DoD EPA DOE SERDP
Strategic Environmental Research and Development Program

Improving Mission Readiness through Environmental Research

EPA-600/R-96-117
September 1996

POLLUTION PREVENTION DEMONSTRATION AND EVALUATION OF PAINT APPLICATION EQUIPMENT AND ALTERNATIVES TO METHYLENE CHLORIDE AND METHYL ETHYL KETONE

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EPA Contract No. 68-D4-0120

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Prepared for:

U. S. Environmental Protection Agency
Office of Research and Development
Washington, D.C. 20460

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before comple

1. REPORT NO.	2.	3.
EPA-600/R-96-117		PB97-104632

4. TITLE AND SUBTITLE	5. REPORT DATE
Pollution Prevention Demonstration and Evaluation of Paint Application Equipment and Alternatives to Methylene Chloride and Methyl Ethyl Ketone	September 1996
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) J. M. Elion, J. B. Flanagan, J. H. Turner, J. T. Hanley, and E. A. Hill	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Research Triangle Institute P.O. Box 12194 Research Triangle Park, North Carolina 27709	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 68-D4-0120
12. SPONSORING AGENCY NAME AND ADDRESS **EPA, Office of Research and Development** **Air Pollution Prevention and Control Division** **Research Triangle Park, NC 27711**	13. TYPE OF REPORT AND PERIOD COVERED Final; 1-2/95 14. SPONSORING AGENCY CODE **EPA/600/13**

15. SUPPLEMENTARY NOTES APPCD project officer is J. Kaye Whitfield, Mail Drop 61, 919/ 541-2509.

16. ABSTRACT The report gives results of demonstrations of technologies to prevent or control emissions of hazardous air pollutants (HAPs) and volatile organic compounds (VOCs) from processes with high-solvent usage (1) paint stripping using methylene chloride, (2) cleaning paint equipment with methyl ethyl ketone (MEK), and (3) applying paint by spraying solvent-borne coatings. In demonstration (1) N-methyl pyrrolidone was chosen to replace methylene chloride because it effectively removed Chemical Agent Resistant Coatings (CARCs) in laboratory tests, is nonflammable, and is not classified as a HAP by EPA. This substitution will lower HAP emissions 11% from 1992 levels. In demonstration (2) a blend of 40% propylene carbonate and 60% benzyl alcohol (PC/BA), by weight, was chosen to replace MEK. This substitution will lower emissions from HAPs 21% from 1992 levels. The objective of demonstration (3) was to determine if the amount of paint applied to a vehicle could be decreased by providing the painters with a real-time readout of the amount of paint they were using. Results showed that, for identical vehicles, differences up to 30% in the amount of paint used occurred, indicating that potential exists for significant reductions. No actual reductions were shown during the demonstration.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Methyl Ethyl Ketone	Pollution Prevention	13B
Paint Removers	Monitors	Stationary Sources	11K 14G
Painting		Paint Stripping	13I
Chloromethanes		N-Methyl Pyrrolidone	07C
Paint Applicators		Methylene Chloride	
Paint Thinners		Paint Equipment Cleaning	11C
Benzyl Alcohols			

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release to Public	**Unclassified**	334
	20. SECURITY CLASS (This page) **Unclassified**	22. PRICE

EPA Form 2220-1 (9-73)

NOTICE

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FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for reducing risks from threats to human health and the environment. The focus of the Laboratory's research program is on methods for the prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites and groundwater; and prevention and control of indoor air pollution. The goal of this research effort is to catalyze development and implementation of innovative, cost-effective environmental technologies; develop scientific and engineering information needed by EPA to support regulatory and policy decisions; and provide technical support and information transfer to ensure effective implementation of environmental regulations and strategies.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

ABSTRACT

The purpose of this project was to demonstrate on a full production scale at the Marine Corps Logistics Base (MCLB) in Albany, GA, pollution prevention technologies to prevent or control emissions of hazardous air pollutants (HAPs) and volatile organic compounds (VOCs). The three processes with high solvent usage selected for demonstration were:

- stripping paint by immersion in methylene chloride,
- cleaning paint equipment with methyl ethyl ketone (MEK), and
- applying paint by spraying solvent-borne coatings.

For the first demonstration, n-methyl pyrrolidone (NMP) was chosen to replace methylene chloride because it effectively removed Chemical Agent Resistant Coatings (CARC) in laboratory tests, is nonflammable, and is considered by the EPA not to be a hazardous air pollutant (HAP). The operators were trained how to operate the new process and equipment, and maintain the system. For the rest of the demonstration period, the operators used the NMP tank for normal stripping operations.

The implementation of NMP eliminates a major source of HAP emissions at the MCLB. The NMP, when heated to 150° ±10°F, was able to remove multiple layers of CARC and strip parts to the base metal within 3-4 hours. The heated NMP was able to successfully remove Plastisol®, a plastic coating, from battery tie-down brackets. The NMP was able to soften epoxy-based topcoats, but removal usually required overnight soaking. The annualized costs for NMP stripping are lower than for methylene chloride stripping, but implementation requires high capital investment. This substitution will lower HAPs 11% from 1992 levels.

For the second demonstration, a blend of 40% propylene carbonate and 60% benzyl alcohol (PC/BA), by weight, was chosen to replace MEK based on the results of laboratory screening, materials compatibility, and paint removal efficiency tests. MCLB used this solvent as a direct replacement for MEK. No capital investment was required.

Based on the demonstration, PC/BA cleans green CARC from the pumps as well as MEK, and cleans epoxy primers better than MEK. Advantages of using PC/BA are lower vapor pressure, reduced solvent use and reduced labor time for cleaning, and classification of the hazardous waste as non-RCRA regulated. The disadvantage is a higher cost for the PC/BA blend than for MEK. This substitution will lower emissions from HAPs 21% from 1992 levels.

For the third demonstration, the task objective was to determine if the amount of paint sprayed to paint a vehicle could be decreased by providing the painters with a real-time read out of how much paint they use. The study began with the design, specification, purchase, and installation of a paint monitoring system in one of MCLB's paint booths. The system monitors paint use gravimetrically by continuously monitoring the weight of the 5-gallon paint pot from which the paint is pumped to the spray guns.

The system proved to work reliably, and paint usage measurements were obtained on a total of 19 vehicles: 10 HMMWVs, 5 cargo trucks, and 4 other vehicles. The measurements show that, for identical vehicles, differences up to 30% in the amount of paint used occurred indicating that potential exists for significant reductions.

This report is submitted in partial fulfillment of Contract No. 68-D4-0120 by Research Triangle Institute under sponsorship of the U.S. Environmental Protection Agency. This report covers the period from October 1994 to December 1995.

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SECTION 1: INTRODUCTION

The Clean Air Act Amendments of 1990 (CAAA) and Executive Order 12856 mandate that military depot activities reduce air emissions. Specifically, the CAAA requires a reduction in hazardous air pollutant (HAP) emissions for major sources and Executive Order 12856 requires that military installations reduce HAP emissions by 50% of their 1992 levels. Accordingly, the U. S. EPA and the U. S. Marine Corps Logistics Base (MCLB), Albany, GA, with sponsorship from the Strategic Environmental Research and Development Program (SERDP), conducted an initial evaluation and subsequent demonstration of pollution prevention (P2) technologies for reduction of HAPs. Processes and related high solvent usage sources were identified and P2 recommendations were made. U. S. EPA and MCLB, the host facility, performed the research. Research Triangle Institute (RTI) personnel provided contractor support.

MCLB carries out maintenance activities on a wide variety of equipment from small arms to tanks, trucks, and other vehicles. Much of the maintenance on the vehicles requires removing existing paint prior to repair procedures and applying new paint once the maintenance has been performed. The processes for paint stripping, repainting, and cleaning of paint equipment release significant amounts of HAPs.

The purpose of this research was to demonstrate the P2 technologies on a full production scale at the MCLB. Three processes with high solvent usage were selected for demonstration:

- stripping paint by immersion in methylene chloride,
- cleaning paint equipment with methyl ethyl ketone (MEK), and
- applying paint by spraying solvent-borne coatings.

For the first demonstration, n-methyl pyrrolidone (NMP) was selected as the alternative to methylene chloride for stripping cured coatings from metal parts. NMP was chosen during a scoping study for the facility demonstration because it effectively removed Chemical Agent Resistant Coatings (CARC) in laboratory tests, is nonflammable, and is considered by the EPA not to be a HAP. Two drawbacks are that the NMP must be heated to be effective, and NMP is subject to reporting under the Superfund Amendments and Reauthorization Act (SARA).

The first step in preparing for the demonstration was to retrofit an existing tank at the

Base. The stripping tank required plumbing to heat the bath with steam, and a recirculating pump to provide enough agitation to ensure uniform temperature throughout the bath. An adjacent rinse tank required a pump to draw recycled NMP for rinsing stripped parts. Finally, a vacuum distillation unit was installed to reclaim used solvent from the stripping bath and provide recycled NMP for rinsing. After the tank retrofit was completed, the heating and recirculating systems were tested using water. The stripping tank was then emptied and filled with an initial charge of 32 55-gal. (208 L) barrels of technical grade NMP. An additional 16 barrels was added to the stripping tank during the course of the demonstration.

The NMP, when heated to 150 ±10°F (66 ±6°C), was able to remove multiple layers of CARC and strip parts to the base metal within 3-4 hours. The heated NMP was able to successfully remove Plastisol®, a plastic coating, from battery tie-down brackets. These parts were previously stripped in a hot alkaline bath, followed by scraping and blasting to remove the coating. The NMP was able to soften epoxy-based topcoats, but removal usually required overnight soaking.

For the second demonstration, a blend of propylene carbonate and benzyl alcohol was chosen to replace methyl ethyl ketone (MEK) for cleaning the paint application equipment (pumps, hoses, and guns). This demonstration consisted of a preliminary screening to identify several possible solvent alternatives, testing to select the most effective cleaners, and full-scale demonstration at the MCLB.

Sixty-five alternative cleaners were tested in preliminary screening for their effect on fully cured single- and plural-component CARCs and an epoxy primer. From these 65 alternatives, 5 were selected for further testing. The cleaners were tested for their compatibility with materials that would come in contact with the paints and the cleaner. No measurable weight gain or loss, pitting, or other signs of corrosion were found between any of the five cleaners or MEK and the four metals tested: aluminum, stainless steel, nickel, and brass. Material compatibility was also tested with four plastics (Teflon®, acetal, Nylon®, and Delrin®). Results showed slight weight changes in all coupons tested with the five cleaners and with MEK. Of the five cleaners, the two showing the least overall weight gain or loss for the four plastics were evaluated for paint removal efficiency in a laboratory setting. Overall, both of the cleaners were comparable to MEK for

CARC, and both cleaners were better than MEK at removing the white primer.

Based on the test results, the blend of 40% propylene carbonate and 60% benzyl alcohol (PC/BA) by weight was selected by EPA, MCLB, and RTI for demonstration. Subsequently, four barrels of this cleaner were shipped to the base and the cleaner was used as a direct replacement for MEK. No capital investment was required.

Use of the PC/BA cleaner was monitored by weighing the amount of cleaner flushed through the system. Amounts of cleaner used for the initial prewash, the final wash, and the filter wash were recorded. Date and time at the start and finish of each step were also recorded.

Results showed that PC/BA cleans green CARC from the paint spray pumps as well as MEK, and cleans epoxy primers from the pumps better than MEK. Advantages of using PC/BA are lowered inhalation hazard to workers, reduced cleaner usage and labor time for cleaning. Other advantages are that the PC/BA is non-RCRA regulated and use of PC/BA significantly decreases downtime of the primer pumps. The disadvantage is a higher cost for the PC/BA blend than for MEK. The higher cost may be offset by cleaner recovery and reclamation, and further waste reduction.

For the third demonstration, the objective was to determine if the amount of paint required to coat a vehicle could be reduced by providing the painters with a real time readout of how much paint they use. The study began with the design, specification, purchase, and installation of a paint monitoring system in a paint booth. The system monitored paint use gravimetrically by continuously measuring the weight of the 5-gallon paint pot that held the paint to be pumped to the spray guns. The system included programmable digital scales, a small printer, and large remote displays visible from within the paint booth. Displays continuously showed the cumulative amount of paint used.

The initial portion of the test period was devoted to baseline or control measurements taken “without feedback” of paint consumption. During this period, the displays were not visible to the painters. After sufficient baseline information had been gathered, the displays were installed in the paint booth and the painters were instructed in how the displays could be used to control their usage rate. “Target” levels for High Mobility Multipurpose Wheeled Vehicles (HMMWVs) and 5-ton trucks were set based on the lowest usage during the baseline period.

The system proved to work reliably, and paint usage measurements were obtained on a total of 19 vehicles: 10 HMMWVs, 5 5-ton cargo trucks, and 4 other vehicles. The measurements show that, for one set of identical vehicles (the 10 HMMWVs), paint consumption differed by up to 30% between the highest and lowest vehicles. This indicates that a potential for significant reductions may exist. However, during the brief study period, no statistically significant decrease in paint usage was seen between the baseline (without feedback) and the experimental (with feedback) portions of the demonstration. This may be due to the short duration of the demonstration and to the presence of monitoring personnel at the paint booth during the baseline period. However, the system could still provide reductions in paint usage and other benefits when used in combination with other strategies such as mixing only the amount needed for each vehicle rather than the current practice of mixing paint in multiples of 5 gallons. The system could also be used to assist in training new employees, and to assess the impact of equipment inspection and maintenance practices on paint consumption.

The recommendation for MCLB is to continue to collect paint usage data for a period of several months to determine if measurable reductions in paint usage are realized after the staff becomes accustomed to the equipment.

The MCLB has already replaced 1,1,1-trichloroethane vapor degreasers with aqueous parts washers. This change alone will reduce emissions from HAPs by 16%. By eliminating the methylene chloride for immersion stripping, the MCLB can reduce emissions another 11%. By replacing methyl ethyl ketone with a propylene carbonate/benzyl alcohol blend for cleaning paint application equipment, the MCLB can reduce emissions from HAPs an additional 21%. These three changes combined result in a reduction of emissions of 48%. The MCLB plans to replace solvent-borne CARCs with water-borne CARCs in 1996 to achieve over 50% reduction in emissions from HAPs.

SECTION 2:

DEMONSTRATION OF
N-METHYL PYRROLIDONE AS A PAINT STRIPPING ALTERNATIVE

By:

**J. M. Elion, J. B. Flanagan,
E. A. Hill, and J. H. Turner**

ABSTRACT

This section contains the Final Report for the demonstration of n-methyl pyrrolidone (NMP) as an alternative to methylene chloride for stripping cured coatings from metal parts. It contains descriptions of both the old and new processes, detailed information on the preparation of the facilities, and the results of the operational evaluation conducted at the Marine Corps Logistics Base (MCLB) in Albany, GA. The research was conducted by U.S. EPA with the contractor services of Research Triangle Institute (RTI). Funding was provided by the Strategic Environmental Research and Development Program (SERDP).

The purpose of this project was to demonstrate on a full production scale a pollution prevention technology to replace methylene chloride used for stripping cured coatings from parts at the MCLB. This base carries out maintenance activities on a wide variety of equipment from small arms to tanks, trucks, and other vehicles.

NMP was chosen during a scoping study for the facility demonstration because it effectively removed Chemical Agent Resistant Coatings (CARC) in laboratory tests, is nonflammable, and is considered by the EPA not to be a hazardous air pollutant (HAP). Two drawbacks are that the NMP must be heated to be effective and NMP is subject to reporting under the Superfund Amendments and Reauthorization Act (SARA).

The first step in preparing for the demonstration was to retrofit an existing tank at the MCLB located near the methylene chloride tank. For successful stripping with NMP, the existing tank required plumbing to heat the bath with steam available from MCLB, and a recirculating pump to provide enough agitation to assure uniform temperature throughout the bath. The adjacent tank required a pump to draw recycled NMP for rinsing stripped parts. Finally, a vacuum distillation unit was installed to reclaim used solvent from the stripping bath and provide recycled NMP for rinsing.

After the tank retrofit was completed, the heating and recirculating systems were tested using water. The stripping tank was then emptied and filled with an initial charge of 32 55-gallon barrels of technical grade NMP. Additional NMP was added to the stripping tank during the demonstration.

In parallel, the operators were trained to operate the new process and equipment, and maintain the system. For the rest of the demonstration period, the operators used the NMP tank for normal stripping operations, and are still using it as of the writing of this report.

The NMP, when heated to 150 ±10 °F, was able to remove multiple layers of CARC and strip parts to the base metal within 3-4 hours. The heated NMP was able to successfully remove Plastisol®, a plastic coating, from battery tie-down brackets. These parts were previously stripped in a hot alkaline bath, followed by scraping and blasting to remove the coating. The NMP was able to soften epoxy-based topcoats, but removal usually required overnight soaking.

The implementation of the NMP stripping eliminates a major source of HAP emissions at the MCLB. This substitution will lower HAP emissions by 11% from 1992 levels.

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ACRONYMS AND ABBREVIATIONS

APPCD	Air Pollution Prevention and Control Division
bbl	barrel
Btu	British thermal unit
CAA	Clean Air Act
CARC	Chemical agent resistant coating
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DMA	Depot Maintenance Activity
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
FTI	Finish Thompson, Inc.
HAP	Hazardous air pollutant
IWTP	Industrial wastewater treatment plant
kW	kilowatt
lb	pound
MCLB	Marine Corps Logistics Base
MSDS	Material Safety Data Sheet
NMP	N-methyl pyrrolidone
P&ID	Piping and instrumentation diagram
P2	Pollution prevention
PP	Payback period
PPE	Personal protection equipment
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
ROI	Return on investment
RTI	Research Triangle Institute
SARA	Superfund Amendments and Reauthorization Act
scfm	standard cubic feet per minute
SERDP	Strategic Environmental Research and Development Program
TLV	Threshold limit value
TRI	Toxics Release Inventory
TWA	Time-weighted average
Vac	Voltage, alternating current
Vdc	Voltage, direct current
VOC	Volatile organic compound

METRIC UNITS

English units have been included in the report to simplify communication with most of the intended readership and because they are the primary units used by the Marine Corps Logistics Base. The multiplying factors for converting from the English units to their metric equivalents are given in the table below.

METRIC CONVERSION FACTORS (Approximate)				
Symbol	*When You Know the Number of*	*Multiply By*	*To Find the Number of*	*Symbol*
LENGTH				
in.	inches	2.54	centimeters	cm
ft.	feet	0.3048	meters	m
VOLUME				
gal	gallons	3.79	liters	l
MASS				
lb	pounds	0.454	kilograms	kg
PRESSURE				
psi	pounds per square inch	6.89	kilopascals	kPa
TEMPERATURE				
°F	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Centigrade	°C
DENSITY				
lb/ft^3	pounds per cubic foot	16.0	kilograms per cubic meter	kg/m^3
FLOW				
cfm	cubic feet per minute	0.472	liters per second	l/sec

ACKNOWLEDGMENTS

The authors gratefully wish to acknowledge the following people at the MCLB, without whose cooperation and assistance this demonstration would not have been possible:

Steve Allan
Wayne Chauncey
Scott Clements
John Gates
George Hagan
Dave Hudson
Mark Joyner
Gary Holton
Gene Palmer

In addition, the authors thank Mark Waldrop of BASF, Inc., and Pete Scantlebury and Link Galeza of Finish Thompson, Inc.

The authors would especially like to recognize the contribution of EPA and MCLB's Project Engineers J. Kaye Whitfield and Dan Gillum to this report. Their project oversight, guidance, direction, and technical assistance contributed greatly to this research demonstration.

NOTICES

QA/QC requirements apply to this project. Data are supported by QA/QC documentation as required by USEPA's QA Policy.

The use of trade names and company names in this section does not signify recommendation for use or endorsement by either the EPA or Research Triangle Institute.

2.1.0 INTRODUCTION

This section reports on the demonstration of n-methyl pyrrolidone (NMP) as an alternative to methylene chloride for stripping cured coatings from metal parts. It contains descriptions of both the old and new processes, detailed information on the preparation of the facilities, and the results of the operational evaluation conducted at the Marine Corps Logistics Base (MCLB) in Albany, GA. The Implementation Plan, which is included as Section 2.5.0, contains specifics on the equipment, piping, and controls installed, information regarding cost savings, and estimated reductions in hazardous air emissions.

2.1.1 Background

This demonstration was performed at the MCLB. This base carries out maintenance activities on a wide variety of equipment from small arms to tanks, trucks, and other vehicles. Much of the maintenance on the vehicles requires removing existing paint prior to the repair procedures and applying new paint once the maintenance has been performed. The processes for paint stripping, repainting, and cleaning of paint equipment release significant amounts of hazardous air pollutants (HAPs). By Executive Order 12856, the MCLB is required to reduce these air emissions by 50% from 1992 levels. The MCLB desires to accomplish this goal by implementing pollution prevention (P2) technologies.

Three groups were instrumental in performing the demonstration:

1) U. S. Environmental Protection Agency (EPA)/Air Pollution Prevention and Control Division (APPCD), Research Triangle Park, NC,
2) Research Triangle Institute (RTI), Research Triangle Park, NC, and
3) MCLB, Albany, GA

The EPA/APPCD initiated this project with funding from the Strategic Environmental Research and Development Program (SERDP) and provided guidance throughout its duration. RTI conducted the on-site demonstration in which the alternative paint stripping process was demonstrated in a production environment. RTI coordinated the project, provided contractor services (e.g. technical expertise for the design and implementation of the demonstration), and reported to the EPA Project Engineer. The primary responsibility of the MCLB was to support the demonstration by providing the facilities and production personnel for carrying out the demonstration. The MCLB technical representative supervised the project at the site and served as the contact person with EPA and RTI.

The paints used on vehicles at the MCLB are generally considered to be very difficult to remove. They include primers, undercoatings, and chemical agent resistant coatings (CARCs). Most of the parts sent to the stripping processes have multiple layers of paint, sometimes as many as seven layers of CARC over the primer. Most of the coatings used by the MCLB can be classified as polyurethane-based plural-component and single-component CARCs, epoxy primers, and undercoatings. The MCLB also uses some epoxy-based topcoats, which also must be stripped.

One of the stripping processes at the MCLB used methylene chloride. This solvent had a high priority for replacement not only because it was a HAP, but was also one of seventeen toxic chemicals identified in the EPA 33/50 Program. The 33/50 Program is a voluntary pollution prevention initiative to reduce national pollution releases and off-site transfers. The seventeen toxic chemicals chosen were selected by the EPA because they pose environmental and health concerns, are high-volume industrial chemicals, and may be reduced through pollution prevention.

The parts stripped at the MCLB mainly consisted of metal vehicle parts such as seats, fenders, brackets, and housings. The MCLB was already using abrasive blasting processes with either coal slag, steel grit, or plastic media to remove CARC from most parts. The only parts that were still being stripped by immersion in methylene chloride were 1) those that would be damaged by mechanical abrasion, such as parts with bearing surfaces or thin skins, and 2) parts with complex geometries or blind holes that would be likely to trap the media or be difficult to mask. This fraction represented less than 3% of all the parts stripped at the MCLB. Even so, the MCLB purchased an average of 120 55-gallon barrels per year over a three year period from 1992 through 1994. In addition to methylene chloride air emissions, the process generated hazardous waste in the form of sludge that contained methylene chloride and paint. The MCLB's Depot Maintenance Activity (DMA) disposed of 8-10 500-lb drums per year of methylene chloride sludge at a cost of approximately \$2.80/lb, an estimated yearly cost of \$11,200 - \$14,000.

N-methyl pyrrolidone (NMP) was chosen as the best alternative from a preliminary laboratory study at Research Triangle Institute. It effectively removed CARC in laboratory tests, is nonflammable, and is not considered by the EPA to be a hazardous air pollutant (HAP) under section 112 of the Clean Air Act (CAA). Two potential drawbacks are that the NMP must be heated to be effective and NMP was added to the SARA 313 list of reportable compounds for chronic health effects, effective January 1, 1995.

2.1.2 Objectives

The objective of this task was to demonstrate pollution prevention technologies or processes to reduce the emissions of HAPs resulting from the paint stripping process. This objective was achieved by replacing the methylene chloride with NMP, a less hazardous and less volatile solvent. The NMP is also not listed as a HAP under section 112 of the CAA. Data for this technology was collected on-site at the MCLB from November 1 through December 21, 1995. This process has been implemented and is in use at the Base.

2.2.0 METHYLENE CHLORIDE STRIPPING PROCESS

The first step in the paint stripping process was immersing a metal basket of coated metal parts in the room temperature methylene chloride for 1-2 hours (depending on the soil loading in the tank). This was followed by three rinses with tap water; 1) an initial rinse to remove most of the methylene chloride residue, 2) a pressure wash and pressure rinse to remove any remaining paint chips, and 3) a final hand rinse. The MCLB estimated the rinsing operations took 10-15 minutes per load. The basket was set aside to allow the parts to air dry. At least two baskets of parts were stripped per day with this process.

The methylene chloride tank had an approximate surface area of 143 ft^2 and was capable of holding two 48 in. by 48 in. baskets side by side. The depth of methylene chloride in the tank was approximately 30 in. A layer of water floated on the methylene chloride, serving as a seal to reduce methylene chloride emissions due to evaporation. The water seal was approximately 2-3 in. thick, but was not monitored to maintain a constant thickness. Water from the first rinse was used to replenish the water seal on the methylene chloride tank; water from the second rinse was used to replenish the first rinse. Water from the third rinse contained very little methylene chloride residue and was treated on site at the facility's Industrial Wastewater Treatment Plant (IWTP).

About every eighteen months, the tank was shut down and cleaned. Most of the paint chips would settle to the bottom of the tank. MCLB personnel would pump most of the methylene chloride into 55-gallon barrels. Then the rest of the sludge would be scooped out into hazardous waste disposal containers, and the methylene chloride from the barrels would be pumped back into the tank.

This tank was shut down and drained in May 1995, because the methylene chloride failed to meet chemical specifications. When the tank was drained, severe damage to the tank walls was discovered. The MCLB decided not to repair the tank, but instead to switch to the NMP process as soon as it was operational. In the meantime, those parts that would have been stripped in the methylene chloride were stripped with abrasive blasting. This was a labor-intensive alternative because these parts required extensive masking to prevent media from becoming trapped, and usually required multiple passes to remove paint satisfactorily. Other parts, such as the battery tie-down brackets coated with plastic coating Plastisol®, were soaked in hot alkaline solution followed by scraping and blasting, also a very time consuming process.

2.3.0 DEMONSTRATION OF NMP PAINT STRIPPING

The first step in preparing for the demonstration was to retrofit an existing tank at the MCLB located near the methylene chloride tank. Retrofitting involved connecting the steam supply to the tank heater, installing the recirculating and rinse pumps, and installing the distillation unit. After the tank retrofit was completed, the heating and recirculating systems were tested using water in the tank. The stripping tank was then emptied and filled with an initial charge of thirty-two 55-gallon barrels of technical grade NMP. In parallel, the operators were trained on operating the new process and equipment, and maintaining the system. For the rest of the demonstration period, the operators used the NMP tank for normal stripping operations. The following sections describe the new stripping process, and the steps to retrofit the tank, train the operators, and carry out the rest of the demonstration.

2.3.1 Description of NMP Stripping Process

The first step in the NMP chemical paint stripping process was immersing a metal basket of painted metal parts in the heated NMP for 2-3 hours (depending on the soil loading in the tank). The operating temperature range of the NMP was initially 140 ±5 °F, but during the demonstration, the range was changed to 150 ±5 °F to increase the effectiveness of the solvent stripping action. After the basket was raised over the stripping tank, the parts were pressure rinsed with recycled NMP. The pressure rinse removed NMP residue and paint chips, and allowed the NMP to drain into the stripping tank. The parts were blown with an air gun to remove additional NMP before the final rinse. The basket was then moved away from the stripping tank and rinsed with tap water to displace the NMP. This rinse drained to the IWTP. The MCLB estimates the rinsing operations took 15 minutes per load. The basket was set aside to allow the parts to air dry. At least two baskets of parts were stripped per day with this new process. This process is illustrated schematically in Figure 2-1.

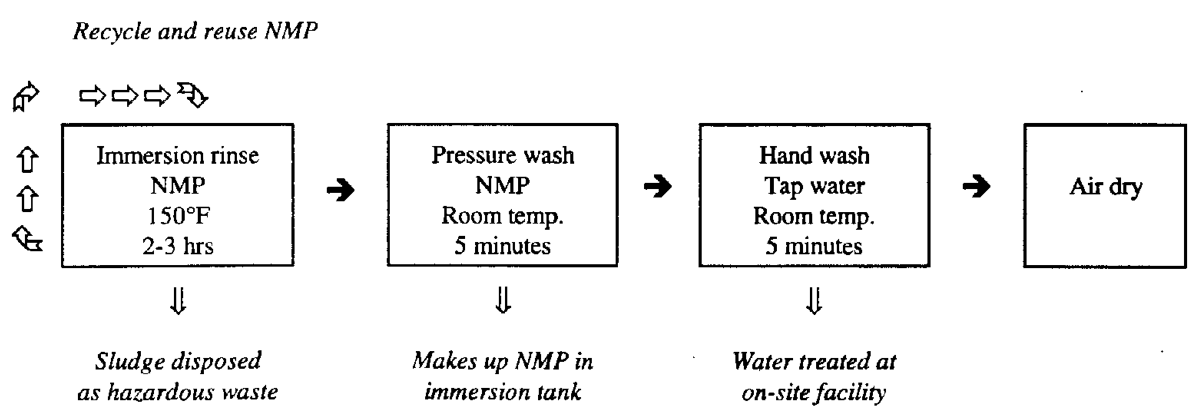


FIGURE 2-1. SCHEMATIC ILLUSTRATION OF NMP IMMERSION PAINT STRIPPING

2.3.2 Retrofit of Existing Equipment

The tank designated by the MCLB for retrofitting as a stripping tank was a large stainless steel tank (see Figure 2-2), about 16 ft. long by 8¾ ft. wide by 8 ft. deep. It was located in a pit in the concrete floor (1) with the top edge even with the surface of the floor. There was about a foot of space (2) between all sides of the tank and the concrete walls. The tank was divided by a steel wall (3) into two areas, each about 8 ft. long by 8¾ ft. wide by 8 ft. deep. Lip vent exhausts (4) were located along the front and rear edge of the tank. It was insulated, but not heated. The area retrofitted for stripping with NMP had previously contained methylene chloride; the area retrofitted to hold the recycled NMP for rinsing was previously a caustic tank. A crane was available over the top of the area to load and unload baskets. The same baskets were used as with the methylene chloride process.

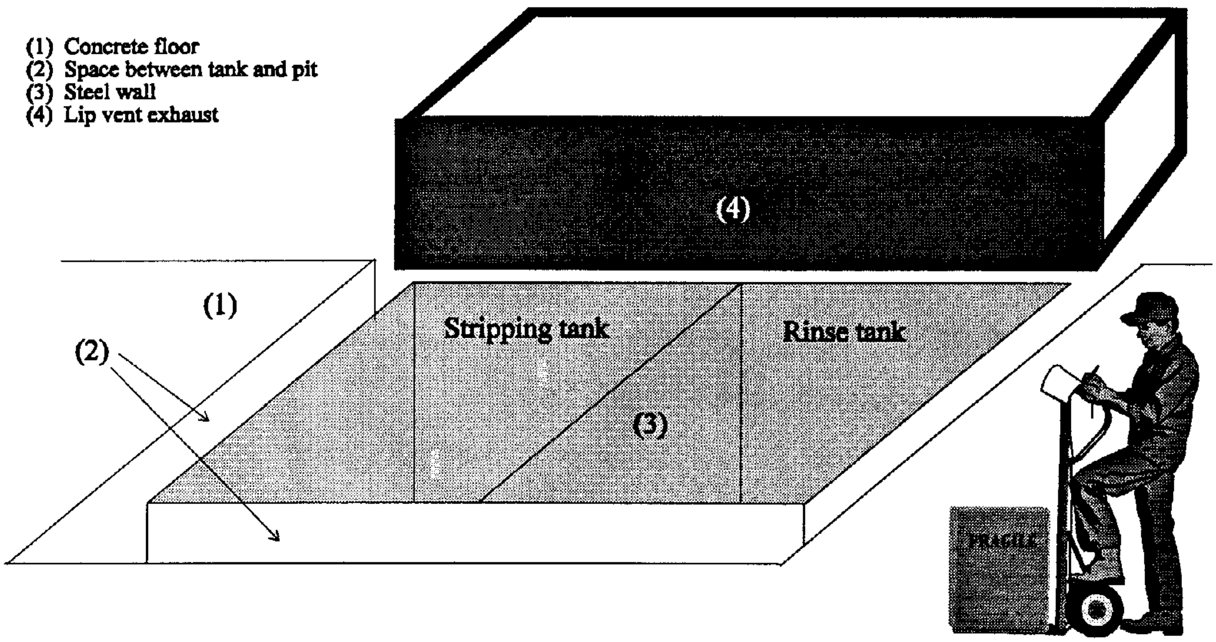


FIGURE 2-2. TANK BEFORE RETROFITTING AS NMP STRIPPING AND RINSE TANKS
Drawing is not to scale.

When the tank was rinsed and inspected before starting the retrofit, a small hole was found in one corner of the tank that was repaired by welding. No other repairs were required. The left side of the tank in Figure 2-2 was retrofitted as the stripping tank because it was closer to the existing steam supply. The right side of the tank in Figure 2-2 was used to hold distilled

NMP reclaimed from the vacuum distillation unit. This side was dubbed the "rinse tank" because the recycled NMP from this tank was used to rinse stripped parts.

The main changes necessary to retrofit the tank for the NMP process were adding the capability to heat and distill the NMP in the stripping tank. Pre-existing steam lines were extended to the platecoil in the tank to provide heat. A recirculating pump was added to distribute the heat and assure a uniform temperature throughout the NMP. A vacuum still was plumbed and wired to the tank to distill the paint-laden NMP and provide clean NMP for rinsing. Level and temperature sensors were added to the stripping and rinse tanks and wired to both visible digital readouts and strip chart recorders. These sensors measured the NMP usage and provided input to the controllers for the steam automatic shutoff valve. The details on the equipment used for retrofitting the tank are discussed in greater detail in Section 2.5.1, including the complete bill of materials, vendor addresses, costs, and a Piping and Instrumentation Drawing (P&ID).

All major equipment and the NMP were purchased on the contract. The MCLB provided the labor and small parts to install and connect all plumbing, steam lines, water lines, and electrical lines for the tank and distillation unit. The MCLB also fabricated a metal grid stand to place on the bottom of the tank. The stand was higher than the eductors so that operators would not accidentally hit the eductors with a loaded basket.

Upon completion of the plumbing and electrical connections for the temperature control and recirculation pump, the stripping tank was filled with water for a "wet check" of the system. No leaks were detected, the pump ran properly and the steam heated the water to 140°F. The tank was drained and filled with thirty-two 55-gallon barrels (14,784 lbs) of NMP to an initial depth of 40.8 inches. The strip chart recorders were turned on with a recording speed set at 12 cm/hour. The tank was heated to 140°F and was ready to be used for paint stripping.

