. 1-Rigid
   2. 1-Flexible

C. **Chalk Line and White Chalk (Only)**

D. **Knives and Cutters**
   1. Utility Knife
   2. Carpet Knife
   3. Slotted Razor Blade
   4. Loop Pile Cutter
   5. Wall Trimmer - Conventional
   6. Wall Trimmer - Cushion Back
   7. Carpet Shears
   8. Nap Shears
   9. Electric Rotary Knife
   10. Hacksaw
   11. Tin Snips
   12. Tackless Strip Cutter

E. **Hammers and Mallets**
   1. Carpenters
   2. Tack
   3. Rubber Mallet
   4. Electric Stapler
   5. Hammer Tacker

F. **Screwdrivers**
   1. Phillips
   2. Standard

G. **Trowels**

H. **Files**
   1. Triangular
   2. Flat

I. **Roller**
   1. 35 lb. (16 kilograms)
   2. 50 lb. (23 kilograms)

J. **Power Stretcher**

K. **Knee Kicker**

L. **Miscellaneous**
   1. Base Shoe Lifter
   2. Drive Down Bar
   3. Stair Tool
   4. Awl
   5. Nail Set
   6. Sharpening Stone
   7. Carpet Spreader
   8. Pliers
   9. 3-in. Hot Melt Seaming Iron and Shield
   10. 6-in. Hot Melt Seaming Iron and Shield
   11. Extension Cord and Adapter
   12. Plastic Squeeze Bottle
   13. Hammer Drill
   14. Metal Miter Box
   15. Hygrometer
   16. pH Paper
   17. Carpet Tractor
   18. Wood Weight to follow Seaming Iron
   19. Door Pin Remover
   20. Bandaids
   21. Stay Nails
   22. Carpenters Square
   23. Pencil and Note Pad
   24. Chalk Stick
   25. Marking Pen
   26. Thimble, curved
   27. Needle and Thread
   28. Putty or Coloring Sticks for touchup of wood
   29. Vacuum Cleaner

TABLE II

MATERIALS

A. **Metal and Vinyl Moldings**
   1. Binder Bars
   2. Cap Molding
   3. Stair Nosing
   4. Accent Molding
   5. Metal Clamp-Down Binder Bar
   6. Access Panel Molding
   7. Combo Metal

B. **Seaming Tape**
   1. Latex
   2. Hot Melt

C. **Tackless Strip**
   1. Standard - no anchoring nails
   2. Pre-nailed wood
   3. Pre-nailed concrete
   4. Commercial or Architectural
   5. Acoustical

TABLE III

ADHESIVES

1. Latex
2. Vinyl Back Carpet Adhesive
3. Carpet Seam Adhesive
4. Carpet Seaming Latex
5. Contact Cement
6. Urethane Carpet Cushion Adhesive
7. Seam Sealer

TABLE IV

TROWEL SIZE - GENERAL GUIDELINES

Direct Glue Down

Carpet Backing	Adhesive Type	Trowel Size width x spacing x depth in inches*	Notch Shape
Jute	Latex	3/32 x 3/32 x 3/32 1/8 x 1/8 x 3/32	V or U
Rubber (foam & sponge)	Latex		
Urethane Cushion	Latex		
Jute/Vinyl	Vinyl		
Vinyl-foam	Vinyl		
Vinyl-slab	Vinyl		
Vinyl-coated	Vinyl		
Synthetic	Latex	1/8 x 1/16 x 1/8 1/8 x 1/8 x 3/32	V or U
Unitary	Latex	1/8 x 1/16 x 1/8 1/8 x 1/8 x 3/16	V or U
Woven	Latex	1/8 x 1/16 x 1/8 1/8 x 1/8 x 3/16	V or U
Hot Melt	Latex	3/32 x 3/32 x 3/32 1/8 x 1/8 x 3/16	V or U

Double Glue Down

Between floor & cushion			
- smooth floor	Latex	1/16 x 1/32 x 1/32	U
- porous floor	Latex	1/16 x 1/16 x 1/16	U
Between cushion & carpet			
- smooth back carpet	Latex	1/8 x 1/8 x 3/32 1/8 x 1/16 x 1/8	U or U
- rough back carpet	Latex	1/8 x 1/8 x 3/16	U

Notes: The above guidelines should only be used when specific recommendations are not available from the manufacturer and/or the adhesive supplier. Rough, porous concrete surfaces and heavily textured carpe may require a trowel with deeper notches than listed above.

*To convert trowel dimensions to metric:

1/32" = 0.8mm
1/16" = 1.6mm
3/32" = 2.4mm
1/8 " = 3.2mm
3/16" = 4.8mm

TABLE V

TACKLESS STRIP

Type	Application
Standard	Use on wood. concrete and other hard surface floors
Pre-nailed (wood)	Use on wood subfloors
Pre-nailed (concrete)	Use on concrete
Acoustical	Use on light-weight aggregate concrete flooring that has been designed for absorbing sound
Architectural	Use when dimensions exceed 30 feet (9m)

TABLE VI

SEAMING

	CARPET	
	TUFTED	WOVEN
Hot Melt Tape	Recommended	
Tape and Latex	Recommended	
Electric Tape	Recommended	
Hand Sewing		Recommended[1]
Pin Tape[2]	Recommended	Recommended

[1]Wilton's MUST be hand sewn.

[2]Check for manufacturer's recommendations.

TABLE VII

STRETCH

(Use if manufacturer's recommendations are not available)

	Length	Width
Tufted[1]		
Jute Secondary	"drum tight"	"drum tight"
Synthetic Secondary	1% - 1½%	1% - 1½%
Woven		
Velvet[2]	snug	more stretch in width than length
Wilton[2]	equal stretch in length and width (drum tight)	equal stretch in length and width (drum tight)
Axminster[3]	tight	snug
Knitted[4]	1% - 1½%	more stretch in width than length approx. 1½%

[1]See Figure 3
[2]See Figure 4
[3]See Figure 5
[4]See Figure 6

TABLE VIII

RESIDENTIAL

CARPET CUSHION SELECTION

Contact the carpet manufacturer to obtain his cushion requirements in order to prevent problems resultant from improper cushion selection and the possible voiding of applicable warranties. Choice of cushion which is inappropriate for the end use application of the carpet may result in accelerated loss of appearance retention, wrinkling, buckling, and the separation of the carpet backing or seams.

Cushion thickness should not exceed 7/16-inch.

FIGURE 1

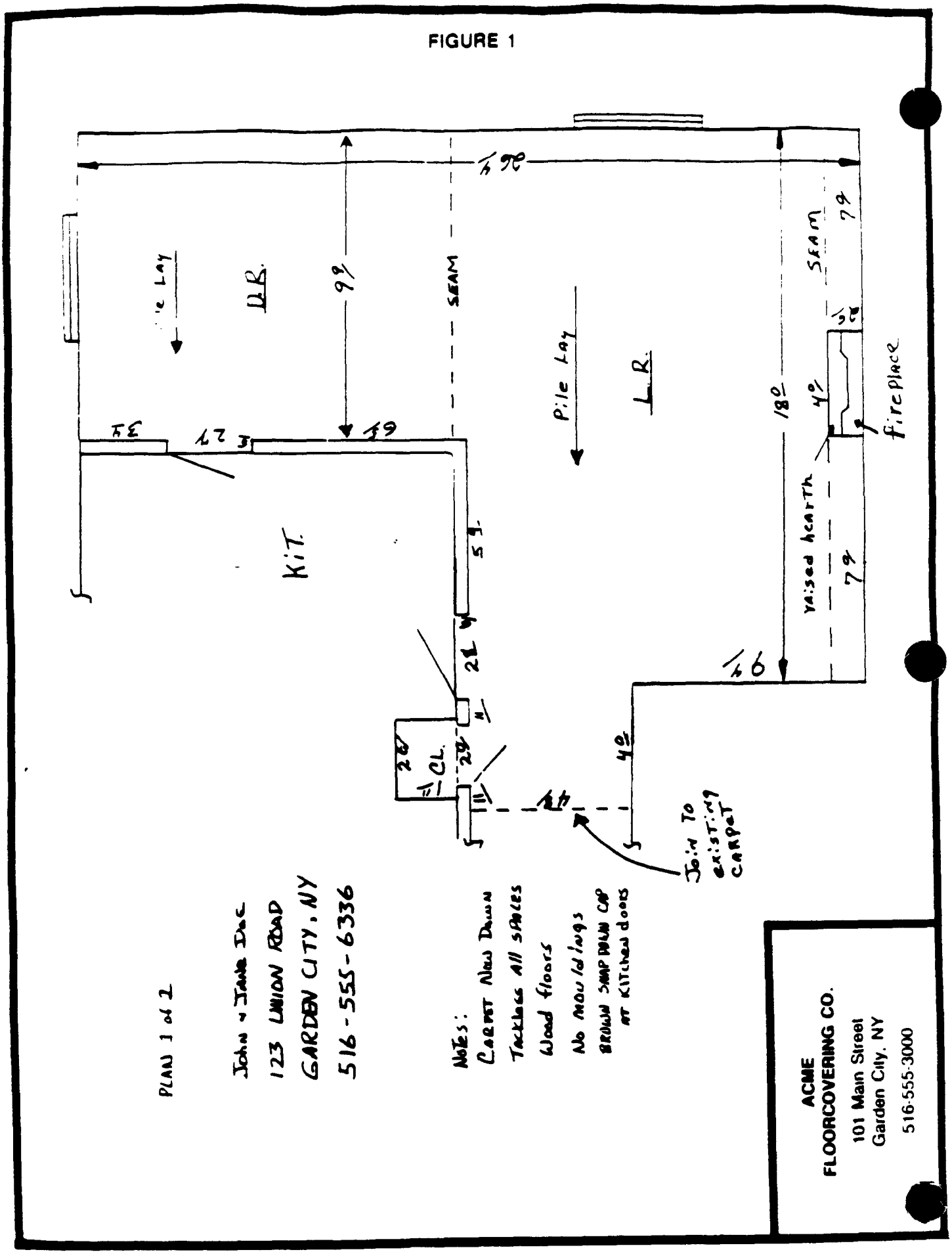
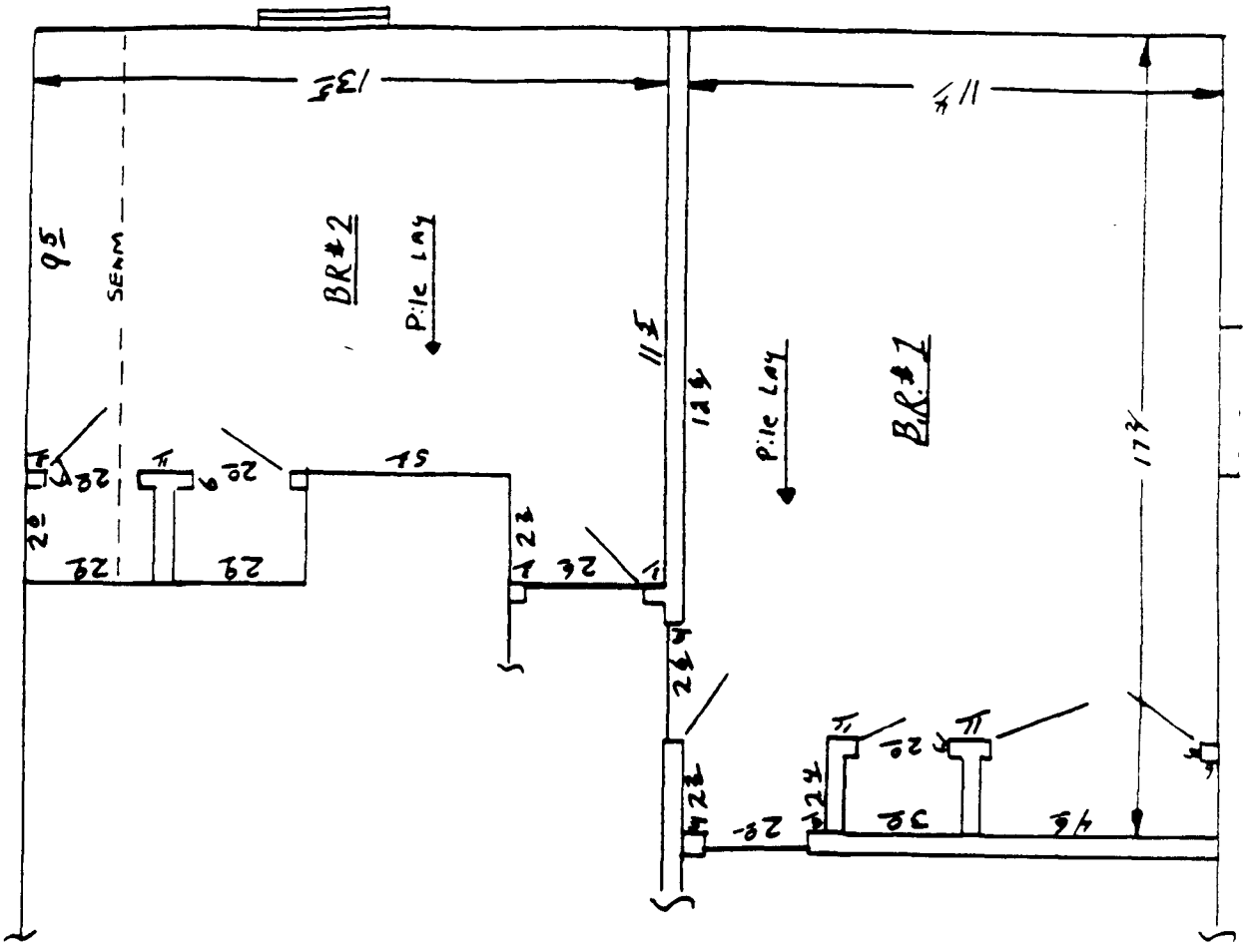

PLAN 1 of 2
John + Jane Doe
123 UNION ROAD
GARDEN CITY, NY
516-555-6336
Notes:
Carpet New Down
Tackless All sides
Wood floors
No Mouldings
Brown Saxon Drum Cap
at Kitchen doors
Join To existing carpet
KIT.
L.R.
D.R.
Pile Lay
SEAM
raised hearth
fireplace
ACME
FLOORCOVERING CO.
101 Main Street
Garden City, NY
516-555-3000

FIGURE 2



PLAN 2 of 2 SECOND FLOOR

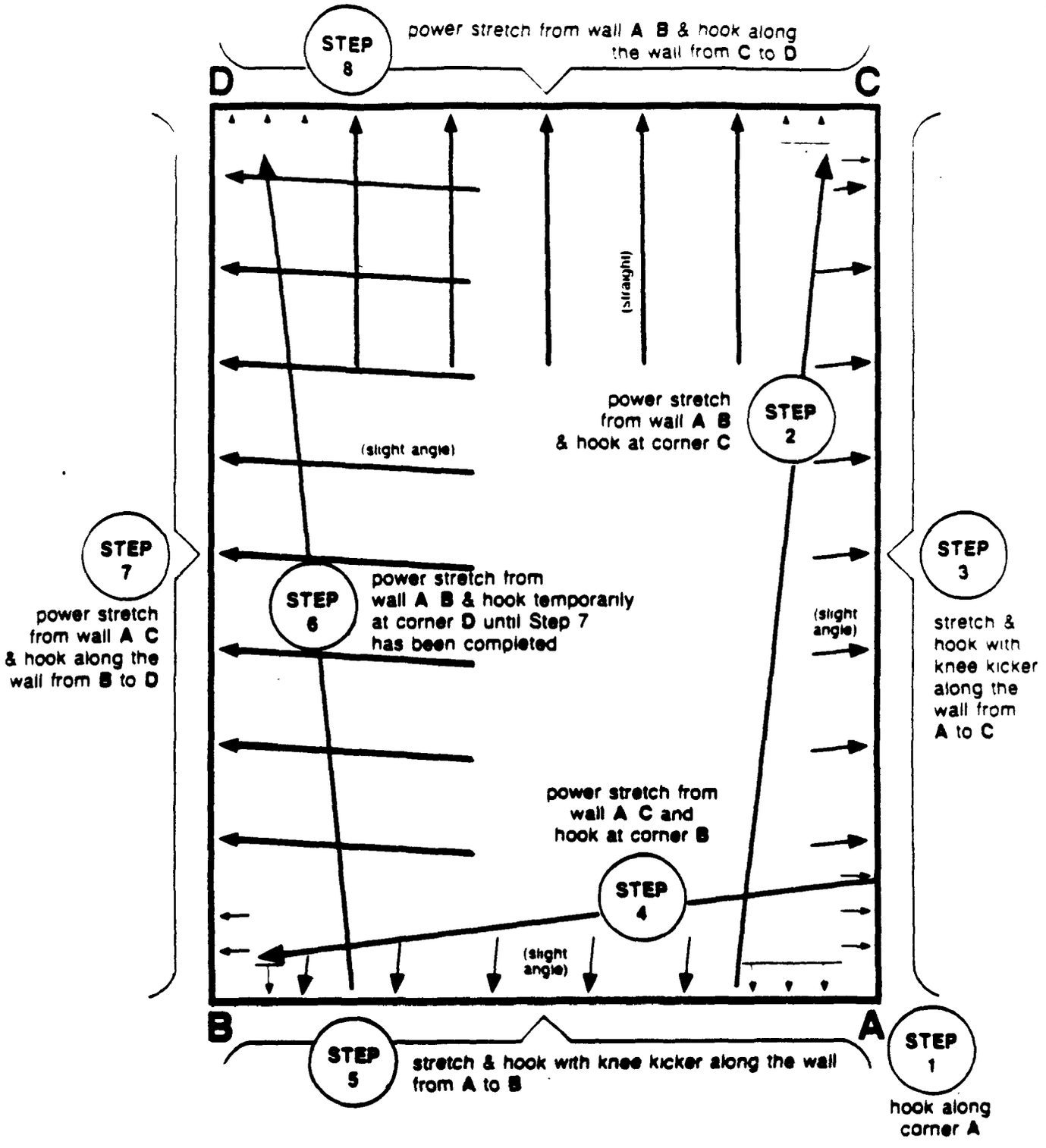
John + Jane Doe
123 UNION ROAD
GARDEN CITY, NY

ACME
FLOORCOVERING CO.
101 Main Street
Garden City, NY
516 555-3000

FIGURE 3

TUFTED

Amount of Stretch as per the Carpet Manufacturer's Recommendation
In Absence of Carpet Manufacturer's Recommendation, Use Diagram Below

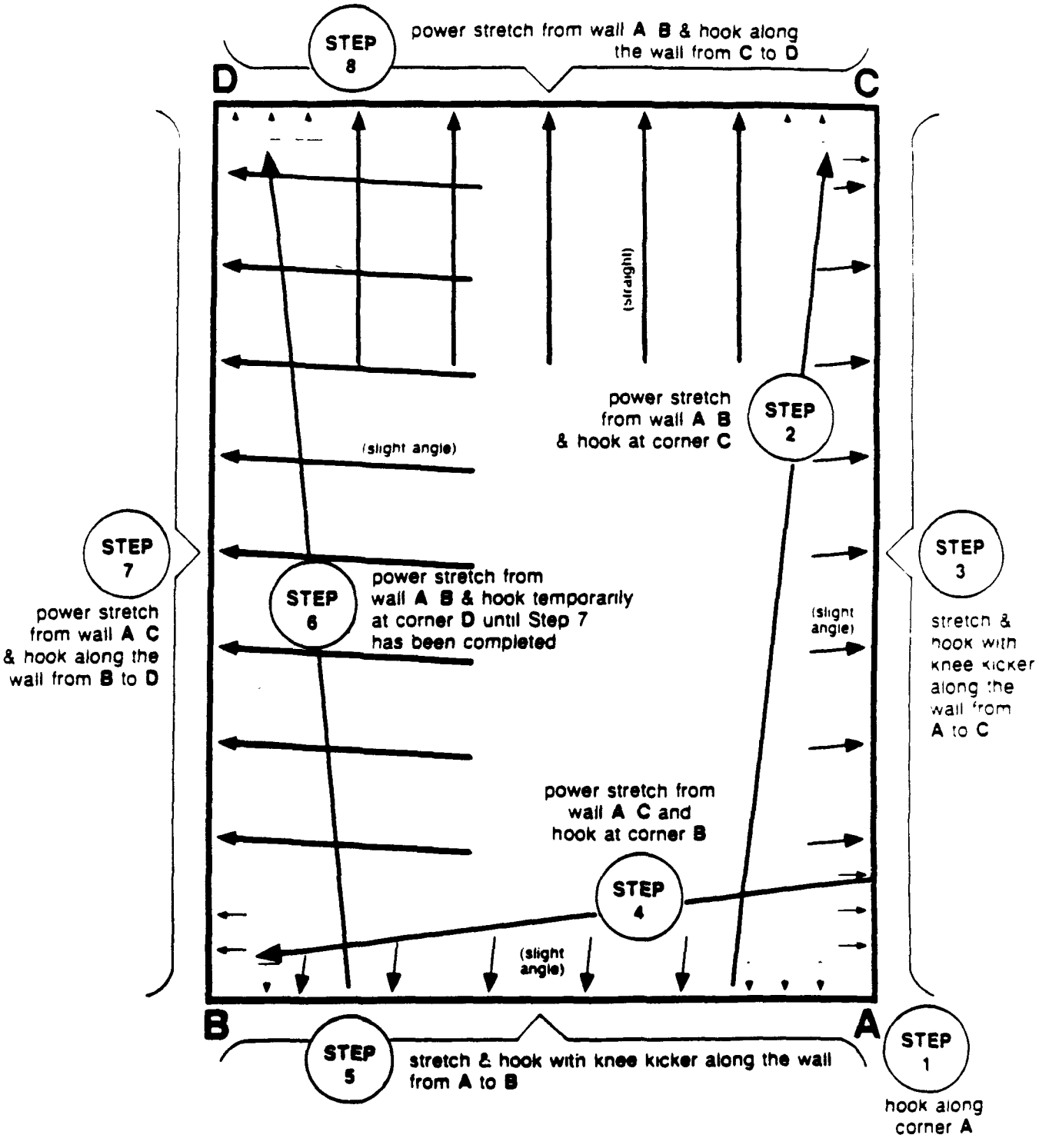


STRETCH:	**Length**	**Width**
Jute Secondary Backing:	"drum tight"	"drum tight"
Synthetic Secondary Backing:	1% - 1½%	1% - 1½%

FIGURE 4

WILTON OR VELVET

Amount of Stretch as per the Carpet Manufacturer's Recommendation
In Absence of Carpet Manufacturer's Recommendation, Use Diagram Below

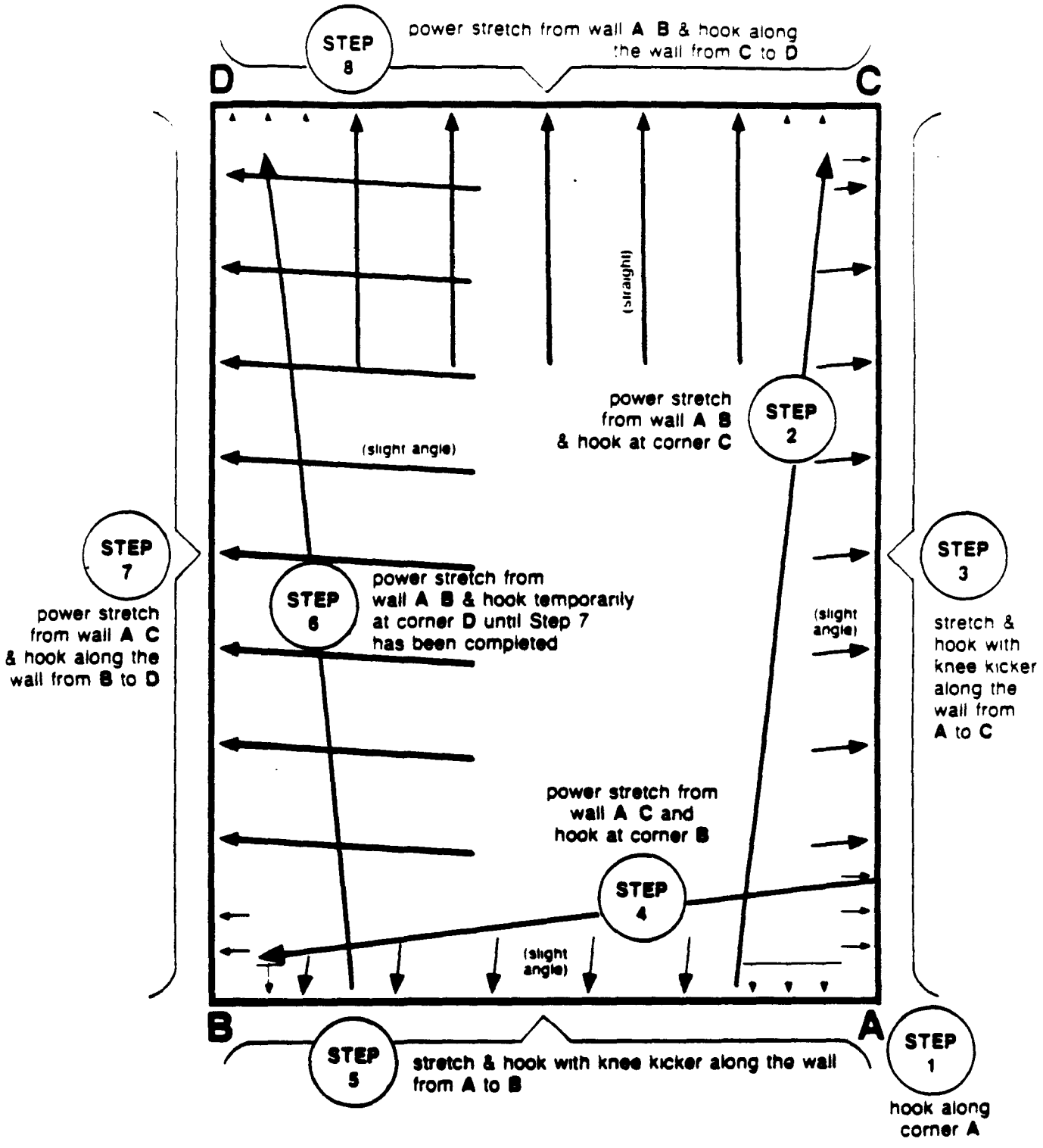


STRETCH:	Length	Width
Wilton:	equal stretch in length and width (drum tight)	equal stretch in length and wid (drum tight)
Velvet:	snug	more stretch in width than leng

FIGURE 5

AXMINSTER

Amount of Stretch as per the Carpet Manufacturer's Recommendation
In Absence of Carpet Manufacturer's Recommendation, Use Diagram Below

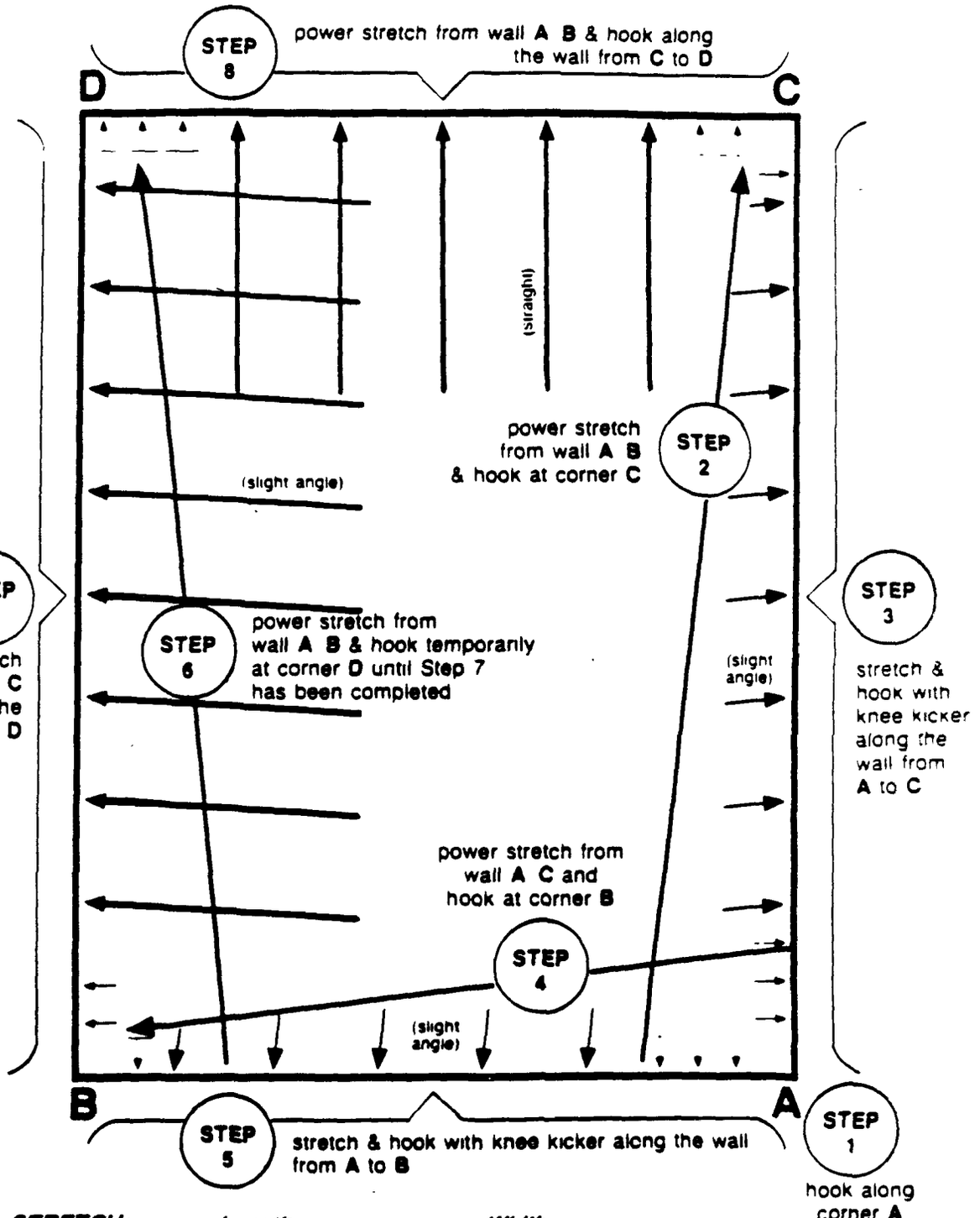


STRETCH:	**Length**	**Width**
	tight	snug

FIGURE 6

KNITTED

Amount of Stretch as per the Carpet Manufacturer's Recommendation
In Absence of Carpet Manufacturer's Recommendation, Use Diagram Below



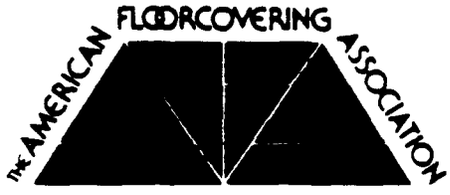
STRETCH: **Length** 1% - 1½% **Width** more stretch in width than length approx. 1½%

STEP 9

In an exceptionally large room a reverse stretch from walls C D to A B, and from walls B D to A C is recommended to assure a tight, satisfactory installation

SPECIAL ACKNOWLEDGEMENTS

Since the beginning of this project, more than 100 individuals generously donated their time, effort, talent, and experience. These individuals represented all affected segments of the carpet industry — manufacturers of carpet, carpet cushion, and adhesives; retailers and installers. In the process of developing this document, almost all disagreements were resolved because of the dedication and expressed commitment by the participants to provide guidelines in the best interest of the ultimate carpet user. The following organizations generously expressed their endorsement of this work:



"AFA supports the concept of CRI-105 for Residential Installation. AFA is pleased to have been involved in the review and development process. The AFA Board of Directors will be reviewing CRI-105 in detail."

CANADIAN CARPET INSTITUTE
INSTITUT CANADIEN DU TAPIS

"The Canadian Carpet Institute and The National Floorcovering Association in Canada have promoted programs to provide improved installer training and practice. The publication of CRI-105 will provide a much needed standard guideline from which to work and we will recommend that all carpet manufacturers, distributors and retailers who are members of our organizations adopt its use."

CMAW
CARPET MANUFACTURERS ASSOCIATION
OF THE WEST

"We have reviewed the 4th Draft received and again we want to compliment you and the Committee on the quality and the comprehensiveness of the Standard."

"We plan to reference CRI-105 in the revision of the CMAW Performance Guidelines . . ."

FLOOR COVERING INSTALLATION CONTRACTORS ASSOCIATION

We support this effort to provide standards for the residential installation community and want to be on record in our endorsement of this new standard."

" we are hopeful that the present document will provide an appropriate guideline

National Association of Floor Covering Distributors

"The National Association of Floor Covering Distributors is pleased that a reference standard for residential installation is now available and, through distributors, will encourage its use with dealers and installers."