2.3.3 Operator Training

One of the most important requirements for introducing a new process is training and gaining acceptance from the operators and maintenance personnel. Upcoming changes were discussed with the operators while the equipment was being installed. The reasons for the process change were explained and questions were answered about the new solvent and process. While the tank retrofits were being completed, a Standard Operating Procedure for the new process was written (Appendix 2-1). The operators were trained on the uses and safety protocols for NMP and on the new stripping procedure during an afternoon classroom training session. A second training session on the new stripping procedure was conducted at the tank, where safety and handling a combustible solvent were discussed again. Project personnel were also on site for the cleaning of the first parts and many other days during the demonstration to inspect parts and answer questions.

Learning the procedure for chemical stripping with NMP was not difficult for the operators because it was similar to stripping with methylene chloride. Parts were still loaded in a 48 in. by 48 in. wire basket and positioned relative to each other so as to prevent nesting. The basket was lowered into the NMP and soaked for about 2-3 hours. The parts were still rinsed, except that the first rinse was with NMP instead of water. The basket was raised over the stripping tank while the parts were rinsed so the NMP drained into the stripping tank. The initial NMP rinse helped make up losses to emissions, dragout, and recycling. Additional NMP was pumped from barrels or from the rinse tank into the stripping tank to keep the stripping tank at operating level.

The main differences in procedures were in the operation of the tank. The methylene chloride process operated at room temperature, but the NMP had to be heated to about 150°F to be effective on the more difficult coatings such as the Plastisol® used to prevent corrosion on battery tie down brackets. The heating and recirculation system automatically maintained the working temperature of the NMP. To reduce NMP loss, the system was turned off during weekends and long shutdowns over holidays.

The second new area that the operators needed to learn was the operation of the distillation unit. The methylene chloride was not distilled; instead the paint was allowed to settle and was removed about every eighteen months as described earlier in this report. The distillation unit is a vacuum still that was designed to be used with the NMP. The still was installed under a shelter just outside the area of the cleaning tank and plumbed to the tanks. It can be operated in batch or continuous mode. Because the amount of paint removed from the parts is small compared to the volume of the tank, the still does not have to operate continuously. It only needs to be operated when the effectiveness of the NMP decreases. Decreased effectiveness is indicated by an increase in stripping time or when the paint is not removed as well. Operators, maintenance personnel, and engineers were trained on the operation of the distillation unit by representatives of the company that manufactured the still. This training included hands-on operation of the unit, and instructions on draining the sludge from the still. During the demonstration, the still was operated after an estimated twenty baskets were stripped, even though the NMP had not yet reached the point where its effectiveness was decreasing.

A second training session on the operation of the stripping tank was found to be necessary and was conducted at the stripping tank for the operators. The need for a second training session was indicated by two instances of tank overheating. The operators were aware that the steam needed to be turned on, but neglected to close the bypass valve when the temperature was within the operating range of 150±5°F. An estimated 91 gallons (770 lbs.) of NMP were lost by evaporation resulting from tank overheating. During this training session, safety protocols and the use of personal protection equipment were reviewed. The steam supply valve, the bypass valve, and the control line valve were labeled. Instructions for tank heat up, operation, and shutdown, contained in the operating procedure, were reviewed. A laminated instruction sheet was attached to the recirculation pump control panel for easy reference. In addition to a second training session, an alarm and a shut-off valve were purchased for the steam line. The shut-off valve would automatically close the steam supply if the temperature of the NMP in the stripping tank exceeded 160°F. An alarm would also sound if the temperature dropped below 140°F as a warning to the operators that the stripping bath was below minimum operating temperature.

2.3.4 Discussion of Parts Stripped with NMP

The first basket stripped with the new process was loaded with battery tie-down brackets and quick disconnects for water pumps. The tie-down brackets were coated with black Plastisol®, a plastic coating that is very difficult to remove. The disconnects were coated with several layers of CARC. The basket was observed after one hour immersion at 140°F. The

Plastisol® was peeling off the battery tie-down brackets, but was not completely removed. Also, the CARC was softening on the disconnects but was not sloughing off. The basket was left in the bath for an additional hour. While the basket was over the NMP bath, the parts were blown with an air gun to force excess NMP back into the tank. The basket was moved away from the tank and the parts were then rinsed with water. The NMP-stripped parts were examined and found to have removal of nearly all of the Plastisol® from the tie-down brackets and the CARC from the disconnects. Some of the remaining coating sloughed off when the parts were handled. On some parts, the coating had softened but still adhered to the part; in these instances, the coating had been very thick. Since NMP is absorbed through multiple layers down to the base metal and then lifts the entire coating, parts with very thick coating or multiple layers would probably need to be left in the stripping tank overnight.

During the first three weeks of November, MCLB stripped about three or four baskets of parts. The parts were mostly battery tie-down brackets, disconnects, and filter housings. After Thanksgiving, MCLB stripped about three or four baskets a week. Of an estimated twenty baskets stripped over the course of the demonstration, MCLB only reported problems with two baskets. All the remaining baskets of parts were stripped well enough for the parts to continue through production.

The project's engineers received reports that two baskets of parts had not been adequately stripped with NMP and investigated both reports. The first basket was stripped early in the demonstration period. The parts were battery tie-down brackets and filter housings that looked like open-ended shoe boxes. The battery tie-down brackets were coated with Plastisol®; the filter housings were coated with green CARC over white primer. The parts had been stacked in a 48 in. by 48 in. wire basket and placed in the tank for 2 hours. The NMP tank was at 140°F when the parts were put in, but had dropped to 127°F when checked 1½ hours later. MCLB personnel reported that the temperature control valve on the steam line did not open. The valve was adjusted, and the NMP temperature rose to 140°F. The parts were inspected during the next site visit. There was indeed paint on the sides of the boxes and some on the supports. When the nested boxes were pulled apart for visual examination, more paint was left on the inside of the boxes than the outside. It could not be determined whether there was more paint on one side than the other. The remaining paint was dry and flaky and was removable by brushing with gloved fingers. The parts were also rusty, which meant they would next be sent through an abrasive blasting process. The report from one of the area Leadermen was that these parts normally require 20-30 minutes abrasive blasting on a Roto-Blaster when they do not use chemical stripping. He thought that the NMP-stripped parts would only need 1-2 minutes in their current condition, a good improvement in time and personnel effort.

During the second training session, one of the operators mentioned that paint was not removed from parts that had been left in the tank for a whole day. The parts had already been sent to abrasive cleaning and were not available for inspection by research project's engineers. Again, the parts had been stacked in a 48 in. by 48 in. wire basket. The steam supply line had been closed and the pump had been shut off the previous day. The steam line had not been re-opened that morning and the pump was not on when the basket was placed in the tank. Based on a similar occurrence during startup, the tank temperature had probably dropped from operating temperature to about 110°F by morning and would have dropped further with the addition of parts. Without the temperature control valve to allow controlled heating of the tank, the bath temperature would have continued to drop.

In both instances, incomplete removal of paint was most likely caused by failing to strip the parts at the correct operating temperature. After the first incident, the operating temperature range was changed from 140 ± 5 °F to 150 ±5 °F. After the second incident, an alarm and a shut-off valve was ordered and placed on the steam line.

During the demonstration, a white vapor sometimes developed over the stripping tank. It was especially noticeable, along with a heavy amine odor, during the two instances when the tank was over heated. It would usually appear when the recirculating pump was on and disappear when the pump was turned off, even at operating temperatures. This suggests that the agitation of the pump is increasing air emissions. The vapor was also obvious when the ventilation and lip vent exhausts were turned off. The vapor is believed to be primarily NMP, perhaps with some water present. Lower pump flow rate may help reduce turbulence in the bath and still maintain an even temperature throughout the bath. Also, the ventilation and exhaust system is to remain on at all times, as it is with other tanks at the MCLB containing caustic or other hazardous compounds.

Currently, the operators are stripping one basket in the morning, one in the afternoon, and occasionally leaving some parts in overnight. MCLB noted that some parts require abrasive blasting to remove corrosion after chemical stripping and that loose coatings or small amounts of coatings remaining on these parts would be easily removed in a single pass.

2.3.5 NMP Level and Temperature Readings

The level and temperature of both the stripping tank and the rinse tank were continuously plotted on strip chart recorders. The strip charts were collected daily by the project engineers during site visits. Pens and paper were changed as necessary. Rippling of the agitated NMP surface caused noise on the level readings that made it difficult to read the levels accurately. Beginning November 16, 1995, daily readings of the tanks were taken with the recirculation pump turned off and no basket in the tank when they were on site.

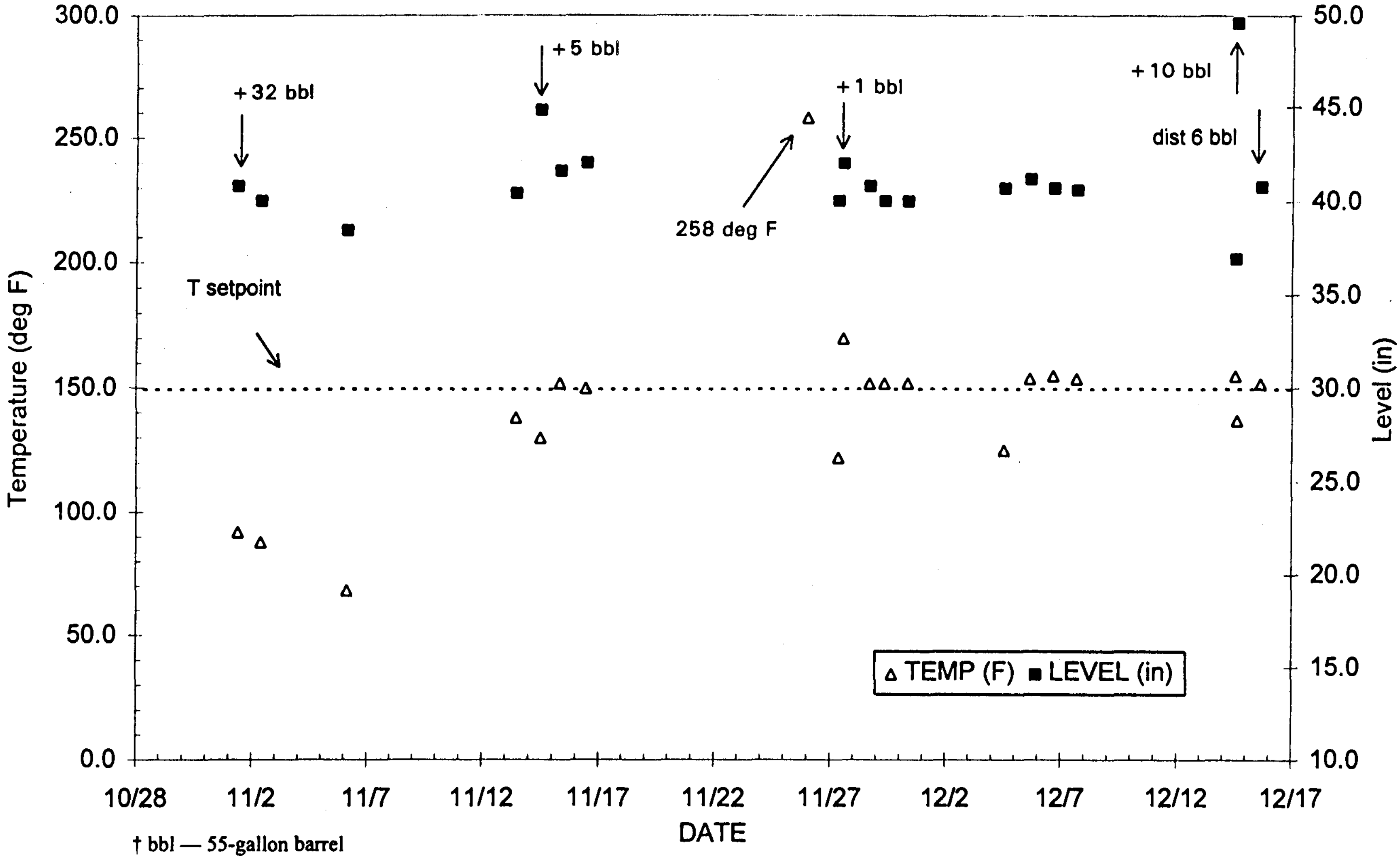
The tank levels and temperatures are summarized in Table 2-1. The data are depicted graphically in Figure 2-3. The rinse tank remained empty until it was filled with recycled NMP, as indicated in Table 2-1.

When the steam valves were set properly, the temperature in the stripping tank maintained a near constant 152 ±2 °F. A number of factors affected the level readings: agitation from the recirculation pump, whether a basket of parts was in the tank, temperature of the tank, and additions of NMP. It was noted following the distillation cycles that the NMP in the rinse tank is slightly warmer than ambient. This is because 1) the NMP is still warm when it drains from the still, and 2) heat from the stripping tank transfers through the steel separating wall. The warmer temperature of the rinse tank is not a cause for concern.

TABLE 2-1. LEVEL AND TEMPERATURE OF NMP IN STRIPPING AND RINSE TANKS

TIME	*DATE*	*STRIP LEVEL (in)*	*STRIP TEMP (°F)*	*RINSE LEVEL (in)*	*RINSE TEMP (°F)*	*COMMENTS*
9:00 AM	11/01/95	40.8	92.0	0.0	N/A	Added 32 bbls† of NMP to stripping tank; took initial readings.
9:00 AM	11/02/95	40.0	88.0	0.0	N/A	
2:30 PM	11/06/95	38.4	68.4	0.0	N/A	Heat off over weekend; not on when reading was taken.
10:30 AM	11/13/95	40.4	138.0	0.0	N/A	Heat off over weekend; tank not at operating temperature when reading was taken.
11:55 AM	11/14/95	44.8	130.0	0.0	N/A	Added 5 bbls of NMP (used to check out distillation unit); addition of room temp NMP raised level and lowered temp. Adjusted thermal control valve to maintain 150°F.
8:00 AM	11/15/95	41.6	152.0	0.0	N/A	
10:35 AM	11/16/95	42.0	150.0	0.0	N/A	
8:15 AM	11/27/95	42.0	170.0	0.0	N/A	Steam bypass not closed and tank overheated; shut off steam bypass valve. Added 1 bbl of NMP to makeup losses.
1:00 PM	11/27/95	40.0	122.0	0.0	N/A	(Steam bypass valve locked out to prevent being its left open.)
4:45 PM	11/28/95	40.8	152.0	0.0	N/A	
8:15 AM	11/29/95	40.0	152.0	0.0	N/A	
8:45 AM	11/30/95	40.0	152.0	0.0	N/A	
12:55 PM	12/04/95	40.7	125.0	0.0	N/A	Heat off over the weekend; tank not at operating temperature when reading was taken.
4:05 PM	12/05/95	41.2	154.0	0.0	N/A	
4:30 PM	12/06/95	40.7	155.0	0.0	N/A	
4:22 PM	12/07/95	40.6	154.0	0.0	N/A	
9:00 AM	12/12/95	37.6	156.0	0.0	N/A	
1:12 PM	12/14/95	36.9	155.0	0.0	N/A	Reading before adding NMP and before distilling.
2:40 PM	12/14/95	49.6	137.0	0.0	N/A	Reading after adding 10 bbls of NMP and before distilling.
3:15 PM	12/15/95	40.8	152.0	10.4	104	Reading after completing 6 distillation cycles.

† bbl — 55-gallon barrel



† bbl — 55-gallon barrel

FIGURE 2-3. LEVEL AND TEMPERATURE OF NMP IN STRIPPING TANK

2.3.6 Estimate of NMP Losses

Mass balance is a more effective method for measuring total air emissions than measuring fugitive air emissions in this system, since it will include losses from any leaks in the equipment and the amount of solvent lost when parts are pulled from the cleaning tank and allowed to dry in a separate area. All of this material eventually ends up as air emissions. These measurements need to be taken over a long enough period to show a statistical difference.

Calculating an accurate mass balance is difficult for the following reasons:

- Shortened duration of demonstration period,
- Changes in tank temperature on weekends,
- Presence of parts being cleaned when some level measurements were being taken,
- Failure of the strip chart recorders that required a project engineer/technician to be present to manually record the temperature and levels, and
- Lack of written records kept of number and type of parts stripped, etc.

The fundamental mass balance equation is as follows:

$$\Delta M = [M_o + M_d] - M_t$$

where, ΔM = mass of solvent lost between times zero and t

M_o = mass of solvent in the tank at time zero

M_d = mass of solvent added from drums between times zero and t

M_t = mass of solvent in the tank at time t

The quantity $[M_o + M_d]$ is known, because forty-eight 55-gallon barrels were added to the tank in whole increments over the course of the demonstration. Paint dissolved in the NMP was assumed to be negligible. This assumption was based on the fact that at the end of the demonstration period, the viscosity of the sludge was below the detection limit of the distillation unit after completing six cycles. The calculations are shown below:

$$
\begin{aligned}
\Delta M &= [NMP_{Start/Total}] - [NMP_{Final/Stripping\ tank} + NMP_{Final/Rinse\ tank}] \\
&= [(NMP_{Start/Total})] - [(A_{tank}) * (h_{NMPs}) * (\rho_{150°F}) + (A_{tank}) * (h_{NMPr}) * (\rho_{100°F})] \\
&= [22{,}176\ lbs] - [(14{,}708\ lbs) + (3829\ lbs)] \\
&= 3639\ lbs
\end{aligned}
$$

where A_{tank} = the surface area of each tank ($A_{stripping\ tank} = A_{rinse\ tank} = 70\ ft^2$),

$h_{NMP\ s}$ = the height of NMP in the stripping tank (in feet),

$\rho_{150°F}$ = the density of NMP at 150°F in the rinse tank ($61.8\ lb/ft^3$), and

$h_{NMP\ r}$ = the height of NMP in the rinse tank (in feet),

$\rho_{100°F}$ = the density of NMP at 100°F in the rinse tank ($63.6\ lb/ft^3$).

Over the course of the six week demonstration, approximately 3,640 lbs. were lost to emissions, dragout, and recycling. At this point, over 95% of these losses may be attributed to NMP emissions and dragout because only six distillation cycles were run at the end of the demonstration period. Over time, as the paint sludge accumulates in the still, the MCLB will be able to determine how much NMP is lost in the still bottoms. At least 25% of this loss may be attributed to tank overheating. Based on these losses, the MCLB will need to add an estimated 3 barrels of NMP each month to the stripping tank. This amount may vary as the operators become more experienced with the process. This is a significant reduction over the previous process, which required the addition of approximately 10 barrels of methylene chloride each month.

2.3.7 Regulations Affecting NMP

Replacing methylene chloride with NMP will reduce the amount of tracking and reporting for the MCLB for this process. Regulations impacting the uses of methylene chloride and NMP are summarized in Table 2-2. NMP is subject to some but not all these regulations. Most importantly, unlike methylene chloride, NMP is not listed as a HAP under section 112 of the

CAA. Therefore, by replacing methylene chloride with NMP, the MCLB eliminates one source of air emissions from HAPs. The use of NMP will still result in air emissions from VOCs.

Releases of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances, in quantities equal or greater than their reportable quantity, are subject to reporting to the National Response Center under CERCLA. Such releases are also subject to state and local reporting under section 304 of SARA Title III. Methylene chloride is classified as a CERCLA hazardous substance; its reportable quantity is 1,000 lbs. NMP is not classified as CERCLA hazardous substances.

Methylene chloride is also classified as a RCRA hazardous waste, but NMP is not. The hazardous waste code for methylene chloride is indicated in Table 2-2.

Under Executive Order 12856, the MCLB is required to file an annual Toxics Release Inventory (TRI) of chemicals listed under section 313 of the Superfund Amendments and Reauthorization Act (SARA) Title III. The TRI includes emissions, transfers, and waste management data as part of the community right-to-know provisions of SARA Title III. Methylene chloride is classified as a toxic chemical and is included on the TRI. NMP was added to SARA Title III, section 313, for chronic health effects and became subject to reporting January 1, 1995. As a result, the MCLB will be required to include NMP on the annual TRI report.

Notice of this requirement was made public in 40 CFR Part 372 in November 1994. By that time, the scoping study and preparatory work for the demonstration had been completed. The ramifications of this change were discussed. MCLB confirmed their commitment to continue with the NMP demonstration since NMP has a much lower vapor pressure than methylene chloride[1], which will minimize the emissions.

TABLE 2-2. REGULATIONS IMPACTING THE USE OF METHYLENE CHLORIDE AND NMP

CAS	*CHEMICAL*	*Section 112, CAA*	*Hazardous Substances CERCLA*	*RCRA Code*	*Toxic Chemical SARA*
75-09-2	Methylene chloride	yes	1,000 lbs	U080	yes
872-50-4	NMP	Not listed	Not listed	Not listed	yes

2.4.0 QUALITY ASSURANCE

2.4.1 NMP Level Measurements

A non-contact ultrasonic level/distance transmitter, Omega Instruments model LV404, was used to monitor the levels of the stripping and rinse tanks. The digital indicator display has 0.1 in. resolution. The accuracy and linearity of the level sensors were assessed by project personnel prior to their shipment to the MCLB. A meter stick and a tape measure were used as the references. The units were then shipped to the MCLB and installed over the tanks. The level sensor over the NMP stripping tank was rechecked after installation by comparing the level sensor reading to the distance as measured with a tape measure. After installation, it was found that there was a problem with the level sensor losing signal over the empty rinse tank, which resulted in large spikes in the strip chart recorder output and on the digital indicator display. This was determined to be caused by the signal bouncing off the walls and floor of the empty tank and scattering. The problem was resolved when the rinse tank was filled with NMP.

A second, smaller problem was the turbulence of the stripping bath with the recirculation pump on, which caused rapid fluctuations in the signal of up to ±0.5 in. This problem was eliminated by turning off the recirculation pump during readings so that the surface of the liquid became less turbulent and noting the reading manually rather than by relying on the strip chart recorder. This reduced the signal variation on the digital indicator display to ±0.1 in.

Relative decreases in the NMP level would be valid only if the decrease were significantly larger than this 0.1 in. uncertainty. If the decrease in level due to evaporation had not been significantly larger than the readability of the instrument, then the maximum probable loss would have been estimated. This would have provided an upper bound on the evaporation rate of NMP.

To ensure comparable level measurements, temperature must be controlled within ±5°F, and there should be no foreign objects (such as parts being stripped) in the tank when level readings are recorded.

2.4.2 Temperature Measurements

Low noise Type J thermocouples with 304 stainless steel sheaths were used to measure temperature in the stripping tank and in the rinse tank. These were checked at RTI's facilities prior to shipment using an ice/water bath (32°F) and boiling water (212°F). Once mounted into position in the tanks at the MCLB, the thermocouples were rechecked with an ice/water bath and at ambient temperature. Although temperature is not a critical measurement, it must be controlled to within approximately ±5°F to avoid errors in level due to thermal expansion of the NMP. On 12/4/95, the RTI QA Officer for the project recorded the NMP level as the temperature rose during the tank's weekly startup. It was found that between 89 and 125°F the level recorded by the level sensor changed by approximately 1 in. This confirms the importance of using only level readings taken close to the target operating temperature of 150°F when making level measurements to determine solvent loss. Representativeness of the temperature measurements is ensured by the rapid agitation induced by the recirculating pump.

2.4.3 Measurement Problems and Corrective Actions

Three significant measurement problems were encountered during the study. Both were rectified satisfactorily. These were as follows:

1. Problem: Excessive noise in level signal due to wave motion of NMP in the stripping tank.

   Solution: Readings were taken only when the recirculating pump was off and the stripping tank was empty of parts. Residual noise in the signal was approximately ±0.1 inch.

2. Problem: Strip chart recorders failed.

   Solution: a) Both strip chart recorders were sent to the manufacturer for repairs. Strip charts up to the time failure occurred do not suggest drift or other anomaly.
   b) Readings were taken by recording the digital readouts of the level meter and thermocouple.

3. Problem: Measurements of the NMP level needed to be made temperatures within ±5°F of the operating temperature of 150°F, but adding NMP changed the temperature significantly more than that. Because we could not interfere with production by adding NMP and dropping the temperature during work hours, NMP was often added near the end of the shift. Therefore, level and temperature readings were often delayed until the next day.

Solution: Change in level vs. change in temperature was measured several times and calculated to be approximately 1 in. rise in level for every 40°F. When possible, readings were taken as soon as NMP was added and after it had come to temperature. When the temperature change was taken into account, the calculations between levels for the before and after temperatures were good.

2.5.0 IMPLEMENTATION PLAN

This section contains the Implementation Plan for the demonstration of n-methyl pyrrolidone (NMP) as an alternative to methylene chloride for stripping cured coatings from metal parts. The plan details the equipment purchased under contract to carry out the demonstration, describes installation of the equipment, and illustrates the plumbing and instrumentation of the retrofitted tank. An economic analysis of the new NMP paint stripping process is included and compared with the previous methylene chloride stripping process.

2.5.1 Equipment

Equipment was required to control the temperature of the stripping bath, circulate the stripping bath, spray rinse the cleaned parts, distill the used NMP, and monitor the process. The layout for all the equipment is shown in the Piping and Instrumentation Diagram in Figure 2-4. More information on the equipment purchased under this contract can be found in Appendix 2-2.

2.5.1.1 Temperature Control

NMP is more effective when it is heated above ambient temperatures. During the bench scale tests, parts were cleaned at 140°F. However, because a basket fully loaded with parts would cause a sudden drop in the bath temperature when first immersed, the target temperature during the demonstration was raised to 150 ±5 °F. The stripping tank was heated using steam available from the MCLB.

Table 2-3 lists the equipment purchased to provide temperature control to the stripping bath. Contact information for the suppliers listed is given in Table 2-8.

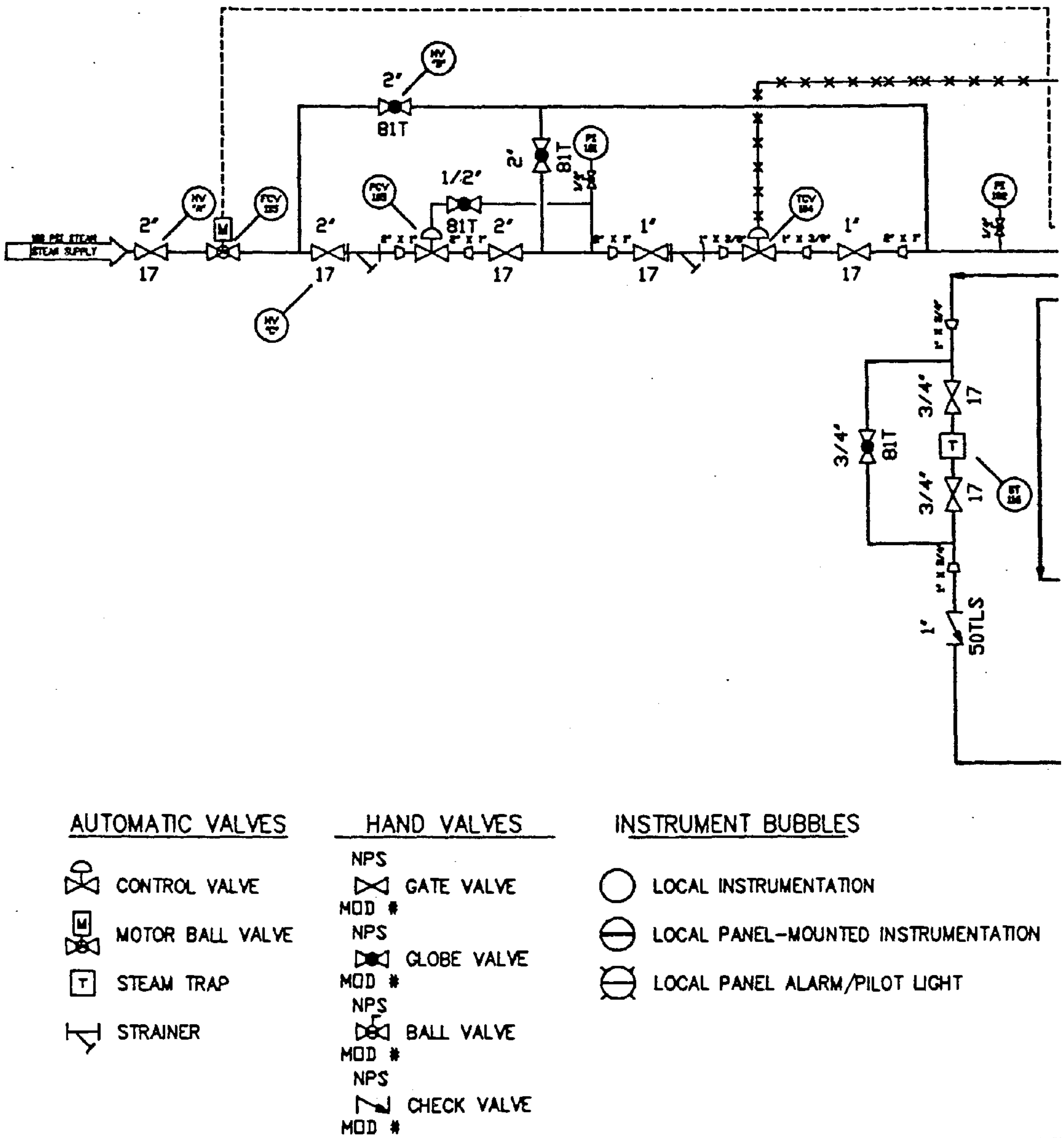
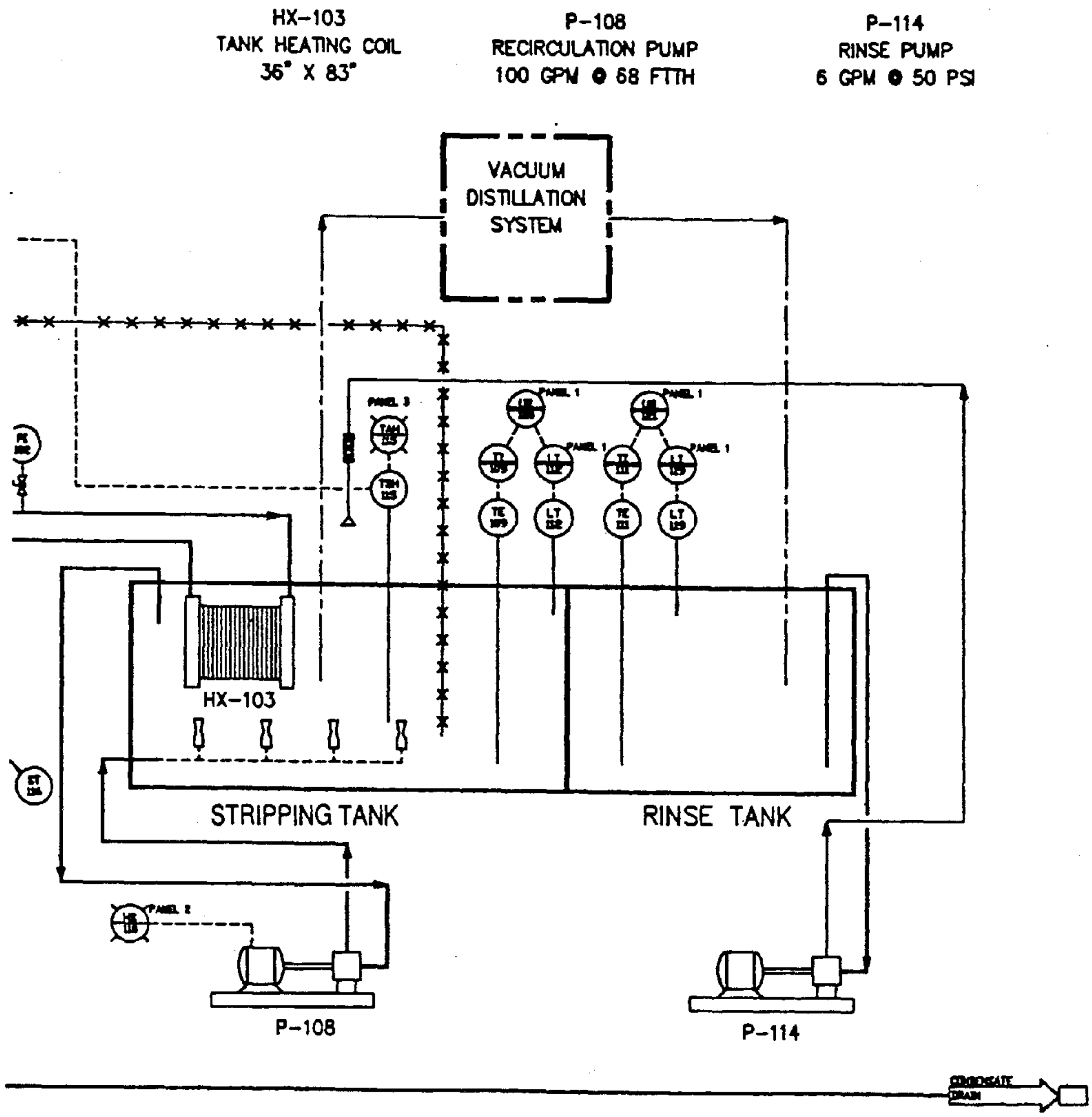


FIGURE 2-4. PIPING AND INSTRUMENTATION DIAGRAM FOR TANK RETROFIT



LETTER DESIGNATIONS

P = PRESSURE
T = TEMPERATURE
E = ELEMENT
A = ALARM
I = INDICATOR
R = RECORDER
H = HAND
S = SWITCH
NPS = NOMINAL PIPE SIZE
MOD # = MODEL NUMBER

PIPING SYMBOLS

MAJOR PROCESS LINE
MINOR PROCESS LINE
ELECTRICAL CONTROL LINE
CAPILLARY CONTROL LINE
FLEXIBLE LINE
HAND-HELD SPRAY WAND
REDUCER
EDUCTOR

ATION

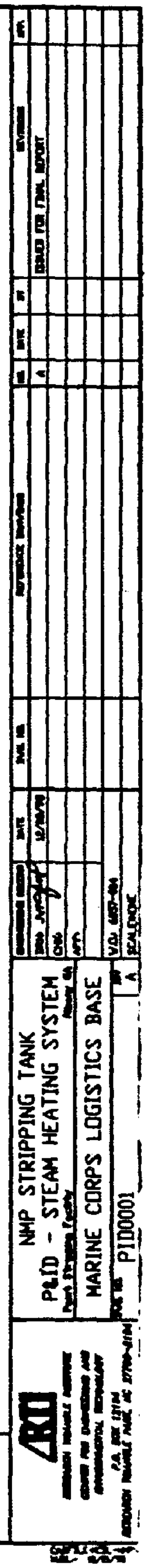


TABLE 2-3. EQUIPMENT USED FOR TEMPERATURE CONTROL

ITEM	*U/M*	*QTY.*	*SUPPLIER*	*MODEL #*
Alarm	EA	1	American Mfg.	Custom made
Check valve, 1 in.	EA	1	United	50TLS
Gate valve, 2 in.	EA	2	United	17
Gate valve, 3/4 in.	EA	4	United	17
Gate valve, 1 in.	EA	2	United	17
Globe valve, ½ in.	EA	1	United	81T
Globe valve, 2 in.	EA	2	United	81T
Globe valve, 3/4 in.	EA	2	United	81T
Motor-driven ball valve	EA	1	Watts	C7000
Pressure gage, 2 in.	EA	2	United	1001K
Pressure control valve, 1 in.	EA	1	Spence	ED
Steam trap, 3/4 in.	EA	2	Engrg. Resources, Inc.	3/4 SG-HB-02
Steam coil, 36 in. x 83 in., 12-gauge carbon steel	EA	1	Tranter	90D
Temperature control valve, 3/8 in.	EA	1	Spence	ET14
Temperature switch	EA	1	Murphy	SPL-BP
Y-Strainer with 20 mesh screen, 2 in.	EA	1	Mueller Steam	02.0-11M
Y-Strainer with 20 mesh screen, 1 in.	EA	1	Mueller Steam	01.0-11M

The heater platecoil was suspended over the side of the stripping tank. The remaining items served to modify the flow of steam into the platecoil. A bypass valve allowed rapid heatup of the NMP from ambient temperatures. When the temperature of the bath approached operating temperature, this valve was shut off. The temperature control valve on the steam line kept the temperature at 150°F ±2°F. The temperature dropped slightly lower when a basket of parts was lowered into the tank.