WESTERN FLOOR COVERING ASSOCIATION

". . . WFCA accepts the standards as proposed . . . this . . . shows that the industry as a whole is trying to improve our practices . . ."

". . . there is no way the retailers, installers and manufacturers could agree on every phase of a proposed standard . . . but . . . it's a good starting point."

". . . WFCA will encourage industry adherence to the standard . . ."

APPENDIX R

Indoor Air Quality Evalualtion of Carpet for the Carpet and Rug Institute

VOLATILE ORGANIC COMPOUND EMISSIONS FROM CARPET AND ASSOCIATED PRODUCTS

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INTRODUCTION

As public awareness of indoor air quality (IAQ) and its impact on productivity, comfort and health continues to grow, pressure increases to provide "quality indoor environments" for occupants of office buildings, personal residences, and other indoor structures. The burden of providing this environment impacts all those involved in the design, construction, and operation of these structures as well as the actual occupants themselves. Ventilation, construction materials, cleaning materials and procedures, internal processes and activities are some of the many factors which may affect IAQ.

Because indoor materials and internal processes are potential sources of indoor air pollutants such as formaldehyde and other volatile organic compounds (VOCs), ozone, particles, microbiologicals, carbon dioxide and other inorganic oxides, mitigative control and proper selection of materials has received recent attention. One practical approach to controlling indoor pollutant exposures is to ensure that low emitting materials are used while simultaneously providing adequate ventilation to the indoor spaces. Proper ventilation has been recognized as an important issue in adequate IAQ and has been addressed in a recent consensus standard (ASHRAE, 1989).

Although there are no current standards for acceptable indoor levels of pollutants, there are guidelines for certain pollutants as established by some various agencies and professional organizations (WHO, 1987; ASHRAE, 1989; Canada, 1987). Since materials and certain processes are believed to be significant contributors to the presence of pollutants in buildings, technology has been developed to measure pollutant emission rates from known sources and to predict resultant air concentrations within buildings.

Flooring materials, floor coatings, wall materials, wall coatings, office furniture, and office machines have been recently listed as potential contributors to VOCs within the indoor air, and suggested maximum emission rates (sometimes referred to as "emission factors") have been proposed for each (Tucker, 1990). The State of Washington has also proposed similar guidelines with maximum acceptable levels of VOCs and other pollutants in the buildings originating from interior finishes, furnishings, and processes (State of Washington, East Campus Plus, 1990).

Carpet materials have received recent attention as potential contributors of VOCs. This interest was primarily generated by a "Citizens Petition" which requested the Environmental Protection Agency (EPA) to regulate the emission of 4-phenylcyclohexene (4-PC) under the Toxic Substances Control Act (TSCA). This particular compound is an odiferous species known to be a manufacturing by-product of carpet incorporating styrene/butadiene rubber.

The EPA rejected the petitioners' request to regulate 4-PC, on the basis that toxicological data did not support the claim of adverse health effects resulting from 4-PC exposure. However, the EPA has requested that the carpet industry take voluntary action to reduce total VOC emissions from their products, as a pollution prevention mitigative initiative (Federal Register, 1990).

To obtain an understanding of the magnitude of VOC emissions from carpet and its associated products, a comprehensive study of VOC emissions was begun in November, 1989 of SBR latex-backed carpets. An environmental chamber technology and testing protocol was developed for accurately and reproducibly assessing VOC emission rates. Using this technology, a study was conducted of representative carpet products, carpet cushions, adhesives, and installed systems. Emission rate changes over time were studied for each of the products for both total volatile organic compound (TVOC) and 4-phenylcyclohexene (4-PC) emissions. Comparative studies were also conducted of other interior products including particleboard, paint, adhesive, and wall covering.

EXPERIMENTAL METHODOLOGY

A complete description of the methodology used in this study is attached as Appendix 1. It describes the technique for determining TVOC emission rates from flooring systems using test conditions defined to simulate product use in realistic settings. Incorporated in this method are applicable terminology, environmental chamber specifications, sample handling protocols, sample collection techniques, sample packaging procedures, product delivery and storage, preparation techniques for the test system, testing protocols, chemical analysis descriptions, emission rate calculations, and quality control and assurance procedures.

A summary of these techniques specific to this study follows.

Environmental Chamber Technology.

An environmental chamber technology, in conjunction with a defined testing protocol, has been designed to accurately assess the VOCs from new SBR latex carpet. This methodology measures TVOC emission rates from flooring systems using test conditions defined to simulate product usage in a realistic manner, both residential and commercial.

The technology employs small stainless steel chambers with a precisely maintained air supply. The controlled parameters include chemical purity of the air supply, moisture content, temperature, amount of air flow measured in air changes per hour, and velocity of the air movement through the chamber. These parameters are precisely regulated with a computerized process control system which provides immediate feedback, control and continuous data logging of the parameters. All of the products were evaluated utilizing consistent, standardized test conditions.

A schematic of the technology system is shown in Figure 1 and a photograph of the five small chambers used in this study is presented in Figure 2. The actual measurement specifications including the chamber system are given in Table 1. The product loading factor of 0.41 m^2/m^3 was chosen to simulate a full coverage of carpet in a room with an 2.4 m ceiling height.

Quality control procedures on the chamber operation included continuous monitoring of the operating parameters including air supply temperature, humidity, and TVOC background; evaluation of mixing efficiency and calibration of the air exchange rate; evaluation of VOC recovery within the chamber using quantitative standards; and monitoring of chamber pressure relative to the atmosphere.

Analytical Measurements.

Analytical measurement specifications are given in Table 2. The low levels of VOCs associated with the carpet materials require a significant pre-concentration of the air prior to chemical analysis. A multibed sorbent of Carbosieve SIII/Carbotrap C/Carbotrap was used for TVOC collection and a water solution was used for the formaldehyde collection. The actual sorbent traps were prepared and purified in the laboratory.

The TVOC analysis, including 4-PC, was conducted by capillary gas chromatography coupled with mass spectrometric detection. The environmental chamber air samples were thermally desorbed into the analytical instrumentation for analysis via a well-controlled and reproducible thermal desorption system.

Formaldehyde analysis was conducted with a double beam UV-visible spectrophotometer following color development of the formaldehyde derivative.

Calibration was determined from standards using a least squares calibration curve fit, and the minimal quantifiable limit was determined to be twice the detection limit as measured from replicate determinations of the lowest level standard.

PRODUCT DESCRIPTIONS

Carpet. Nineteen individual SBR latex-backed carpet products were evaluated for TVOC and 4-PC emissions. The generic description of each is given in Table 3 indicating the face fiber type identification, dye method, and whether or not topical soil/stain resist treatments were applied. Each product was obtained from the manufacturer's finishing line. Laboratory instructions were that samples taken off the manufacturing line were to be immediately packaged and delivered to the laboratory as soon as possible.

Each carpet sample was obtained from the manufacturing finish line in a 12 foot by 2 foot piece so that it incorporated the complete width of the finished product. The material was rolled and packaged first in a 6 mil polyethylene bag followed by an air tight wrap of 3 mil aluminum foil. Once the materials were delivered to the laboratory, they were stored in a conditioned room maintained at 68°C - 78°C and 40%-60% relative humidity. The material remained in its packaging until immediately before chamber evaluations.

The packaging was chosen prior to the start of the program to ensure that it would not contaminate the product with additional VOCs and that it would not allow permeation of the carpet VOCs to the outside air. The materials chosen have TVOC emission rates less than 0.005 $mg/m^2 \cdot hr$.

Associated Carpet Products. An initial VOC emissions survey of carpet cushions and adhesives was also conducted. Three different types of cushions and four adhesives, as generically identified in Table 4, were evaluated. The carpet cushions were obtained and packaged as the carpet. The first three adhesives were obtained in unopened 5 gallon containers from local suppliers. The special "low VOC" adhesive was supplied as a small sample directly from the specific manufacturer.

PREPARATION OF THE PRODUCT TEST SYSTEM

The products were evaluated in the chambers as realistically as possible. Each was prepared as it would be during an actual building installation; the loading was simulated within the chambers to be commensurate with a complete floor coverage in a room with a 2.4 m ceiling height; and environmental conditions were maintained at 50% relative humidity and 25°C. A complete discussion of these standardized parameters is given in Appendix 1.

The universal subflooring was concrete although some studies were conducted with particleboard underlayment as might be found in residential structures. The sample mounting allowed only the surface of the prepared test specimen to be exposed to the air flow within the chamber, and the edges were sealed with a stainless steel band.

Each type of product, carpet, cushion and adhesive was studied individually as well as in a complete system. Installation systems which were evaluated included:

carpet on subflooring, no adhesive or cushion;

carpet on subflooring with adhesive (direct glue down);

carpet on subflooring with cushion, no adhesive; and

carpet on subflooring with cushion and adhesive (double glue down).

The installations were prepared according to the manufacturers' instructions and the use of The Carpet and Rug Institute's (CRI) Installation Guide for Commercial and Residential Structures, CRI Publications 104 and 105. The manufacturers' instructions had priority, if available.

DATA PRESENTATION

SBR LATEX CARPET PRODUCTS.

Formaldehyde Emissions.

There were no detectable formaldehyde emissions measured from any of the nineteen SBR carpet products during this study. This indicated that the new SBR latex carpets evaluated were not pollutant sources of formaldehyde.

TVOC and 4-PC Emission Rates.

Chemical emissions of each individual carpet product, evaluated for one-week exposure periods, produced similar TVOC decay patterns with time. Typical emission profile patterns for two independent carpet products are shown in Figure 3. The level of TVOCs was highest at the first measurement point, one hour after exposure in the environmental chamber, and exponentially decreased with time. Initial studies were conducted by taking data points at 1,4,8,12,24,48,72,96,120, and 144 exposure hours. After these initial studies, daily test measurements were made at 24-hour increments. A representative chromatogram of the TVOCs is shown in Figure 4 for a carpet sample. The chromatogram is relatively simple with only a few detectable peak responses.

The emission profiles of 4-PC were obtained simultaneously and were found to be similar to those of TVOC as shown in Figure 5. One primary observable difference was noted; while the TVOCs decreased with time after initial exposure to the atmosphere, the 4-PC emissions appeared to peak out sometime within the first 24 hours before they began to decrease. Once 4-PC began to decrease, however, it was continual. The peak response of 4-PC varied among products between the 1st and 24th hour of exposure.

The percentage changes in TVOC and 4-PC levels are shown in Table 5 for exposure time between immediate exposure and the 24th hour and the 144th hour. Within 24 hours, the TVOC levels decreased rapidly by an average of 58%, and by the end of one week, the TVOC levels had decreased by an average of 91%. The 4-PC level showed a wide variation within the first 24-hour exposure period. On an average, it increased 7.9% within the first 24 hours, but had decreased by 63% at the end of a one-week exposure.

The 24th hour and 144th hour emission factors and "k" constants for the TVOC and 4-PC decreases with time are summarized in Table 6 for each product. A generic emission rate profile over time was generated using the mean of the measured emission rates at each measurement point of all the SBR products.

This graph, as presented in Figure 6, shows a pattern consistent with each of the individual emission rate graphs and illustrates that the emission rates are low and significantly below the 0.6 $mg/m^3 \cdot hr$ guideline recently proposed by EPA (Tucker, 1990). The same generic graph is presented in Figure 7 incorporating the 99% and 95% confidence levels around the mean of each emission rate.

General trends observable in this data include:

1. The TVOC emission profiles among the SBR latex products are very similar and predictable from a generic model generated from the mean measurements.

2. TVOC and 4-PC emissions decrease with time.

3. TVOC emissions decrease more rapidly (half life of 1.8 days) than those of 4-PC (half-life of 2.9 days).

4. 91% of the TVOC emissions decrease by the end of one week.

5. 63% of the 4-PC emissions decrease by the end of one week.

6. The variation in TVOC emissions among the SBR products decrease with time. For example, there is 81% relative variation among the products at the 24-hour exposure and 52% variation on the 7th day. This variation, however, when considered in TVOC concentration, only corresponds to ±50 $\mu g/m^3$ and ±2 $\mu g/m^3$, respectively. This variation level at the end of a one-week exposure is at the instrumental detection limit.

4. The variation in 4-PC emissions among products increases in time with a 53% relative variation at 24 hours to 68% on the 7th day. This corresponds, however, to only ±14 $\mu g/m^3$ (±2 ppb) and ±7 $\mu g/m^3$ (±1 ppb), respectively.

5. The TVOC emissions from the 24th exposure hour are all below the 0.6 $mg/m^2 \cdot hr$ guideline as presented by EPA (Tucker, 1990).

6. The mean TVOC profile indicates with 95% certainty that all similar SBR latex products have emission rates less than 0.6 $mg/m^2 \cdot hr$ within the first hour of exposure, and with 99% certainty that all similar SBR products have emission rates less than 0.6 $mg/m^2 \cdot hr$ within 24 hours of exposure.

Manufacturing/Product Variables.

This study was designed to present an overview of carpet emissions and was not intended to be of statistical design. However, there were certain observations relating TVOC emissions and known manufacturing parameters which are noteworthy. These observations, as presented below, are generally based on single measurements and should be considered strictly qualitatively.

Fiber Types.

The majority of products evaluated in this study consisted of face fiber identified as type 1. When the emission data of this group of products were considered as an aggregate, and the individual data of other fiber products are compared to it, the following are observed:

1. The emission profiles of all follow similar TVOC decay patterns;

2. The TVOC levels of the two face fiber type 2 and one face fiber type 4 products fall within 1 standard deviation of the face fiber type 1 group variation, indicating similar magnitude; and

3. The TVOC level of the one face fiber type 3 material falls within 4 standard deviations of the type 1 variation (using the 24-hour data as the comparative exposure point), indicating a potential difference.

Mill Variability.

A generic type 1 fiber product was produced at four different manufacturing locations, with each mill producing an independent sample. The TVOC data, C-9 through C-12, showed little variation (with the exception of C-10 at the 24-hour point, which appears to be an outlier) among the TVOC emission data at 24- and 144-hour exposures. At the end of one week, the measured TVOC variation was within the analytical measurement variability, basically indicating no difference in magnitude.

Finishing Speed.

Two type 1 fiber products were manufactured identically with the exception of residence time in the same drying oven. The product which remained in the oven for a longer period of time indicated lower TVOC emissions than its traditional counterpart.

LARGE CHAMBER/SMALL CHAMBER CORRELATION.

TVOC emission evaluations in this study were primarily conducted in small (0.05 m^3) environmental chambers. An experiment was undertaken to confirm that this small chamber data can be correlated to that obtained in an actual room situation.

TVOC emission profiles for product C-3 were studied simultaneously in both a large (26 m^3) chamber and a small (0.05 m^3) chamber under identical operating conditions with a loading factor of 0.41 m^2/m^3. The emission profiles were monitored over a 6-week period, and the resultant correlations were quite good. Linear regression analysis indicated an r^2 of 0.92 for the TVOC measurements, and an r^2 of 0.97 for the 4-PC emissions. This excellent correlation indicated good sample homogeneity with respect to the chemical characteristics of this particular product.

The homogeneity of another SBR product was evaluated in a different manner. Five independent samples were cut from one continuous manufacturing run of product C-11, and each sample was studied independently, but simultaneously in five different small environmental chambers. The resultant TVOC data showed a 7.2% relative variation among the TVOC results and 7.0% relative variation among the 4-PC measurements. Such variation is within the relative standard deviation of the analytical measurement technique. This data was further confirmation of good sample homogeneity within a specific SBR carpet product.

CARPET CUSHIONS, ADHESIVES AND SUBFLOORS.

Some representative carpet cushions and adhesives, as previously described in Table 4 were evaluated for TVOC emissions. Carpet cushions were analytically studied in the same manner and loading ratio as carpet, 0.41 m^2/m^3. The adhesives were applied to a properly cured concrete subflooring using an appropriate trowel at the spread rate recommended by the manufacturer or the CRI Installation Guide. The adhesive loading based on surface exposure was also 0.41 m^2/m^3.

A summary of the TVOC emission rates obtained from the cushions, adhesives, and subflooring materials are shown in Table 7 for both the 24-hour and 144-hour exposure points. Two cushions displayed TVOC profiles similar to carpet and decreased with continual exposure time. The third cushion, in contrast, had increasing TVOC values due primarily to the release of heavier molecular weight compounds later in the exposure period.

The first three adhesives displayed similar TVOC patterns with time. However, their emissions were significantly higher than those of the cushions and carpets. A typical TVOC decay curve is presented in Figure 8 for one of the latex adhesives; it required a 35-day exposure time to bring the level of TVOCs down to the level which SBR latex carpet displays within the first 24 hours of exposure. A chromatographic scan of this particular adhesive is shown in Figure 9. This organic compound pattern is significantly dense in comparison to the carpet chromatogram previously shown in Figure 4.

Particleboard, a common subflooring material in residential and commercial structures was evaluated as a TVOC source. As can be seen in Figure 10, it has an elevated level of TVOC which appears to be generally constant over the one-week exposure period. Primary TVOC contributions include formaldehyde and other aldehydes and terpenes. The particleboard emission rate is significantly greater than either the cushions or the carpet.

INSTALLATION SYSTEMS.

Various carpet systems were prepared for environmental chamber emission studies. These systems included a variety of possibilities coupling subflooring with cushions, adhesives, and carpet. The first set of systems, which did not use adhesive, are summarized in Table 8 along with the 24-hour emission rates and approximate resultant air concentrations. The particleboard underlayment contributed significant TVOCs to the system.

The second set of data, as presented in Table 9, indicates the magnitude of adhesive TVOCs. The general latex adhesives appear to contribute significant TVOC loads to the carpet systems resulting in TVOC concentration approximately 1000 fold higher than a non-adhesive system. The carpet VOCs are analytically masked by the adhesive VOCs. The decay time required to bring the adhesive TVOC level down to below 0.6 $mg/m^2 \cdot hr$ guideline (Tucker, 1990) ranges from 3 to 6 weeks dependent on the adhesive and type of application (single glue or double glue). By the time the adhesive TVOCs have significantly decreased, the carpet specific TVOCs have dissipated.

The "low VOC" adhesive, Ad-4 did have considerably lower TVOCs than the other three adhesives. Decay profiles of this adhesive by itself and in a carpet system are shown in Figure 11. Detectable VOCs present are from the adhesive as well as the carpet.

TVOC emission rate comparisons between carpet systems and their individual components are presented in Figure 12. The carpet (C) and pad or cushion (P)

are minor contributors in comparison to the adhesive (Ad). The TVOCs are highest for the two systems, C/Ad (a single glue down with carpet and adhesive) and C/Ad/P/Ad (a double glue down with carpet, cushion and two applications of adhesive).

SUMMARY

The TVOC emission profiles of the SBR latex products were very similar and predictable by a generic model generated from the mean measurements obtained. The available data indicate with 95% certainty that all similar SBR latex products would have emission rates less than 0.6 $mg/m^2 \cdot hr$ (or simply will result in <500 $\mu g/m^3$ of TVOC air concentrations) within their first hour of exposure.

The TVOC emissions emanate rapidly from the SBR latex products, reducing an average 58% within the first 24 hours and 91% by the end of one week. The 4-PC levels similarly decrease, but at a slightly slower rate. The TVOC contributions from new SBR carpet are barely detectable at the end of one exposure week.

Comparative data among other carpet system components including cushions, wood subflooring, and adhesives indicate SBR carpet to be one of the lower TVOC emitters. TVOCs from carpet installations appear to be primarily dominated by the adhesive component, which can contribute 10^3 levels higher of TVOCs. In addition, comparative data (Figure 13) among other interior products such as pressed wood, wall covering, adhesive, and paint show carpet itself to be a minor TVOC source.

TABLE 1

ENVIRONMENTAL CHAMBER SPECIFICATIONS

Stainless steel with rounded, electropolished interior surfaces.

Internal volume of 0.05 m^3.

Internal construction free of mixing fan, obstructions or contamination.

Internal velocity reproducible at 0.05 - 0.2 m/sec.

Internal mixing within 5% of theoretical well-mixed model.

Recovery rates >90% for representation compounds at 25 $\mu g/m^3$.

Positive pressure chamber operation relative to atmosphere (1" H_2O).

Standard environmental controls include:

1.0 ACH ± 0.05 ACH
25.0°C ± 0.2°C
50.0% RH ± 2.0% RH
TVOC background < 2 $\mu g/m^3$

Product loading ratio at 0.41 m^2/m^3 (square area of exposed carpet surface to volume of chamber).

TABLE 2

ANALYTICAL MEASUREMENT SPECIFICATIONS

TVOC collection and analysis by solid sorbent trapping/thermal desorption/GC/MS analysis.

CHOH collection and analysis by modified pararosaniline spectrophotometric technique (Miksch, 1984; Black, 1987.).

TVOC quantifiable limit: 2 $\mu g/m^3$ (0.5 ppb)

CHOH quantifiable limit: 6 $\mu g/m^3$ (5 ppb)

4-PC quantifiable limit: 2 $\mu g/m^3$ (0.3 ppb)

TVOC quantitation by a representative gaseous TVOC mixture including decane, toluene, and cyclohexane (methanol was incorporated for adhesive analysis).

TVOC quality control duplicates of carpet indicated an analysis variation of 7-11% relative standard deviation.

VOC identification made by customized mass spectral library and retention time.

CHOH and 4-PC quantitation by specific gaseous standards.

TABLE 3

PRODUCT DESCRIPTIONS OF CARPET MATERIALS MANUFACTURED WITH STYRENE BUTADIENE RUBBER (SBR) ADHESIVE

PRODUCT DESIGNATION	GENERIC DESCRIPTION		
	FACE FIBER TYPE	DYE METHOD	SOIL/STAIN RESIST* TREATMENT
C- 1	1	Continuous	No
C- 2	1	Continuous	Yes
C- 3	1	Continuous	Yes
C- 4	1	Continuous	Yes
C- 5	1	Continuous	No
C- 6	1	Beck	No
C- 7	1	Solution	No
C- 8	1	Solution	No
C- 9	1	Continuous	Yes
C-10	1	Continuous	Yes
C-11	1	Continuous	Yes
C-12	1	Continuous	Yes
C-13	1	Continuous	No
C-14	1	Continuous	No
C-15	2	Beck	No
C-16	3	Solution	No
C-17	4	Stock	No
C-18	2	Beck	No
C-19	1	Solution	No

*The exact treatment of each was not known.

TABLE 4

PRODUCT DESCRIPTIONS OF CARPET CUSHIONS AND FLOORING ADHESIVES

PRODUCT DESIGNATION	GENERIC DESCRIPTION
P-1	Flat
P-2	Fibrous
P-3	Flat
Ad-1	Multipurpose Latex
Ad-2	Multipurpose Latex
Ad-3	Multipurpose Latex
Ad-4	Synthetic, "Low VOC"

TABLE 5

PERCENTAGE TVOC AND 4-PC EMISSION CHANGES WITH ELAPSED EXPOSURE TIME

	% REDUCTION OR INCREASE			
	TVOC		4-PC	
PRODUCT	24 HR[a]	144 HR[b]	24 HR[a]	144 HR[b]
C- 1	-29.6	-93.0	+82.8	-85.7
C- 2	-40.0	-97.1	+9.6	-94.0
C- 3	-35.3	-86.9	+10.1	-78.3
C- 4	-67.6	-95.7	-52.9	-94.1
C- 5	-32.9	-82.6	-3.85	-51.2
C- 6	-35.5	-80.3	+17.6	-62.2
C- 7	-51.1	-86.6	-24.3	-77.1
C- 8	-44.0	-95.3	+12.9	-67.7
C- 9	-82.6	-96.5	-5.56	-52.8
C-10	-77.0	-81.5	-10.7	-53.6
C-11	-70.2	-94.4	+83.3	-39.4
C-12	-79.1	-97.0	-50.9	-74.5
C-13	-77.2	-87.6	-10.0	-62.0
C-14	-64.4	-88.2	+16.9	-60.4
C-15	-68.9	-96.1	+113	-63.3
C-16	-40.0	-93.6	+13.2	-23.7
C-17	-71.1	-88.0	-6.82	-44.3
C-18	-83.8	-96.1	-25.0	-69.6
C-19	-59.3	-93.1	-17.9	-45.5
Mean	-58.4	-91.0	+7.97	-63.1
±Standard Deviation	±18.8	±5.6	±43.2	±18.5

[a] Taken after a 24-hour equilibration period within the environmental chamber.

[b] Taken after a one-week (144 hours) exposure period within the environmental chamber.

TABLE 6

TVOC AND 4-PHENYLCYCLOHEXENE (4-PC) EMISSION RATES OF NEW CARPET

	TVOC			4-PC		
PRODUCT	24 HR[a]	144 HR[b]	$k(HR^{-1})$[c]	24 HR[a]	144 HR[b]	$k(HR^{-1})$[c]
C- 1	0.071	<0.005	0.027	0.064	<0.005	0.017
C- 2	0.109	<0.005	0.021	0.091	<0.005	0.018
C- 3	0.183	0.037	0.013	0.152	0.030	0.011
C- 4	0.045	0.006	0.020	0.040	0.005	0.018
C- 5	0.098	0.040	0.009	0.075	0.038	0.0065
C- 6	0.097	0.030	0.012	0.087	0.028	0.0075
C- 7	0.131	0.036	0.013	0.106	0.032	0.0093
C- 8	0.102	0.064	0.010	0.035	0.010	0.0081
C- 9	0.166	0.033	0.020	0.034	0.017	0.0058
C-10	0.041	0.033	0.010	0.025	0.013	0.0056
C-11	0.182	0.034	0.018	0.033	0.020	0.0034
C-12	0.179	0.026	0.022	0.025	0.013	0.0080
C-13	0.060	0.036	0.013	0.045	0.019	0.0075
C-14	0.054	0.018	0.014	0.062	0.021	0.0075
C-15	0.127	0.016	0.023	0.064	0.011	0.010
C-16	0.500	0.053	0.018	0.043	0.029	0.0052
C-17	0.195	0.081	0.014	0.082	0.049	0.0040
C-18	0.092	0.022	0.018	0.042	0.017	0.0079
C-19	0.438	0.074	0.016	0.110	0.073	0.0040
Mean	0.151	0.034	0.016	0.064	0.025	0.010
±Standard Deviation	0.123	0.018	0.005	0.034	0.017	0.008

[a] Emission rate taken after a 24-hour equilibration period within the environmental chamber.

[b] Emission rate taken after a one-week (144 hours) exposure period within the environmental chamber.

[c] The rate constant of TVOC decay.

TABLE 7

SUMMARY OF TVOC EMISSION RATES FOR CUSHIONS, ADHESIVES, AND SUBFLOORING

Product Designation	TVOC Emission Rate ($mg/m^2 \cdot hr$)	
Cushions	24 Hr[a]	144 Hr[b]
P-1	0.123	0.059
P-2	0.240	0.012
P-3	3.36	8.11
Adhesives		
Ad-1	90.0	11.9
Ad-2	76.6	3.95
Ad-3	99.0	17.2
Ad-4	0.698	0.076
Subflooring		
Concrete	<0.005	<0.005
Particleboard	0.952	0.837

[a] Emission rate taken after a 24-hour equilibration period within the environmental chamber.

[b] Emission rate taken after a one-week (144 hours) exposure period within the environmental chamber.

TABLE 8

SUMMARY OF TVOC DATA FOR CARPET SYSTEMS (NO ADHESIVE USED)

SAMPLE IDENTIFICATION	24 HR EMISSION RATES $mg/m^2 \cdot hr$	24 HR CONCENTRATION[a] mg/m^3	ppb
Carpet + P-1 on concrete	0.136	0.056	15
Carpet + P-1 on wood underlayment	0.549	0.225	61
Carpet + P-3 on concrete	0.776	0.318	86

[a] Concentration estimations based on a simple model assuming:
- 1 ACH with a well-mixed atmosphere
- 50 ± 0.5% RH
- 25 ± 0.2°C
- No additional sources of VOCs present
- No sinks or re-emitting sources of VOCs present
- 36 m^3 room volume with a 2.4 m ceiling height

TABLE 9

SUMMARY OF TVOC DATA FOR CARPET SYSTEMS (WITH ADHESIVE USED)

SAMPLE IDENTIFICATION	24 HR EMISSION RATES $mg/m^2 \cdot hr$	24 HR CONCENTRATION[a] mg/m^3	ppb
Carpet + Ad-1 on concrete (single stick)	98.0	40.2	10,854
Carpet + Ad-1 + P-1 on concrete (double stick)	145	59.6	16,092
Carpet + Ad-2 on concrete (single stick)	88.3	36.2	9,774
Carpet + Ad-3 on concrete (single stick)	153	62.8	16,956
Carpet + Ad-4 on concrete (single stick)	0.783	0.321	87

[a] Concentration estimations based on a simple model assuming:
- 1 ACH with a well-mixed atmosphere
- 50 ± 0.5% RH
- 25 ± 0.2°C
- No additional sources of VOCs present
- No sinks or re-emitting sources of VOCs present
- 36 m^3 room volume with a 2.4 m ceiling height

FIGURE 1

SCHEMATIC OF TECHNOLOGY SYSTEM

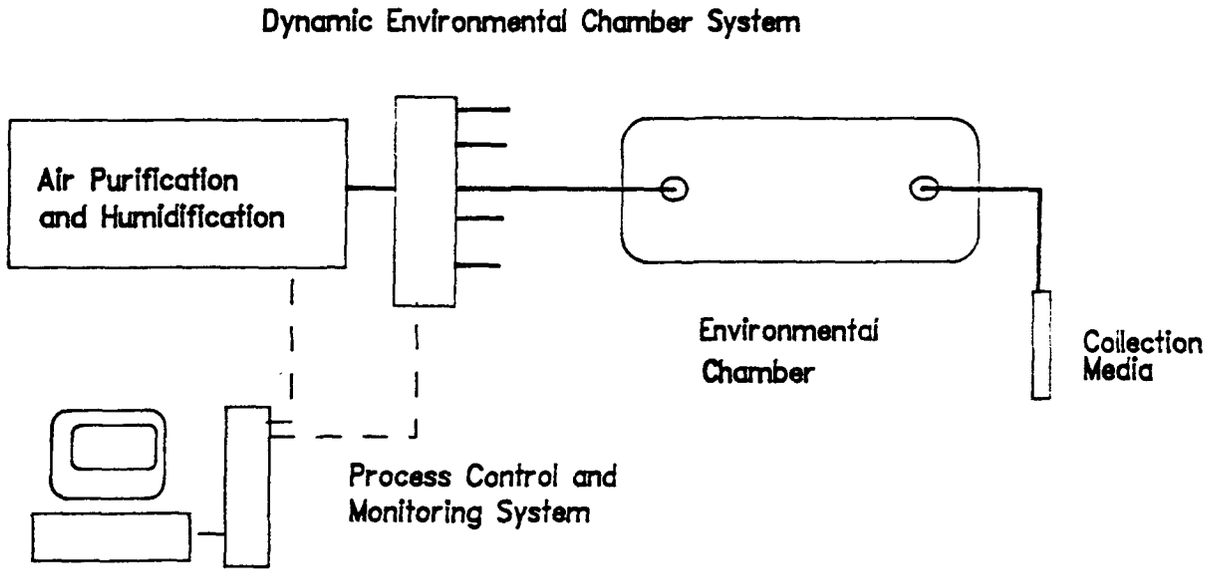


FIGURE 2

PHOTOGRAPH OF SMALL ENVIRONMENTAL CHAMBER

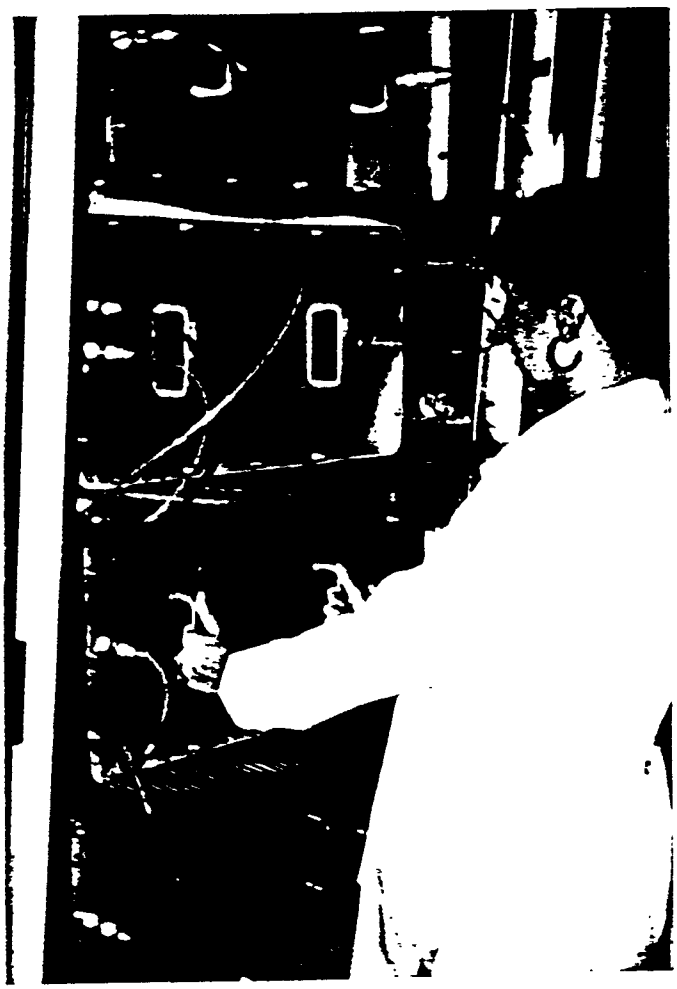


FIGURE 3

TYPICAL TVOC EMISSION PROFILE WITH TIME (SBR LATEX CARPET)