An automatic shutoff and alarm system was recommended and ordered to ensure the correct temperature range. At 160°F, the steam supply will automatically shut off and an audible alarm will sound. The most likely cause of this condition is neglecting to shut off the steam bypass valve when the temperature nears 150°F. As temperature increases, the vapor pressure of NMP increases and more NMP will be emitted into the environment. It will also create a noticeable amine odor in the work area. Once in operating mode, an alarm will also sound if the temperature drops below 140°F. NMP loses its effectiveness as a CARC stripper at ambient temperatures, and as the temperature of the bath decreases, the time necessary to strip parts increases.

2.5.1.2 Stripping Bath Recirculation

To prevent hot spots from building up and to promote uniform temperature distribution throughout the bath, a recirculation pump was installed in the stripping tank. The equipment used to provide recirculation to the stripping tank is shown in Table 2-4. The layout for the equipment is shown in the Piping and Instrumentation Diagram in Figure 2-4 and contact information for the suppliers listed is given in Table 2-8.

A wire mesh cage was built in the corner of the stripping tank. This cage was intended to prevent large clumps of paint from being sucked into the pump and clogging the eductors. Agitation of the pump helped break down large clumps. The pump inlet was located inside the cage. The distillation unit inlet was also located inside the cage. The pump outlet fed into a manifold with four eductors. The horizontal manifold was mounted about eight inches from the bottom of the tank.

TABLE 2-4. EQUIPMENT USED FOR BATH RECIRCULATION

ITEM	*U/M*	*QTY*	*SUPPLIER*	*MODEL #*
Eductors, 3/4 in.	EA	4	Jerguson/Jacoby	JRG-JT TLA 3/4 in.
Self-priming recirculation pump, 316 SS w/Teflon seals	EA	1	R. S. Corcoran	5000
3 ft x 4 ft 4x4 mesh, 0.080 in.	EA	2	McMaster-Carr	9226T447
Pump control panel	EA	1	Mechanical Equipment Co.	Custom made

2.5.1.3 Rinsing

The parts were rinsed after the basket was raised above the stripping tank. The rinse pump (separate from the recirculation pump) draws either fresh NMP or recycled NMP from the rinse tank. The NMP was sprayed onto the parts; excess NMP drained into the stripping tank. After rinsing, the parts were sprayed with an air gun to minimize dragout. The basket of parts was moved and then rinsed with water to displace any residual NMP. Because the NMP is biodegradable and the concentration of NMP in the rinsewater is low, the wastewater can be treated on-site at the MCLB's IWTP.

Equipment required for the rinsing operation is listed in Table 2-5. Contact information for the suppliers listed is given in Table 2-8.

TABLE 2-5. EQUIPMENT USED FOR RINSING

ITEM	*U/M*	*QTY*	*SUPPLIER*	*MODEL #*
Air hose assembly, 25 ft.	EA	1	McMaster-Carr	5313K13
Air blowgun, extended reach	EA	1	McMaster-Carr	5536K15
Extension tube, 60 in.	EA	1	Spraying Systems, Inc.	9702S-60
Male NPT fittings, 3/8 in.	EA	2	McMaster-Carr	52515K53
Tip, full cone nozzle	EA	1	Spraying Systems, Inc.	TG-8510
Solvent spray gun, GunJet Model 60	EA	1	Spraying Systems, Inc.	AA-60-3/8-SS
Positive displacement pump (rinse pump)	EA	1	Rotan	HD33-BRM-1U4B2
Teflon hose w/SS braided sheath	FT	25	McMaster-Carr	52515K23

2.5.1.4 Distillation

A distillation unit links the stripping tank and the rinse tank. The unit draws NMP from the stripping tank when it becomes loaded with paint sludge. Under vacuum, the unit distills the solvent and separates the sludge. The unit is also equipped with a water diverter since NMP absorbs moisture from the air. The distilled NMP is drained into the rinse tank, and is used for rinsing parts. The still operates at a noise level of about 75-80 decibels. The supplier and model of the distillation unit are provided in Table 2-6. Contact information for the suppliers listed is given in Table 2-8. A schematic of the distillation unit is shown in Figure 2-5.

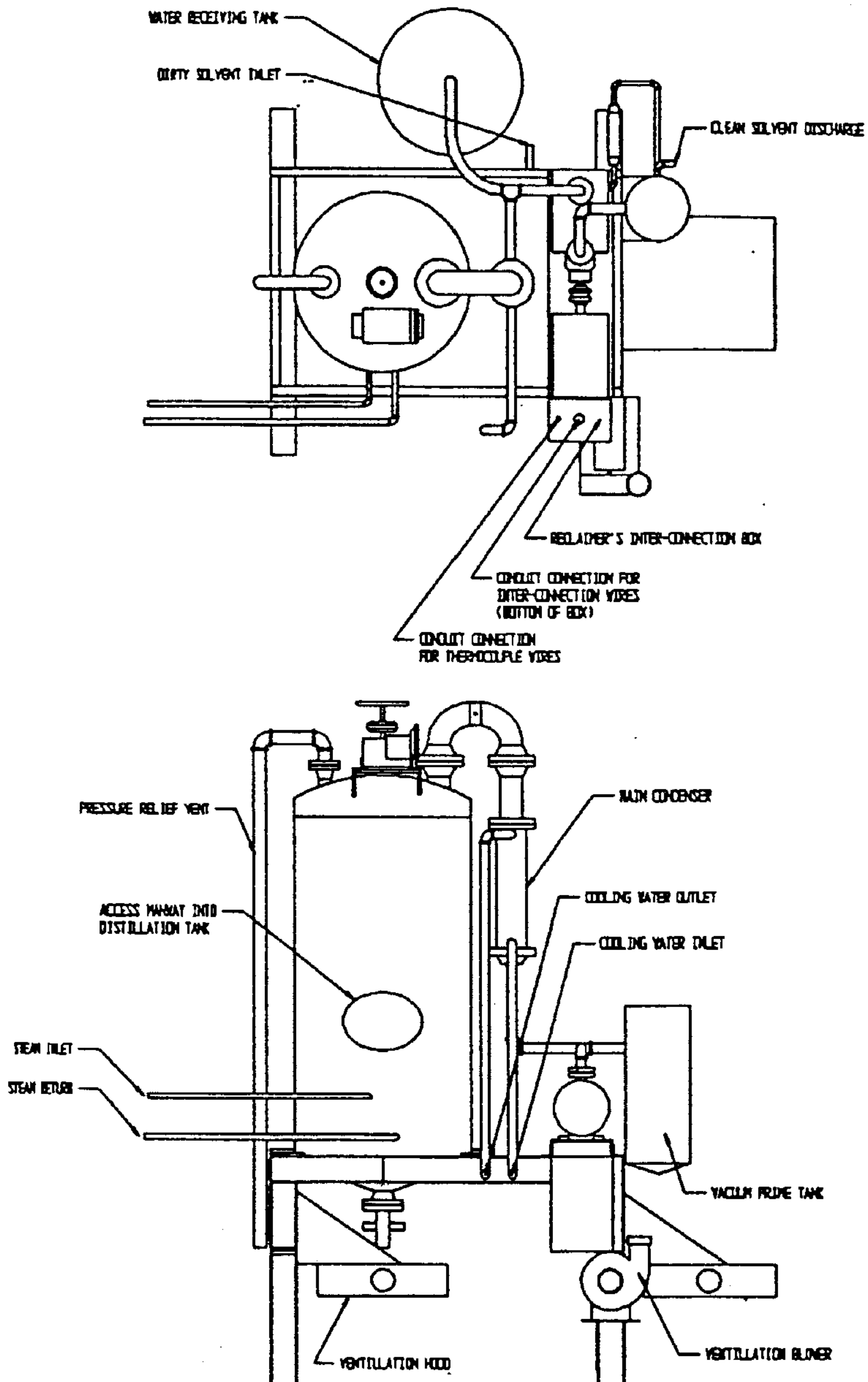


FIGURE 2-5. SCHEMATIC OF VACUUM DISTILLATION UNIT
(reprinted with permission from Finish Thompson, Inc.)

TABLE 2-6. EQUIPMENT USED FOR NMP DISTILLATION

ITEM	*U/M*	*QTY*	*SUPPLIER*	*MODEL #*
Vacuum distillation system	EA	1	FTI	BCF 380

2.5.1.5 Sensing and Monitoring Devices

The equipment used to monitor and record information about the process is listed in Table 2-7. Some of this equipment is necessary for the process; other equipment was only needed to gather data to calculate mass balance for the demonstration of the new process. The six foot thermocouple was placed in the stripping tank. A longer thermocouple was placed in the rinse tank so less NMP could be used to fill it. The level sensors sent an ultrasonic signal to the surface of the bath. The sensors and thermocouples were mounted in the adjacent back corners on brackets fabricated by the MCLB. Cables ran from the sensors to the work cabinet which housed the indicators, recorders, and power supply.

The thermocouples were wired into temperature indicators that provided an LED digital display of the temperature. The indicators had 0-10 Vdc output to the recorders and were scaled from 0 to 200 °F. The chart paper had divisions from 0 to 100; actual temperature was twice the value plotted on the strip chart.

The remote level sensors were wired into the sensor indicator displays. Both displays were powered with the same 120 Vac to 12 Vdc regulated power supply. The sensor displays had 0-10 Vdc output to the recorders. Because the sensors sent a signal to the surface of the NMP in the tank, higher readings on the level sensors corresponded to lower levels of NMP. The high setting for the sensors was 95 in., which corresponded to an empty tank. The low setting was 15 in.

Two channel recorders were used to simultaneously plot temperature and level. Because the recorders would be left on almost continuously, variable chart speeds with slow options were chosen. Also, the recorders had to accept dual 0-10 Vdc inputs. Replacement paper and pens were also ordered.

TABLE 2-7. EQUIPMENT USED FOR MONITORING AND RECORDING

ITEM	*U/M*	*QTY*	*SUPPLIER*	*MODEL #*
Extension grade thermocouple wire, 100 ft.	EA	1	Omega	EXPP-J-20-TWSH
120 Vac to 12 Vdc power supply	EA	1	Radio Shack	22-120
J-thermocouple, 304 SS sheath, 6 ft.	EA	1	Omega	GJQSS-14(U)-72
J-thermocouple, 304 SS sheath, 7-1/2 ft.	EA	1	Omega	GJQSS-14(U)-90
Non-contact ultrasonic level sensor	EA	2	Omega	LV404-RT(30)
Stripchart recorder, 2-channel flatbed	EA	2	Cole-Parmer	G-08380-82
Replacement paper	EA	1	Cole-Parmer	G-08380-83
Replacement pens, Channel 1 (green)	EA	2	Cole-Parmer	G08380-73
Replacement pens, Channel 2 (red)	EA	2	Cole-Parmer	G-08380-74
Temp. controller/indicator w/0-10Vdc output	EA	1	Omega	CN76060-PV
Temp. indicator w/0-10Vdc output	EA	1	Omega	DP21-TC-A03
Work cabinet, single door	EA	1	Grainger	1W814

TABLE 2-8. VENDOR LIST

Cole-Parmer Instrument Company
7425 North Oak Park Avenue
Niles, IL 60714
800-323-4340

Engineering Resources, Inc.
142 Crossen Avenue
Elk Grove Village, IL 60007
312-693-5500

Finish Thompson, Inc.
921 Greengarden Rd.
Erie, PA 16501-1591
800-888-3743

Grainger
6100 Fulton Industrial Boulevard
Atlanta, GA 30336-2852
404-346-7000

Jerguson®/Jacoby-Tarbox®
16633 Foltz Industrial Parkway
Strongsville, OH 44136
216-572-1500

McMaster-Carr Supply Company
PO Box 740100
Atlanta, GA 30374-0100
404-346-7000

Mechanical Equipment Company
PO Box 16272
Greensboro, NC 27406
919-596-8123

Mueller Steam Specialty
NC Hwy. 20 West
St. Pauls, NC 28384
910-865-8241

OMEGA Engineering
PO Box 4047
Stamford, CT 06907-0047
800-826-6342

Paul N. Gardner Company, Inc.
316 NE 1st Street
Pompano Beach, FL 33060
800-762-2478

R.S. Corcoran Company
500 North Vine Street
PO Box 429
New Lenox, IL 60451-0429
815-485-2156

Radio Shack
Local

Rotan
Borneman Pumps, Inc.
2825 Tophill Road
Monroe, NC 28110
704-289-1150

Spence Engineering Company, Inc.
150 Coldenham Road
PO Box 230
Walden, NY 12586
914-778-5566

Spraying Systems Company
PO Box 19444
Charlotte, NC 28219
704-392-9448

Tranter, Inc.
PO Box 2289
Wichita Falls, TX
817-723-7125

United
PO Box 60950
Charlotte, NC 28260
910-498-2661

2.5.2 Materials

NMP is readily available in large quantities and can be purchased commercially in different grades. The three producers of NMP in the United States are Arco, BASF, and ISP; contact information is provided in Table 2-9. There is sufficient production to meet expected needs. For estimating purposes, high-grade NMP costs roughly $2.00/lb while lower grades cost less. Producers may provide volume discounts for purchasing bulk quantities.

For this demonstration, 26,740 lbs of NMP were purchased from BASF.

TABLE 2-9. PRODUCERS OF NMP IN THE US

Arco Chemical Co.	BASF, Inc.	ISP Technologies Inc.
3801 West Chester Pike	3000 Continental Drive	1361 Alps Road
Newtown Square, PA 19073	Mt. Olive, NJ 07828	Wayne, NJ 07470
610-359-2000	201-426-4671	201-628-4000
800-321-7000 (orders)	800-634-9127 (orders)	
	800-828-6627 (NMP Hotline)	

2.5.3 Safety

The Material Safety Data Sheet for NMP is included in Appendix 2-3. The threshold limit value—time-weighted average (TLV—TWA) is the time-weighted average concentration for a normal eight-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. The TLV—TWA for NMP is given below in Table 2-10. The TLV—TWA for methylene chloride has been included for comparison.

TABLE 2-10. THRESHOLD LIMIT VALUES FOR NMP AND METHYLENE CHLORIDE

CHEMICAL	*CAS*	*FLASH POINT (°F)*	*TLV-TWA [a] (ppm [b])*
N-methyl pyrrolidone	872-50-4	195	100
Methylene chloride	75-09-2	none	50

[a] Threshold Limit Value — Time-Weighted Average.

[b] Parts of vapor or gas per million parts of contaminated air by volume at 77°F and 1 atmosphere.

NMP is classified as combustible and must be stored in accordance with applicable regulations. NMP is highly biodegradable and NMP waste may be effectively treated in an industrial wastewater treatment facility using activated sludge technology. Information on biodegradability and aquatic toxicity is included in Appendix 2-4. NMP will be classified as hazardous waste only if it contains hazardous components from the stripped parts.

NMP is a skin and eye irritant. NMP will not burn skin on contact, but because of its low vapor pressure, it will not quickly evaporate either. Personnel are required to wear splash goggles, butyl rubber gloves and butyl rubber aprons when working with NMP. This personal protection equipment (PPE) designed to protect the eyes and skin from direct contact is similar to that required now when working with methylene chloride and MEK. Areas must be properly ventilated to prevent vapor buildup to levels above the TLV.

As discussed in Section 2.3.7, NMP was added to SARA Title III, section 313, for chronic health effects. The basis of this decision were animal studies suggesting that NMP may cause reproductive toxicity. Additionally, there is considerable variation in the reported toxicology data in the MSDSs prepared by different chemical manufacturers. However, variation in the toxicological data may result from genetic variation in the species strain or from the models used to extrapolate the LD50 from the test data. Also, the data reported in Registry of Toxic Effects of Chemical Substances does not contain information on dosage, which also may greatly affect the results. Data for the same test may differ by a factor of two or more; even a factor of ten would not be considered unusual[2]. Under these circumstances, one would either use the most conservative figure, which would provide the most protection, or use the most recent data, which would take into account genetic drift in the species strain.

2.5.4 Economic Analysis

One aspect of changing process operations for pollution prevention purposes is the effect on capital and annual cost. Pollution prevention changes are more likely to be accepted if these costs stay the same or decrease. The following sections provide measures of capital and annual costs for replacing methylene chloride with NMP for paint stripping.

The methodology for estimating costs is taken from the EPA methods described in the OAQPS Control Cost Manual[3], which allows a convenient means of comparing different processes based on their annualized costs. Where actual costs were not known, factors applied to base equipment costs were used to estimate the remaining costs. These factors have been developed from a wide variety of sources associated with pollution control systems. The method provides a study estimate, which is intended to give a cost estimate within an accuracy range of ±30% of the actual cost when all the information affecting the costs is reasonable well known. This accuracy range is typical for EPA's estimates of pollution control systems when assessing cost impacts on existing or model facilities. Greater accuracy can be obtained with budget authorization estimates (±20%), definitive estimates (±10%), or contractor's estimates (±5%). Improved accuracy of the estimate is obtained only by improving the detailed knowledge of items that make up the estimate. In the present case, the firm costs obtained for most of the capital items could lead to a contractor's estimate if no assumptions were required for the remaining costs. However, unit costs, rates, and consumptions (listed in section 2.5.4.3) are not known with sufficient accuracy to go beyond a study estimate.

The estimates for NMP costing include most of the capital and annual cost items in the EPA methodology.

2.5.4.1 OAQPS Control Cost Manual

Analysis of the costs associated with the pollution prevention project is performed such that comparisons can readily be made between competing processes. A consistent format for costing is used so that comparisons are valid. To be compatible with EPA usage, the format in this report is taken from the OAQPS Control Cost Manual as mentioned above. The methodology used in the manual divides costs into two major categories, capital costs and annual costs. For the cost analysis to be meaningful, it must include all elements associated with implementation of new technologies. An exception is the case in which no new capital costs are incurred. Capital and annual costs can be further subdivided into the categories shown below:

- Site preparation and buildings
- Equipment

- Emission controls
- Materials
- Energy and utility requirements
- Labor requirements, including training
- Waste disposal
- Special transportation costs (hazardous materials)
- Recovery credits
- Overheads and capital recovery
- Accommodation costs (for changes in use or behavior forced by the new technology).

Treatment of each of the cost elements is briefly described below. As used in the OAQPS Control Cost Manual, the first three items are capital costs, while the remainder are annual costs. After all the cost elements are collected, they are presented as tables of capital and annual costs.

Capital Costs

Capital cost items are those requiring relatively large expenditures for land, buildings, and equipment expected to have a lifetime longer than a year (usually many years). Specific items are collected in the following paragraphs. For those cases in which explicit costs are not available, the factor method is used to estimate reasonable costs. Factors (as multipliers of the purchased equipment cost) are available in costing manuals or can be based on engineering judgement.

Site Preparation and Buildings: No site preparation (land clearing and leveling) or new buildings were required for the pollution prevention project.

Equipment and Emission Controls: Equipment costs include either new purchases (including add-ons) or modifications for existing items such as stripping and rinse tanks, heaters, storage tanks, water supply, fans, hoods, ducts, pollution control equipment, waste handling, or the vacuum distillation for recycling NMP. Costs include installation. These costs are taken from invoices, vendor quotes, or other records where available, or are estimated from cost manual data.

Indirect Costs: Associated with purchase and installation of equipment are the indirect costs that include engineering, construction and field expense, contractor fees, start-up, performance tests, and contingencies. Not all of these items are required.

Annual Costs

Annual costs include expenditures for operating and maintenance labor and materials, utilities, and waste disposal. Indirect costs include overhead, administrative charges, property taxes (where applicable), insurance, and capital recovery. With the exception of overhead, the indirect annual costs are related to capital costs. The annual cost elements are described in the following paragraphs. The sum of the annual costs provides a total annual cost that is useful for comparison with other systems or technologies.

Materials: Materials include raw materials for operation, and maintenance materials for repairs and preventive maintenance. Costs and usage rates for materials are obtained from MCLB records, vendors, or estimates from MCLB or RTI project personnel.

Energy and Utility Requirements: Energy and utility usage rates are taken from MCLB records, project data, or estimates for the equipment or process being analyzed. Included for this project are electric power, steam, water, and compressed air.

Labor Requirements: As with materials, labor is divided into operating and maintenance categories. Operator labor hours are estimated from project records or from observation by project personnel. Maintenance labor hours are projected based on estimates of project personnel. Labor hours are also required for supervision and for training.

Waste Transportation and Disposal: Waste disposal costs include wastewater treatment, solid waste disposal, and hazardous waste treatment or disposal. Transportation costs are included in the waste disposal costs. Quantities are taken from MCLB records or are projected from project data.

Recovery Credits: Recycling of spent solvents may provide money to offset costs of operation. For this project, on-site distillation of NMP is analyzed for its contribution to reducing costs.

Overheads and Capital Recovery: General and administrative overheads, property tax, and insurance are taken from information provided by MCLB or from estimates by project personnel. Capital recovery charges are estimated from current EPA usage for interest rates; equipment lifetimes are based on engineering judgement.

Accommodation Costs: Identifiable costs are included here that are associated with a changeover to new technology. An example for this project is higher than normal initial solvent usage while learning to use NMP for paint stripping.

2.5.4.2 Obtaining Cost Elements

Capital Costs

Because the factor method is dependent on base equipment costs for its capital cost accuracy, special care must be taken to record all of the individual items purchased. For the present work, each required item is purchased through RTI's purchasing department. All RTI purchases are posted on a computer operated accounting system that allows identification of each item associated with the project.

Annual Costs

Annual cost items are largely dependent on the labor, utility, and materials costs associated with operating a process and on recovery of capital. As with capital costs, accuracy of the annualized cost estimate depends on the accuracy of the information collected for these cost elements and also for the usage rates associated with the operating costs. Capital costs remain important in estimating annualized costs because most of the costs and the capital recovery cost depend on purchased equipment costs. For the present project, unavailability of some unit costs and usage rates may affect the accuracy (and the conclusions) of the cost analysis.

2.5.4.3 Unit Costs, Rates, and Assumptions for Economic Analysis

Unit Costs and Rates Used Throughout Economic Analysis

The following unit costs and rates were used throughout the cost analysis:

- Operating labor costs are $16.52/hr, taken and updated from the OAQPS Control Cost Manual, pp. 7-43, April 1991.
- Maintenance labor costs are $18.17/hr, taken and updated from the OAQPS Control Cost Manual, pp. 7-43, April 1991.
- Supervisory labor costs are 115% of operating labor costs, taken from the OAQPS Control Cost Manual, pp. 7-43, April 1991.
- Training costs are $33.04/hr based on twice the operating labor rate.
- Waste disposal costs for low-end wastes include $0.35/lb for transportation and $0.80/lb for disposal, based on interpolation from MCLB estimate.
- Waste disposal costs for high-end wastes include 0.35/lb for transportation and $1.80/lb for disposal, based on interpolation from MCLB estimate.
- Water costs $0.21/1,000 gal, taken and updated from OAQPS Control Cost Manual, pp. 9-51, July 1992.
- Electricity costs $0.0709/kWh, cited in *Chemical Engineering*, January 1995.
- Compressed air costs $0.19/1,000 scfm, from example problem in OAQPS Control Cost Manual, pp. 5-49 (April 1991) and updated with *Chemical Engineering* (CE) cost index.
- Steam cost $3.40/1,000 lb based on estimate from MCLB.
- Wastewater disposal or treatment costs $4.75/1,000 gal updated from OAQPS Control Cost Manual, pp. 9-51, July 1992.
- Methylene chloride costs $0.51/lb based on MCLB records and includes shipping charges of $0.05/lb.
- NMP costs $1.82/lb based on RTI accounting records and includes shipping charges of $0.05/lb.

- State emissions fee of $25/ton required for hazardous air emissions is not charged because MCLB is below the minimum.

Assumptions Used for NMP Stripping

The following assumptions were used for NMP stripping.

- Capital costs are taken from RTI accounting records. The initial charge of NMP is included in the capital costs.
- Operator hours are the same as for methylene chloride stripping, but no annual tank cleaning charge is added.
- Maintenance hours and compressed air usage are the same for methylene chloride and NMP stripping.
- NMP consumption is 16,632 lbs/yr (3 bbl/month), based on RTI projections.
- Power usage is estimated at 2.8 kW for miscellaneous electrical loads plus the NMP distillation unit.
- Steam usage is based on 100 lb/hr per FTI boiler specifications, plus 20% for startups and losses. The still operates 1 shift/ week, 2 hrs/shift. Dip tank heating is included at a weekly rate of 1,570,000 Btu as estimated by project personnel. One pound of steam is assumed equivalent to 1,000 Btu.
- Water usage is taken as 20 gal/shift for rinsing plus 7 gal/min for the still (per Finish Thompson range of 4 to 10 gal/min).
- Waste water disposal taken as 20 gal/shift (all of the rinse water).
- Waste disposal based on same quantity of paint waste sludge as for methylene chloride stripping. Low-end disposal charge applies.

Assumptions Used for Methylene Chloride Stripping

The following assumptions were used for methylene chloride stripping.

- Capital costs include tank clean out and charging with fresh methylene chloride.
- Operator hours estimated from observation. Annualized charge of $1,588 added for periodic tank cleaning.

- Methylene chloride usage is based on MCLB estimates.
- Power usage is estimated at 2 kW for miscellaneous electrical loads.
- Compressed air usage is estimated at 20 scfm/hr based on 3 scfm/gun x 15 min use/day.
- Water usage is estimated at 60 gal/shift for rinsing.
- Waste water disposal is based on treating one-third of the rinsing water (the other two thirds goes into the methylene chloride tank or the first rinse tank).
- Assumes disposal of 10 500-lb drums/yr containing tank sludge, based on MCLB estimate. High-end disposal charge applies.

2.5.4.4 Paint Stripping

Results of NMP Costing

Tables 2-11 and 2-12 provide estimated capital and annual costs for NMP paint stripping. Total capital investment is $166,260, with the major items being the purchase of a distillation unit to recover used NMP and the original charge of NMP. Factors were used to obtain values for most of the direct and indirect installation costs, which may be conservative.

Annualized cost is $90,695/yr, with the largest elements being materials, capital recovery, labor, and waste disposal.

Discussion of NMP Costing

The short time available for actual operation of the stripping system and the non-separability of capital cost elements impact the accuracy of the cost estimates. While a study estimate is typically within ±30% of the true cost, it is likely that such accuracy is not reached for this project. A relatively modest increase in operating experience and the opportunity to search MCLB records in more depth should provide a significant increase in accuracy.

One item that can be included under accommodation costs is several hundred dollars for NMP that was lost while learning how to operate the stripping tank controls.

TABLE 2-11. CAPITAL COSTS FOR NMP PAINT STRIPPING

DIRECT COSTS		
Purchased Equipment Costs		
System with controls*		$141,870
Instrumentation (if not included in controls)		$6,131
Sales Taxes		$0
Freight		$7,093
Purchased Equipment Cost, PEC		*$155,094*
Direct Installation Costs		
Foundations and supports		$0
Handling and erection		$1,551
Electrical		$1,241
Piping		$1,551
Insulation for ductwork		$0
Painting		$620
Direct Installation Costs		*$4,963*
Site Preparation	*as required,*	
Buildings	*as required,*	
Total Direct Cost		*$160,057*
INDIRECT COSTS (INSTALLATION)		
Engineering		$3,102
Construction and Field Expense		$0
Contractor Fees		$0
Start-up		$775
Performance Test		$0
Contingencies		$2,326
Total Indirect Costs, IC		*$6,203*
TOTAL CAPITAL INVESTMENT, TCI		**$166,260**

(*Includes initial NMP charge of $39,153)

TABLE 2-12. ANNUALIZED COST ANALYSIS OF NMP PAINT STRIPPING

DIRECT ANNUAL COSTS, DC		
Operating Labor		
Operator *([2.5 hours/day]*[260 days/year]*[$16.52/hour])*		$10,738
Supervisor *(15% of operator)*		$1,611
Training *([8 hours/year/employee]*[$33.04/hour]*[10 employees])*		$2,643
Operating Materials		
NMP *([$1.82/pound]*[16,632 pounds/year])*		$30,270
Maintenance		
Labor *([0.5 hours/day]*[260 days/year]*[$18.17/hour])*		$2,362
Material *(Equal to Maintenance Labor)*		$2,362
Utilities†		
Electricity *([2.8 kW]*[$0.071/kWhour]*[2080 hours/year])*		$414
Steam *([45 pounds/hour]*[$3.40/1000 pounds]*[2080 hours/year])*		$318
Compressed air *([40 scfm/hour]*[$0.19/1000 scfm]*[2080 hours/year])*		$16
Water *([23.5 gal/hour]*[$0.21/1000 gal]*[2080 hours/year])*		$10
Wastewater Treatment *([2.5 gal/hour]*[$4.75/1000 gal]*[2080 hours/year])*		$25
Waste Disposal *([2.5 tons/year]*[$2,300/ton])*		$5,750
	Total Direct Cost, DC	*$56,519*
INDIRECT ANNUAL COSTS, IC		
Overhead (60% of sum of labor + maintenance materials)		$11,830
Administrative charges	*TCI * 0.02*	$3,325
Property taxes	*TCI * 0.01*	$1,663
Insurance	*TCI * 0.01*	$1,663
Capital recovery	*CRF*TCI (CRF=0.0944)*	$15,695
	Total Indirect Costs, IC	*$34,176*
	TOTAL ANNUAL COST, TAC (TAC = DC + IC)	**$90,695**

† In calculating the annualized costs, consumption of utilities has been normalized to one eight-hour shift, five days per week, fifty-weeks per year.

Economic Comparison with Methylene Chloride Stripping

Estimated stripping costs with methylene chloride are shown in Tables 2-13 and 2-14. Capital costs are limited to dip tank preparation and an initial charge of methylene chloride. Most of the direct and indirect installation costs do not apply in this case.

A summary comparison of the capital and annualized costs is presented in Table 2-15. Assuming that an existing tank system is either to be cleaned and filled with methylene chloride or is to be refurbished for use with NMP, capital costs are significantly lower for the methylene chloride system (about 11 percent of the NMP system). Estimated annualized costs are $86,888, or about 96% that for NMP. The major cost is for the methylene chloride, which is used in much larger quantities than estimated for NMP (almost ten times as much). Other significant costs, as with NMP stripping, are labor and waste disposal.

Given the assumptions of this analysis, NMP stripping is comparable to methylene chloride stripping on an annualized basis. Taking advantage of NMP depends on being able to acquire the significantly higher amount of capital required to purchase and install the distillation unit and heating system.

TABLE 2-13. CAPITAL COSTS FOR METHYLENE CHLORIDE PAINT STRIPPING

DIRECT COSTS		
Purchased Equipment Costs		
System with controls*		$17,854
Instrumentation (if not included in controls)		$0
Sales Taxes		$0
Freight		$893
Purchased Equipment Cost, PEC		*$18,747*
Direct Installation Costs		
Foundations and supports		$0
Handling and erection		$187
Electrical		$0
Piping		$0
Insulation for ductwork		$0
Painting		$0
Direct Installation Costs		*$187*
Site Preparation	*as required,*	
Buildings	*as required,*	
Total Direct Cost		*$18,934*
INDIRECT COSTS (INSTALLATION)		
Engineering		$0
Construction and Field Expense		$0
Contractor Fees		$0
Start-up		$187
Performance Test		$0
Contingencies		$562
Total Indirect Costs, IC		*$749*
TOTAL CAPITAL INVESTMENT, TCI		**$19,683**

(*Includes cleaning costs of $1,639 and initial methylene chloride charge of $16,215)

TABLE 2-14. ANNUALIZED COST ANALYSIS OF METHYLENE CHLORIDE PAINT STRIPPING

DIRECT ANNUAL COSTS, DC	
Operating Labor	
Operator *([2.5 hours/day]*[260 days/year]*[$16.52/hour]) + ([8 hours/day]*[9 days/year]*[$16.52/hour]) for clean out*	$11,927
Supervisor *(15% of operator)*	$1,789
Training *([8 hours/year/employee]*[$33.04/hour]*[10 employees])*	$2,643
Operating Materials	
Methylene chloride *([$0.54/pound]*[73,000 pounds/year])*	$39,420
Maintenance	
Labor *([0.5 hours/day]*[260 days/year]*[$18.17/hour])*	$2,362
Material *(Equal to Maintenance Labor)*	$2,362
Utilities†	
Electricity *([2.0 kW]*[$0.071/kWhour]*[2080 hours/year])*	$295
Steam *([0 pounds/hour]*[$3.40/1000 pounds]*[2080 hours/year])*	$0
Compressed air *([40 scfm/hour]*[$0.19/1000 scfm]*[2080 hours/year])*	$16
Water *([7.5 gal/hour]*[$0.21/1000 gal]*[2080 hours/year])*	$3
Wastewater Treatment *([2.5 gal/hour]*[$4.75/1000 gal]*[2080 hours/year])*	$25
Waste Disposal *([2.5 tons/year]*[$4,300/ton])*	$10,750
Total Direct Cost, DC	*$71,592*

INDIRECT ANNUAL COSTS, IC		
Overhead (60% of sum of labor + maintenance materials)		$12,650
Administrative charges	*TCI * 0.02*	$394
Property taxes	*TCI * 0.01*	$197
Insurance	*TCI * 0.01*	$197
Capital recovery	*CRF*TCI (CRF=0.0944)*	$1,858
	Total Indirect Costs, IC	*$15,296*
	TOTAL ANNUAL COST, TAC (TAC = DC + IC)	**$86,888**

† In calculating the annualized costs, consumption of utilities has been normalized to one eight-hour shift, five days per week, fifty-weeks per year.

TABLE 2-15. SUMMARY COMPARISON OF COST ANALYSIS

PROCESS	*CAPITAL COSTS*	*ANNUALIZED COSTS*
Methylene Chloride Stripping	$19,683	$86,888
NMP Stripping	$166,260	$90,695

2.5.4.5 Return on Investment and Payback Period for NMP Stripping

Return on investment (ROI) and payback period (PP) are two common measures for estimating the profitability of a venture. Return on investment as used for this project is the average yearly profit divided by total capital investment, expressed as a percentage. The average yearly profit is taken as the difference in annualized cost between the existing process and its intended pollution prevention replacement.

Payback period is the total capital investment divided by the sum of profit (as used above) and depreciation of the pollution prevention equipment. For this project, the straight line depreciation method is used with a 5 percent salvage value. Depreciation is total capital investment minus salvage value, all divided by equipment life.

Table 2-15 suggests switching to NMP would result in a yearly loss of approximately $3800. For this reason, calculations of ROI and PP are not shown here. However, given the uncertainty in the estimate, the costs should be considered comparable. Also, the largest annual cost element in switching to NMP is for operating materials. Additional steps taken to further reduce air emissions, such as covering the tanks when not moving baskets of parts in and out, will significantly reduce the amount of NMP needed and thus lower the operating material cost.