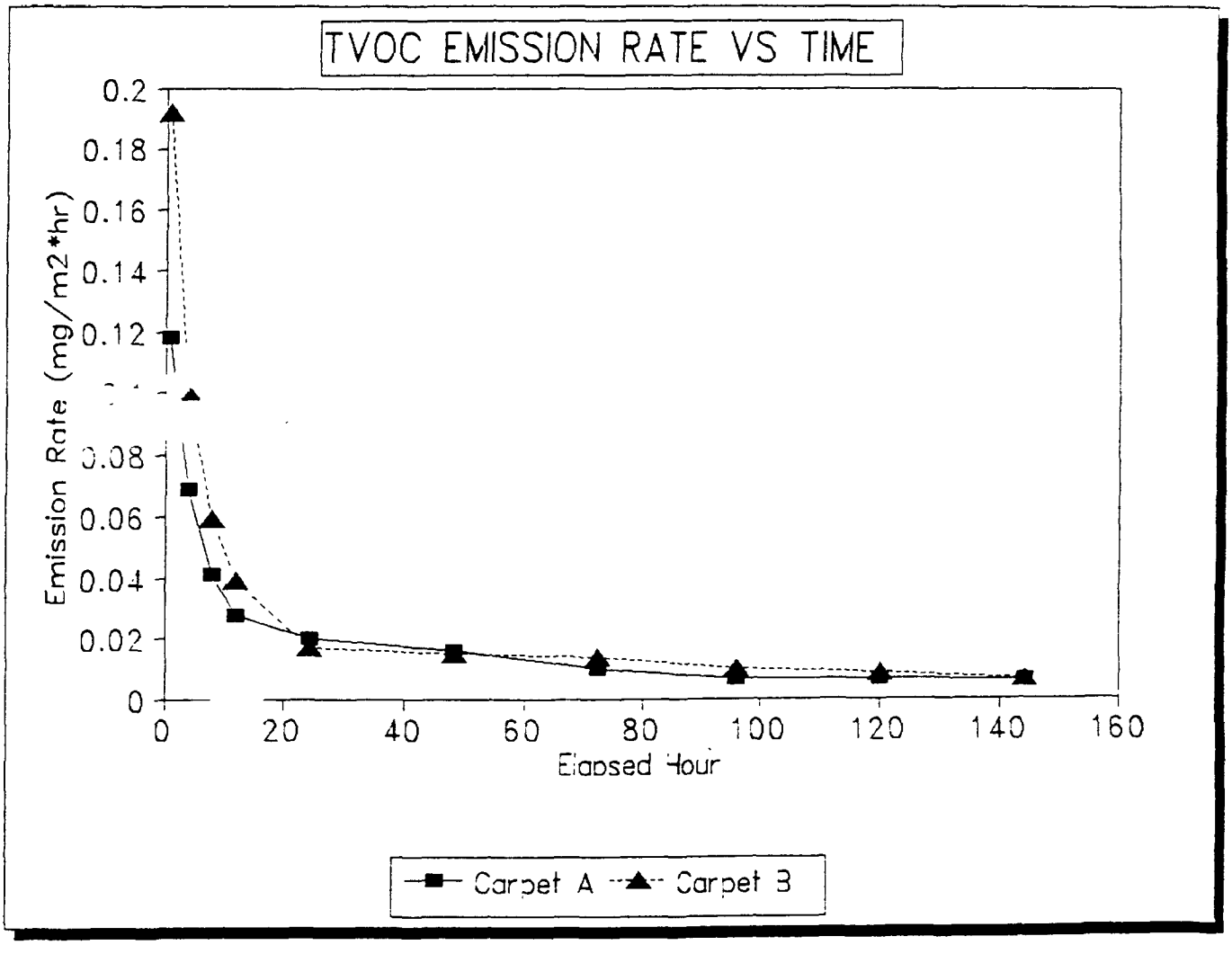


FIGURE 4

TYPICAL TVOC CHROMATOGRAM OF CARPET EMISSIONS (1 HR EXPOSURE)

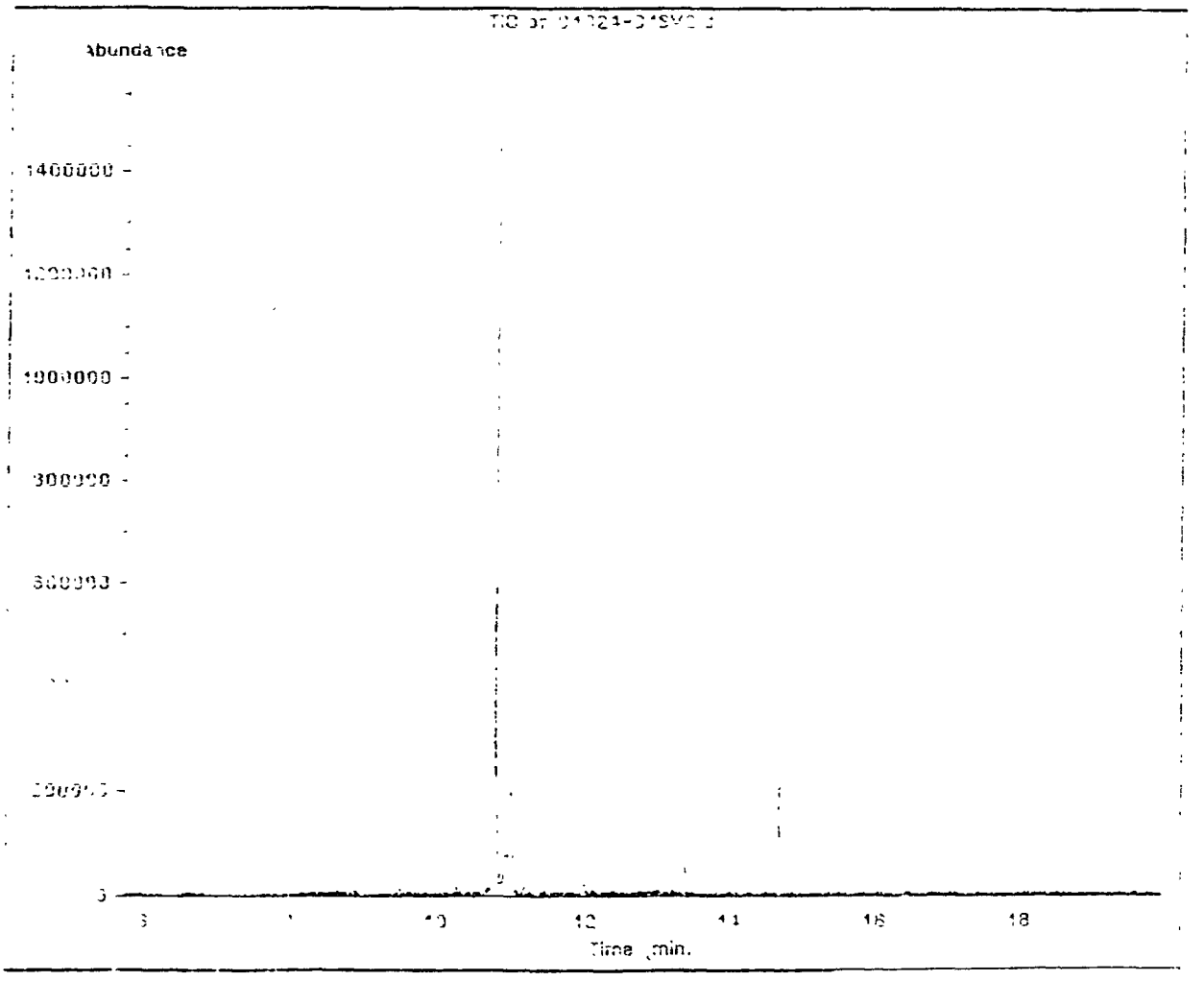
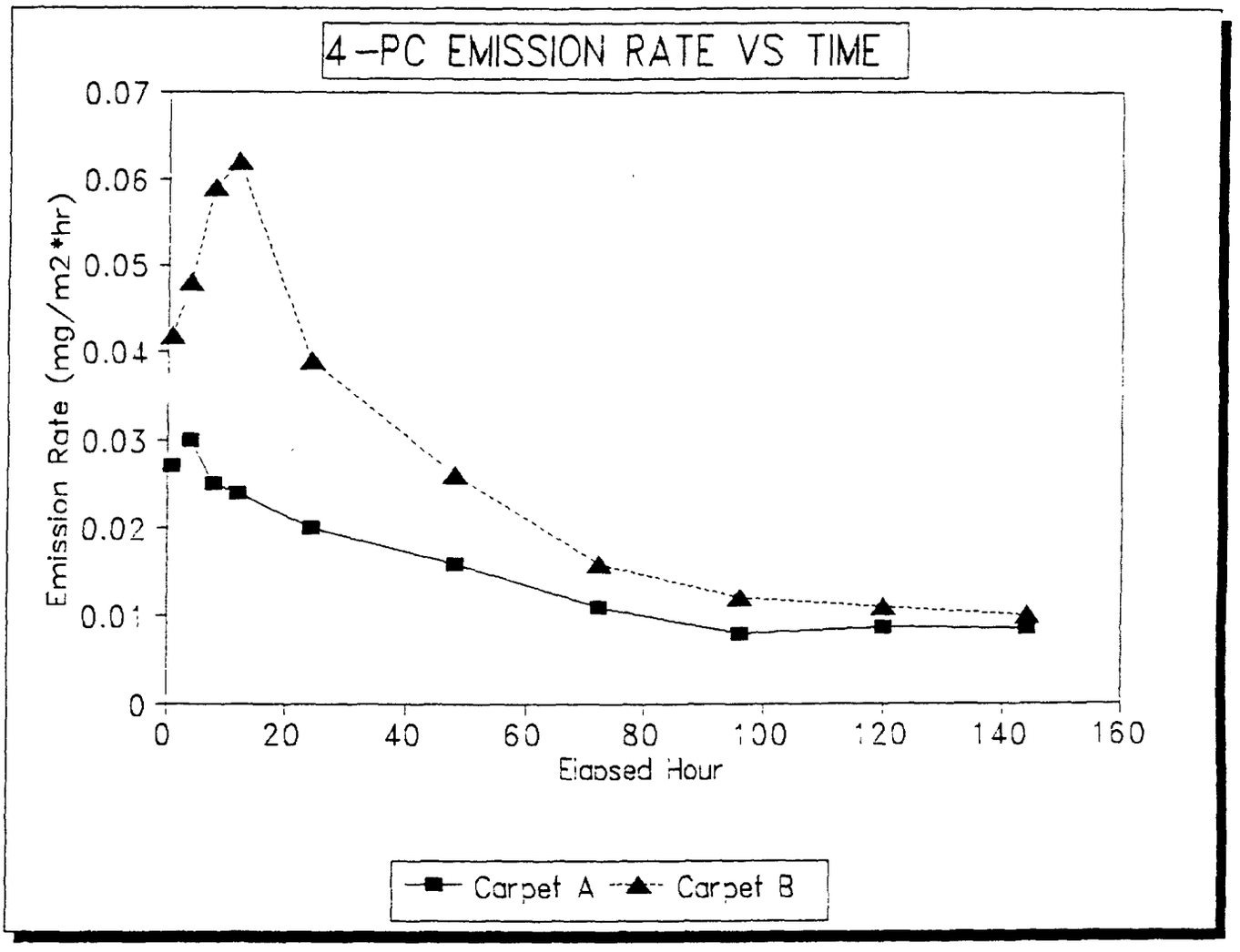


FIGURE 5

TYPICAL 4-PC EMISSION PROFILE WITH TIME (SBR LATEX CARPET)



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AQS Project #: 01021
Date Prepared: January 8, 1991

FIGURE 6

"MEAN" TVOC EMISSION RATE PROFILE WITH TIME (SBR PRODUCTS)

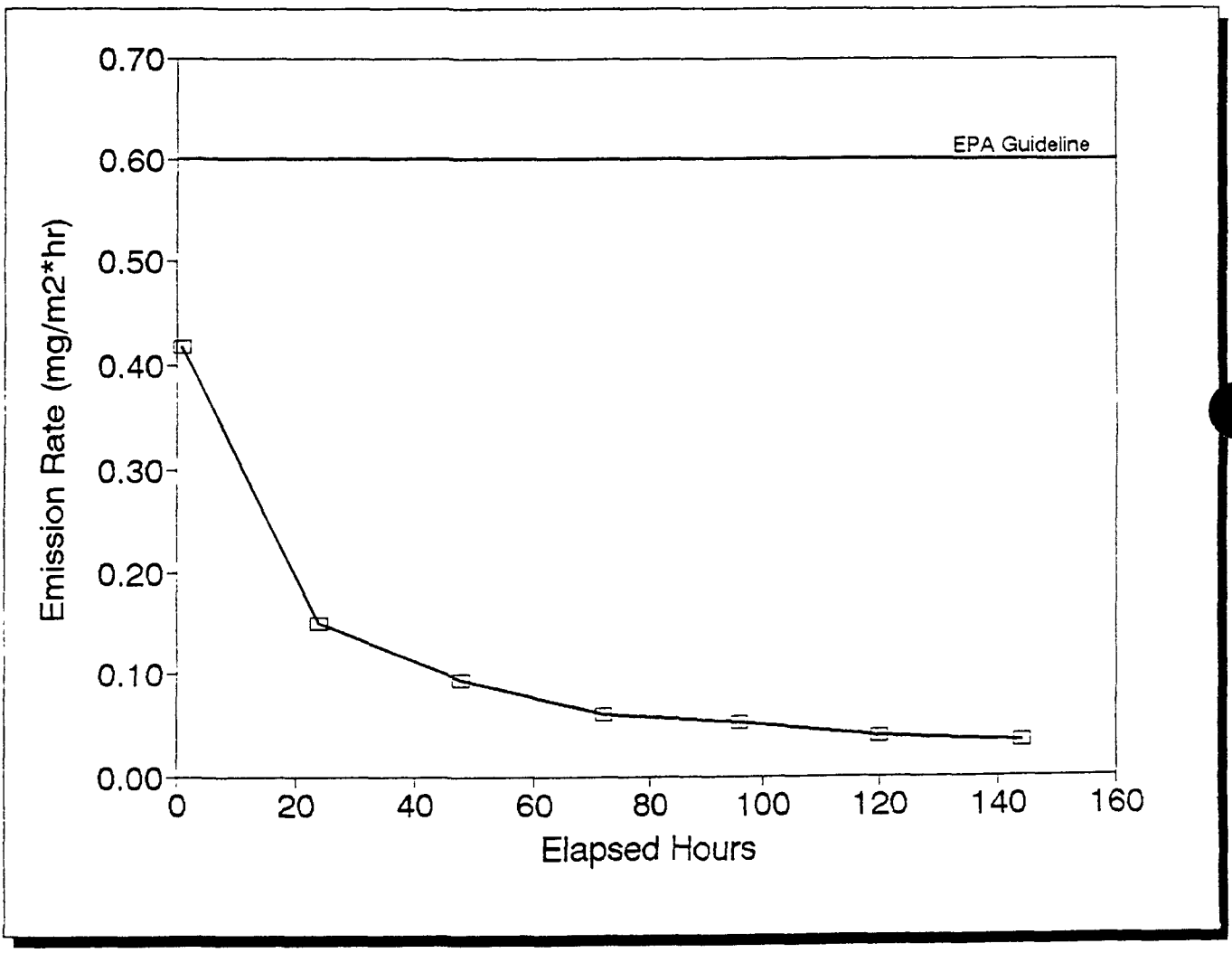
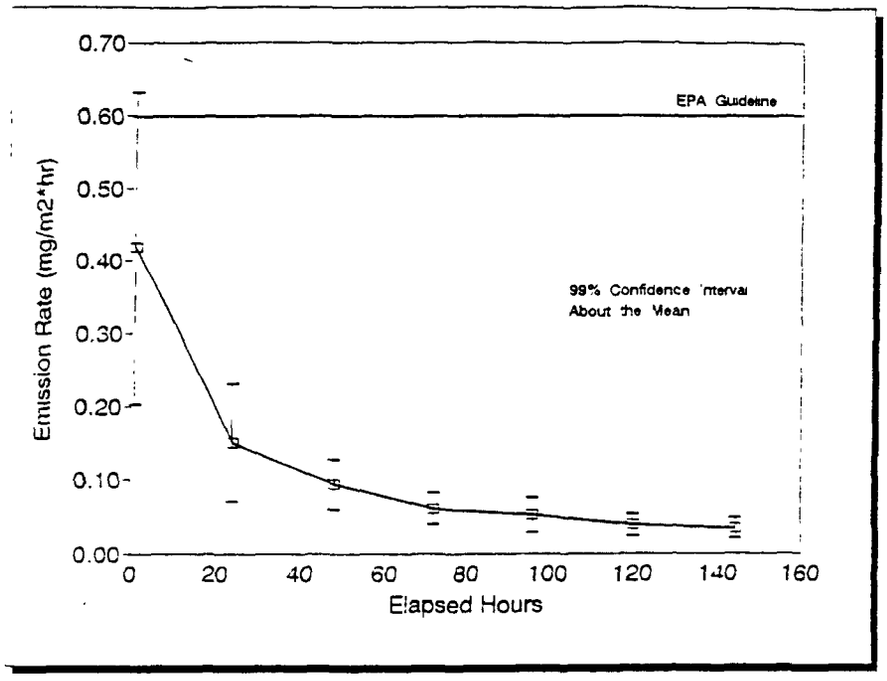


FIGURE 7

CONFIDENCE LEVELS OF "MEAN" TVOC EMISSION RATE PROFILE WITH TIME (SBR PRODUCTS)



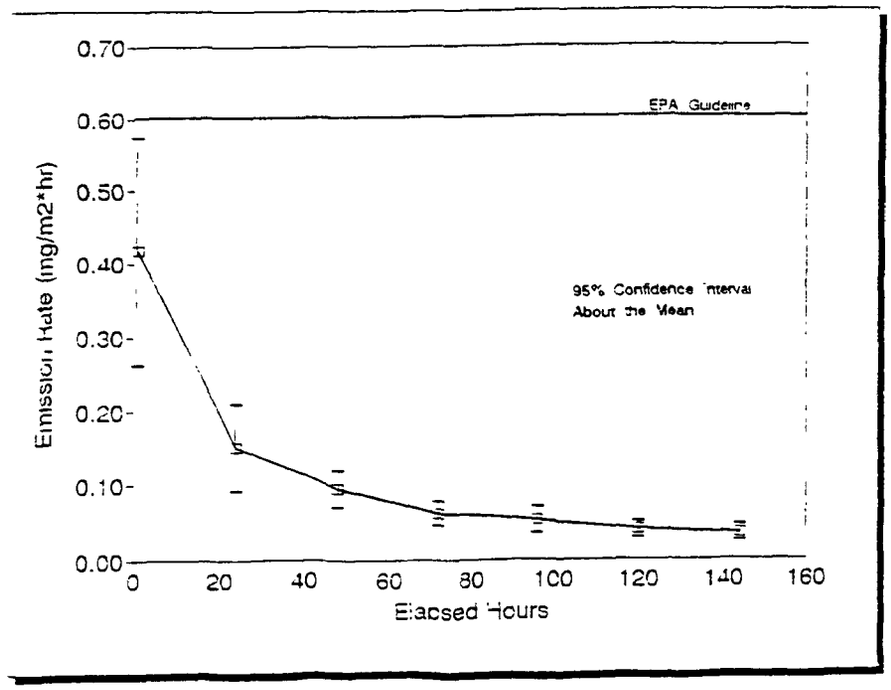
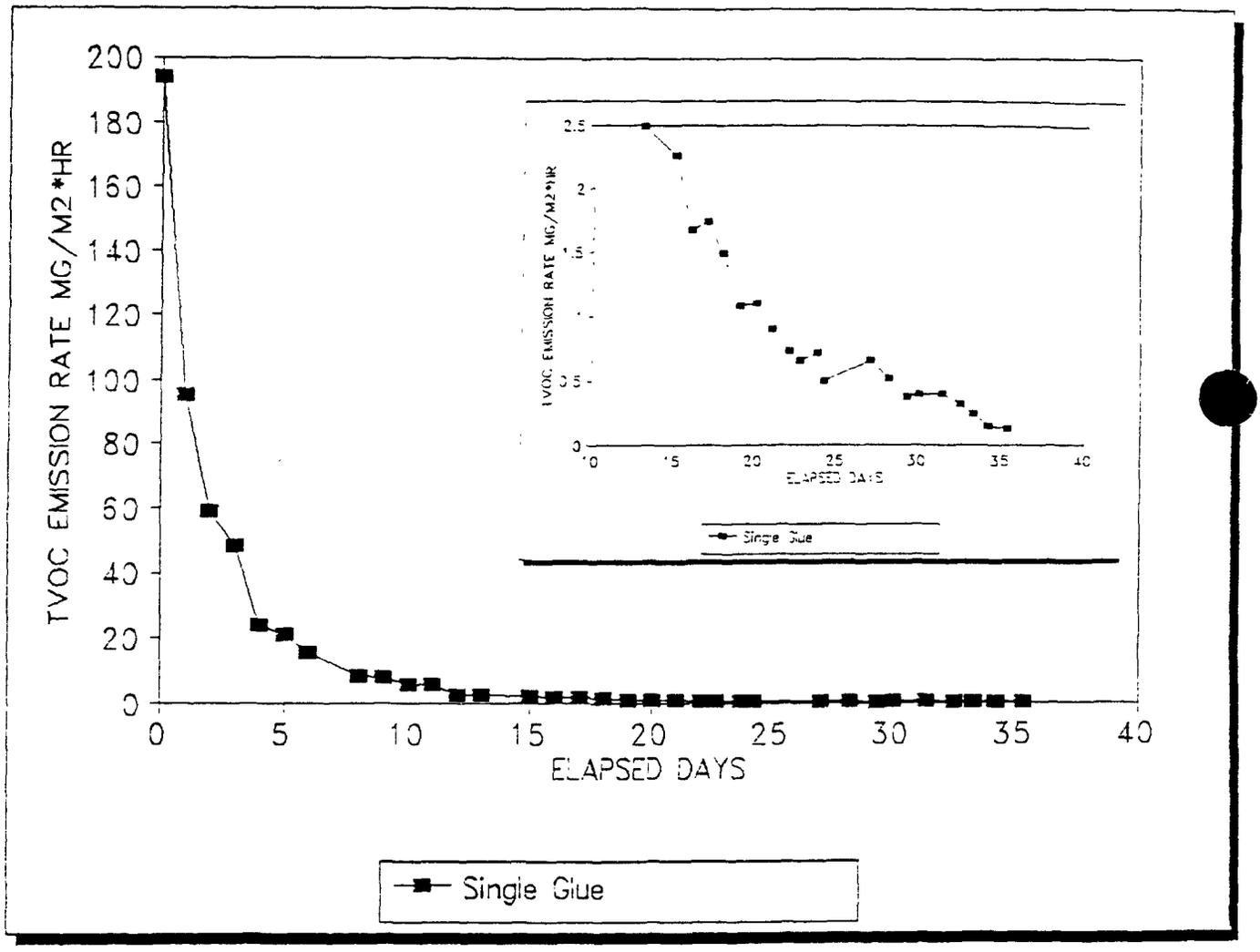


FIGURE 8

TYPICAL TVOC EMISSION PROFILE OF LATEX ADHESIVE



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Date Prepared: January 8, 1991