2.6.0 DISCUSSION OF OBJECTIVE

As discussed previously, the MCLB is required to reduce air emissions from hazardous air pollutants by 50% from 1992 levels. The MCLB provided a summary of their purchase history of toxic materials for 1992[4]. Table 2-16 shows the hazardous air pollutants from this list.

The MCLB has already replaced 1,1,1-trichloroethane vapor degreasers with aqueous parts washers. This change alone will reduce emissions from HAPs by 16%. By eliminating the methylene chloride for immersion stripping, the MCLB can further reduce emissions another 11%. The MCLB has also replaced methyl ethyl ketone with a propylene carbonate/benzyl alcohol blend for cleaning paint application equipment, reducing emissions from HAPs an additional 21%. These three changes combined result in a reduction of emissions of 48%.

Five of the chemicals listed in Table 2-16 are components in paints and coatings used at the MCLB. The MCLB plans to replace solvent-borne CARCs with water-borne CARCs in 1996 to achieve over 50% reduction in emissions from HAPs.

TABLE 2-16. SUMMARY OF HAZARDOUS AIR POLLUTANTS BASED ON 1992 PURCHASE HISTORY

CONSTITUENT	*LBS.*	*USE*
1,1,1-trichloroethane	49,077	neat - degreaser
ethyl benzene	1,465	component - aircraft thinner
ethylene glycol	75,527	neat - antifreeze
methyl isobutyl ketone	613	component - paints
methyl ethyl ketone	89,787	63,810 lbs. neat for paint cleanup/remainder in paints
methylene chloride	33,700	component - paint stripper
toluene	18,533	component - paints
trivalent chromium	16,801	component - paints
xylene	16,600	component - paints

2.7.0 CONCLUSIONS

Based on this demonstration, the following conclusions may be drawn:

1) NMP was demonstrated to be an effective replacement for methylene chloride for MCLB's immersion paint stripping process.

- The NMP, when heated to 150 ±5 °F, will remove multiple layers of CARC and strip parts to the base metal within 3-4 hours.
- The heated NMP will successfully remove Plastisol®, a plastic coating, from battery tie-down brackets within 3-4 hours. These parts were previously stripped in a hot alkaline bath, followed by scraping and blasting to remove the coating.
- The NMP will soften epoxy-based topcoats, but removal usually requires overnight soaking.

2) Emissions of HAPs from paint stripping was reduced to zero by replacing methylene chloride with NMP. This is an important achievement for MCLB towards meeting their overall emissions reduction goals. Air emissions from VOCs are still present, since NMP is a VOC.

3) The distillation unit may provide a convenient method of removing paint sludge. It is expected that the pump agitation combined with the solvency of the NMP will dissolve paint chips in the tank; the paint will be separated from the NMP during distillation. It is likely that there will be no need to drain the tank for paint sludge removal as required with the methylene chloride. The course of this demonstration was too short to confirm this.

4) Annualized cost of NMP stripping is comparable to stripping with methylene chloride, although the start-up cost is higher.

The recommendations for MCLB are continued use of NMP as an immersion stripper and to consider the use of NMP as a stripper in other applications where immersion is the preferred process.

2.8.0 REFERENCES

1. Letter from James L. Taylor, USMC, to J. K. Whitfield, US EPA, April 21, 1995.

2. Personal conversation with Dr. Rochelle Tyl, Research Director for RTI's Center for Life Sciences and Toxicology, July 23, 1995.

3. OAQPS Control Cost Manual, EPA-450/3-90-006 (NTIS PB90-169954), January 1990.

4. Letter from John Woodward, MCLB Albany, GA, to Principal Director, Maintenance Directorate, June 14, 1993.

APPENDIX 2-1

STANDARD OPERATING PROCEDURE
FOR
IMMERSION STRIPPING IN
N-METHYL PYRROLIDONE

Prepared By:	Approved By:	Approved By:	Approved By:	Revision
J. M. Elion	E. A. Hill	J. K. Whitfield	D. Gillum	—

1. SCOPE

1.1. Scope.

This document covers the general requirements for stripping cured chemical agent resistant coating (CARC) systems from tactical military equipment via immersion in n-methyl pyrrolidone. It is intended for use as a guide and as a supplement to information available in the below referenced specifications. This document also includes information regarding health and safety guidelines, environmental restrictions, and operating techniques.

2. APPLICABLE DOCUMENTS

2.1. Government documents

The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

MIL-C-53072	Military Specification, Chemical Agent Resistant Coating (CARC) System Application Procedures and Quality Control Inspection
TT-C-490	Federal Specification, Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings

2.2. Order of precedence

In the event of a conflict between the text of this document and the references cited herein, the text of the specifications takes precedence. Nothing in this document supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1. Equipment

3.1.1. Distillation unit

3.1.2. Paint adhesion test kit

3.1.3. Platecoil heater

3.1.4. Recirculation pump

3.1.5. Rinse pump

3.1.6. Spray wands

3.1.7. Stripchart recorder

3.1.8. Thermocouple probes, Type J

3.1.9. Ultrasonic level/distance transmitter

3.2. Materials

3.2.1. N-methyl pyrrolidone (NMP)

3.3. Health & Safety

Operators are required to wear butyl rubber aprons, butyl rubber gloves, and butyl rubber boots to minimize skin contact. Operators are required to wear eye goggles and face shields. The Material Safety Data Sheet shall be easily accessible to all operators.

Ventilation will be run continuously while NMP is in either the wash tank or the immersion tank. Operators are to notify their immediate supervisor if there is a noticeable fish-like odor (typical of NMP). This indicates insufficient ventilation or a possible leak in the tank.

3.4. Environmental Restrictions

NMP has been added to the SARA Title III list of chemicals and is subject to reporting under Toxic Release Inventory (TRI) guidelines effective January 1, 1995. Although NMP is a volatile organic compound (VOC), it is not classified as a hazardous air pollutant (HAP).

3.5. Processes and operation

3.5.1. Removal of paint from finished parts

3.5.1.1. Recirculation pump operation

Turn on the recirculation pump by rotating the breaker located in the upper right corner of the control panel 90° clockwise from OFF to ON. Turn pump switch from OFF to MANUAL. The recirculation pump must be operated whenever the tank heater is on. The pump promotes even temperature distribution throughout the tank and provides agitation to the bath.

3.5.1.2. Tank heatup

Prior to stripping parts, the NMP in the tank shall be heated to 150°F ±10°F. The recirculation pump must be operating before starting the tank heatup procedure. Heat the NMP from room temperature by opening the 2" gate valve, the 2" globe bypass valve, and the 1" gate valve near the temperature control valve (Figure 1a).

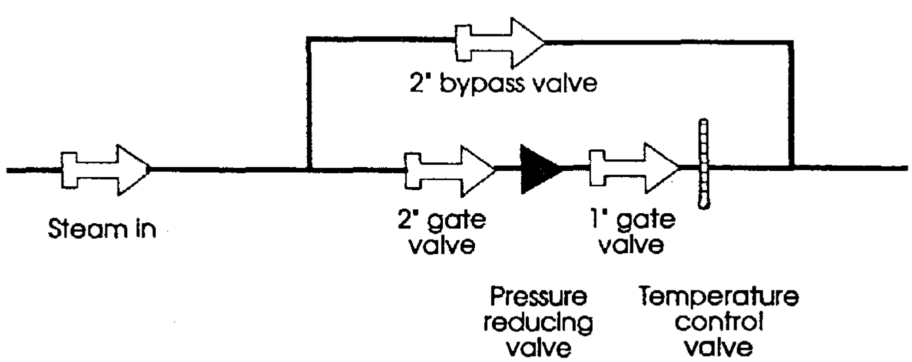


Figure 1a. Valve Configuration for Startup

When the temperature reaches 140°F, close the 2" globe bypass valve (Figure 1b). It will take approximately 20 minutes to heat from room temperature to 140°F. During routine operation and shutdown, the 2" and 1" gate valves will remain open.

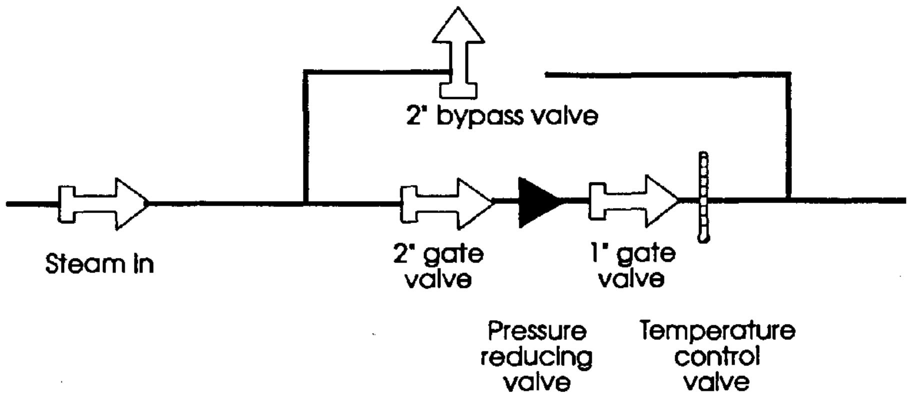


Figure 1b. Valve Configuration for Routine Operation

Once the tank is heated, it should be left at operating temperature except for weekends and plant shutdowns. To shutdown, close the 2" globe bypass valve, the 2" gate valve in the control line, and the steam supply valve (Figure 1c).

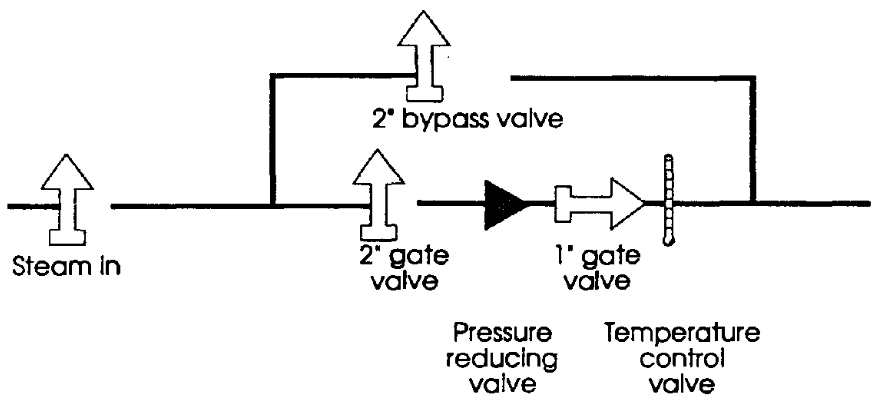


Figure 1c. Valve Configuration for Shutdown

3.5.1.3. Loading parts

Load parts to be stripped in 4' x 4' wire baskets. Parts shall be loaded in the basket to allow for easy drainage. Parts should be racked to avoid nesting and to allow the NMP to contact all surfaces.

3.5.1.4. Immersing parts

Lower the basket of parts into the tank at a sufficiently slow speed to prevent excessive splashing of the NMP.

3.5.1.5. Soaking parts

Soak the parts in the heated NMP bath 180 ± 30 minutes. When soaking is complete, raise the basket and hold it just above the tank to allow excess NMP to drain back into the tank.

3.5.1.6. Primary rinse

With the basket of parts held just above the immersion tank, rinse the parts by spraying with NMP. Operators will use virgin or recycled NMP to rinse paint sludge and dirty NMP from the parts. The NMP rinse will used as makeup NMP in the immersion tank. Use caution to avoid NMP splashback.

3.5.1.7. Air blowoff

Blow off remaining NMP with shop air. Use caution to avoid NMP splashback.

3.5.1.8. Second rinse

Move the basket of parts away from the NMP immersion and recycled reservoir tanks. Rinse the parts with water. The waste water will be treated by the MCLB's on-site industrial waste water treatment plant.

3.5.1.9. Dry

Allow parts to air dry before the next process step.

3.5.2. Process maintenance

3.5.2.1. Solvent distillation

The distillation process itself is not part of this operating procedure. The unit will be run in batch mode on second shift or on weekends and will shut off automatically when the NMP level in the immersion tank reads 50.00 as indicated on the level sensor. Frequency of operation will be determined by level of use of the stripping bath.

Rinsing with NMP will deplete the reservoir tank and add to the immersion tank. Distillation will stabilize the immersion tank level, provide recycled NMP for rinsing, and prevent high dissolved solids build-up in the immersion tank. The NMP in the immersion tank will be distilled when any one of the following conditions are met:

1) The NMP level is within 24" of the top of the immersion tank when a basket of parts is immersed.
2) The heating platecoil is exposed in the stripping bath with no basket present.
3) Parts are not satisfactorily stripped in less than 4 hours. This may indicate a high concentration of dissolved solids which need to be removed.

3.5.2.2. Immersion tank cleaning

Over time, paint sludge will accumulate on the bottom of the tank. At least once a year, the immersion tank will be drained by running the distillation unit in a continuous mode. The recycled NMP will be stored in the reservoir tank. Personnel will wear coveralls, boots, butyl rubber gloves, goggles, and an appropriate respirator when cleaning out paint sludge. Paint sludge will be drummed and disposed of as hazardous waste. The immersion tank will be refilled from the reservoir tank.

3.5.3. Shut-down procedures

3.5.3.1. Daily

Once the tank is heated, it should be left at operating temperature except for weekends and plant shutdowns.

Parts with thick coatings or multiple layers of coatings may be left in the tank overnight.

3.5.3.2. Weekly

Turn off heat as shown in Figure 1c. Turn off recirculation pump by switching pump from MANUAL to OFF and rotating the breaker 90°counterclockwise from ON to OFF. Remove basket of parts from tank.

3.5.3.3. Long-term

Turn off heat as shown in Figure 1c. Turn off recirculation pump by switching pump from MANUAL to OFF and rotating the breaker 90°counterclockwise from ON to OFF. Remove basket of parts from tank.

4. QUALITY ASSURANCE PROCEDURES

4.1. Process monitoring and control

Temperature and fluid levels in both the immersion tank and recycled NMP reservoir tank are continuously monitored. The thermocouple in the heated tank is connected to an indicator panel, which provides the current temperature of the bath. The level sensors provide high and low level alarms for the distillation unit.

(Data from the thermocouples and the level sensors will also be continuously plotted on strip chart recorders as part of the demonstration. Data from these sensors are used to calculate a mass balance for the system and determine emissions.)

4.2. Sensor checkout and calibration

The monitoring and control equipment should be checked prior to startup according to the following procedures. Record all readings and the reference standards used.

4.2.1. Thermocouples

Thermocouples and indicators will be checked prior to the demonstration program by immersing each thermocouple in a water bath of known temperature. A reference mercury-in-glass thermometer or other suitable temperature reference will be used. The indicators have been scaled to provide direct current voltage analog output from 0° to 200°F. The output of the stripchart recorder should agree with the reading from the reference thermometer within ±1 degree.

4.2.2. Level indicators

Level meters, alarms, and stripchart recorders will be checked prior to the demonstration program by comparing the output with a graduated rod that extends to the bottom of the tank (reference zero level). The sensors have been scaled to provide direct current voltage analog output from 15.0 to 95.0 inches. The output of the stripchart recorder should agree with the reading from the reference within ±0.5 inches.

4.3. Inspection and monitoring

4.3.1. Process controls

The correct configuration for the control panel on the strip chart recorders is shown in Figure 2. From left to right, the first switch should be on the red circle, the second switch should be on the point down triangle, the indicator dial should be on the "10/12", the fourth switch should be in the neutral center, and the fifth switch should be on the "cm/h".

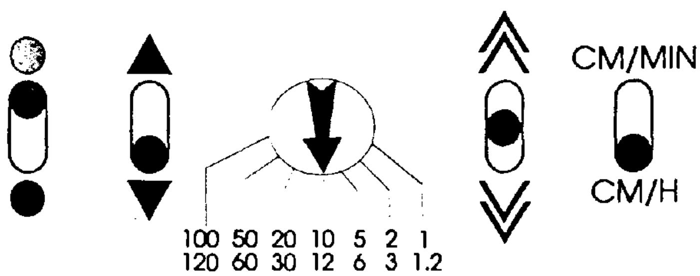


Figure 2. Correct Configuration shown for Strip Chart Recorder Control Panel

The correct configuration for the channel panel on the strip chart recorders is shown in Figure 3. Both the level sensors and thermocouple indicators provide 0 to 10 volts direct current analog input to the strip chart recorders.

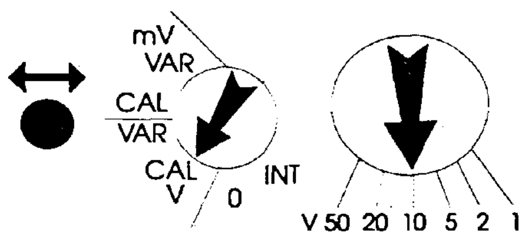


Figure 3. Correct Configuration for Strip Chart Recorder Channels

During the demonstration period, continuously record the temperature and fluid levels of both the immersion tank and the recycled NMP reservoir tank while the system is in use. The operator is responsible for checking the test equipment on a daily basis. The operator will verify that the recorder has chart paper and the pens are not dried out. The operator should refer to the operator's manual when changing paper and/or pens. Both channels should be re-zeroed when the paper is changed.

Plotting temperature and fluid levels upon completion of the demonstration will be at the discretion of the MCLB.

4.3.2. Inspection records

At the start of each first shift, the operator will indicate the date and time on the chart paper using a blue or black ball point pen. The operator should also indicate significant events such as unscheduled shut-downs on the chart. Whenever possible, the operator should also indicate routine operations such as immersing a load of parts, running the distillation unit, or adjusting the temperature.

4.4. Production acceptance tests

Acceptance of the NMP stripping method will be based on achieving successful adhesion of CARC to the cleaned parts, applied in accordance with MIL-C-53072.

5. NOTES

5.1. Intended use

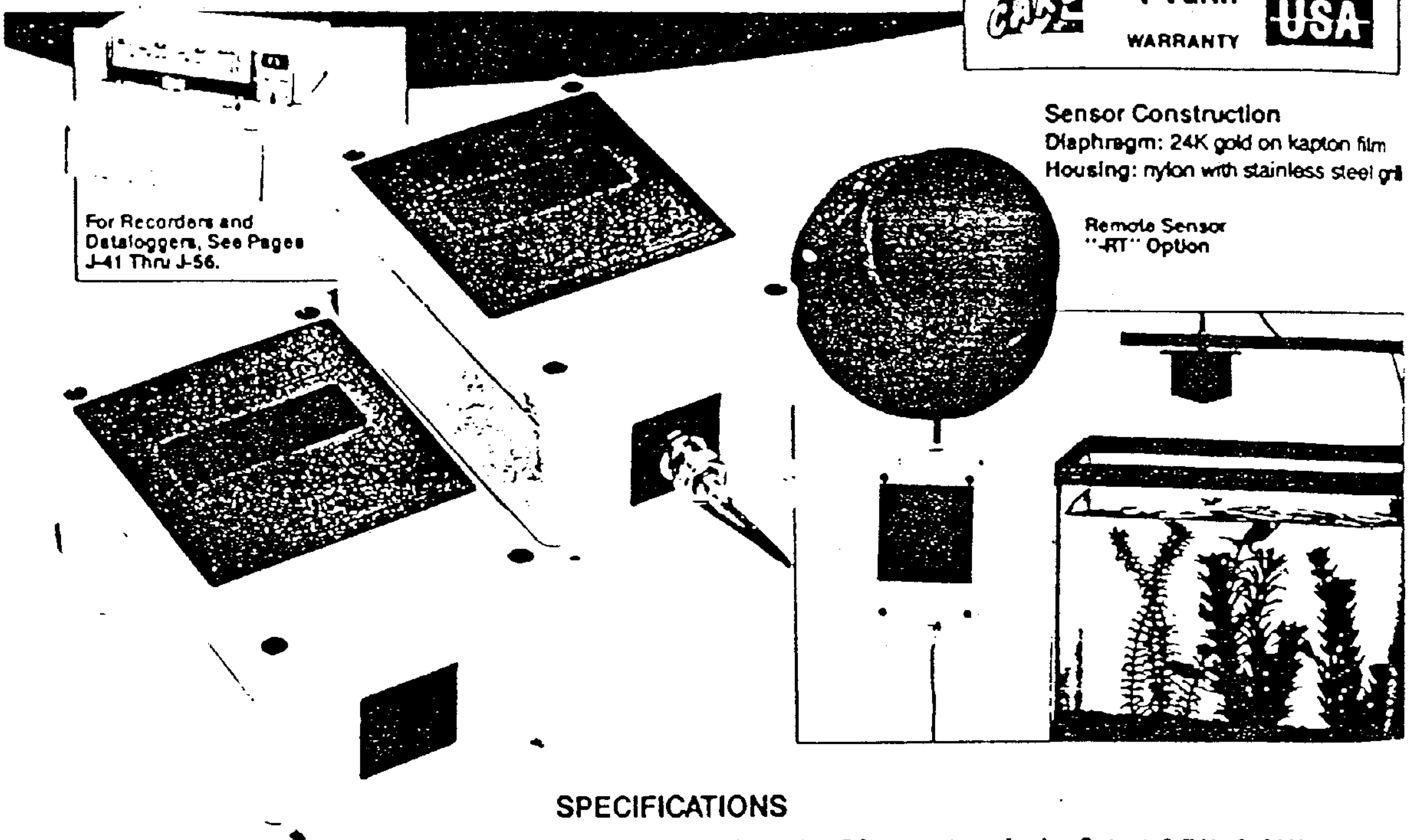
This standard operating procedure is intended to conform to the requirements of TT-C-490, Method II.

APPENDIX 2-2

EQUIPMENT DESCRIPTIONS

NON-CONTACT ULTRASONIC LEVEL/DISTANCE TRANSMITTER Series LV400

1 YEAR WARRANTY MADE IN USA



Shown smaller than actual size

The LV400 series displays and transmits the distance of objects located in front of the sensor in the open air in the range from 0.5 to 30 feet with an accuracy of up to 1% of reading. It is suitable for measuring liquid levels in tanks open to the air (0 psig internal), certain solid levels as well as other general distance measurements. All units feature a 4 digit LED display with 0.1 inch resolution. Available with alarm relays, analog outputs, RS-232 or RS-422 2-way computer communications, and a remote transducer. Setting the limits of the alarms and analog output can be performed manually by presenting targets at the desired setpoints or by entering the exact distance value (in inches) by computer communication. Alarm setpoints equal the analog output span.

Temperature compensation for variations in air temperature is done automatically by placing a reference target at an exact distance away from the sensor.

SPECIFICATIONS

Resolution: .007" for analog, RS-232 and RS-422 outputs, 0.1" display
Temp. Effect: 1% shift in accuracy/every 18°F away from 68°F air temperature when not using the Auto Temperature Compensation
Beamwidth: 12 degrees; target should occupy one square ft/10 ft of distance for optimal performance.
Range: 0.5 to 30 feet
Weight: 11 oz.
Dimensions: 2.14" X 3.14" X 4.72"
Output Cable: 24" length
Relay: .25 AMP @ 120 Vac resistive, SPDT
Analog Output: 0-3Vdc, 0-10 Vdc, or 4-20 mA, 256 steps within setpoints. 4-20 mA requires external 5-50 Vdc power supply. Max loop resistance = (supply voltage −5) x 53. 1000 ohms for 24 Vdc supply. Standard output increases with increasing distance from sensor face.
Power: 7.5 to 12 Vdc @ 500 mA (LV404 accepts 12 Vdc ONLY!)
Operating Temp: −20°F to 160°F for sensor; 32°F to 158°F for electronics
Relative Humidity: 5% to 95% Non Condensing

HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY

To Order (Specify Model Number)

Model number	Price	Description
LV401	$329	Unit with high relay ONLY
LV402	399	Unit with high relay and 4-20 mA output
LV403	399	Unit with high relay and 0-3 Vdc output
LV404	399	Unit with high relay and 0-10 Vdc output

Add suffix "-RS232" or "-RS422" for communication option. Add $140 to price. Add suffix "-R" for additional low relay output, and add $39 to price. Add suffix "-RS" to reverse action of analog output (increasing output with decreasing distance from the sensor face), and add $29 to price. Add suffix "-RT(*)" for remote sensor, replacing asterisk with cable length in feet up to 40, and add $109 for first 5', and add $1 per additional foot. To display height, reverse the distance display with option "-AZ0" and add $29 to price. For extended range measurement, displays in feet (0.1) up to 60-ft range, add suffix "-ER" and add $29 to price. Ordering Example: LV401-RT(5), calls for ultrasonic transmitter, with high relay and remote sensor with 5.0 ft cable. Price: $329 + 109 = $438.

120- AND 200-MM FLATBED RECORDERS

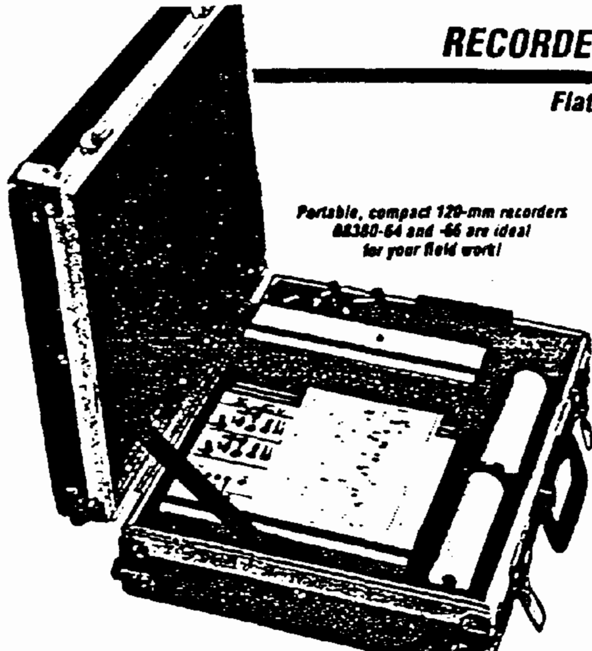
COMPACT 120-MM RECORDERS

These lightweight recorders are available in one- or two-channel models. All feature 12 chart speeds, with fast advance of 50 cm/min. Inputs range from 10 mV to 50 V; variable gain setting allows full-scale deflection between the fixed range settings. Use convenient knob to manually position paper on grid marks.

Line-powered models operate on 115/230 VAC, 50/60 Hz (switchable); include a 7-ft cord with plug. Portable models operate on 12 VDC; order either the rechargeable NiCd power supply 08380-70 or the connector 08380-72 for hookup to an existing 12 VDC power source. All compact recorders come with chart paper and pens (one per channel).

Catalog number	No. of channels	Power source	Price
H-08380-60	One	115/230 VAC, 50/60 Hz	$950.00
H-08380-62	Two		1280.00
H-08380-64	One	12 VDC	920.00
H-08380-66	Two		1250.00

H-08380-70 Rechargeable NiCd power supply (two 6 VDC batteries) $134.00
H-08380-71 Battery recharger, 110 VAC operation. For 08380-70 above $63.00
H-08380-78 Battery recharger, 220 VAC operation. For 08380-70 above $63.00
H-08380-72 Connector for hookup to an external 12 VDC power source $13.00
H-08380-76 Optional carrying case for recorders 08380-64 and-66..............$180.00



Portable, compact 120-mm recorders 08380-64 and -66 are ideal for your field work!

Compact recorder 08380-64 shown with power supply 08380-70, recharger 08380-71, and optional carrying case 08380-76.

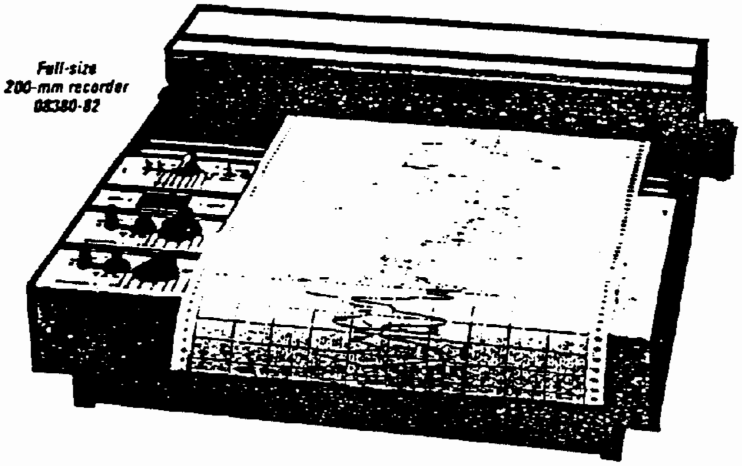
FULL-SIZE 200-MM RECORDERS

Get one- or two-channel recording on a full-size 200-mm chart width. Recorders feature 28 chart speeds, with fast advance of 100 cm/min. Voltage settings range from 1 mV to 50 V (full-scale); use the gain control to continuously vary voltage sensitivity between fixed ranges.

Use convenient knob to manually position paper on grid marks. Chart drive provides forward/reverse direction and external start/stop control. Recorders also feature an event marker (on channel one only), and ±100% zero suppression (via zero setting).

Operate on 115/230 VAC, 50/60 Hz (switchable). Recorders come with a 7-ft power cord with plug, chart paper, and pens (one for each channel).

Catalog number	No. of channels	Power source	Price
H-08380-80	One	115/230 VAC, 50/60 Hz	$1070.00
H-08380-82	Two		1630.00



Full-size 200-mm recorder 08380-82

REPLACEMENT CHART PAPER

Catalog number	Width	Length/roll	Price/pk of 10 rolls
H-08380-83	200 mm	52 ft	$63.00
H-08380-75	120 mm	52 ft	34.00

REPLACEMENT FIBER-TIP PENS

Catalog number	Channel (nib size)	Color	Price/pk of 5 pens
H-08380-73	One (short)	Green	$24.00
H-08380-74	Two (long)	Red	24.00

SPECIFICATIONS

Number of channels: one or two

Chart width
Models 08380-60, -62, -64, -66: 120 mm
Models 08380-80, -82: 200 mm

Chart drive: crystal-controlled stepper motor

Chart speeds
120-mm models: (12 total) 1, 2, 5, 10, 20, and 50 cm/min and cm/hr
200-mm models: (28 total) 10, 12, 20, 24, 50, 60, 100, 120, 200, 240, 500, 600, 1000, and 1200 mm/min and mm/hr

Input ranges
120-mm models: 10, 20, 50, 100, 200, 500 mV; 1, 2, 5, 10, 20, 50 V
200-mm models: 1, 2, 5, 10, 20, 50, 100, 200, 500 mV; 1, 2, 5, 10, 20, 50 V

Accuracy
120-mm models: ±0.5%
200-mm models: ±0.35%

Input impedance: 2 MΩ (V); 30 MΩ (mV)

Zero setting: ±100%

Attenuation: up to 2.5 times input signal

Pen drive: pulse servo potentiometric

Pen response
120-mm models: 0.35 second full-scale
200-mm models: 0.4 second full-scale

Power
Models 08380-60, -62, -80, -82: 115/230 VAC, 50/60 Hz (switchable)
Models 08380-64, -66: 12 VDC

Dimensions
120-mm models: 10"W x 4¾"H x 12¾"D
200-mm models: 13"W x 3½"H x 13"D

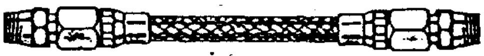
Shpg wt
120-mm models: 17 lbs (7.7 kg)
200-mm models: 20 lbs (9.1 kg)

Braided Hose Assemblies

Teflon Hose Assemblies with Stainless Steel Braided Covers

Male Pipe to Male Pipe

Male Pipe to Male Union



Male Union to Male Union

Ready to install for most fluid applications, these lightweight assemblies feature virgin Teflon cores with super-smooth, nonstick surfaces, plus flexible, corrosion-resistant Type 304 stainless steel braids. They meet SAE 100R14 requirements.

Since Teflon is nonadhesive, hose can carry asphalt, dyes, grease, glue, latex, and paints. There is no carbon buildup when used on a compressor-discharge line. Teflon hose assemblies are excellent for handling many problem fluids and gases . . . acids, hydraulic fluids, steam, solvents, fuels, alcohols, elastomers, coolants, and many other chemicals. Teflon's nonstick properties make cleaning the inside surface of the hose easy, too. Teflon is virtually nonaging and will provide extra-long service life. Its low coefficient of friction ensures continuous low-pressure drop during service while maintaining a good pressure rating. In addition, Teflon is FDA approved for food and pharmaceutical use.

All hose materials are resistant to corrosion and weather extremes. They also stand up to bending and vibration. Assemblies are lightweight for easy handling and installation.

Assemblies have a working temperature range of -65° F to +450° F and are rated for steam up to 200 psi at +388° F.

They're available in a variety of fitting arrangements and hose lengths to meet most requirements.

Assemblies are furnished in 6" increments. To order, please specify the "Base Price for 12" Assembly" part number and the length required.

Hose ID	End Fittings	Min. Bend Radius	Max. Pressure	Vacuum Rating	*Base Price: 12" Ass'y w/Brass Fittings*	Each	*Base Price: 12" Ass'y w/304 SS Fittings*	Each	*Adder for Hose Per Inch*
Male Pipe To Male Pipe NPT Fittings									
3/16"	1/8"-27	2"	3000 psi	28" Hg	5522K201	$5.74	5522K211	$11.76	$0.14
1/4"	1/4"-18	3"	3000 psi	26" Hg	5522K202	7.16	5522K212	18.86	.18
5/16"	3/8"-18	4"	2500 psi	28" Hg	5522K203	8.78	5522K213	19.70	.20
1/2"	1/2"-14	6½"	1500 psi	28" Hg	5522K204	15.10	5522K214	33.44	.28
5/8"	3/4"-14	7¼"	1200 psi	20" Hg	5522K205	20.40	5522K215	46.04	.42
7/8"	1" -11½	9"	1000 psi	14" Hg	5522K206	39.70	5522K216	72.16	.60
Male Pipe To Male Union NPT Fittings									
3/16"	1/8"-27	2"	3000 psi	28" Hg	5240K301	8.20	5240K311	16.40	.14
1/4"	1/4"-18	3"	3000 psi	28" Hg	5240K302	10.58	5240K312	29.24	.18
5/16"	3/8"-18	4"	2500 psi	28" Hg	5240K303	12.92	5240K313	26.32	.20
1/2"	1/2"-14	6½"	1500 psi	28" Hg	5240K304	23.40	5240K314	53.60	.28
5/8"	3/4"-14	7¼"	1200 psi	20" Hg	5240K305	29.96	5240K315	77.92	.42
7/8"	1" -11½	9"	1000 psi	14" Hg	5240K306	47.06	5240K316	116.28	.60
Male Union To Male Union NPT Fittings									
3/16"	1/8"-27	2"	3000 psi	28" Hg	5607K401	10.72	5607K421	21.04	.14
1/4"	1/4"-18	3"	3000 psi	28" Hg	5607K402	13.94	5607K422	33.72	.18
5/16"	3/8"-18	4"	2500 psi	28" Hg	5607K403	17.04	5607K423	32.94	.20
1/2"	1/2"-14	6½"	1500 psi	28" Hg	5607K404	28.62	5607K424	73.74	.28
5/8"	3/4"-14	7¼"	1200 psi	20" Hg	5607K405	38.78	5607K425	109.80	.42
7/8"	1" -11½	9"	1000 psi	14" Hg	5607K406	53.26	5607K426	160.36	.60

Do-It-Yourself Teflon Hose Assemblies with Stainless Steel Braided Covers

Male Pipe Fitting

37° JIC Swivel Fitting

Easy assembly in minutes!