FIGURE 9

TVOC CHROMATOGRAPHIC SCAN OF LATEX ADHESIVE

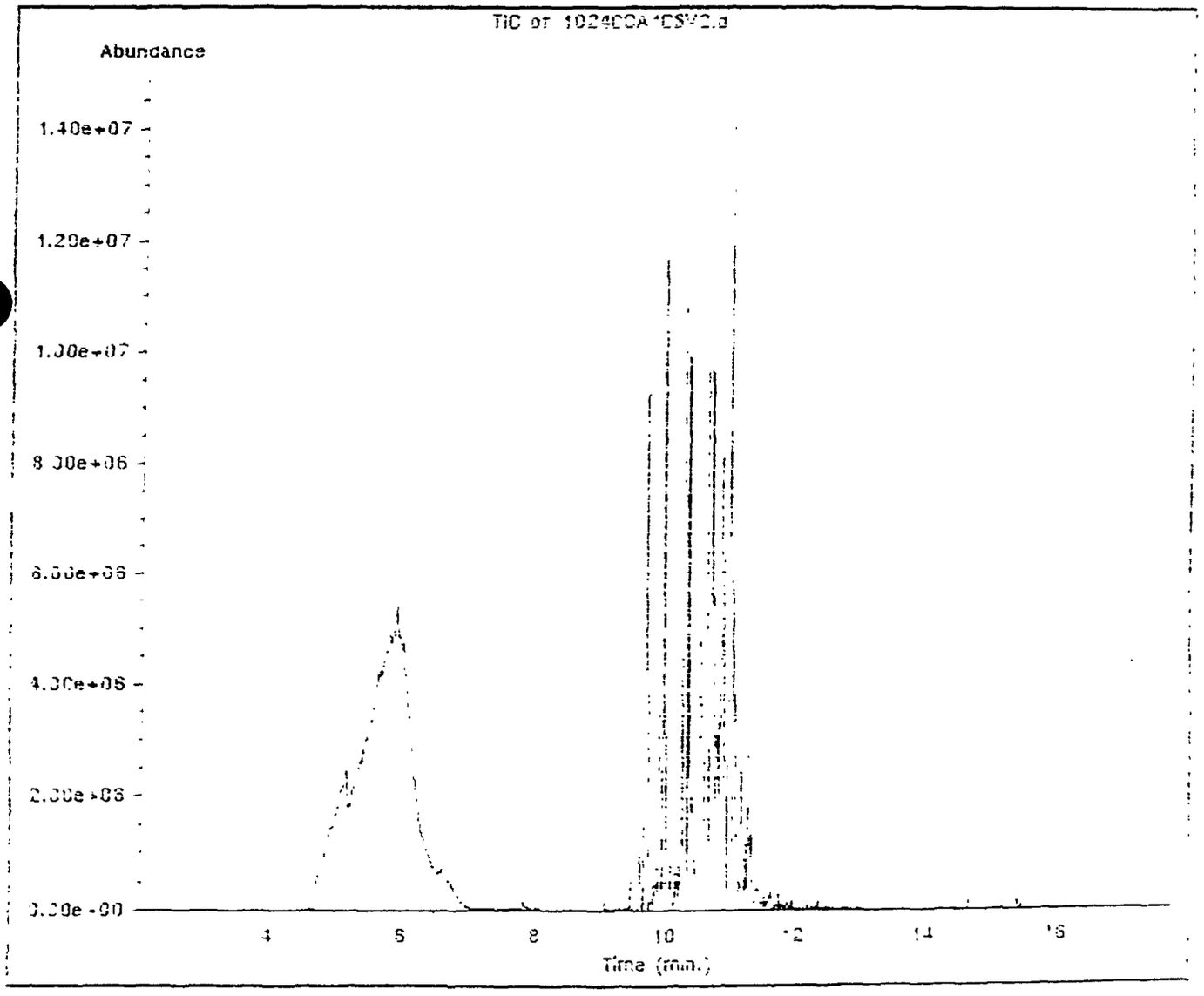


FIGURE 10

TVOC EMISSION PROFILE OF PARTICLEBOARD UNDERLAYMENT COMPARED TO CARPET

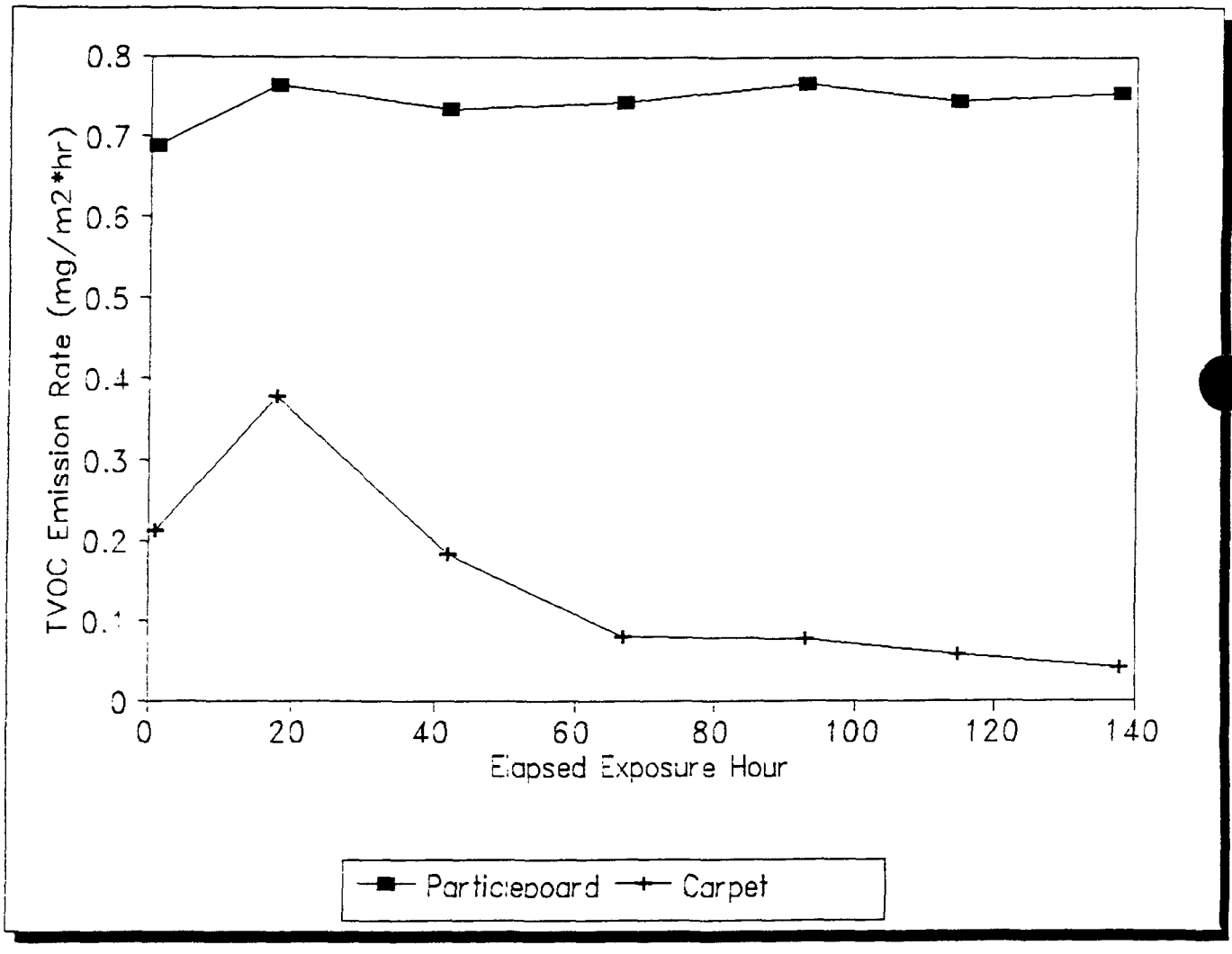


FIGURE 11

TVOC EMISSION PROFILE OF "LOW VOC" ADHESIVE WITH AND WITHOUT CARPET OVERLAY

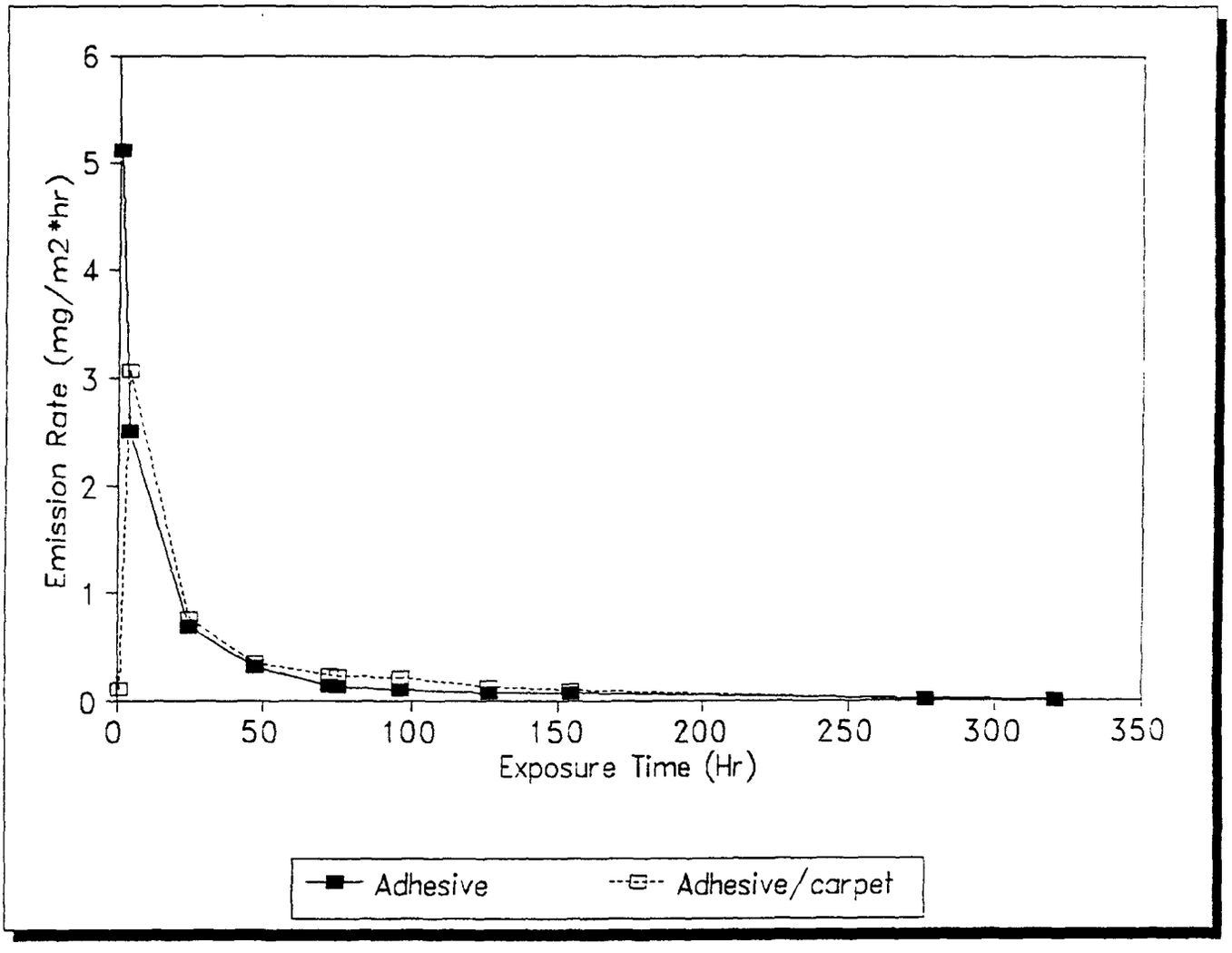


FIGURE 12

TVOC EMISSION RATE COMPARISON OF "CARPET SYSTEM" AND INDIVIDUAL CONTRIBUTORS

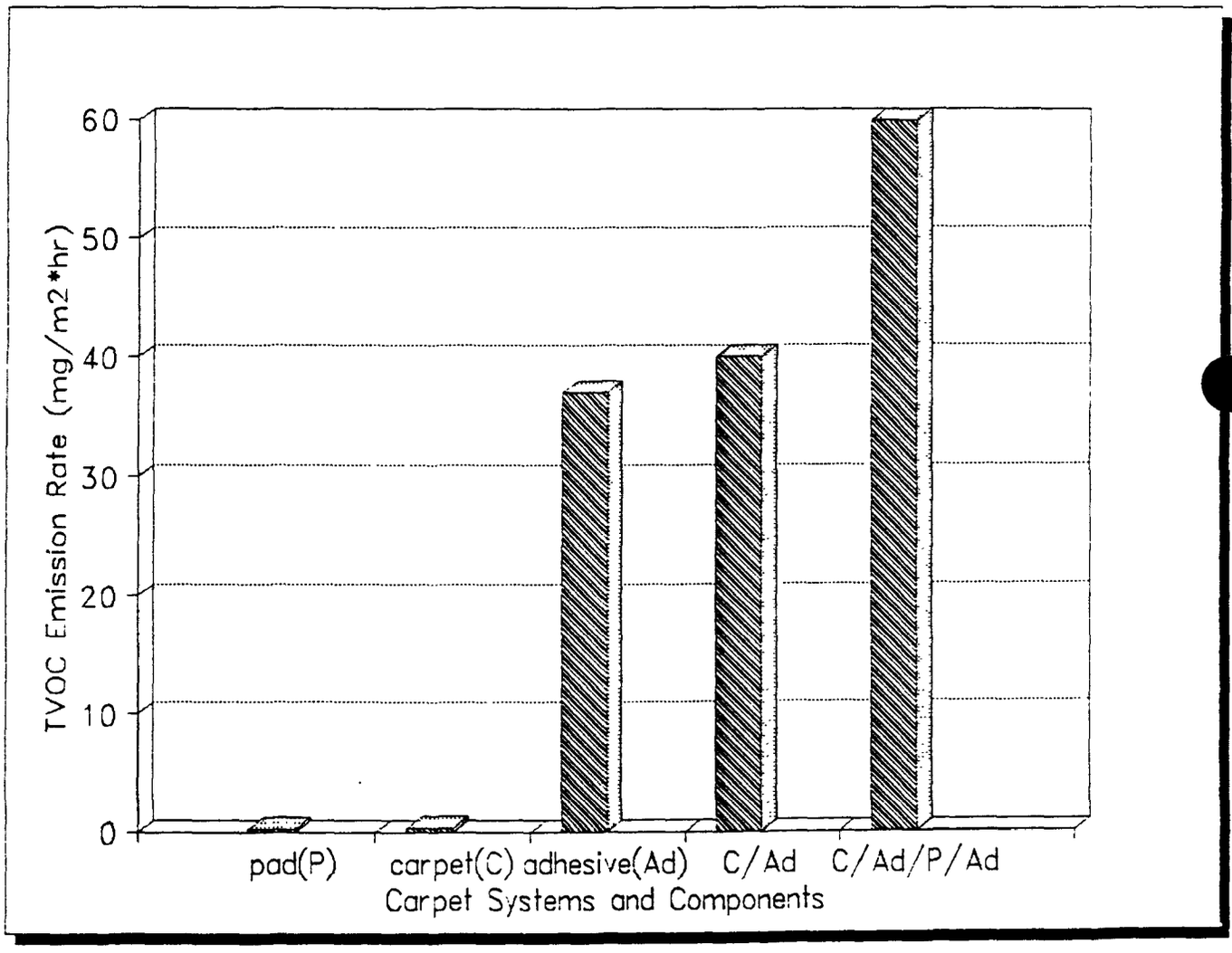
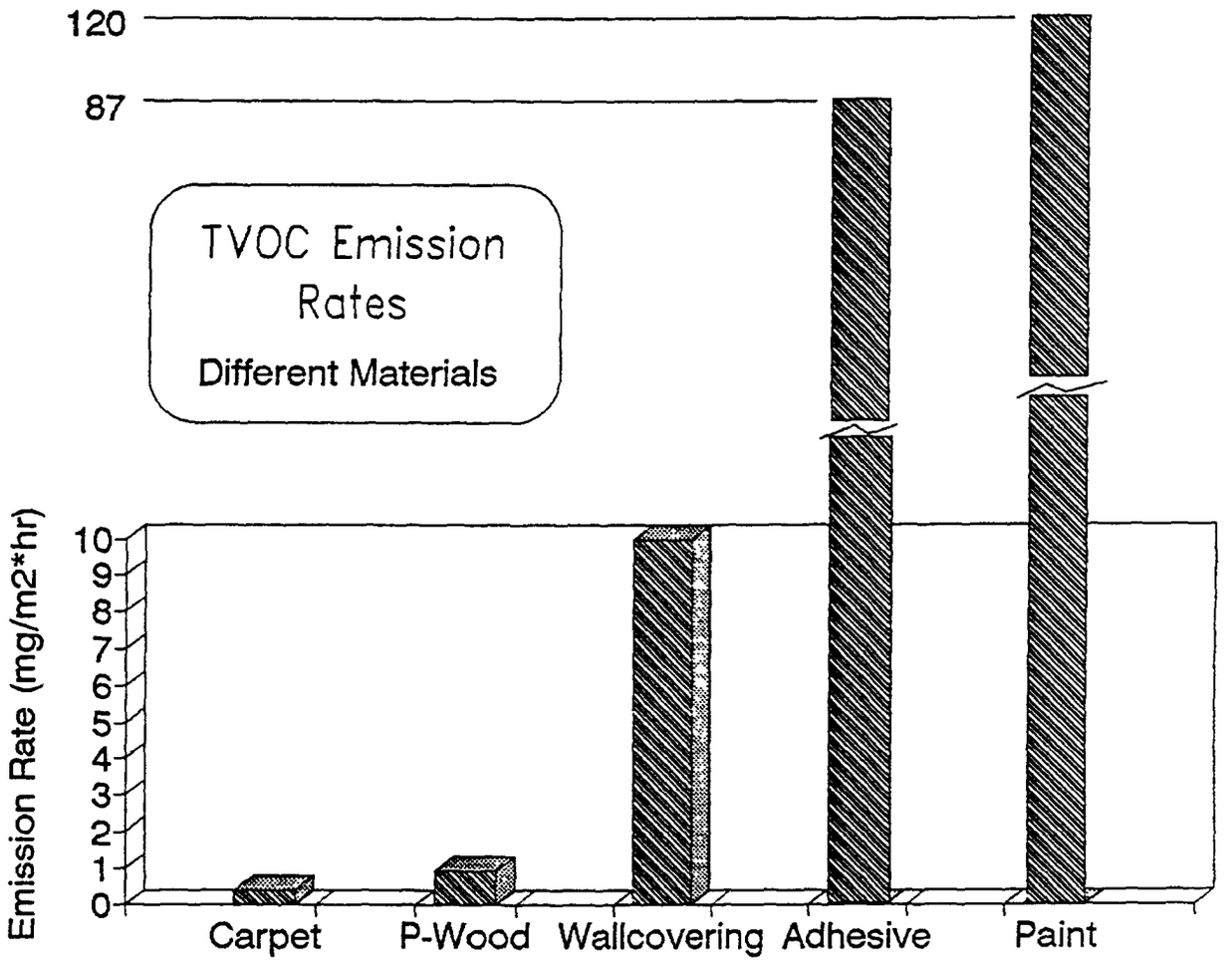


FIGURE 13

COMPARISON OF TVOC EMISSION RATES OF DIFFERENT INTERIOR PRODUCTS



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APPENDIX 1

STANDARD TEST METHOD FOR DETERMINING TOTAL VOLATILE ORGANIC COMPOUND EMISSION RATES FROM FLOORING MATERIALS UNDER DEFINED TEST CONDITIONS USING SMALL ENVIRONMENTAL CHAMBERS

1.0 SCOPE

1.1 The following methodology measures the total volatile organic compound (TVOC) emission rates from flooring materials using test conditions defined to simulate product use in realistic settings, residential and commercial structures. The level of total volatile organic chemical emissions is determined by observing the TVOC concentration in a small environmental chamber under specified test conditions. The observed concentration is then related by a mathematical calculation to an emission rate, a product specific variable. The quantity of TVOC in the environmental chamber air is determined by gas chromatography or gas chromatography/mass spectrometry. The methodology is generally applicable to volatile organic compounds with boiling points from less than 0°C to 290°C emanating from individual flooring materials including carpet, carpet cushions, adhesives, subflooring and associated "installed systems".

1.2 The "generic" standard environmental chamber practices currently described by the U.S. EPA in its document "INDOOR AIR SOURCES: USING SMALL ENVIRONMENTAL CHAMBERS TO CHARACTERIZE ORGANIC EMISSIONS FROM INDOOR MATERIALS AND PRODUCTS," EPA REPORT 600/8-89-074, and ASTM Guide D5116-90, "STANDARD GUIDE FOR SMALL-SCALE ENVIRONMENTAL DETERMINATIONS OF ORGANIC EMISSIONS FROM INDOOR MATERIALS/PRODUCTS," are coupled with "flooring specific" environmental chamber requirements and analytical procedures. These requirements are necessary for the study of TVOC emission rates from carpet and other flooring specific materials if acceptable accuracy and precision are to be achieved.

1.3 The methodology provides a standard means of reproducibly and accurately testing carpet and other flooring materials under a realistic, yet highly controlled, atmosphere.

2.0 REFERENCE DOCUMENTS

2.1 ASTM Guide D5116-90 for Small Scale Environmental Determinations of Organic Emissions from Indoor Materials/Products.

2.2 ASTM Test Method 741 for Determining Air Leakage Rates by Tracer Dilution.

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2.3 ASTM D3195 Recommended Practice for Rotameter Calibration.

2.4 ASTM D1356 Definitions of Terms Related to Atmospheric Sampling and Analysis.

2.5 ASTM E355 Recommended Practice for Gas Chromatography Terms and Relationships.

2.6 ASTM D3609 Practices for Calibration Techniques Using Permeation Tubes.

2.7 Tichenor, "Indoor Air Sources: Using Small Environmental Chambers to Characterize Organic Emissions From Indoor Materials and Products," EPA report 600/8-89-074.

2.8 Matthews, "Environmental Chamber Test Methodology for Organic Vapors from Solid Emission Sources," ATMOS. Env., 21, 1987.

2.9 Tichenor, "Organic Emissions from Consumer Product and Building Materials to the Indoor Environment," J of APCA, 38, 1988.

2.10 Black, "Environmental Chamber Methodology for the Study of VOCs Emitting from Manufactured Products," Proceeding of Indoor Air '90, Toronto, August, 1990.

3.0 TERMINOLOGY

3.1 *Definitions and Terms Specific to This Standard*

AIR CHANGE RATE (ACH). The ratio of the volume of purified and environmentally controlled air brought into the chamber hourly and the chamber volume measured in identical units (typically expressed in air changes per hour (ACH) or hr^{-1}.

EMISSION RATE ($mg/m^2 \cdot hr$). A product specific factor describing the mass of chemical emitted from a product per exposed area of the product per unit time.

ENVIRONMENTAL TEST CHAMBER (ETC). A test apparatus with highly controlled operational parameters designed to realistically provide accurate and reproducible TVOC studies for flooring materials.

LOADING RATIO (m^2/m^3). The ratio of exposed surface area of the test product and the free chamber volume, measured as m^2/m^3.

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4.0 SIGNIFICANCE AND USE

4.1 The minimization of VOC emissions from interior products and processes has been suggested as a prudent step in reducing human exposures to chemical emissions.

4.2 Architects, interior designers, indoor air consultants and those involved with the design of new construction and building refurbishing are specifying allowable VOC emissions from products and interior activities.

4.3 This methodology provides a standard means of testing carpet and other flooring materials under realistic product loadings with operational parameters and environmental conditions consistent with a product's end use.

4.4 The method incorporates a small environmental chamber, 0.05 m^3 in size to evaluate the level of TVOC in the flooring materials over a specified duration of time. Environmental chambers larger in size may be used if acceptable correlation with the latter chamber is shown (correlation coefficient greater than 0.95). Conditions controlled in the method include:

4.4.1 Sample collection and packaging to preserve the product's manufactured chemical integrity;

4.4.2 Sample preparation in a realistic presentation for individual materials and "installed systems";

4.4.3 Conditioning of the product or system prior to obtaining the test value;

4.4.4 Exposed surface area of the product being tested;

4.4.5 Environmental test chamber construction and operation;

4.4.6 Environmental test chamber temperature and moisture content;

4.4.7 Environmental test chamber air changes per hour;

4.4.8 Air circulation and velocity within the test chamber;

4.4.9 Accuracy and precision control of the chamber system; and

4.4.10 Accuracy and precision of the analytical measurements.

4.4.11 Sample archiving.

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4.5 The test procedure employs a single set of experimental parameters to assess the TVOC emissions of certain carpet and associated flooring materials. Care must be exercised in the extension of the results to actual TVOC emissions under different conditions. This method provides an accurate and precise comparison of TVOC levels from different products intended for the same use.