(1) Wrap hose with masking tape at desired cutoff point. Place in vise and cut with hacksaw or cutoff wheel. (2) Slide back nut over hose. Remove masking tape. Clean and trim hose ends. (3) Flare braid away from hose with a small screwdriver. Push sleeve between braid and tubing. (4) Clamp main body in vise. Slide hose end over stem of main body. (5) Bring back nut forward and thread onto main body until it is hand tight. (6) Tighten back nut with wrench.

No special equipment is needed! Just cut the hose length you need and attach the fittings using simple bench tools. This super-tough, extruded Teflon hose with stainless steel braid cover handles the most demanding liquid-flow service applications, including problem fluids such as acids, hydraulic fluids, steam, solvents, fuels, and chemicals. Keep a supply of hose and fittings on hand so you can quickly solve your hose-replacement problems and reduce equipment downtime.

Smooth-bore hose offers minimal resistance to flow, and the nonstick surface makes hose easy to clean. Hose also offers long flex life. Corrosion-resistant, Type 304 stainless steel braid acts as a pressure carrier and protects the Teflon hose. Temperature range is -65° F to +450° F.

Choose from brass and Type 303 stainless steel fittings.

Hose ID	*Fitting Threads* Male NPT Fitting	37° JIC Swivel	Min. Bend Radius	Max. Pressure	Vacuum Rating	*Hose*	Per Foot 1-24	25-Up
3/16"	1/8"-27	7/16"-20	2"	3000 psi	28" Hg	52515K21	$2.49	$2.04
1/4"	1/4"-18	1/2" -20	3"	3000 psi	28" Hg	52515K22	3.09	2.53
5/16"	3/8"-18	9/16"-18	4"	2500 psi	28" Hg	52515K23	3.60	2.95
13/32"	1/2"-14	3/4" -16	5¼"	2000 psi	28" Hg	52515K24	4.53	3.71
1/2"	1/2"-14	7/8" -14	6½"	1500 psi	28" Hg	52515K15	5.51	4.51
5/8"	3/4"-14	1 1/16"-12	7¼"	1200 psi	20" Hg	52515K16	7.62	6.33
7/8"	1" -11½	1 5/16"-12	9"	1000 psi	14" Hg	52515K27	10.40	8.67
1 1/8"	1 1/4"-11½	1 5/8" -12	16"	750 psi	12" Hg	52515K18	18.65	15.78

Hose ID	*BRASS FITTINGS* *Male Pipe*	Each	*37° JIC Swivel*	Each	*TYPE 303 STAINLESS STL. FITTINGS* *Male Pipe*	Each	*37° JIC Swivel*	Each
3/16"	52515K31	$5.40	52515K41	$5.45	52515K51	$14.18	52515K61	$12.85
1/4"	52515K32	5.70	52515K42	6.85	52515K52	16.50	52515K62	16.12
5/16"	52515K33	5.90	52515K43	11.68	52515K53	17.83	52516K63	17.43
13/32"	52515K34	12.62	52515K44	8.88	52515K54	27.75	52515K64	28.73
1/2"	52515K35	12.67	52515K45	13.15	52515K55	33.43	52515K65	36.38
5/8"	52515K36	17.80	52515K46	20.25	52515K56	42.22	52515K66	52.30
7/8"	52515K37	20.97	52515K47	26.55	52515K57	55.62	52515K67	71.07
1 1/2"	52515K38	43.05	52515K48	66.68	52515K58	139.67	52515K68	134.95

About Safety Blowguns . . .

These blowguns feature safety nozzles that prevent tip pressure build-up in the event the air outlet is obstructed or dead-ended, reducing the potential for injury. They meet OSHA standards for 30 psi maximum outlet pressure when used on air lines of 150 psi or less. Please refer to the individual blowguns for maximum inlet-pressure ratings.

Pistol-Grip Safety Blowguns

For blowgun tips and extensions, please see page 1282.

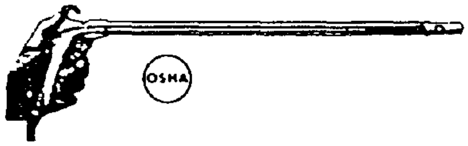
Standard Blowguns

For all-around use, these blowguns with lever-style trigger provide variable air-flow control for most jobs. Air inlet size: ¼" female pipe thread (NPT). Maximum inlet pressure: 150 psi.

Standard blowgun has a chrome-plated cast-aluminum body with brass nozzle and hang-up hook. Deluxe blowgun also has a non-slip, vinyl gripping surface.

Description		Each
Standard	5668K21	$13.19
Deluxe	5668K11	23.56

Extended-Reach Blowguns



STANDARD EXTENDED-REACH BLOWGUNS—Clean-up hard-to-reach areas with lightweight, aluminum extensions up to 6-ft. long. The special venturi tip increases air thrust by 200%. Blowguns have a cast-aluminum body with lever-style trigger and hang-up hook, and come with listed extension. Air inlet size: ¼" female pipe thread (NPT). Maximum inlet pressure: 150 psi. **NOTE:** Overall length is measured from the nozzle tip to the back of the handle.

Popular replacement parts are inventoried. Please specify No. 5536K5 and part name.

Overall Length	*Complete Blowgun*	Each	*Replacement Extension*	Each
12"	5536K11	$21.78	5536K17	$7.80
24"	5536K12	23.47	5536K18	9.37
36"	5536K13	25.37	5536K19	11.28
48"	5536K14	27.28	5536K2	13.19
60"	5536K15	29.19	5536K22	15.10
72"	5536K16	31.10	5536K23	17.01

Replacement Blowgun Nozzle .... 5536K21 Each $3.37

HIGH-THRUST EXTENDED-REACH BLOWGUNS—When you have heavy-duty cleaning jobs or are moving large volumes of debris, these are the guns of choice. The large nozzle and internal design delivers twice the air volume and thrust of our standard extended-reach blowgun. Cast-aluminum pistol-grip body has a full-length trigger. Air inlet size: ¼" female pipe (NPT). Maximum inlet pressure: 150 psi. **NOTE:** We recommend using full-flow quick-disconnect couplers, not standard quick disconnects that restrict air volume.

Overall Length		Each	Overall Length		Each
12"	5474K41	$25.26	48"	5474K44	$33.35
24"	5474K42	27.96	60"	5474K45	36.04
36"	5474K43	30.65	72"	5474K46	38.73

Triple-Volume Blowguns

Triple the volume of air flow for faster debris removal, and less labor and compressor use. These blowguns use one part compressor air and two parts ambient air—all at noise levels well below OSHA requirements.

Tamperproof design won't allow user modifications that may lead to damage or injury. Cast-aluminum guns are self-regulated and sealed at the factory, and have a hang-up hook.

Air inlet size: ¼" female pipe thread (NPT). Maximum inlet pressure: 120 psi.

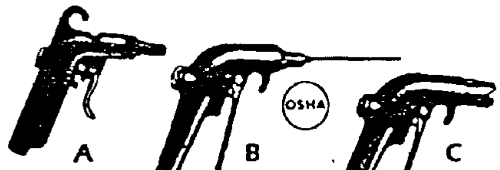
BLOWGUNS

Nozzle Size	Air Intake CFM	Air Output CFM		Each
⅜"	10.7	26.7	54725K41	$29.31
⅝"	18	67.6	54725K51	43.13

EXTENSIONS

Size		Each	Size		Each
⅜" × 6"	54725K42	$11.59	⅝" × 15"	54725K53	$18.27
⅜" × 12"	54725K43	13.64	⅝" × 36"	54725K54	26.25
⅝" × 6"	54725K52	13.91			

Air-Shield Blowguns



Center jet blows away debris, while the outer spray acts as a shield to protect you from flying chips and dirt. The blowguns have a cast-aluminum body with hang-up hook and lever throttle. Air inlet size: ¼" female pipe thread (NPT).

A Adjustable air blast model has a knurled adjusting nut on the two finger trigger. The adjusting nut allows the air volume to be set for a whisper or up to a full blast.

B Extension nozzle model has a standard nozzle and a removable 6" long brass extension for hard-to-reach spots. Extension is 3/16" OD × 1/8" ID and can be annealed for bending to angles. Features a full four finger trigger.

C Recessed nozzle model handles general-purpose duties. It has a tamper-resistant opening recessed inside the nozzle. Features a full four finger trigger.

Repair kit for B and C blowguns includes an extra valve seal, spring, and gasket.

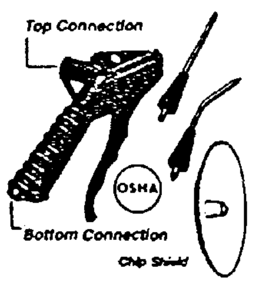
Description	Max. Inlet Pressure		Each
Adjustable Air Blast	120 psi	5450K13	$13.05
Extension Nozzle Blowgun	120 psi	5450K14	19.59
Recessed Nozzle Blowgun	150 psi	5450K16	16.60
Repair Kit (for B and C only)		5450K18	2.69
Replacement 6" Brass Extension		5450K22	2.99

Quiet-Air Blowgun

This gun's unique nozzle reduces air-stream vibrations without losing air velocity. Noise levels are reduced by 6 to 8 decibels when compared to regular blowguns. The nozzle doesn't have a center hole so static pressure is zero, even when the nozzle is blocked. The blowgun body is cast aluminum with a finger-grip trigger. Air inlet size: ¼" female pipe thread (NPT). Maximum inlet pressure: 150 psi

54615K16 .... Each $19.37

Dual-Connection Blowgun



Two connections for twice the versatility: use the top connection for overhead hoses, and the bottom connection for bench and floor hoses. A plug seals off the unused connection. Blowgun body is made of high-impact plastic that insulates against cold air, and has a variable-flow trigger. Tubes (sold separately) have a simple twist-and-lock bayonet-style connection for fast changes. Tip has six-outlet star configuration for even air distribution. Air inlet size: ¼" female pipe thread (NPT). Maximum inlet pressure: 175 psi.

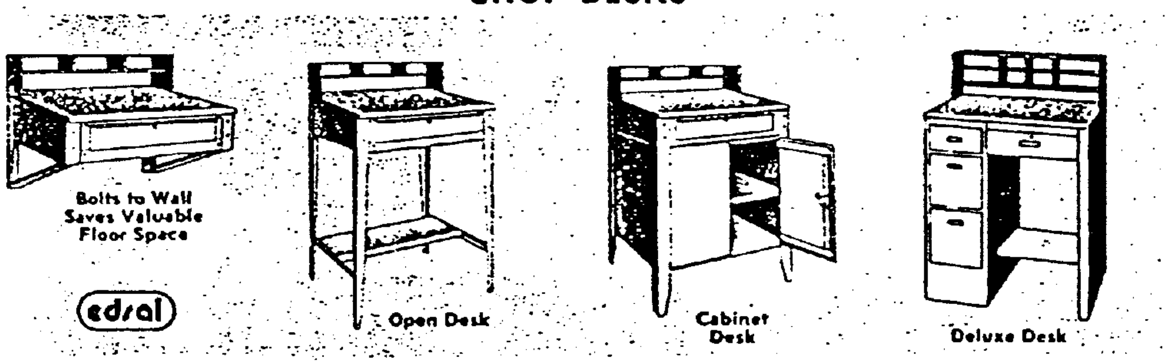
Chip shield is transparent and slides over tube.

Description		Each
Blowgun Body	54375K61	$18.
4" Straight Tube	54375K62	7.
4" Bent Tube	54375K63	7.
13" Straight Tube	54375K64	14.
20" Straight Tube	54375K65	18.
Chip Shield	54375K68	4.

STORAGE EQUIPMENT

SHOP DESKS AND WORK TABLE CABINETS

SHOP DESKS



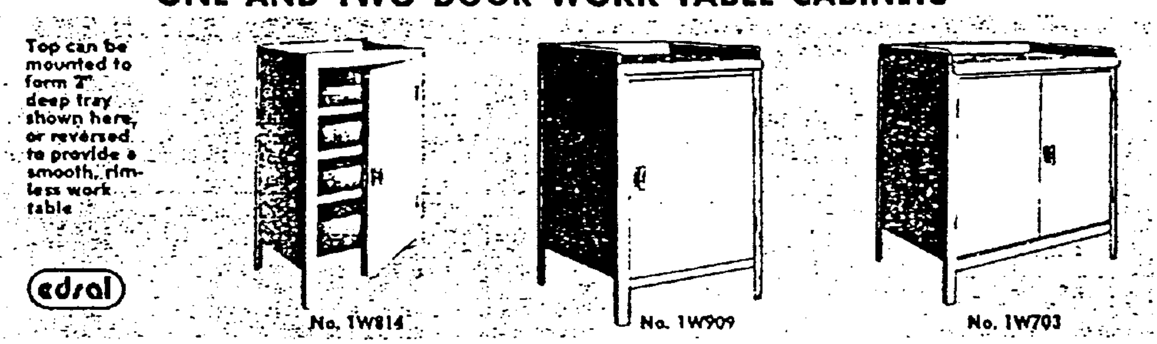
Space saving desks provide a convenient, efficient work area for shop foremen, shipping and receiving clerks, and watchmen. Back riser has three open compartments, each 3H x 9W x 11½D; No. 4W345 has eight compartments. Desks have a top locking drawer 3½H x 24W x 28"D (keyed differently), mounted on 4 nylon rollers for smooth operation. Open style model has foot rest; cabinet style has locking doors and full size shelf adjustable 3" OC. Deluxe desk has locking tray drawer, two full suspension file drawers, and one all-purpose drawer. Open and cabinet desks are 53" high overall; deluxe desk is 55½"H. 14-gauge corner posts. 20-gauge top and 19-22 gauge panels; 16-gauge drawer front. Gray enamel finish. Shipped unassembled. Edsal brand.

SHOP DESK SPECIFICATIONS AND ORDERING DATA

Unit Description	Desk Dimensions H	W	D	Edsal Model	Stock No.	List	Each	Lots 3	Shpg. Wt.
Wall-Hung	37½"*	34½"	30"	650	1W952	$177.16	$140.75	$133.67	70.0
Open Desk	45⅝†	34½	30	620	1W907	206.54	158.25	150.34	88.0
Cabinet Desk	45⅝†	34½	30	640	1W908	346.47	264.75	251.51	150.0
Deluxe Desk	43¾†	39	28¾	660	4W345	628.99	489.25	464.78	163.0

(*) Height from bottom of bracket to top of desk. (†) Height from floor to top of work surface.

ONE AND TWO DOOR WORK TABLE CABINETS



Provide safe, locked-in storage of valuable tools, merchandise, parts and serve as a work table with edge-stop on sides and back. Cylinder locks are built into the T-handle on the door for added security (keyed differently).

No. 1W814. 2½ sq ft work surface can be mounted to form a 2" deep tray or reversed to provide a smooth, rimless work table. Mount a drill press, grinder, or other bench tool or use as extra work space. Posts are 14-gauge steel, door 22-gauge, shelves 22-gauge and panels 24-gauge. Three adjustable shelves inside the 6.2 cu ft interior provide ample storage space.

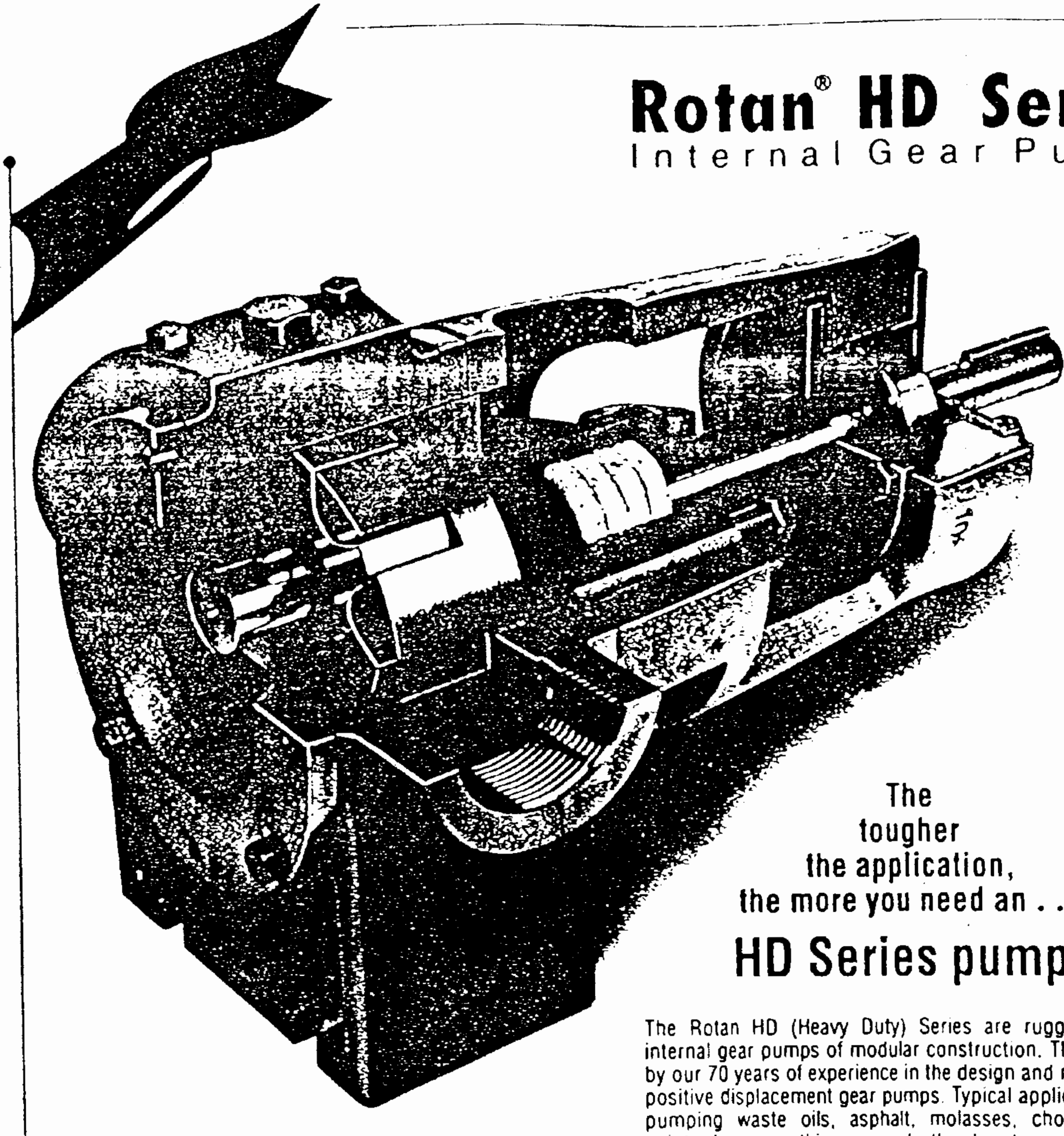
Nos. 1W909, 1W703. Cabinets have 14-gauge steel corner posts, 16-gauge steel top, 20-gauge doors. 19-gauge side and back panels provide 2" deep lip to prevent supplies from falling off top and can be inverted to obtain a flat surface. Double door cabinet has 6 sq ft of work area and 18 cu ft of storage space; single door model has 4 sq ft work top and 12 cu ft of storage space. Full size center shelf adjustable on 1½" centers.

All cabinets have gray enamel finish and are shipped unassembled. Edsal brand.

WORK TABLE CABINET SPECIFICATIONS AND ORDERING DATA

Unit Description	Dimensions H*	W	D	Top Surface Sq Ft	Storage Cu Ft	Edsal Model	Stock No.	List	Each	Lots 3	Shpg. Wt.
Single Door	32¼"	21"	15½"	2.5	6.3	630	1W814	$108.98	$89.00	$84.55	46.0
Single Door	35	24	24	4	12	59242	1W909	166.45	136.50	129.68	80.0
Double Door	35	36	24	6	18	59243	1W703	215.04	176.75	167.91	102.0

(*) Height from floor to top of work surface.



Rotan® HD Series
Internal Gear Pumps

The tougher the application, the more you need an . . .

HD Series pump!

The Rotan HD (Heavy Duty) Series are rugged, cast iron, internal gear pumps of modular construction. They are backed by our 70 years of experience in the design and manufacture of positive displacement gear pumps. Typical applications include pumping waste oils, asphalt, molasses, chocolate, soaps, paints, lacquers, thinners, and other low to medium viscosity fluids.

In addition to the cast iron housing, rotor and idler gear, each pump is equipped with a steel drive shaft and idler pin. In packed pumps, the idler and main bearings are either cast iron, bronze, carbon, ceramic, or tungsten carbide sleeve-type bearings. These internal bearings are typically lubricated by the pumped fluid, but can be externally lubricated as well. When supplied with single or double mechanical seals, a ball bearing serves as the main bearing.

Rotan pumps require little maintenance. However, should repair or disassembly be required, it is easily accomplished. With our modular design, all pumps can be disassembled and inspected without removing the casing from the process line and bolt-on heating jackets and relief valves are simple and inexpensive options. Complete systems can also be supplied with the pump, motor, gear reducer (if required) and couplings mounted on a common baseplate.

Design Parameters

Capacity Range	1.0 to 750 GPM
Speed	Up to 1750 RPM
Differential Pressure	Up to 250 PSI for sizes 26 - 81 Up to 150 PSI for sizes 101 - 201
Suction Lift	Up to 15" Hg vacuum while priming Up to 24" Hg vacuum while pumping
Viscosity Range	32 to 350,000 SSU (1 to 75,000 cSt)
Temperature	Up to 500° F
Jacket Pressure	Up to 150 PSI as standard
Relief Valve Setting	Approximately 20 PSI above system design pressure is recommended

Design Principle

The Rotan Series Internal Gear Pump is a positive displacement rotary gear pump with only two rotating parts: a main power rotor driving an internal idler gear. The rotor and idler are arranged in a circular pump casing with both rotating in the same direction. The rotor is mounted on a solid shaft that passes through a main bearing located in the rear cover. A second bearing, mounted in the rear bracket, supports the free shaft end. The idler gear rotates freely on a pin fixed in the front cover. A non-rotating part, the crescent, is positioned between the rotor and idler and separates the suction and discharge sides of the pump

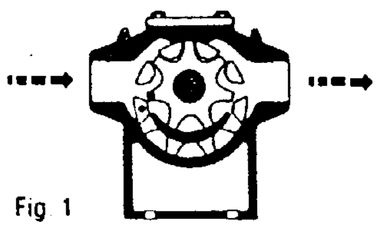


Fig 1

As the pump shaft rotates, a finite amount of liquid enters the pump through the suction port and fills the voids between the teeth of the rotor and idler gears.

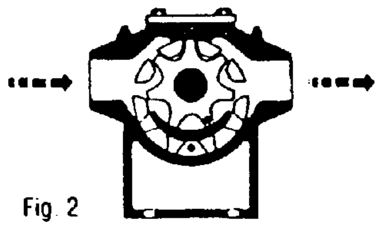


Fig 2

As the rotor and idler gears rotate, the liquid is separated by the crescent and locked into the spaces between the gear teeth.

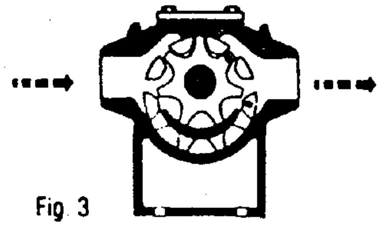


Fig 3

As the liquid moves past the crescent, the rotor and idler gears mesh, forcing the liquid out of the gear teeth and into the discharge port of the pump.

Design Advantages

MOST PARTS ARE COMMON AND INTERCHANGEABLE.

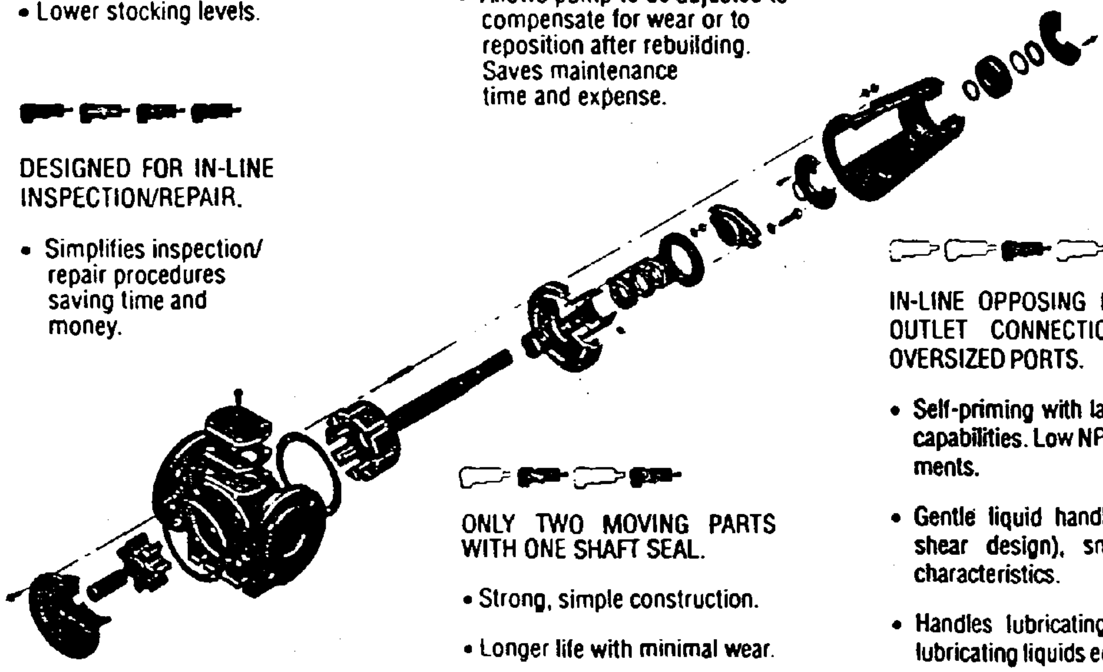
- Shorter lead times & lower cost.
- Lower stocking levels.

AXIAL ADJUSTMENT OF ROTOR AND SHAFT POSITION IS POSSIBLE WITHOUT DISMANTLING PUMP.

- Allows pump to be adjusted to compensate for wear or to reposition after rebuilding. Saves maintenance time and expense.

DESIGNED FOR IN-LINE INSPECTION/REPAIR.

- Simplifies inspection/ repair procedures saving time and money.



IN-LINE OPPOSING INLET AND OUTLET CONNECTIONS WITH OVERSIZED PORTS.

- Self-priming with large suction capabilities. Low NPSH requirements.
- Gentle liquid handling (low shear design), smooth flow characteristics.
- Handles lubricating and non-lubricating liquids equally well.

ONLY TWO MOVING PARTS WITH ONE SHAFT SEAL.

- Strong, simple construction.
- Longer life with minimal wear.

How To Select

The pump capacity is directly proportional to the pump speed. The maximum speed of the pump must be reduced when the following liquid specifications are encountered:

- Liquids with abrasive particles
- Liquids sensitive to mechanical agitation (emulsions)

When the capacity (gpm) and viscosity (cSt) are known, the pump size and speed can be readily determined using the Selection Chart on page 5 and the following steps:

1. Find the point of intersection of the horizontal *CAPACITY (gpm)* line and appropriate *VISCOSITY (cSt)* curve.
2. From the point of intersection of the *CAPACITY* line and *VISCOSITY* curve, move left horizontally until you meet the first diagonal *PUMP* curve. Each *PUMP* curve is labeled with the corresponding pump size in the box just above it (for example 151).
3. The pump speed is found by dropping straight down from the point on the selected *PUMP* curve to the horizontal *SPEED (rpm)* axis.
4. The pump speed, as a percentage of the maximum allowable speed for the pump size selected, can then be found by following the *VISCOSITY* curve to where it crosses the *PERCENT OF MAXIMUM RPM* scale. The percentage of maximum speed will indicate if a larger (or smaller) pump could possibly be used.
5. The calculated pump speed should then be adjusted according to the liquid's abrasiveness or shear sensitivity by multiplying the speed by the appropriate *Speed Reduction Factor* (Refer to table at top of Selection Chart). The chart automatically compensates for viscosity changes between 400 cSt and 75,000 cSt. For viscosities below 400 cSt, use the 400 cSt curve. For applications involving a viscosity greater than 75,000 cSt, please contact your local Rotan distributor.

How to Select Example

An application involving a clean, non-abrasive liquid ar design parameters of . . .

130 gpm and 50,000 cSt

Proceed as follows:

1. Locate the 130 gpm line on the *CAPACITY (gpm)* axis a the 50,000 cSt curve on the *VISCOSITY (cSt)* axis. Fi the intersection of these two curves.
2. In this example, the intersection of the *VISCOSITY* a *CAPACITY* curves occur on the 151 *PUMP* curve. Ther fore, the 151 pump size is selected.
3. The pump speed is determined by dropping straight do from the 151 *PUMP* curve to the *SPEED (rpm)* axis at t bottom of the chart. In this example, the pump speed approximately 180 rpm.
4. The actual pump speed as a percentage of maximu recommended speed can then be found by following t 50,000 cSt curve until it intersects the *PERCENTAGE MAXIMUM RPM* scale. In this example the pump would operate at 32% of the recommended maximum speed.
5. The pump speed should then be adjusted to compens for the liquid's abrasiveness or shear sensitivity. Sin this example involves a clean, non-abrasive liquid, t pump speed remains at 180 rpm.

Additional Information

In addition to the HD Series, a complete line of internal gear pumps is offered. Contact your local Rotan distributor for additional product information.

GP - General Purpose

Close-coupled pumps of cast iron construction.

CD - Chemical Duty

Pumps of stainless steel construction.

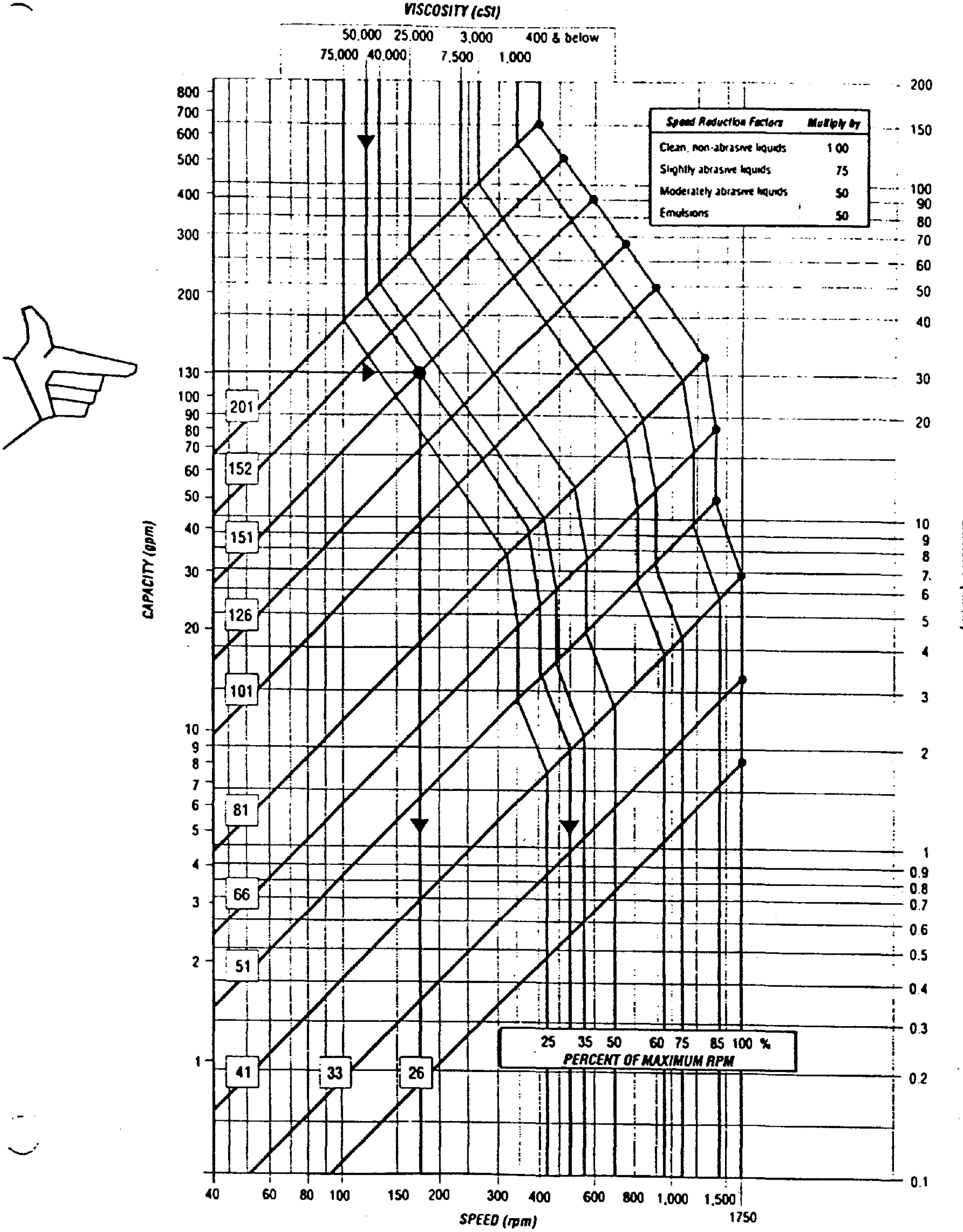
PD - Petrochemical Duty

Pumps of carbon steel construction (API-676).

MD - Magnetic Drive

MagneDrive magnetically coupled pumps available in cast iron, carbon steel, and stainless steel constructions.

Selection Chart



How to Order

HD 101 | E RDK | 1U | 22 | B | S

Pump Size

26, 33, 41, 51, 66, 81
101, 126, 151, 152, 201

[See Selection Chart - Page 5]

Optional Features

[See Table 2 - Below]

Bearing Lubrication

U - Bearings lubricated by pumped liquid

M - Bearings lubricated externally

Bearings, Idler Pins and Shaft Materials

[See Table 3 - Below]

Primary Shaft Seal

B - Packing

2 - Single Mechanical Seal

22 - Double Mechanical Seal

Special Configuration

S - Consult Rotan Distributor

Table 1 - Standard Materials for Main Parts

Component	Material
Casing	Cast Iron
Front/Rear Covers	Cast Iron
Rotor	Cast Iron
Idler	Cast Iron
Idler Pin	Hardened Carbon Steel
Shaft	Carbon Steel

For other material combinations, consult your Rotan distributor.

Table 2 - Optional Features

Code	Description
E	Suction/Discharge connections in-line (No other options available)
(blank)	Packed pump supplied as standard unless other seal options are specified
M *	Single mechanical shaft seal
MM	Double mechanical shaft seal (tandem orientation, non-pressurized sealing fluid required)
MMP	Double mechanical shaft seal (back-to-back orientation, pressurized sealing fluid required)
D	Front cover heating jacket
K	Rear cover heating jacket (packed pumps only)
R	One way, pressure relief valve
RR	Two way, pressure relief valve
T	Special clearances
E CHD	Chocolate Execution (includes front (D) and rear (K) heating jackets)

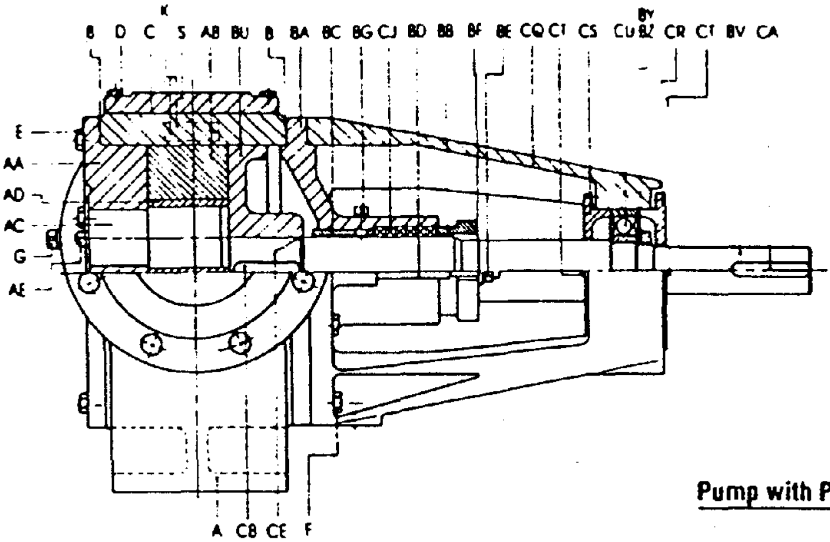
* The Main Bearing must be a Ball Bearing when a single mechanical shaft seal is specified.

Table 3- Material Codes and Standard Combinations for Bearings, Idler Pins and Shafts

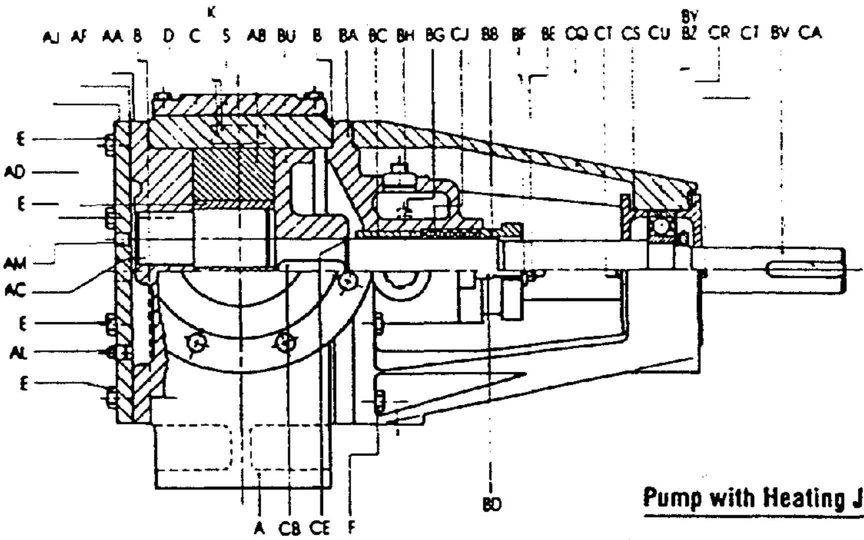
Code	Idler Bearing	Main Bearing	Idler Pin	Shaft
11	Cast Iron	Cast Iron	Carbon Steel	Carbon Steel
18*	Cast Iron	Ball Bearing	Carbon Steel	Carbon Steel
22	Bronze	Bronze	Carbon Steel	Carbon Steel
28*	Bronze	Ball Bearing	Carbon Steel	Carbon Steel
33	Carbon	Carbon	Carbon Steel	Carbon Steel
38*	Carbon	Ball Bearing	Carbon Steel	Carbon Steel
41	Ceramic	Cast Iron	Cr. Oxide Coating	Carbon Steel
42	Ceramic	Bronze	Cr. Oxide Coating	Carbon Steel
44	Ceramic	Ceramic	Cr. Oxide Coating	Cr. Oxide Coating
53	Carbon	Carbon	Ceramic, Polished	Carbon Steel
58*	Carbon	Ball Bearing	Ceramic, Polished	Carbon Steel
73	Carbon	Carbon	Tungsten Carbide	Carbon Steel
84	Tungsten Carbide	Ceramic	Tungsten Carbide	Cr. Oxide Coating
88*	Tungsten Carbide	Ball Bearing	Tungsten Carbide	Carbon Steel

* The Main Bearing must be a Ball Bearing when a single mechanical shaft seal is specified.
For other material combinations, consult your Rotan distributor.

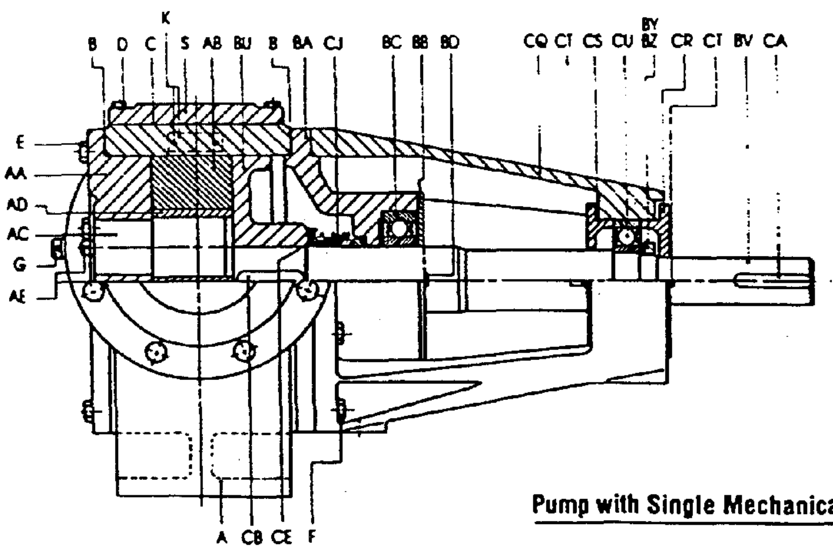
Assembly Drawings



Pump with Packing



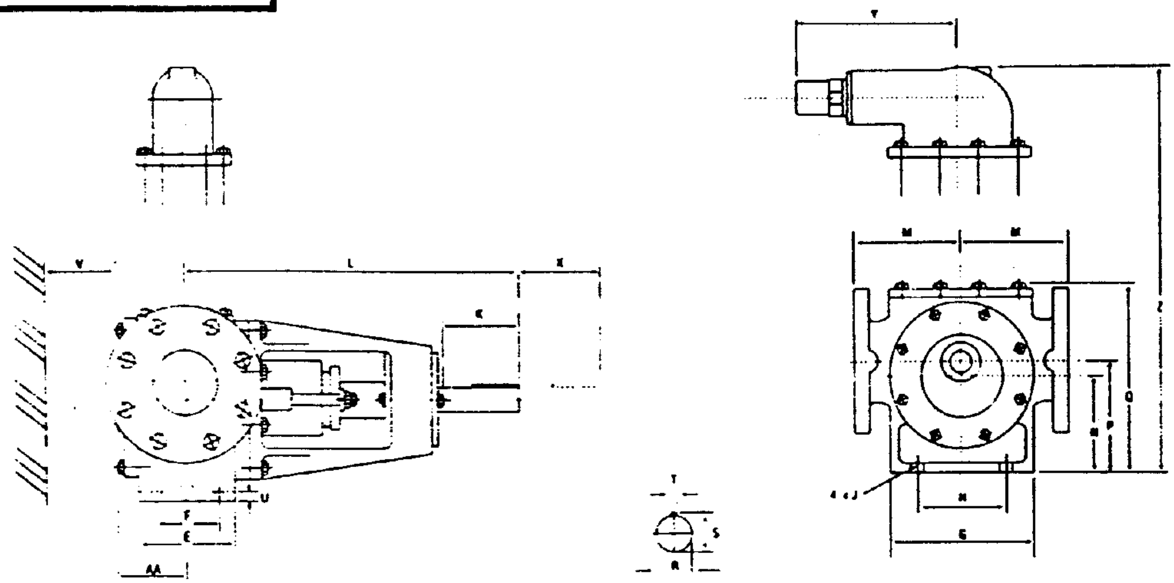
Pump with Heating Jackets



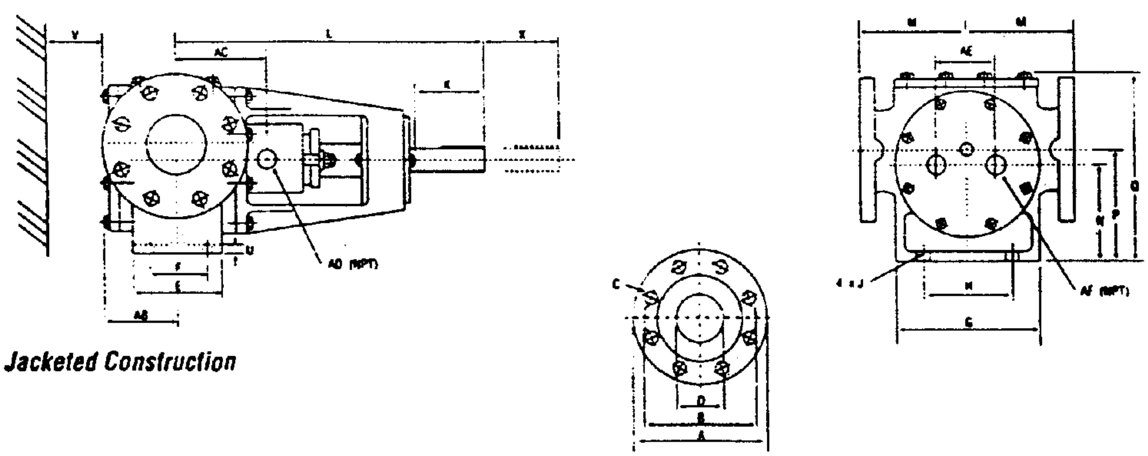
Pump with Single Mechanical Seal

Index of Parts	
Item	**Part**
A	Pump Casing
B	Gasket
C	Gasket
D	Bolt
E	Bolt
F	Bolt
G	Pipe Plug
K	Name Plate
S	Blind Cover
AA	Front Cover
AB	Idler
AC	Idler Pin
AD	Idler Bushing
AE	Lube Nipple
AF	Gasket
AJ	Heating Jacket
AL	Pipe Plug
AM	Pipe Plug
BA	Rear Cover
BB	Packing Gland/ Bearing Cover
BC	Main Bushing
BD	Stud Bolt
BE	Nut
BF	Washer
BG	Pipe Plug
BH	Bolt
BU	Lube Nipple
BV	Shaft
BY	Ball Bearing Nut
BZ	Locking Ring
CA	Key
CB	Key
CE	Snap Ring
CJ	Packing/ Mechanical Seal
CQ	Bearing Bracket
CR	Bearing Cover
CS	Bearing Cover
CT	Bolt
CU	Ball Bearing

HD Series Dimensions



Standard Construction with Optional Pressure Relief Valve



Jacketed Construction

Pump Size	Pressure Gauge Connections
26-66	1/4" NPT Female
81-201	3/8" NPT Female

Pump Size	Flanges / Ports
26-41	NPT Female Ports
26-201	ANSI 125 Lbs. FF Flanges

mp ze	Line Size	Dimensions																								
		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V	X	Z	AA	AB	Weight
26	1"	4.53	3.11	0.63	0.98	1.77	1.10	3.54	1.97	0.28	1.57	8.66	2.36	2.80	3.11	4.96	12	13.5	4	0.31	1.97	2.76	6.54	1.34	2.05	17 lbs.
33	1 1/4"	5.51	3.50	0.63	1.26	1.77	1.10	3.54	1.57	0.28	1.57	8.82	2.36	2.80	3.11	4.96	12	13.5	4	0.31	2.36	3.15	6.54	1.50	2.20	18 lbs.
41	1 1/2"	5.91	3.86	0.63	1.57	2.76	1.97	4.72	2.56	0.39	1.89	9.96	3.54	3.94	4.33	6.89	16	16.0	5	0.39	2.56	2.17	9.17	1.88	2.28	35 lbs.
51	2"	6.50	4.76	0.75	1.97	3.35	2.36	6.30	3.74	0.47	2.60	13.58	4.92	4.41	4.96	8.39	27	30.0	8	0.47	2.76	2.76	11.34	2.40	2.91	90 lbs.
56	2 1/2"	7.28	5.51	0.75	2.56	3.74	2.36	6.30	3.74	0.47	2.60	13.78	4.92	4.41	4.96	8.39	27	30.0	8	0.47	3.15	3.15	11.34	2.80	3.11	101 lbs.
81	3"	7.87	5.98	0.75	3.15	4.72	3.15	7.87	4.92	0.59	4.06	16.93	5.91	5.20	6.02	10.12	32	35.5	10	0.55	3.94	3.94	14.29	3.23	3.86	165 lbs.
01	4"	8.66	7.52	0.75	3.94	5.51	4.33	8.65	6.30	0.59	4.06	17.13	7.09	6.30	7.36	12.09	32	35.5	10	0.56	4.53	4.53	16.26	3.62	4.25	220 lbs.
26	5"	9.84	8.50	0.87	4.92	6.30	4.72	11.02	7.48	0.75	4.76	22.24	7.87	7.87	8.09	14.45	42	45.5	12	0.71	5.51	5.51	20.67	4.21	4.84	352 lbs.
51	6"	11.22	9.49	0.87	5.91	7.48	5.91	12.99	9.84	0.75	4.76	22.83	8.86	8.86	10.31	16.46	42	45.5	12	0.71	6.50	6.50	22.64	4.82	5.71	462 lbs.
52	6"	11.22	9.49	0.87	5.91	8.66	6.30	15.35	11.02	0.94	5.24	25.35	10.83	9.84	11.61	18.90	55	60.0	16	0.87	7.09	7.09	27.17	5.67	6.54	748 lbs.
01	8"	13.39	11.73	0.87	7.87	9.84	7.87	18.31	12.40	0.94	7.09	33.46	11.81	12.40	14.53	22.91	70	76.0	20	0.94	8.46	8.46	31.18	6.81	7.60	1,144 lbs.

Dimensions in inches, except R, S, and T which are in millimeters.
Dimensions subject to change. Certified prints on request.

Rotan Flexibility

Flexibility is the keyword for Rotan pumps!

The Rotan pump offers the benefit of both our 70 years experience in rotary pump manufacturing and the advantages of our state-of-the-art modular design concept. This design and our constant dedication to innovation and improvement are the key reasons why Rotan pumps are recognized as the most advanced internal gear pump available in the world today.

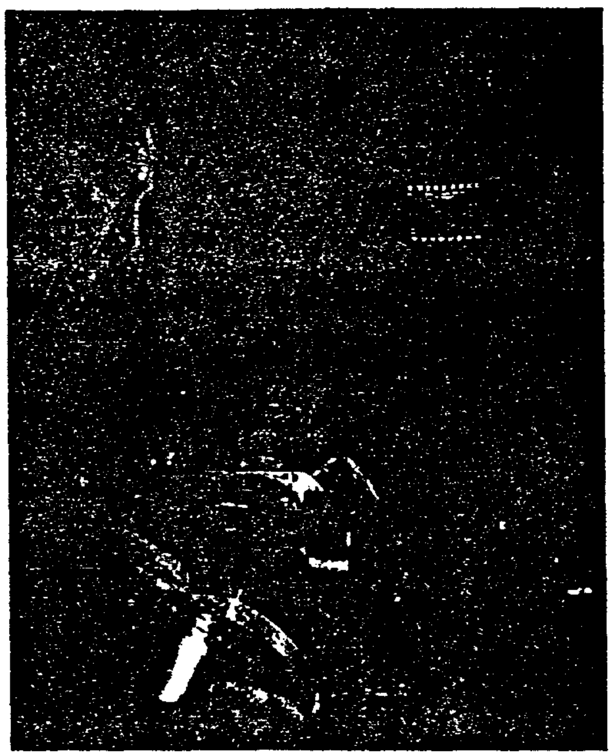
The advantages of this design include:

- Pump selection is simplified as there is only one general set of curves for the entire Rotan Series.
- Special pump constructions are prepared as easily as standard pumps.
- Customized pumps are fitted exactly to end-user specifications.
- Interchangeability of parts minimizes stocking requirements, resulting in lower costs.
- Short delivery times for all pump constructions.

A fully computerized Sales and Engineering staff stand ready to assist you with your most difficult pumping problems.

Rotan Quality

To insure a high and constant quality level, every Rotan pump undergoes both hydrostatic and performance tests before leaving the factory. A Test Certificate, attached to each pump before it ships, documents the performance of the pump for the end-user. A copy of each Test Certificate is kept in our file, an extensive archive that includes information on all Rotan pumps manufactured since the early 1920's. All Rotan pumps are designed, built, and tested to general ISO 9000 guidelines.



All Rotan pumps are tested before leaving our factory. This is your guarantee of a high quality product.

CORPORATE PROFILE

In 1957 the engineers at R. S. Corcoran Company designed a small stainless steel centrifugal pump to replace a cast iron pump for a friend of Mr. Corcoran's. By 1965 several OEMs were using this and another, somewhat larger, design. By 1981 the company decided to divest itself of all other interests (through the years Corcoran had been actively involved in the manufacture and distribution of hand tools and small compressors, proprietary food products and artesian well-water, blow-molded bottles, extruded wire harnesses, military bomb fuses, material handling equipment and auxiliary machinery for plastics processors). As of 1985, this multiple divestiture has been complete and now the R.S. Corcoran Company manufactures only corrosion-resistant centrifugal pumps for the vast Chemical Processing Industry and OEM markets.

Our design is unique. The shape of our housings is concentric, not a "volute". They are deep-drawn from special grades of wrought 304L and 316L sheet and hand-fabricated from plate stock, using proven techniques developed by manufacturers of pipe, tanks and other process equipment. Wrought metal has several advantages over its cast alloyed counterpart. Wrought metal is more uniformly dense and generally of higher density; it has better mechanical properties; it is less porous; in many instances the wrought metal has significantly higher corrosion resistance.

Corcoran fabricates pumps from independently certifiable plate material in 304L and 316L stainless steel, Carpenter 20 Cb-3 and Mo-4, Hastelloy B-2, C-22 and C-276, Ferralium 255, Monel 400, Nickel 200, commercially pure Titanium and its alloys, Zirconium, and other metals. Sizes range from 1/2 through 6 inch discharge, three through 14.5 inch impellers and 1/6 through 100 HP.

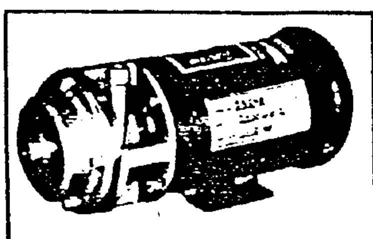
Corcoran offers a complete line of Horizontal pumps (close-coupled or pedestal mounted ANSI B73.1 dimensional) with single seal, double seal, dynamic seal, or packing... each with a SELF-PRIMER option.

Corcoran also offers a complete VERTICAL Line: submerged bearings (Rulon J or Graphalloy, product or externally flushed), with four sizes of thrust bearings and extended lengths from 6" to 21 feet below the cover plate. CANTILEVER versions: from close-coupled for compact design (often provided with the "repeller" option for continuous, sealless, dry-mount operation) through heavy duty models with extensions up to 60" and shafts to 4.5" in diameter... each with optional top suction or the vortex (recessed) impeller are available.

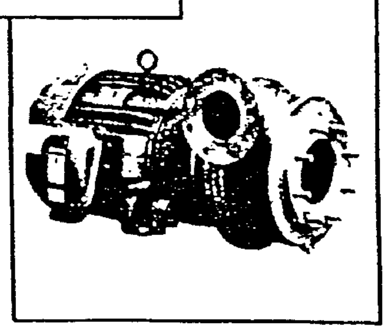
In addition, Corcoran manufactures a series of small, heavy duty, industrial design, 316L stainless steel and exotic alloyed SUBMERSIBLE sump pumps available in 1/2 through 1.5 inch discharge and 1/2 through 2 HP.

Corcoran offers an adaptable, customer-oriented line of corrosion-resistant pumps. Case histories of our near limitless flexibility and adaptability to customer requirements are well documented: (1) Pumps built to withstand up to 1000 PSIG system pressure, close-coupled, and frame mounted; (2) Pedestal-mounted, packed-box vertical pairs, each built as the mirror-image of the other; (3) Left-handed pumps (the reason for which has long since been forgotten), close-coupled, frame-mounted, and vertical; (4) Pumps built to duplicate dimensionally a competitor's discontinued model or to help a customer move up quickly to a less expensive, more corrosion-resistant pump with no piping changes; (5) Non-sanitary, otherwise standard pumps provided with sanitary fittings, hand-polished external welds and other "clean-in-place" features; (6) Pumps built to meet the demanding, sometimes questionable but always respected, design and QA parameters of the military; (7) High speed, stainless steel, Monel 400-fitted, 2" non-clog vertical inline sewage pumps; (8) Special heavy-duty cantilevered verticals for nitro-cellulose, radio-active waste water and "pink water", which allow no liquid residue to be trapped after removal from the sump or require the pump to be completely welded into one solid unit and guaranteed for 100,000 hours of non-maintained operation; and (9) Horizontal in-line stainless steel pumps for hot, concentrated nitric acid in a condensing, dripping nitric acid atmosphere, with a fan-cooled, self flushing double seal chamber, special narrow vane impeller for flow limitation, and 316 stainless steel plasma-sprayed explosion-proof motors.

There is a little isolated box in most of Corcoran's brochures which capsulize our business attitude. It reads: **Corcoran specializes in adapting to your specific requirements. Call the factory for information on unpublished modifications.**



Model 2000MD-2, close-coupled, end suction, 2-stage centrifugal; available in all Corcoran materials of construction; wide variety of single internal mechanical seals; FNPT, flanged, hose or sanitary clamp connections; and 56C frame motors, heads to 60 PSI and maximum flow of 35 GPM



Model 6000D, 6X4-13 close-coupled, end suction, horizontal, 316 stainless steel centrifugal; pumping brine and walnut shell slurry at 150° F; single internal non-flushed, hard face rubber bellows mechanical seal; 1450 RPM, 380V, 50HZ; produces 870 USGPM at 80 Feet TH.

R.S.
CORCORAN
COMPANY

P.O. BOX 429 • 500 N. VINE ST.
NEW LENOX, IL 60451-0429
Phone: 815-485-2156 • Fax: 815-485-5840
Toll Free: 800-637-1067

CORCORAN

▶ MODELS

5000-D - Close coupled
5000-F - Pedestal mounted

▶ MATERIALS OF CONSTRUCTION

304 Stainless Steel	Manganese Steel
316 Stainless Steel	Zirconium
Carpenter 20 CB-3	Titanium
Monel	Tantalum
Nickel	Hastelloy B, C

▶ PORTS AVAILABLE

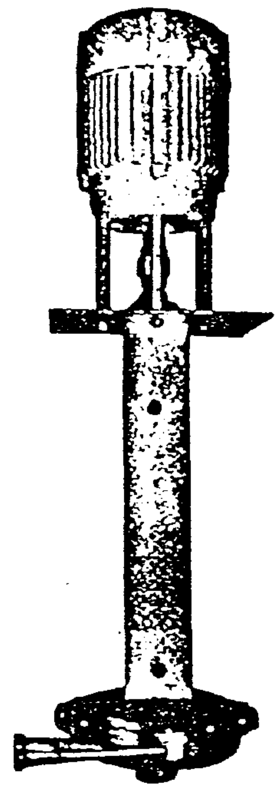
IPS threaded
ASA flanged

▶ STANDARD PORTS

1-1/2 x 2 IPS threaded
2 x 2-1/2 IPS threaded
2-1/2 x 3 ASA flanged
3 x 4 ASA flanged
4 x 5 ASA flanged

▶ MECHANICAL SEAL AND GASKET

Neoprene
Viton A
Teflon



MODEL 5000 VE

▶ OTHER MODELS AVAILABLE:

5000-H	(Double mechanical seal)
5000-VE	(Vertical extended shaft)
5000-VEC	(Vertical cantilever shaft)
5000-RS	(Rear suction)
5000-2	(Two stage)
5000-FHP	(High pressure, high temperature with double balanced seal and optional seal lubrication system)

▶ PACKINGS

Braided Teflon
African Blue Asbestos impregnated with Teflon
Asbestos impregnated with Graphite

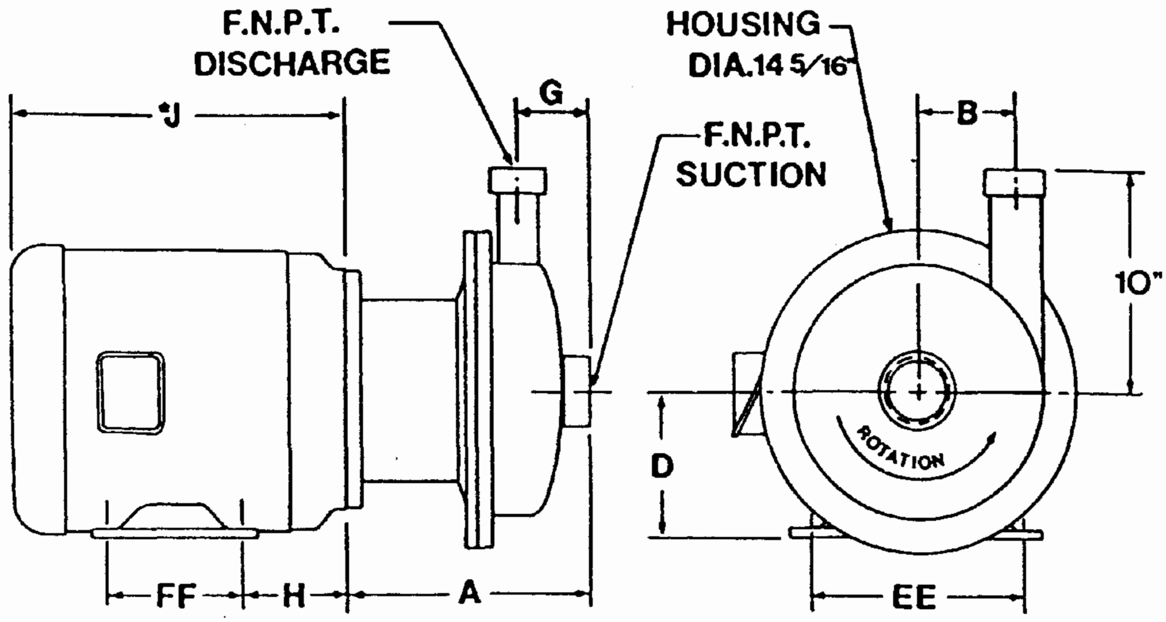
▶ PUMPS AVAILABLE

WITH PACKING GLAND AND LANTERN RING IF REQUIRED

▶ CUSTOM DESIGNED MODELS ARE AVAILABLE FOR PROCESS AND O.E.M. APPLICATIONS WITH DELIVERY USUALLY MADE IN LESS TIME THAN OUR COMPETITORS REQUIRE FOR STANDARD PUMPS.

R. S. CORCORAN COMPANY • P.O. Box 246 • New Lenox, Illinois 60451

F.N.P.T. PORTS
MODEL 5000D



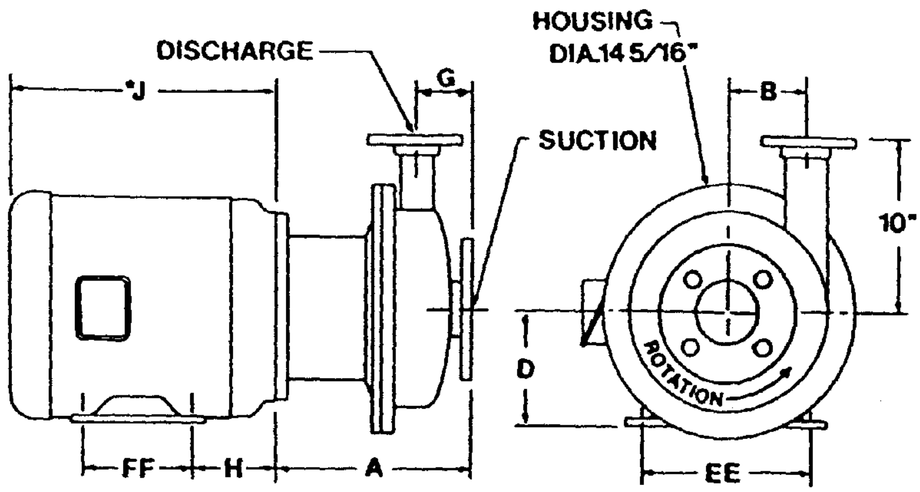
DIMENSIONS OF MODEL 5000D F.N.P.T. PORTS

For planning purposes only. Do not use for construction unless certified.
**For Motor Dimensions J see Motor Dimensions Table.*

MOTOR FRAME SIZE	D	EE	FF	PORTS	A	B	G	H
143TC	3.5	5.5	4	1½ x 1	10.44	5.47	3.62	2.88
				2 x 1½	10.44	5.16	3.62	2.88
				3 x 1½	10.44	5.16	3.62	2.88
145TC			5	3 x 2	10.44	4.77	3.62	2.88
				4 x 3	13.62	4.37	5.44	2.88
182TC	4.5	7.5	4.5	1½ x 1	10.87	5.47	3.62	3.62
				2 x 1½	10.87	5.16	3.62	3.62
				3 x 1½	10.87	5.16	3.62	3.62
184TC			5.5	3 x 2	10.87	4.77	3.62	3.62
				4 x 3	14.06	4.37	5.44	3.62
213TC	5.25	8.5	5.5	1½ x 1	11.37	5.47	3.62	4.50
				2 x 1½	11.37	5.16	3.62	4.50
				3 x 1½	11.37	5.16	3.62	4.50
215TC			7	3 x 2	11.37	4.77	3.62	4.50
				4 x 3	14.56	4.37	5.44	4.50
254TC	6.25	10	6.25	1½ x 1	12.37	5.47	3.62	4.50
				2 x 1½	12.37	5.16	3.62	4.50
				3 x 1½	12.37	5.16	3.62	4.50
256TC			10	3 x 2	12.37	4.77	3.62	4.50
				4 x 3	15.56	4.37	5.44	4.50
284TC	7	11	9.5	1½ x 1	12.50	5.47	3.62	5.00
				2 x 1½	12.50	5.16	3.62	5.00
				3 x 1½	12.50	5.16	3.62	5.00
284TSC				3 x 2	12.50	4.77	3.62	5.00
				4 x 3	15.69	4.37	5.44	5.00

MOTOR FRAME SIZE	D	EE	FF	PORTS	A	B	G	H
286TC	7	11	11	1½ x 1	12.50	5.47	3.62	5.00
				2 x 1½	12.50	5.16	3.62	5.00
				3 x 1½	12.50	5.16	3.62	5.00
286TSC				3 x 2	12.50	4.77	3.62	5.00
				4 x 3	15.69	4.37	5.44	5.00
324TC	8	12.5	10.5	1½ x 1	13.31	5.47	3.62	5.50
				2 x 1½	13.31	5.16	3.62	5.50
				3 x 1½	13.31	5.16	3.62	5.50
324TSC				3 x 2	13.31	4.77	3.62	5.50
				4 x 3	16.50	4.37	5.44	5.50
326TC	8	12.5	12	1½ x 1	13.31	5.47	3.62	5.50
				2 x 1½	13.31	5.16	3.62	5.50
				3 x 1½	13.31	5.16	3.62	5.50
326TSC				3 x 2	13.31	4.77	3.62	5.50
				4 x 3	16.50	4.37	5.44	5.50
364TC	9	14	11.25	1½ x 1	14.12	5.47	3.62	6.12
				2 x 1½	14.12	5.16	3.62	6.12
				3 x 1½	14.12	5.16	3.62	6.12
364TSC				3 x 2	14.12	4.77	3.62	6.12
				4 x 3	17.31	4.37	5.44	6.12
365TC	9	14	12.25	1½ x 1	14.12	5.47	3.62	6.12
				2 x 1½	14.12	5.16	3.62	6.12
				3 x 1½	14.12	5.16	3.62	6.12
365TSC				3 x 2	14.12	4.77	3.62	6.12
				4 x 3	17.31	4.37	5.44	6.12

FLANGED PORTS
MODEL 5000D



DIMENSIONS OF MODEL 5000D FLANGED PORTS

For planning purposes only. Do not use for construction unless certified.
**For Motor Dimensions J see Motor Dimensions Table.*

MOTOR FRAME SIZE	D	EE	FF	PORTS	A	B	G	H
143TC			4	1½ x 1	11.44	5.47	4.62	2.88
				2 x 1½	11.44	5.16	4.62	2.88
				3 x 1½	11.44	5.16	4.62	2.88
	3.5	5.5		3 x 2	11.44	4.77	4.62	2.88
145TC			5	4 x 3	14.16	4.37	6.00	2.88
				6 x 4	14.16	3.87	6.00	2.88
				6 x 5	14.56	3.34	6.00	2.88
182TC			4.5	1½ x 1	11.88	5.47	4.62	3.62
				2 x 1½	11.88	5.16	4.62	3.62
				3 x 1½	11.88	5.16	4.62	3.62
	4.5	7.5		3 x 2	11.88	4.77	4.62	3.62
184TC			5.5	4 x 3	14.59	4.37	6.00	3.62
				6 x 4	14.59	3.87	6.00	3.62
				6 x 5	15.00	3.34	6.00	3.62
213TC			5.5	1½ x 1	12.37	5.47	4.62	4.50
				2 x 1½	12.37	5.16	4.62	4.50
				3 x 1½	12.37	5.16	4.62	4.50
	5.25	8.5		3 x 2	12.37	4.77	4.62	4.50
215TC			7	4 x 3	15.09	4.37	6.00	4.50
				6 x 4	15.09	3.87	6.00	4.50
				6 x 5	15.50	3.34	6.00	4.50
254TC			8.25	1½ x 1	12.88	5.47	4.62	4.50
				2 x 1½	12.88	5.16	4.62	4.50
				3 x 1½	12.88	5.16	4.62	4.50
	6.25	10		3 x 2	12.88	4.77	4.62	4.50
256TC			10	4 x 3	15.59	4.37	6.00	4.50
				6 x 4	15.59	3.87	6.00	4.50
				6 x 5	16.00	3.34	6.00	4.50
284TC				1½ x 1	13.50	5.47	4.62	5.00
				2 x 1½	13.50	5.16	4.62	5.00
				3 x 1½	13.50	5.16	4.62	5.00
	7	11	9.5	3 x 2	13.50	4.77	4.62	5.00
284TSC				4 x 3	16.22	4.37	6.00	5.00
				6 x 4	16.22	3.87	6.00	5.00
				6 x 5	16.62	3.34	6.00	5.00