4.6 The test method permits variance of experimental parameters to assess TVOC emissions of carpet and associated flooring materials under different usage situations. Parameters which can be independently controlled include air temperature, air moisture level and air exchange rate.

5.0 THE ENVIRONMENTAL CHAMBER

5.1 The interior volume of the environmental chamber should be a minimum of 0.05 m^3. The interior must be constructed of inert smooth stainless steel and must assure that a representative TVOC mixture is not irreversibly retained on the interior surfaces. Recovery rates of a representative mixture of TVOCs including methanol, toluene, cyclohexane and decane must be greater than 95% at a mixture concentration of 40 $\mu g/m^3$. All joints of the chamber must be permanently sealed except those absolutely necessary, i.e. the opening for loading and unloading the sample and environmental probes. These ports must have a self sealing capacity comprised of non-VOC emitting and non-VOC adsorbing/absorbing materials.

5.2 The air within the chamber must be free of any obstructions or contamination such as fans, humidifiers or coils. The internal air must only come in contact with the inert chamber walls, the air diffusion system, which includes inlet and outlet ports and environmental measurement devices.

5.3 Internal air velocity within the chamber must be reproducibly maintained in the range of 0.1 m/sec which is typical of the occupied zone of interior spaces. As discussed in ASTM Guide D5116-90, reference document 2.1, the air velocity near the surface of the product being tested can affect the mass transfer coefficients of the organic chemicals emitting from the product. Control must be exercised to ensure that the air velocity at the surface of the product being tested is maintained within the suggested range of 0.1 m/sec. The air mixing mechanism must also be well controlled.

5.4 Internal chamber air must be well-mixed and must comply within 5% of the theoretical well-mixed model. A discussion of this evaluation is given in reference document 2.1, ASTM Guide D5116-90. It is recommended that SF6, or an other inert gas, be used as a tracer gas to determine compliance with the theoretical curve. A known concentration and constant supply of SF6 is

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introduced into the chamber, and the chamber concentration of SF6 versus time profile is measured. Mathematically, this experimental curve should comply within a 5% relative standard deviation of the theoretical curve.

This mixing evaluation should be confirmed with the flooring mounting substrate in place. An empty chamber may not give a realistic representation of the air mixing within the chamber during actual testing.

5.5 Clean air must be generated as the chamber supply air. It is necessary that the supply air backgrounds be sufficiently low to achieve statistically meaningful analytical measurements at the levels anticipated. Purified air must not have a background contributing concentrations greater than 2.0 $\mu g/m^3$ of TVOC with any individual VOC not contributing more than 2.0 $\mu g/m^3$.

Supply air must be accurately and reproducibly metered to the chambers, and maintained at a rate of 1.00 ± 0.05 (standard deviation) air changes per hour. The accuracy of this air exchange rate must be confirmed using ASTM method 741 for tracer gas applications, and found to have less than 10% relative error.

5.6 Other environmental conditions must be maintained reproducibly within the ETC environment including;

Temperature at 25°C ± 0.5°C (standard deviation)

Relative Humidity at 50% ± 2% (standard deviation)

Acceptable accuracy levels are 5% average relative error based on twelve measurements over a 24 hour period as measured within the ETC supply air.

5.7 The chamber must be operated under slight positive pressure (1+ inches of water) relative to atmospheric pressure.

5.8 Sample ports must be affixed to the outlet exhaust of chamber in a manner that does not produce a backpressure effect on the chamber flow. The sampling protocol must not pull over more than 50% of the outlet air flow.

5.9 A process control system must be used to maintain the exactness required of the chamber control, and continuous monitoring and data logging of the chamber operating parameters must be maintained and available at frequent intervals.

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6.0 SAMPLE HANDLING

6.1 The primary intent of a well-defined sample handling procedure is to ensure preservation of the sample's chemical integrity. This process involves defined and controlled procedures encompassing sample collection, sample packaging, sample delivery to the testing facility and storage of the sample prior to testing. All of these parameters are important once the sample has been collected and until it is tested.

6.2 *Sample Collection.*

6.2.1 The collected sample must ensure accurate representation of the actual performance parameter being evaluated. Since the measured performance factor, in this case, is TVOC, its composition must be retained and uncontaminated during all the phases of the sample handling process. Because of the very low levels of TVOC associated with carpet products, it is recommended that the carpet and associated materials be collected directly from the manufacturer's production line, and packaged immediately. This is the only way to ensure that original sample integrity is maintained.

6.2.2 In actual building usage applications, one may wish to more closely simulate the handling of the product prior to its delivery to a job site. This may be attempted if the handling procedures are known, but it may be very difficult to control. There would be no assurance that the TVOC levels and composition of the product after this type of treatment would be product specific TVOCs. This approach is not recommended for product specific information. Contamination of the carpet and its associated products may occur by atmospheric exposure, activities and materials during this type of preparatory stage.

6.2.3 For rolled materials such as broadloom carpet and cushions, the sample should be collected as a minimum size of 2 ft. by 2 ft. This will allow for rolling of the product so that there is an internal layer from which a minimum of two samples can be collected from the internal product roll. Other products such as carpet tile should be obtained and packaged so that one internal piece is sandwiched between two outer pieces. Any other solid or liquid material, such as adhesive, should be placed from the manufacturing facility into appropriately clean and sealed metal containers, protecting it from the external atmosphere.

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6.3 ***Sample Packaging.***

It is essential to package the product with materials which will not contaminate the product nor allow VOC permeability from either the interior or exterior. An aluminized packaging (shiny side out) lined with polyethylene or Tedlar is recommended. The sample background on the packaging material, as tested according to this protocol, must have a consistent TVOC background level less than 0.005 $mg/m^2 \cdot hr$.

6.4. ***Product Delivery and Storage.***

Once the sample is collected and packaged, it must arrive at the testing facility ASAP, with a maximum allowable delivery time of 36 hours following collection. It should then be stored in its packaged state in an environmentally controlled interior space for a maximum period of 8 hours prior to testing. The sample is to remain sealed until it is to be tested. There should not be any preliminary observation of the sample.

6.5 ***Product Storage.***

Following testing, the product should be repackaged and stored for a 6 month time period by the testing facility. This storage should be maintained in an environmentally conditioned interior environment. The test specimen packaging must be air-tight and VOC free as required of the original packaging with a VOC background less than 0.005 $mg/m^2 \cdot hr$.

7.0 PREPARATION OF THE PRODUCT TEST SYSTEM

7.1 The sample must be prepared in a realistic manner. The universal test mount substrate should be concrete, the most universal in commercial and the most inert substrate of all sub-flooring materials. If prepared and cured properly, the concrete will be a non-TVOC source and will not present a problem in the analysis. A stainless steel plate may be used for the carpet cushion material or other solid material if it is tested alone. The stainless steel plate cannot be used for adhesive. The mounting must have the ability to seal the edges of the test specimen or entire mounting block. A stainless steel edge sealer is recommended for this.

Other substrates such as particleboard underlayment or plywood, the most common in residential homes, or other materials, such as resilient flooring, may be used. However, these flooring systems will contribute VOCs and complicate the studies, since they too will be emitters of VOCs. A background control of their VOC emissions must be obtained so that the product test results may take the substrate contributions into account.

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APPENDIX 1
Page 8

7.2 The flooring material must be prepared to comply with a loading ratio of 0.41 m^2/m^3. This loading is based on a standard ceiling height of 2.4 m allowing complete floor coverage with the material being tested. The flooring must be laid on the appropriate sub-flooring (concrete, the standard) and tested as a complete package. The edges of the flooring system, including the sub-flooring and carpet, must be sealed or considerable error could be incurred in the analysis.

Once the appropriate system has been prepared, it should be immediately loaded into the test chamber for conditioning and testing.

7.3 Each flooring material, i.e. carpet, cushion, adhesive, etc. must be evaluated independently for accurate product-specific emission data to be obtained.

Installation systems of specific products may be assembled and tested, but individual product specific information will not be obtainable. It is simply a "whole" or complete system emission description. If the total system as well as component contributions are required information, then each component and the "whole" will have to be tested.

It is suggested that all component pieces be tested simultaneously in order to avoid aging effects on the individual component contributions to the whole.

7.4 The standard assembly for component testing will be that component installed on the concrete sub-flooring, i.e. carpet on concrete, cushion on concrete, adhesive on concrete, each with the edges sealed. The other floorings, as mentioned in 7.1, may be used if specified for special applications.

7.5. If system installation studies are required, the following combinations are standard:

carpet on sub-flooring, no adhesive or cushion;

carpet on sub-flooring with adhesive (direct glue down);

carpet on sub-flooring with cushion, no adhesive; and

carpet on subflooring with cushion and adhesive (double glue down).

These installations and systems should be prepared according to the manufacturer's instructions and the use of CRI's Installation Guide for Commercial and Residential Structures, CRI Publications 104 and 105. The manufacturer's instructions should have priority, if available.

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8.0 ENVIRONMENTAL CHAMBER TESTING PROTOCOL

The testing should be conducted in environmental chambers. These chambers must be constructed and designed to evaluate ultra-trace levels of organic compounds. Chamber test conditions must be controlled if accurate and reproducible data is to be obtained.

8.1 *Procedure*

8.1.1 The test chamber shall be purged prior to loading under normal operating conditions, but without the test specimen. A chamber background test conducted on the chamber must confirm a TVOC background level less than 2.0 $\mu g/m^3$ with any individual VOC not contributing more than 2.0 $\mu g/m^3$. Once that is ascertained, the chamber may be opened and loaded.

8.1.2. The test specimen is prepared immediately prior to loading, and is subsequently loaded into the chamber so that it is centered and does not interfere with the flow of the supply air.

8.1.3. The standard test chamber operating parameters are:

1.00 ± 0.05 (standard deviation) Air Changes per Hour

50 ± 2% (standard deviation) Relative Humidity

25°C ± 0.5°C (standard deviation) Temperature

8.1.4. The test specimen is loaded so that the square area of the exposed surface to chamber volume ratio of 0.41 m^2/m^3 is achieved. All edges of the test specimen are sealed. The test specimen is allowed to equilibrate within the chamber for a 24 hour period, immediately after which the first test sample is taken. For one point in time testing, the 24 hour point is used. In that case, duplicate samples are collected.

8.1.5. For those tests requiring other exposure points such as the change in emission profile over time, additional samples are taken. Sample collection points for dry materials should include at a minimum 6 data points for example, 4 hour, 8 hour, 24 hour, 48 hour, 120 hour, 168 hour. Wet materials may require additional weekly test points after 168 hours until measured levels in the desired range are achieved.

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8.1.6. Prior to sample collection, the sampling lines are purged for a total of 5 times their volume. The sampling line length should be minimized to reduce potential sample loss. In addition, the sampling lines should be heated if high boiling compounds (>150°C) are expected in the emissions.

9.0 CHEMICAL ANALYSIS

9.1 *Chamber Air Collection.*

The low levels of VOCs associated with flooring materials require a significant pre-concentration of the air prior to chemical analysis. A multi-bed sorbent trap containing Carbosieve SIII, Carbotrap C, and Carbotrap, is recommended for this purpose. The adsorbents are selected based on the actual compounds present in the air sample. The adsorbents selected must provide greater than 90% collection and desorption efficiencies for the majority of the chemicals present in the product emissions under the test conditions established for sample collection and analysis. Any other sorbent system meeting these requirements may be used.

Actual sorbent traps must be conditioned in the laboratory making sure that they are purified and contain no greater than 9 ng of TVOC.

9.2 *Organic Instrumentation.*

The TVOC analysis must be conducted by capillary gas chromatography coupled with flame ionization detection or mass spectrometric detection. Sensitivity is comparable between mass selective detectors and the flame ionization detectors, and the compounds associated with the flooring materials respond well to both detector systems. If individual compounds are to identified, a mass spectrometer must be used as the detector. The air sample must be efficiently desorbed from the sample sorbent tube to the analytical instrumentation via a well-controlled, reproducible thermal desorption system.

9.3 *Standard Operating Procedures.*

The laboratory must present Standard Operating Procedures (SOPs) for all aspects of the analytical procedures with confirmation of their compliance with the detection capability and established QC parameters. The SOP should address:

9.3.1 Assembly, calibration and operation of the sampling system;

9.3.2 Preparation, handling and storage of the sorbent collection media;

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9.3.3 Description and operation of the instrumentation systems including the sampling device, sample introduction system, separation chemistry, and data system;

9.3.4 All aspects of data recording and processing;

9.3.5 The operating procedures should be specific and be readily available to those involved in the analysis and testing.

9.4 Quantitation of the analytical system is with a TVOC mixture representative of the types of VOCs present in the sample. A standard mixture containing hexanol, toluene, cyclohexane, and decane is recommended. The average mass response of this mixture is used for quantitation. This mixture must be introduced as a gas into the analytical system and be subjected to the same processes as the sample. Internal usage of perfluorotoluene or bromofluorotoluene is recommended to trace instrumental system performance.

9.5 ***Method Accuracy and Precision.***

The requirements for those representative compounds included in the TVOC mix are greater than 90% recovery (incorporating sample collection through analysis) and less than 10% relative standard deviation. Any deviations beyond these are unacceptable. The minimal quantifiable limit is 4.0 $\mu g/m^3$ which is twice the required detection limit of 2.0 $\mu g/m^3$ (or an absolute value of 36 ng with no individual compound exceeding 9 ng).

9.6 ***Method Detection Limit.***

The system detection limit is obtained from calibration standards and is defined as:

$$DL = A + 3.3\ s$$

where DL = the calculated detection limit in nanograms,
A = the intercept from a least squares calibration curve fit, and
S = the standard deviation of replicate determinations of the lowest level standard.

The minimal quantifiable limit is twice the detection limit or 4.0 $\mu g/m^3$ which is twice the detection limit of 2.0 $\mu g/m^3$ or 36 ng TVOC. The quantifiable limit is 0.01 $mg/m^2 \cdot hr$ emission rate.

9.7 All detected mass responses corresponding to the quantifiable limit should be summed and used in the TVOC determination. Calibration is by TVOC mixture response factors as determined from a calibration curve.

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10.0 EMISSION RATE CALCULATIONS

10.1 *The 24 hr. One Point in Time Test.*

This emission factor (ER_{24}) should be calculated as:

$$ER_{24} = C(N/L) = mg/m^2 \cdot hr$$

where N = chamber air exchange rate, hr^{-1}
L = Product Loading, m^2/m^3
C = 24 hr. chamber concentration, mg/m^3

10.2 For those studies involving the change in emission levels over a defined test period, determine the initial emission rate (ER_0) and the rate constant (k) by fitting the chamber concentration versus time date to the equation:

$$C = A(ER_0)(e^{kT}-e^{-Nt})/(N-k)$$

where C = chamber concentration, mg/m^3
A = product area, m^2
ER_0= initial emission rate, $mg/m^2 \cdot hr$
e = natural log base
k = first order rate constant, h^{-1}
t = time, hr
N = Air change rate in hr^{-1}

The total predicted emission over the lifetime of the product is:

$$ER_0/k = \mu g/m^2$$

This assumes a decreasing emission rate with time. Any other type of emission pattern will require a different calculation based on an appropriate mathematical model.

11.0 QUALITY CONTROL AND ASSURANCE

11.1 A quality control/assurance plan is designed to ensure the integrity of the measured and reported data obtained during its product evaluation studies. This program encompasses all facets of the measurement program from sample receipt to final review and issuance of reports.

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11.2 Various measures should be routinely implemented in a product evaluation program including, but not limited to:

appropriate record keeping of sample identifications and tracking throughout the study;

calibration of all instrumentation and equipment used in the collection and analysis of samples;

tracking of all chamber and analytical performance parameters including air purification, environmental controls, air change rate, sample recovery, detection capability and background levels;

analysis of spiked samples for accuracy determinations;

duplicate analyses of 10% of all samples evaluated and analyzed;

linear regression of all standardization;

analysis of controls including chamber backgrounds, sampling media, and instrumental systems;

quality control charting of operational and analysis parameters; and

periodic audits by appropriate QA personnel.

12.0 REPORT FORMAT

The report should contain all pertinent information including:

testing laboratory name, address and contact person;

testing objectives;

date of sample arrival;

sample identification and description;

sample handling procedures;

testing preparation procedures for the product;

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experimental protocol including conditioning and testing;

test date and exposure duration;

data analysis procedures;

test results as required by the objective;

accuracy and precision bounds of test results;

analytical instrumentation and analytical methodology;

operational parameters and performance specifications of chambers and instrumentation;

quality control assurance procedures and data.

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