MOTOR FRAME SIZE	D	EE	FF	PORTS	A	B	G	H
286TC				1½ x 1	13.50	5.47	4.62	5.00
				2 x 1½	13.50	5.16	4.62	5.00
				3 x 1½	13.50	5.16	4.62	5.00
	7	11	11	3 x 2	13.50	4.77	4.62	5.00
286TSC				4 x 3	16.22	4.37	6.00	5.00
				6 x 4	16.22	3.87	6.00	5.00
				6 x 5	16.62	3.34	6.00	5.00
324TC				1½ x 1	14.31	5.47	4.62	5.50
				2 x 1½	14.31	5.16	4.62	5.50
				3 x 1½	14.31	5.16	4.62	5.50
	8	12.5	10.5	3 x 2	14.31	4.77	4.62	5.50
324TSC				4 x 3	17.03	4.37	6.00	5.50
				6 x 4	17.03	3.87	6.00	5.50
				6 x 5	17.44	3.34	6.00	5.50
326TC				1½ x 1	14.31	5.47	4.62	5.50
				2 x 1½	14.31	5.16	4.62	5.50
				3 x 1½	14.31	5.16	4.62	5.50
	8	12.5	12	3 x 2	14.31	4.77	4.62	5.50
326TSC				4 x 3	17.03	4.37	6.00	5.50
				6 x 4	17.03	3.87	6.00	5.50
				6 x 5	17.44	3.34	6.00	5.50
364TC				1½ x 1	15.12	5.47	4.62	6.12
				2 x 1½	15.12	5.16	4.62	6.12
				3 x 1½	15.12	5.16	4.62	6.12
	9	14	11.25	3 x 2	15.12	4.77	4.62	6.12
364TSC				4 x 3	17.84	4.37	6.00	6.12
				6 x 4	17.84	3.87	6.00	6.12
				6 x 5	18.25	3.34	6.00	6.12
365TC				1½ x 1	15.12	5.47	4.62	6.12
				2 x 1½	15.12	5.16	4.62	6.12
				3 x 1½	15.12	5.16	4.62	6.12
	9	14	12.25	3 x 2	15.12	4.77	4.62	6.12
365TSC				4 x 3	17.84	4.37	6.00	6.12
				6 x 4	17.84	3.87	6.00	6.12
				6 x 5	18.25	3.34	6.00	6.12

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Phone 815/485-2156 Telex: 72-3422

MOTOR DIMENSIONS

MOTOR DIMENSIONS FOR 4000D AND 5000D

H.P.	R.P.M.	PH.	ENCL.	FRAME	J
1	1725	1	O.D.P.	56C	10.00
1	1725	3	O.D.P	56C	9.00
1	1725	1	T.E.F.C	56C	11.25
1	1725	3	T.E.F.C	56C	10.25
1	1725	1	XP	56C	13.19
1	1725	3	XP	56C	12.31
1	3450	1	O.D.P.	56C	11.31
1	3450	3	O.D.P.	56C	8.19
1	3450	1	T.E.F.C	56C	11.25
1	3450	3	T.E.F.C	56C	9.31
1	3450	1	XP.	56C	13.19
1	3450	3	XP.	56C	12.31
1.5	1725	1	O.D.P.	56C	10.00
1.5	1725	3	O.D.P.	56C	9.00
1.5	1725	1	T.E.F.C	56C	12.12
1.5	1725	3	T.E.F.C	56C	10.25
1.5	1725	3	XP.	56C	12.31
1.5	3450	1	O.D.P.	56C	13.19
1.5	3450	3	O.D.P.	56C	9.00
1.5	3450	1	T.E.F.C.	56C	11.25
1.5	3450	3	T.E.F.C.	56C	10.25
1.5	3450	3	XP.	143TC	12.31
2	1725	1	O.D.P.	145TC	11.81
2	1725	3	O.D.P.	56C	10.00
2	1725	1	T.E.F.C.	182TC	13.94
2	1725	3	T.E.F.C	56C	11.25
2	1725	3	XP.	56C	13.19
2	3450	1	O.D.P.	56C	10.00
2	3450	3	O.D.P.	56C	9.00
2	3450	1	T.E.F.C.	56C	12.12
2	3450	3	T.E.F.C	56C	11.25
2	3450	3	XP.	145TC	13.19
3	1725	1	O.D.P.	184TC	12.37
3	1725	3	O.D.P.	182TC	11.00
3	1725	1	T.E.F.C.	184TC	15.44
3	1725	3	T.E.F.C	182TC	12.56
3	1725	3	XP.	182TC	14.19
5	1725	3	O.D.P.	184TC	12.37

H.P.	R.P.M.	PH.	ENCL.	FRAME	J
5	1725	3	T.E.F.C	184TC	13.94
5	1725	3	XP	184TC	17.87
5	3450	3	O.D.P	182TC	12.37
5	3450	3	T.E.F.C	184TC	13.94
5	3450	3	XP	184TC	16.25
7.5	1725	3	O.D.P	213TC	13.94
7.5	1725	3	T.E.F.C	213TC	15.56
7.5	1725	3	XP	213TC	16.19
7.5	3450	3	O.D.P.	184TC	12.37
7.5	3450	3	T.E.F.C.	184TC	15.44
7.5	3450	3	XP.	184TC	17.75
10	1725	3	O.D.P.	215TC	13.94
10	1725	3	T.E.F.C.	215TC	16.69
10	1725	3	XP.	215TC	17.56
10	3450	3	O.D.P.	215TC	17.31
10	3450	3	T.E.F.C.	215TC	15.56
15	1200	3	T.E.F.C	284TC	19.31
15	1740	3	T.E.F.C.	254TC	19.31
15	3500	3	T.E.F.C.	254TC	19.31
20	1200	3	T.E.F.C	286TC	25.06
20	1740	3	T.E.F.C	256TC	19.31
20	3500	3	T.E.F.C.	254TC	19.31
25	1140	3	T.E.F.C	324TC	23.69
25	1740	3	T.E.F.C.	284TC	19.31
25	3500	3	T.E.F.C.	284TSC	19.31
30	1140	3	T.E.F.C.	326TC	23.69
30	1740	3	T.E.F.C.	286TC	25.06
30	3500	3	T.E.F.C.	286TSC	25.06
40	1140	3	T.E.F.C.	364TC	26.81
40	1740	3	T.E.F.C	324TC	23.69
40	3500	3	T.E.F.C.	324TSC	23.69
50	1140	3	T.E.F.C.	365TC	26.81
50	1740	3	T.E.F.C.	326TC	23.69
50	3500	3	T.E.F.C.	326TSC	23.69
60	1740	3	T.E.F.C.	364TC	26.81
60	3500	3	T.E.F.C.	364TSC	26.81
75	1740	3	T.E.F.C.	265TC	26.81
75	3500	3	T.E.F.C.	365TSC	26.81

- Tolerance ± 0.12
- All motors are 60 hertz. Single phase motors are 115-208/230 volts A.C. Three phase motors are 208-230/460 volts A.C. Single phase XP motors are 115/230 volts A.C.
- ODP = Open Drip Proof; TEFC = Totally Enclosed Fan Cooled; XP = Explosion Proof.
- FNPT - Internal national pipe thread (tapered).
- All dimensions are inches.
- Discharge may be turned in 90° increments. Dimension B remains the same off the center line.

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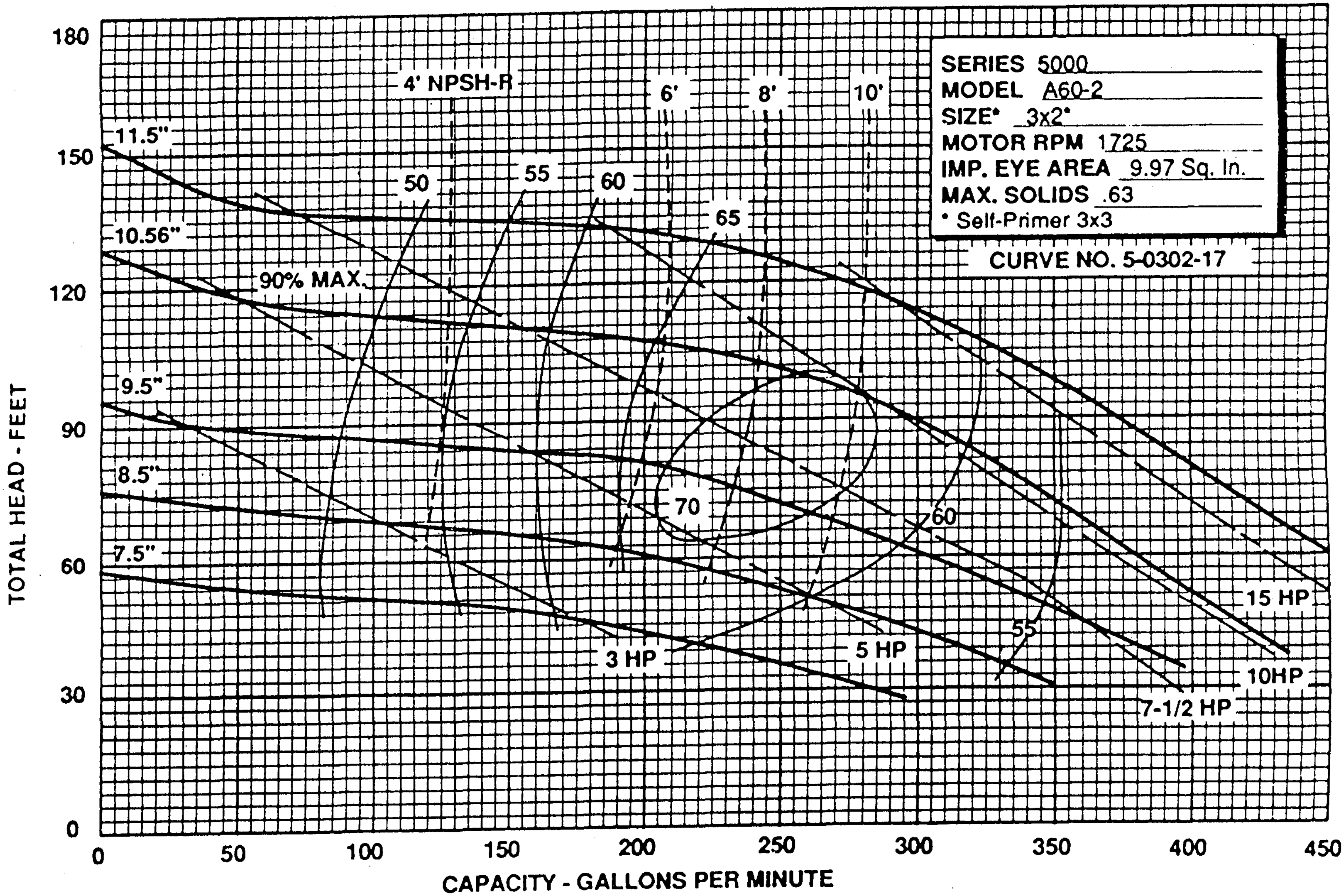
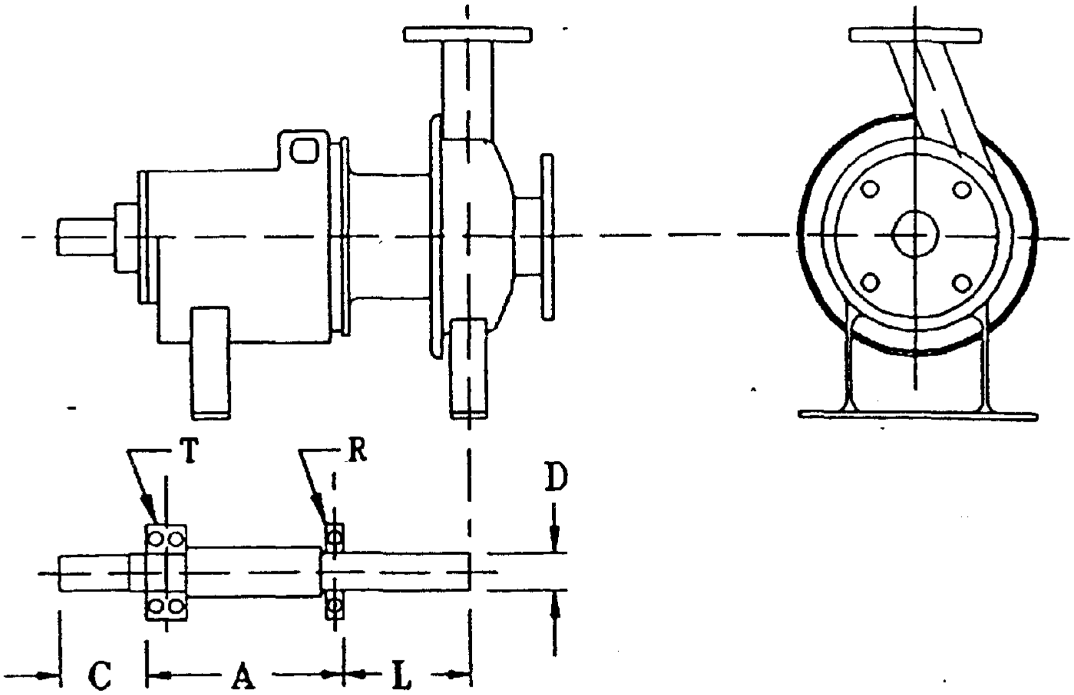


SERIES 5000
MODEL A60-2
SIZE* 3x2*
MOTOR RPM 1725
IMP. EYE AREA 9.97 Sq. In.
MAX. SOLIDS .63
* Self-Primer 3x3
CURVE NO. 5-0302-17
4' NPSH-R
6'
8'
10'
11.5"
10.56"
9.5"
8.5"
7.5"
90% MAX.
50
55
60
65
70
60
55
3 HP
5 HP
7-1/2 HP
10HP
15 HP
TOTAL HEAD - FEET
CAPACITY - GALLONS PER MINUTE
180
150
120
90
60
30
0
0
50
100
150
200
250
300
350
400
450

R.S. CORCORAN CO.
ANSI B73.1 PUMP SPEC SHEET #001



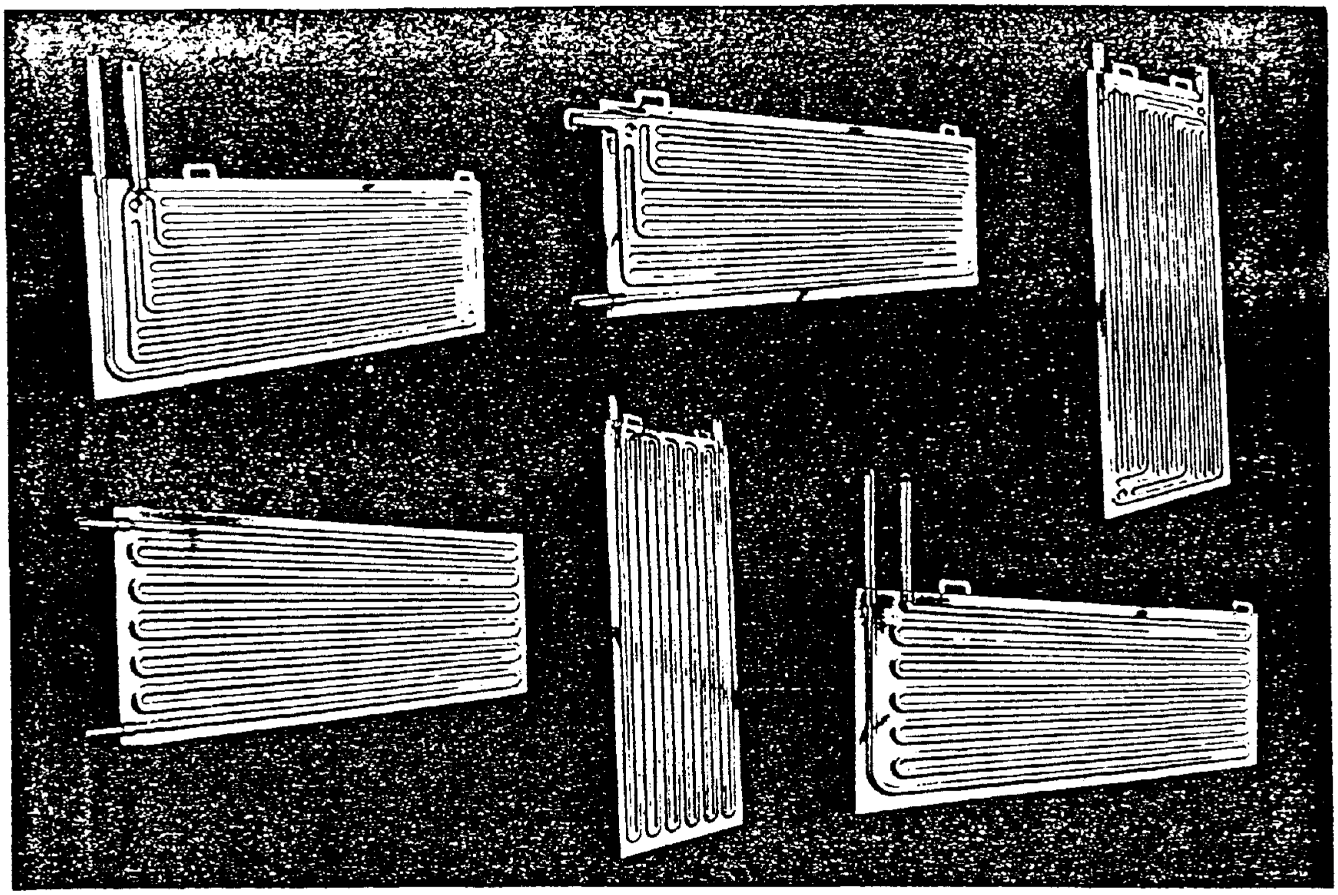
GROUP	THRUST BEARING "T"	RADIAL BEARING "R"	"C"	BEARING SPAN "A"	OVERHANG "L"	L^3/D^4
I	5306WG	306W	3.06	6.25	4.19	45.9
II	5309WG	309W	3.94	9.25	6.31	26.8
IIB*	5310WG	310W	3.94	9.25	6.31	20.3
III	5314WG	314W	6.09	13.03	8.50	15.8

*GROUP II HEAVY-DUTY OPTION w/ 1 7/8" SEAL SIZE (ALL SERIES)

PUMP SERIES	ANSI NO.	NOMINAL SIZE	BARE PUMP WEIGHT (LBS)	MAX. DIA. SPHERE	IMPELLER EYE AREA (SQ IN)	IMPELLER DIA. MAX./MIN.	SEAL SIZE
3000	AA05-1	1.5 x 1/2 - 6	58	1/4	4.67	6.25 / 4.0	1 1/8
	AA-1	1.5 x 1 - 6	59	1/2	4.67	6.25 / 4.0	1 1/8
	AB-1	3 x 1.5 - 6	65	1/2	4.67	6.25 / 4.0	1 1/8
	A10-1	3 x 2 - 6	68	9/16	4.67	6.25 / 4.0	1 1/8
	A10-2	3 x 2 - 6	96	9/16	4.67	6.25 / 4.0	1 3/4
4000	AA05-1	1.5 x 1/2 - 8	62	1/4	4.67	8.25 / 6.0	1 1/8
	AA-1	1.5 x 1 - 8	63	9/16	4.67	8.25 / 6.0	1 1/8
	AB-1	3 x 1.5 - 8	69	9/16	9.97	8.25 / 6.0	1 1/8
	A50-2	3 x 1.5 - 8	98	9/16	9.97	8.25 / 6.0	1 3/4
	A60-2	3 x 2 - 8	100	9/16	9.97	8.25 / 6.0	1 3/4
	A70-2	4 x 3 - 8	110	5/8	16.4	8.25 / 6.0	1 3/4
5000	AA05-2	2 x 1/2 - 11	101	1/4	4.67	11.5 / 8.0	1 3/4
	A05-2	2 x 1 - 11	102	1/2	4.67	11.5 / 8.0	1 3/4
	A50-2	3 x 1.5 - 11	106	1/2	9.97	11.5 / 8.0	1 3/4
	A60-2	3 x 2 - 11	110	5/8	9.97	11.5 / 8.0	1 3/4
	A70-2	4 x 3 - 11	118	3/4	16.4	11.5 / 8.0	1 3/4
	A80-2	6 x 4 - 11	137	3/4	35.1	11.5 / 8.0	1 3/4
	A85-2	6 x 5 - 11	150	3/4	35.1	11.5 / 8.0	1 3/4
	A90-2	8 x 6 - 11	210	1 1/2	35.1	11.5 / 8.0	1 3/4
6000	AA05-2	2 x 1/2 - 14	157	1/4	4.67	14.5 / 10.0	1 3/4
	A10-2	2 x 1 - 14	158	1/2	4.67	14.5 / 10.0	1 3/4
	A20-2	3 x 1.5 - 14	162	5/8	9.97	14.5 / 10.0	1 3/4
	A30-2	3 x 2 - 14	170	5/8	9.97	14.5 / 10.0	1 3/4
	A40-2	4 x 3 - 14	178	3/4	16.4	14.5 / 10.0	1 3/4
	A80-2	6 x 4 - 14	190	1 1/8	35.1	14.5 / 10.0	1 3/4
	A90-3	8 x 6 - 14	310	1 1/2	59.3	14.5 / 10.0	2 1/2

BULLETIN PD-26

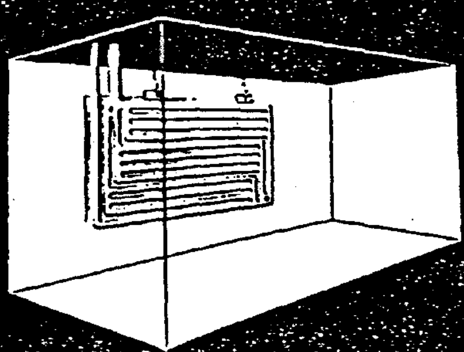
Platecoil. Off-the-shelf speedy selector.



by tranter

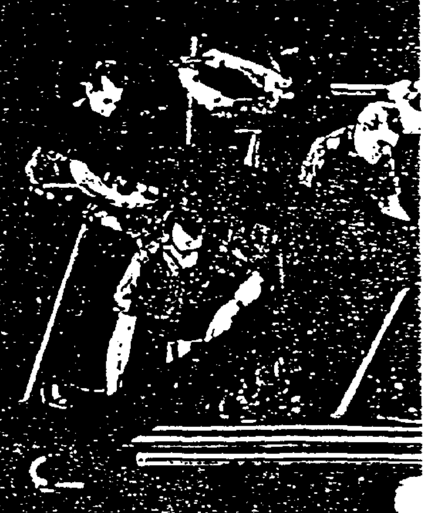
TRANTER, Inc., Texas Division, P.O. Box 2289, Wichita Falls, Texas 76307
Phone: 817/723-7125 Telex: 734-410 Fax: (817) 723-

Platecoil simplifies tank heating and cooling problems.



IMMEDIATE DELIVERY FROM WAREHOUSE STOCKS GAINS VALUABLE PRODUCTION TIME

Over 300 stock sizes and styles of PLATECOIL meet most tank heating and cooling needs. You can get delivery in a matter of days, putting new installations into production faster and cutting down time on replacement jobs. PLATECOIL is delivered to you factory-tested. You can install them knowing that operation will not be held up by leaks. Installation is fast with hangers and brackets provided.



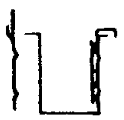
INCREASES TANK CAPACITY FOR PRODUCTION WORK

A 22" x 47" PLATECOIL provides the same heat transfer as 32 ft. of 1½" pipe requiring approximately 30" x 60".

WEIGHS ABOUT 1/2 AS MUCH AS EQUIVALENT PIPE COIL

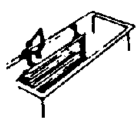
Lightweight PLATECOIL units are handled easily by one or two men – no need for hoisting machinery.

EASY TO INSTALL



"Quick Change Hangers" make PLATECOIL installation in open tanks easy. It takes just minutes to place the handles of the PLATECOIL units on the hanger hooks and bend the top of the hangers over the edge of the tank.

NO THREADED JOINTS IN TANK



Welded and pressure tested, PLATECOIL units have no threaded joints to corrode or leak. Both connections can be located above the liquid level of the tank, free from contamination.

LOW FIRST COST

In most instances, users find it costs less to buy PLATECOIL than to fabricate pipe coils. Reduced installation time saves, too.

RIGID STRUCTURAL DESIGN

PLATECOIL's structural rigidity permits its use as walls, baffles, or partitions. It can be used in many applications where pipe coil is impractical.

QUICK REPLACEMENT

No need to empty a tank to change PLATECOIL; just set new units in on "Quick Change" hangers. This allows double sets of PLATECOIL to be rotated quickly between shifts for cleaning with no production downtime.

EASY TO CLEAN

The streamlined design of PLATECOIL makes it unusually simple to clean. Experience also has proved that deposits tend to form less readily on PLATECOIL than on pipe coils.

HIGH BUILT-IN SAFETY FACTOR

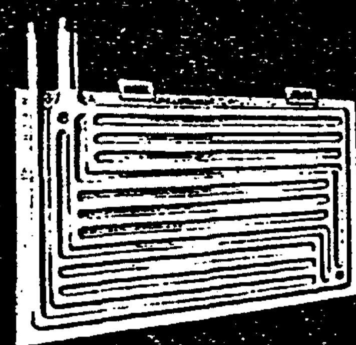
Laboratory tests to destruction have demonstrated a built-in safety factor of more than 5 to 1. Every PLATECOIL is factory tested.

EXTRA CORROSION RESISTANCE

All stainless steel PLATECOIL are fully annealed for maximum corrosion resistance at no extra cost as a standard feature. (Only Tranter, inc. supplies this feature.)

FACTORY-FABRICATED UNITS ELIMINATE THE HIGH COST OF ENGINEERING AND BUILDING PIPE COILS

Calculation of PLATECOIL needed to do the job is fast and reliable. Standard heat transfer ratings and precalculated capacities save you engineering time. No need to wait for engineering, estimating and assignment of work by your own departments and crews or outside fabricators. Mass production, advanced fabricating techniques and close quality control save you money and assure performance.



MORE EFFICIENT HEAT TRANSFER PROVIDES FASTE START-UP, MORE CONSTANT TANK TEMPERATURES

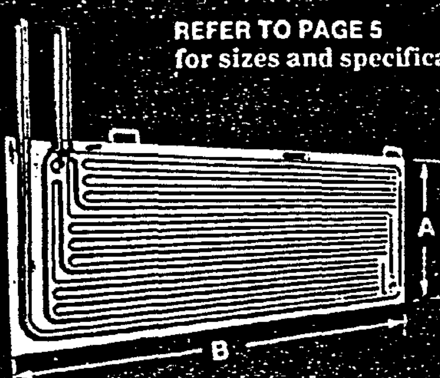
PLATECOIL design produces max imum prime heat transfer surface Streamlined surfaces resist fouling In heating applications, patente MULTI-ZONE pass arrangemen delivers steam almost simultane ously to all levels of the PLATE COIL from top to bottom an avoids efficiency-robbing conden sate "blocking" commonly encoun tered in pipe coils or straight headered equipment.

How to select the Platecoil you need.

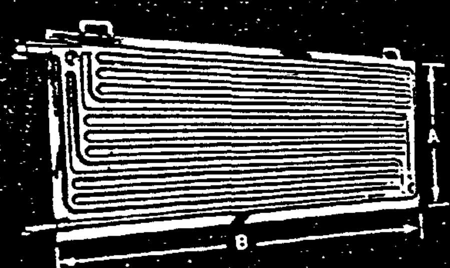
MULTI-ZONE PLATECOIL

PIPE SIZES — ALL MULTI-ZONE STYLES
Steam inlet 1", 1½" or 2" MPT
Condensate outlet ¾" or 1" MPT depending on PLATECOIL size.

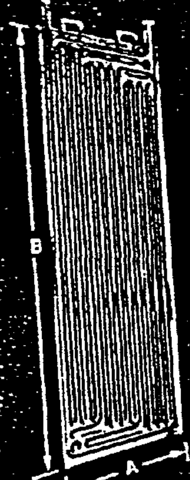
REFER TO PAGE 5
for sizes and specifications.



STYLE 90D PLATECOIL
For use in long shallow tank.
All pipe connections above the solution.



STYLE 70D PLATECOIL
For piping through the end of the tank and for use in banks.



STYLE 70AD PLATECOIL
Very useful for short, deep tanks.

MULTI-ZONE PLATECOIL

have been specially designed for use with steam. They have replaced pipe coils in thousands of plating and metal processing plants. The patented zoned headers have proven superior in heat transfer rates and condensate removal. This results in faster heat-up to get production started sooner.

Refer to chart on Page 6 for details concerning use of Multi-zone PLATECOIL when used with steam.

Most Style 90D Multi-zone PLATECOIL in the sizes indicated below are available in carbon steel or Type 316 fully annealed stainless steel as stock items ready for immediate shipment. Other Multi-zone styles are also available from stock in various sizes. Contact factory for size and style needed.

SERPENTINE PLATECOIL

are particularly designed for use with liquids and refrigerants and generally used for cooling purposes. The pass configuration results in the best possible heat transfer rates due to high internal velocities. The serpentine design also prevents short circuiting with refrigerants.

Refer to Page 7 for details on selecting Serpentine PLATECOIL when used to remove heat from plating solutions, etc.

Most Style 60D and Style 50D Serpentine PLATECOIL in the sizes indicated below are available in carbon steel or Type 316 fully annealed stainless steel as stock items ready for immediate shipment.

ELECTROPOLISH

This is an economical electrochemical surface finish for stainless steel PLATECOIL which greatly reduces the tendency for scaling in phosphatizing and other similar solutions.

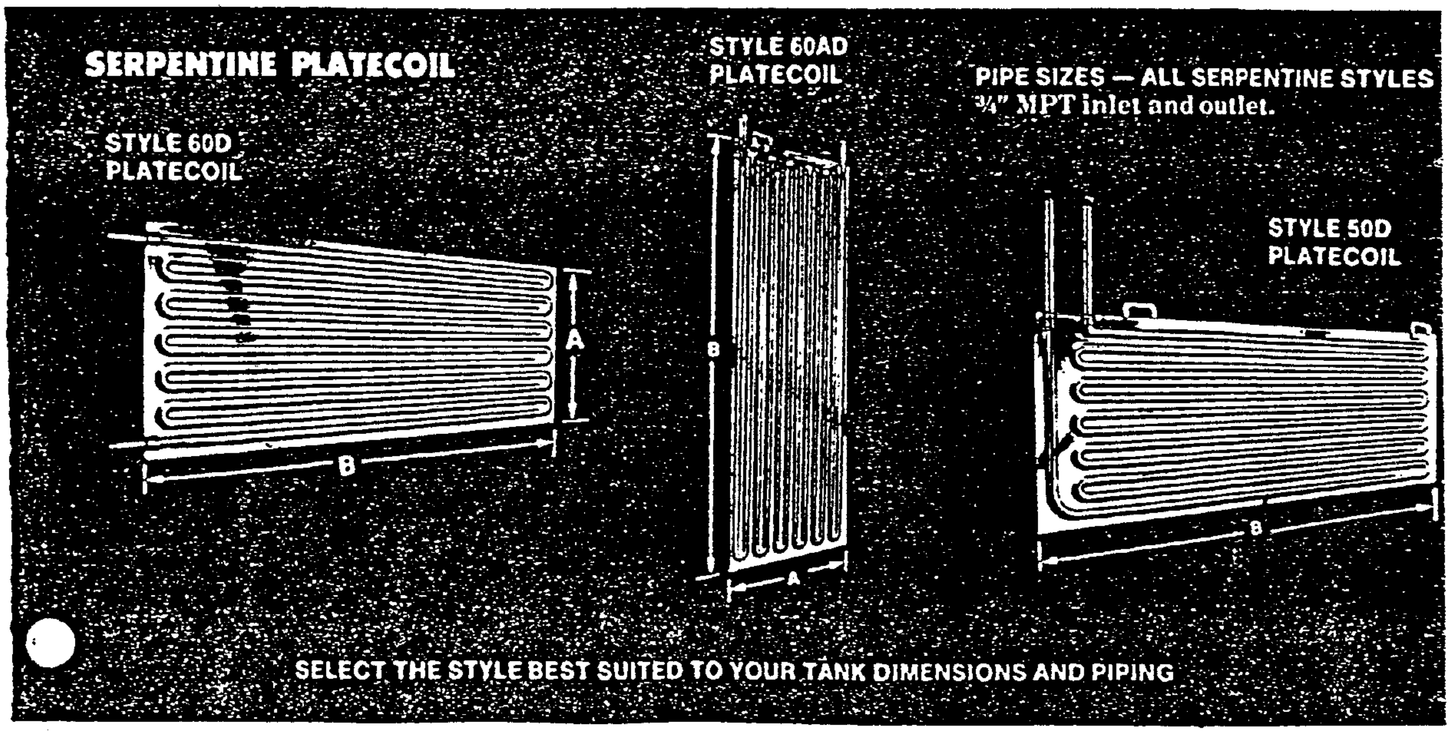
Some Style 90D Electropolished PLATECOIL are available as stock items ready for immediate shipment.

HANGERS

Standard PLATECOIL hangers hold the PLATECOIL at the optimum distance from the tank wall for best chimney effect which improves heat transfer. Just bend the hanger over the edge of the tank at the desired height. Two hangers are used per PLATECOIL except 12" wide 70A and 60A where only one hanger is needed.

	STANDARD WIDTHS ALL STYLES						
"A" Dimension:	12"	18"	22"	26"	29"	36"	43"
	STANDARD LENGTHS ALL STYLES						
"B" Dimension:	23"	29"	35"	47"	59"	71"	
	83"	95"	107"	119"	131"	143"	

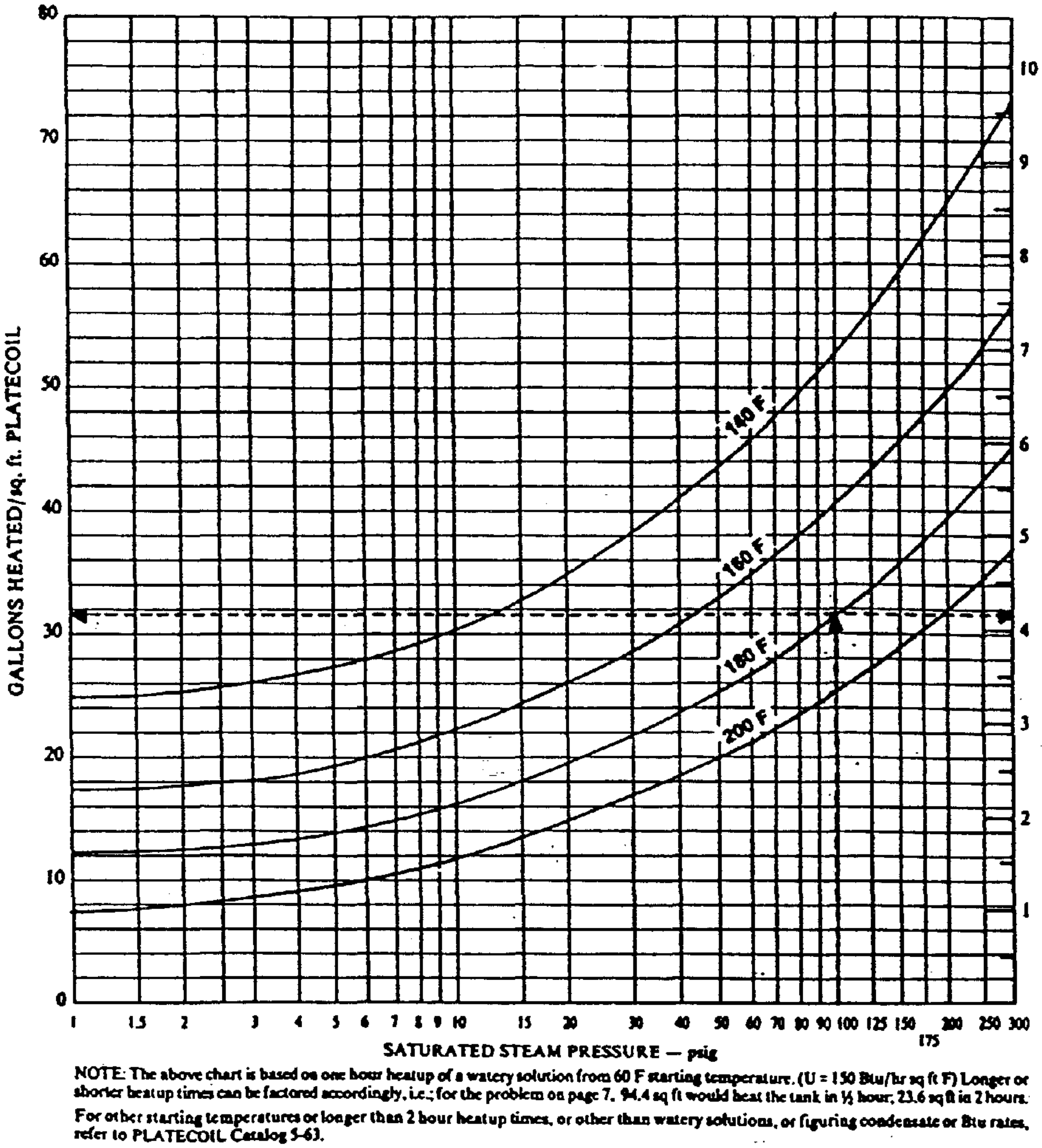
PLATECOIL are also available in non-standard dimensions and in materials other than carbon steel and Type 316 stainless steel. Refer to PLATECOIL Product Data Manual No. 5-63 for details.



How to calculate Platecoil area.

STEAM HEATING WITH MULTI-ZONE PLATECOIL

FIG. 1 MULTI-ZONE HEATING CURVES



NOTE: The above chart is based on one hour heatup of a watery solution from 60 F starting temperature. (U = 150 Btu/hr sq ft F) Longer or shorter heatup times can be factored accordingly, i.e.; for the problem on page 7, 94.4 sq ft would heat the tank in ½ hour; 23.6 sq ft in 2 hours. For other starting temperatures or longer than 2 hour heatup times, or other than watery solutions, or figuring condensate or Btu rates, refer to PLATECOIL Catalog 5-63.

HOW TO USE MULTI-ZONE HEATING CURVES (Fig. 1)

EXAMPLE: Determine the total square feet of PLATECOIL required to heat a watery solution from 60F to 180F using 100 psig steam. The tank measures 10′ x 5′ x 5′, and the solution depth is 4′.

SOLUTION: 1. Calculate the solution volume: V=10′ x 5′ x 4′ = 200 cubic feet. (This is equivalent to 200 x 7.5 gal/cu ft = 1500 gal.)

2. Enter the bottom of the chart at the 100 psig steam pressure line. Follow the line up to the curve for 180 F final temperature. From this intersection, move horizontally to read 31.8 gal heated per sq ft of PLATECOIL, or 4.24 cu ft heated per sq ft of PLATECOIL.

3. Divide the result of step (1) by the result of step (2) to obtain the required PLATECOIL area:

$$\frac{200}{4.24} \text{ or } \frac{1500}{31.8} = 47.2 \text{ sq ft}$$

4. Select the appropriate PLATECOIL size from the area table Fig. 3. Either a 26″ x 119″ or 29″ x 107″ PLATECOIL will do the job.

COOLING WITH SERPENTINE PLATECOIL

FIG. 2. HOLDING TEMPERATURE IN PLATING SOLUTIONS

Watts Removed Per Sq Ft	GPM/Sq Ft Cooling Water	Cooling Water Inlet Temperature	Solution Holding Temperature	Btu/hr Removed Per Sq Ft
1140	.4	50	100	3900
1730	.6	50	120	5900
2320	.8	50	140	7900
850	.3	60	100	2900
1440	.5	60	120	4900
2020	.7	60	140	6900
410	.2	70	100	1900
1140	.4	70	120	3900
1730	.6	70	140	5900

NOTE: The above table is based on a "U" value of 100 Btu/hr/sq ft F for a watery solution and a cooling water temperature rise of approximately 20F through the PLATECOIL. Generally city water pressure will supply adequate cooling water for a style 60 or 50 PLATECOIL up to about 30 sq ft. For tanks requiring more than 30 sq ft of cooling surface, several smaller PLATECOIL may be desirable. Page 71 of the PLATECOIL PRODUCT DATA MANUAL gives more complete pressure drop data.

HOW TO USE THE TABLE (Fig. 2)

EXAMPLE: Maximum current input into a 4′ x 6′ x 4′ liquid level Cyanide Copper plating bath is 30,000 watts. Determine the size of PLATECOIL required to hold 120 F operating temperature using 60 F cooling water.

SOLUTION: 1. Entering the table at 60 F cooling water and 120 F solution temperature, a PLATECOIL capacity of 4900 Btu/hr/sq ft or 1440 Watts/sq ft is noted.

2. Divide input by PLATECOIL capacity to obtain the required PLATECOIL area.

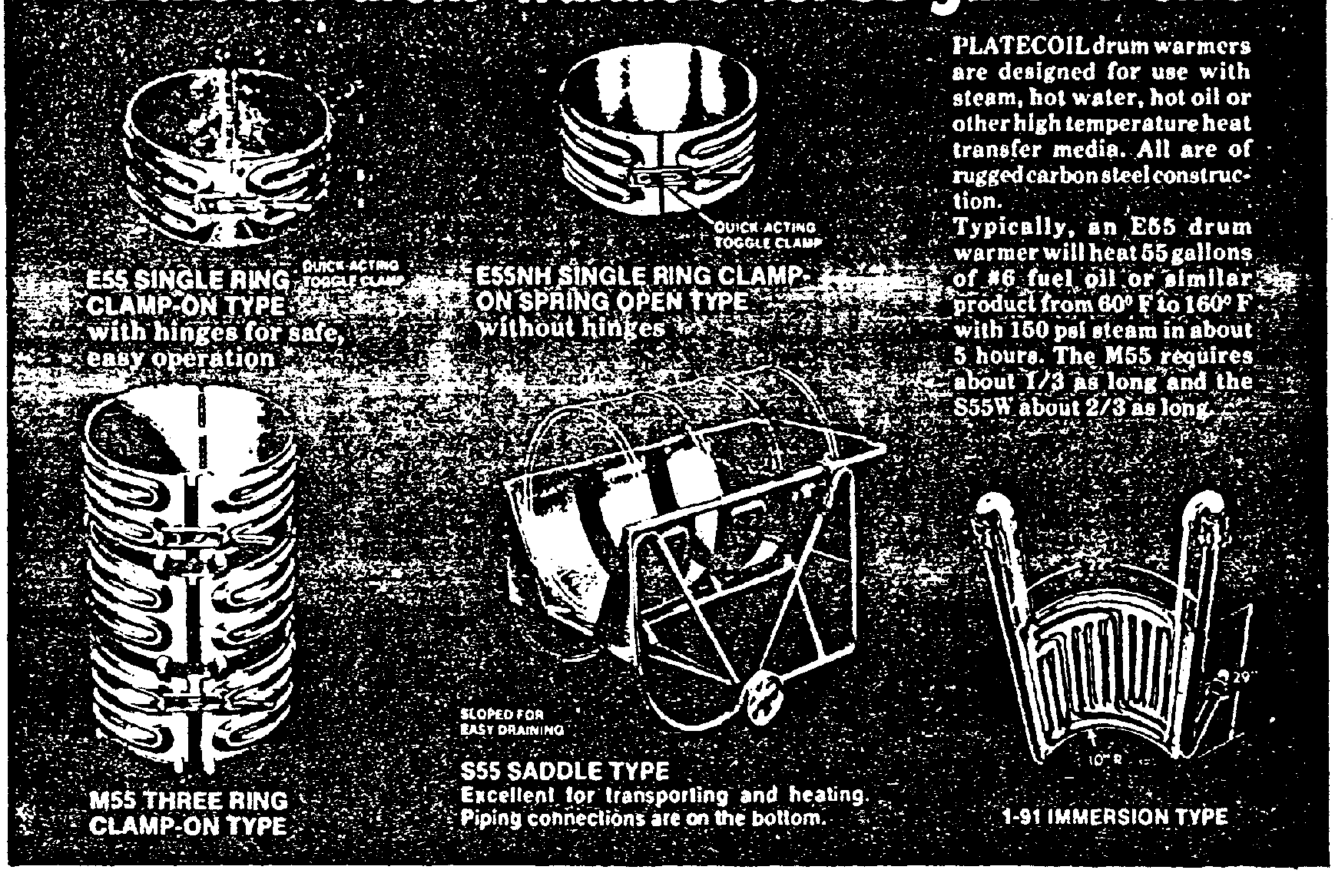
$$\frac{30{,}000}{1{,}400} = \begin{array}{l}\text{20.8 sq ft}\\ \text{PLATECOIL Area}\end{array}$$

3. Select the appropriate PLATECOIL size from the area table Fig. 3. A 22″ x 59″ PLATECOIL will do the job, utilizing 20.8 x .5 = 10.4 GPM cooling water.

FIG. 3. HEAT TRANSFER AREA IN SQUARE FEET for ALL Double Embossed PLATECOIL Styles.

Nominal Width Inches (A dimension)	LENGTH in INCHES (B dimension)											
	23	29	35	47	59	71	83	95	107	119	131	143
12	4.3	5.4	6.6	8.8	11.1	13.3	15.6	17.8	20.1	22.3	24.6	26.8
16	6.8	8.5	10.3	13.9	17.4	21.0	24.5	28.1	31.6	35.2	38.7	42.3
22	8.0	10.1	12.2	16.4	20.6	24.8	29.0	33.2	37.4	41.6	45.8	50.0
26	9.2	11.7	14.1	18.9	23.8	28.6	33.5	38.3	43.2	48.0	52.9	57.7
29	10.5	13.2	16.0	21.5	27.0	32.5	38.0	43.5	49.0	54.5	60.0	65.5
36	12.9	16.3	19.7	26.5	33.3	40.1	46.9	53.7	60.5	67.3	74.1	80.9
43	15.4	19.5	23.6	31.8	39.7	47.8	55.9	64.0	72.1	80.2	88.3	96.4

Platecoil drum warmers for 55 gallon drums



Drum Warmer Description	Part Numbers Without Hoses	Part Numbers With Hoses	Operating Pressure (Including Hose)	Hose Description	Approx. Wt. Lbs., With Hoses Net	Approx. Wt. Lbs., With Hoses Shipping
SINGLE RING CLAMP-ON HINGED	E55	E55H	150 PSIG	3—½" x 22" hoses one is jumper hose	30	50
SINGLE RING CLAMP—ON SPRING OPEN WITHOUT HINGES	E55NH	E55NHH	150 PSIG	2—½" x 22" hoses	30	50
3 RING CLAMP-ON HINGED	M55	M55H	150 PSIG	4—½" x 22" hoses connected in pairs with tees to provide 1 inlet & 1 outlet	75	120
SADDLE TYPE	S55W	S55WH	150 PSIG	2—¾" x 42" hoses	80	125
IMMERSION TYPE	1-91	1-91H	250 PSIG	2—¾" x 42" hoses with swivel adaptor	45	65

TRANTER, Inc., Texas Division, P.O. Box 2289, Wichita Falls, Texas 76307
Phone: 817/723-7125 TELEX: 734410 FAX: 817/723-5131
Manufactured in Great Britain by Senior PLATECOIL Ltd., P.O. Box 38, Caldervale Road, Wakefield West Yorkshire, WFI 5PF England

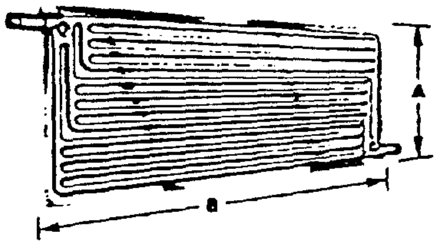
ORDER LOCALLY FROM:

PLATECOIL
by
tranter

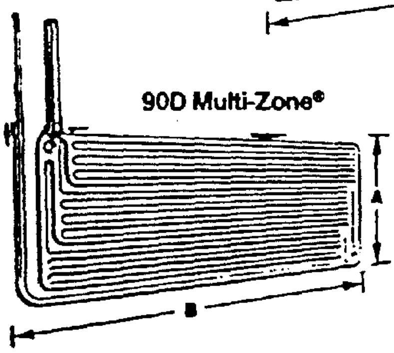
A WIDE RANGE OF SPECIFICATIONS

PLATECOIL STYLES

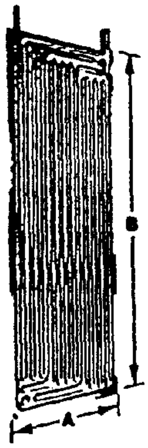
80D Multi-Zone®



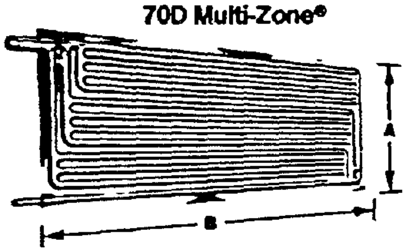
90D Multi-Zone®



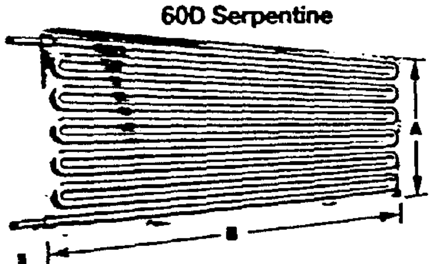
70AD Multi-Zone®



70D Multi-Zone®

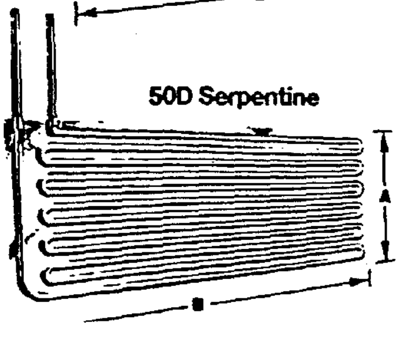


60D Serpentine



60AD Serpentine

50D Serpentine



PLATECOIL AREAS & WEIGHTS

DOUBLE EMBOSSED SURFACE AREAS

TABLE 1 ALL STYLES IN SQUARE FEET

Nom. Width Inches A. DIM.	NOMINAL LENGTH IN INCHES B. DIM.											
	23	29	35	47	59	71	83	95	107	119	131	[illegible]
12	4.3	5.4	6.5	8.8	11.1	13.3	15.6	17.8	20.1	22.3	24.6	2
18	6.8	8.5	10.3	13.8	17.4	21.0	24.5	28.1	31.6	35.2	38.7	4
22	8.0	10.1	12.2	16.4	20.6	24.8	29.0	33.2	37.4	41.6	45.8	5
26	9.2	11.7	14.1	18.9	23.8	28.6	33.5	38.3	43.2	48.0	52.9	5
29	10.5	13.2	16.0	21.5	27.0	32.5	38.0	43.5	49.0	54.5	60.0	6
36	12.9	16.3	19.7	26.5	33.3	40.1	46.9	53.7	60.5	67.3	74.1	8
43	15.4	19.5	23.5	31.6	39.7	47.8	55.9	64.0	72.1	80.2	88.3	9

AREAS OF FLAT SIDE ONLY FOR SINGLE EMBOSSED

TABLE 2 ALL STYLES IN SQUARE FEET

Nom. Width Inches A. DIM.	NOMINAL LENGTH IN INCHES B. DIM.											
	23	29	35	47	59	71	83	95	107	119	131	1
12	1.9	2.4	2.9	3.9	4.9	5.9	6.9	7.8	8.8	9.8	10.8	11
18	3.0	3.8	4.6	6.1	7.7	9.3	10.8	12.4	14.0	15.5	17.1	18
22	3.6	4.5	6.4	7.3	9.1	11.0	12.8	14.7	16.5	18.4	20.2	22
26	4.1	5.2	6.2	8.4	10.5	12.7	14.8	16.9	19.1	21.2	23.4	25
29	4.7	5.9	7.1	9.5	11.9	14.4	16.8	19.2	21.6	24.1	26.5	29
36	5.7	7.2	8.7	11.7	14.7	17.7	20.7	23.7	26.7	29.7	32.7	35
43	6.8	8.6	10.4	14.0	17.6	21.1	24.7	28.3	31.9	35.4	39.0	42

QUICK DELIVERY OF 2-3 WEEKS for single embossed PLATECOIL can be supplied in limited quantities for 22" wide embossings in 14 ga. carbon steel. Flat side of PLATECOIL can be custom designed for thicknesses up to 10 ga. Commonly, single embossed PLATECOIL is used as clamp-on to the side wall of tanks or for applications requiring one flat side.

PLATECOIL INTERNAL OPERATING PRESSURE

(NON ASME CODE)

Gauge		CARBON STEEL	304, 304L, 316, 316L, MONEL
Double Embossed		PSI	PSI
16		180	250
14		300	330
12		400	400
Single Embossed			
Embossing	Companion	PSI	PSI
16	16	130	160
16	14	145	190
16	12	180	205
16	11	205	240
14	14	190	240
14	12	215	270
14	11 & over	265	290
12	12 & over	265	300

QUICK SELECTION CHARTS

Fig. 1 QUANTITY OF SOLUTION HEATED PER SQ FT VS. STEAM PRESSURE Based on one hour heat up time from 60F (U=150 Btu/hr sq ft F)

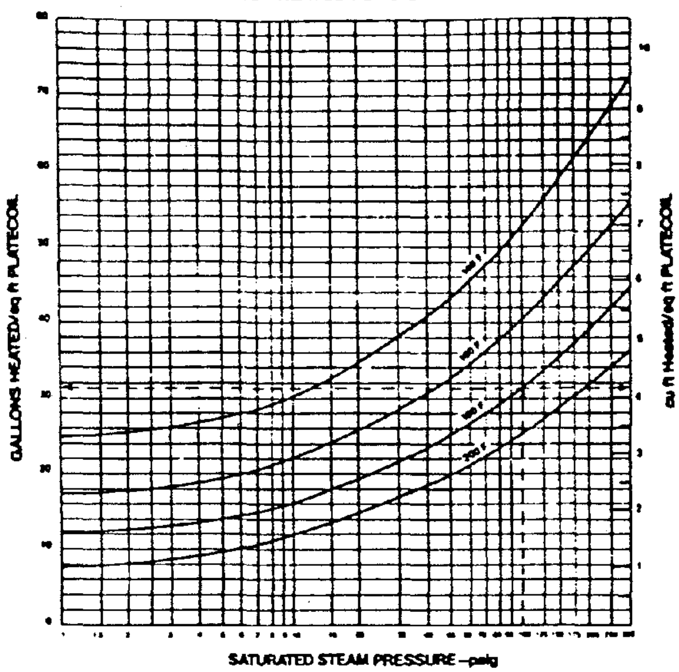


Fig. 1
EXAMPLE ILLUSTRATING THE USE OF THE CHART

Determine the total sq ft of PLATECOIL needed to heat a watery solution from 60F to 180F in one hour with steam at 100 psig. The tank measures 10'x5'x5' and the solution depth is 4'. Also determine pounds of steam condensed.

1. Calculate solution volume: V = 10'x5'x4' = 200 cu ft (This is equivalent to 200x7.5 gal/cu ft = 1500 gallons.)
2. Enter the bottom of Fig. 1 at the line for 100 psig steam pressure. Follow it vertically to the curve for 180F operating temperature. From this intersection, move horizontally to the left and read: 30 gal heated per sq ft of PLATECOIL or move right and read 4 cu ft heated per sq ft of PLATECOIL.
3. Divide result of Step 1 by result of Step 2 to obtain PLATECOIL AREA = $\frac{200}{4.24}$ or $\frac{1500}{31.8}$ = 47.2 sq ft
4. Select the appropriate size Style 90 PLATECOIL from Table 1 on page 7. A 26"x119" will provide 48 sq ft and will be the most economical choice.

Fig. 2
HOW TO USE THE HOLDING TEMPERATURE CHART

EXAMPLE: Maximum current input into a 4'x6'x4' liquid level cyanide copper plating bath is 30,000 watts. Determine the size of PLATECOIL required to hold 120F operating temperature using 60F cooling water.

SOLUTION: 1. Entering the chart at 60F cooling water and 120F solution temperature, a PLATECOIL capacity of 4900 Btu/hr/sq ft or 1440 watts/sq ft is noted.

2. Divide input by PLATECOIL capacity to obtain the required PLATECOIL area.

$\frac{30,000}{1440}$ = 20.8 sq ft PLATECOIL area

3. Select the appropriate PLATECOIL size from the surface area chart in Table 1 on page 7. A 22"x59" PLATECOIL will do the job, utilizing 20.8x.5 = 10.4 GPM cooling water.

HOLDING TEMPERATURE IN PLATING SOLUTIONS
Fig. 2 Cooling With Serpentine PLATECOIL

Watts Removed Per Sq Ft	GPM/Sq Ft Cooling Water	Cooling Water Inlet Temp.	Solution Holding Temperature	Btu/hr Removed Per Sq Ft
1140	.4	50	100	3900
1730	.6	50	120	5900
2320	.8	50	140	7900
850	.3	60	100	2900
1440	.5	60	120	4900
2020	.7	60	140	6900
410	.2	70	100	1400
1140	.4	70	120	3900
1730	.6	70	140	5900

NOTE: The above table is based on a U value of 100 Btu/hr sq ft F for an agitated watery solution and a cooling water temperature rise of approximately 20F through the PLATECOIL. Generally city water pressure will supply adequate cooling water for a Style 60 or 50 PLATECOIL up to about 30 sq ft. For tanks requiring more than 30 sq ft of cooling surface, several smaller PLATECOIL may be desirable. Page 82 of PLATECOIL Data Manual gives more complete pressure drop data.

Fig. 3 AVERAGE OVERALL HEAT TRANSFER COEFFICIENTS U=Btu/hr sq ft F (For Immersed Or As Integral Vessel Jackets)

HEATING APPLICATIONS		PLATECOIL	CLEAN SURFACE COEFFICIENTS		DESIGN COEFFICIENTS Considering Usual Fouling in this Service	
HOT SIDE	COLD SIDE	STYLE	Nat. Convect.	Forc. Convect.	Nat. Convect.	Forc. Convect.
1. Steam	Watery solution	90-80-70	250-500	300-550	125-225	150-275
2. Steam	Light oils	90-80-70	50-70	110-140	40-45	60-110
3. Steam	Medium lube oil	90-80-70	40-60	100-130	25-40	50-100
4. Steam	Bunker C or #6 fuel oil	90-80-70	20-40	70-90	10-30	60-80
5. Steam	Tar or asphalt	90-80-70	15-35	50-70	15-25	40-60
6. Steam	Molten sulphur	90-80-70	35-45	60-80	4-15	50-70
7. Steam	Molten paraffin	90-80-70	35-45	45-55	25-35	40-50
8. Steam	Air or gases	90-80-70	2-4 *	5-10 *	1-3 *	4-8
9. Steam	Molasses or corn syrup	90-80-70	20-40	70-90	15-30	60-80
10. High temp. hot water	Watery solutions	60-50-40	80-100	100-225	70-100*	110-160*
11. High temp. ht. transfer oil	Tar or asphalt	60-50-40	12-30	45-65	10-30	30-50
12. Therminol	Tar or asphalt	60-50-40	15-30	50-60	12-20	30-50
COOLING APPLICATIONS						
COLD SIDE	HOT SIDE					
13. Water	Watery solution	60-50-40	70-100	90-160	50-80	80-140
14. Water	Quench oil	60-50-40	10-15	25-45	7-10	15-25
15. Water	Medium lube oil	60-50-40	8-12	20-30	5-8	10-20
16. Water	Molasses or corn syrup	60-50-40	7-10	18-26	4-7	8-15
17. Water	Air or gases	60-50-40	2-4	5-10	1-3	4-8
18. Freon or ammonia (dir. exp.)	Water solution	60-50	35-45	60-90	20-35	40-60
19. Calcium or sodium brine	Watery solution	60-50-40	100-120	175-200	50-75	80-125

CLAMP ON PLATECOIL :	WATER AND SOLVENTS		VISCOUS PRODUCTS		AIR AND GASES**	
	Heating	Cooling	Heating	Cooling	Heating	Cooling
20. With heat transfer mastic	30-40	20-30	12-20	8-12	1-3	1-3
21. Without heat transfer mastic	15-25	10-20	6-12	3-8	1-3	1-3

: Clamp-On PLATECOIL should be used only for holding conditions. DO NOT use for heat up or cool down except in moderate requirement situations and with calculated area doubled as a safety factor. * See curves on page 86 of PLATECOIL Data Manual for more detailed data.
** For low velocity air or gas.

OPL SERIES PRESSURE SWICHGAGE® AND MURPHYGAGE®

4.5 In/114 mm Dial Diameter; Bourdon Tube Actuated Movement; Ranges From 30" Vacuum to 20,000 psi; OPL Ⓢ Approved; OPL-BP Ⓤ Listed

DESCRIPTION

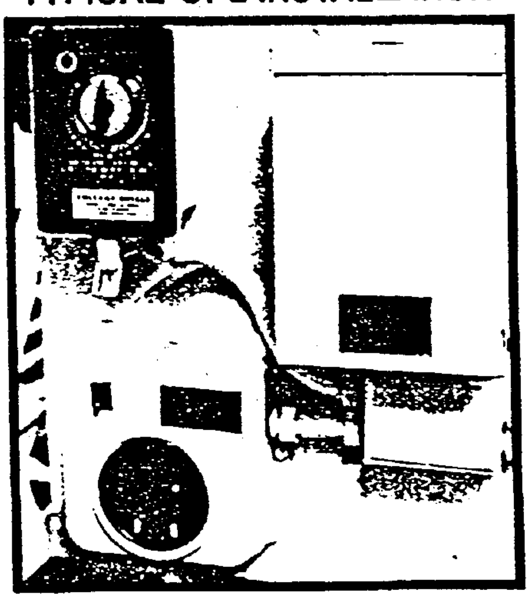
The OPL series SWICHGAGE® is a mechanical, analog gauge with adjustable high and low pressure limit contacts. The visible limit contacts are self-wiping for positive switching and are rated pilot duty for limit switch activation of alarms and/or equipment shut-down. Gauge pointer closure with either contact makes a circuit.

A bourdon tube sensing element actuates the stainless steel, geared movement to translate pressures into accurate dial readings: inches of mercury, kilo-Pascals or psig. The MURPHYGAGE is a gauge-only version of this series.

APPLICATIONS

The OPL series are used to protect, to start and stop, to automate systems and equipment, such as pumps, steam generators, air and gas compressors. Through use with Murphy relays, magnetic switches, or transformer relays, the OPL can become a controller for most engine or electric motor applications involving pressure control.

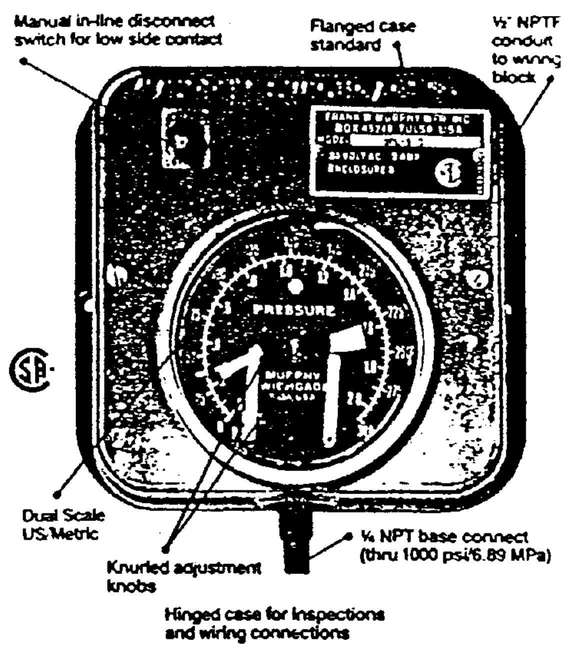
TYPICAL OPL INSTALLATION



OPL SWICHGAGE:®
3 Instruments in 1
- Accurate/Rugged Mechanical Gauge
- Low Pressure Limit Switch
- High Pressure Limit Switch

Use It To Alarm, Control, or Shut-Down

OPL SWICHGAGE®



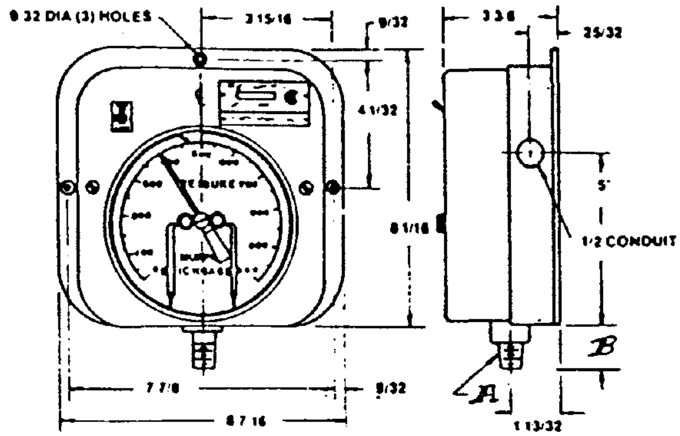
A FULL 2 YEAR WARRANTY is carried by all Murphy SWIC GAGES® against defective parts and/or workmanship.

BASIC MODELS: OPL Series Pressure SWICHGAGES®

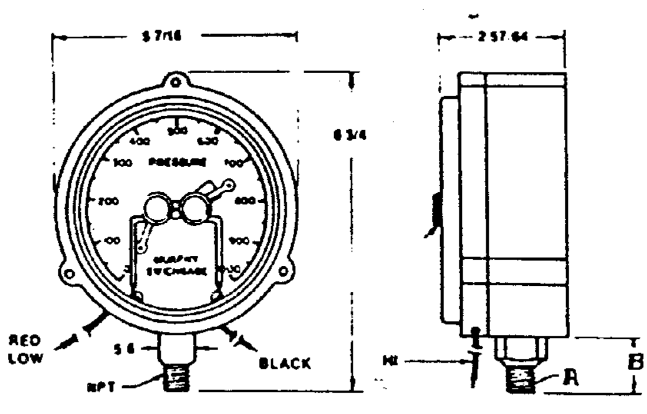
Models	Description	Models	Description
OPL	Standard OPL SWICHGAGE®, Standard Case	OPL-BP	Ⓤ Listed Controller, Standard Case OPL w/Control Relay
OPL-C	Standard OPL w/ungrounded contacts		
OPL-F	SWICHGAGE®, Round/Flush Case	OPL-G	Gauge Only, Standard Case
OPL-FC	SWICHGAGE® w/ungrounded contacts, Round/Flush Case	OPL-FG	Gauge Only, Round/Flush Case

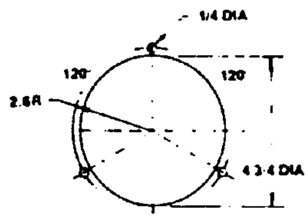
STANDARD DIMENSIONS

OPL: Standard Case



OPL-F: Panel/Flush Mount Case





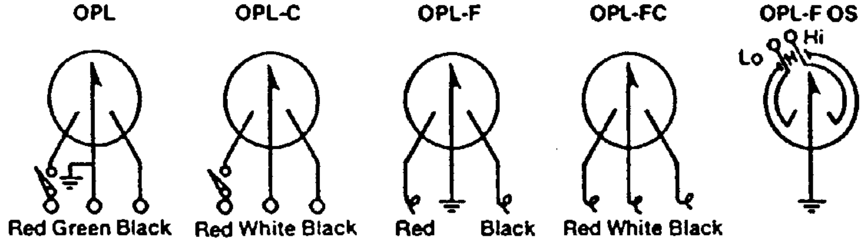
SCHEDULE

RANGE	A	B
Thru 1000 PSI	1/4 NPT	1-1/16
2000-20,000 PSI	1/2 NPT	1-7/8

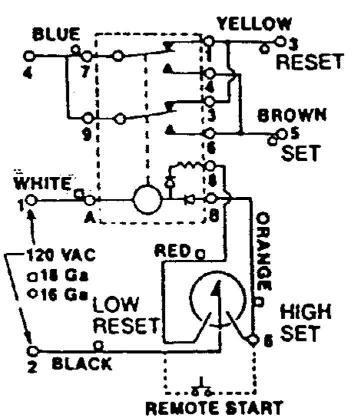
STANDARD ELECTRICAL DIAGRAMS

OPL PRESSURE SERIES.

THESE DIAGRAMS ARE SHOWN WITH PRESSURE POINTER IN NORMAL OPERATING RANGE.



OPL-BP



WIRING CONNECTION

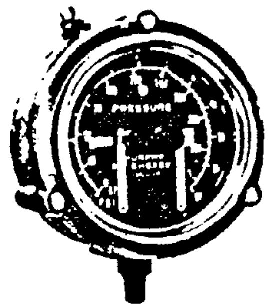
OPL & OPL-C: terminal block; 1/2" conduit connect
OPL-F & OLP-FC: wire leads
OPL-F OS: open terminals
OPL-FC OS: 1/2 NPTM conduit & wires (epoxy filled)
OPL-BP: terminal block / 1/2" conduit

STANDARD SPECIFICATIONS

(See also OPTIONS LIST)

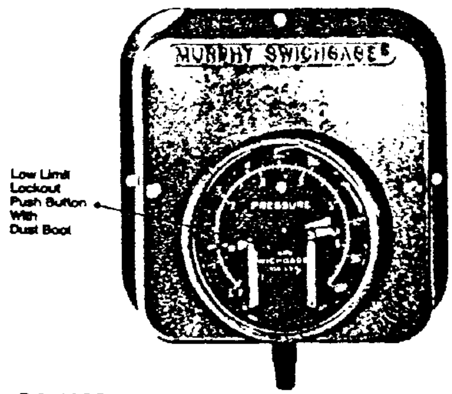
Dial: 4.5" (114 mm), white on black, psi & kPa
Case: die cast aluminum: standard OPL is flanged, OPL-F has a flush case for panel mounting
Gauge Connection: ¼ NPT thru 1000 psi (6.89 MPa); 1/2-NPT for models 2000-20,000 psi (13.8-138 MPa)
Sensing Element: bourdon tube: bronze to 1000 psi (6.89 MPa); Stainless Steel 2000 psi (13.8 MPa) and up
Gauge Movement: Stainless Steel w/pointer calibration hub
Gauge Accuracy: ± 1% in the Operating Range (mid 1/3 of scale)
SWICHGAGE® Contacts: SPDT: pointer and limit contacts: N.C. when a pressure limit is met; N.O. when gauge is operating between limits. Contact Area: pointer is nickel silver with fine silver contact area; stationary contacts are heavy silver; current carrying areas are gold flashed.
Contact Rating: 2 A @30 VAC, resistive (pilot duty)
Limit Contact Adjustment: full range by knurled knobs
Disconnect Switch: standard case has an in-line switch for low side disconnect.
Shipping Weight: std. 6 lbs. (2.7 kg); F models 4 lbs (1.8 kg)

OPL OPTIONS



OPL-F-OS-60
OIL SEALED **SPECIFY: OS**

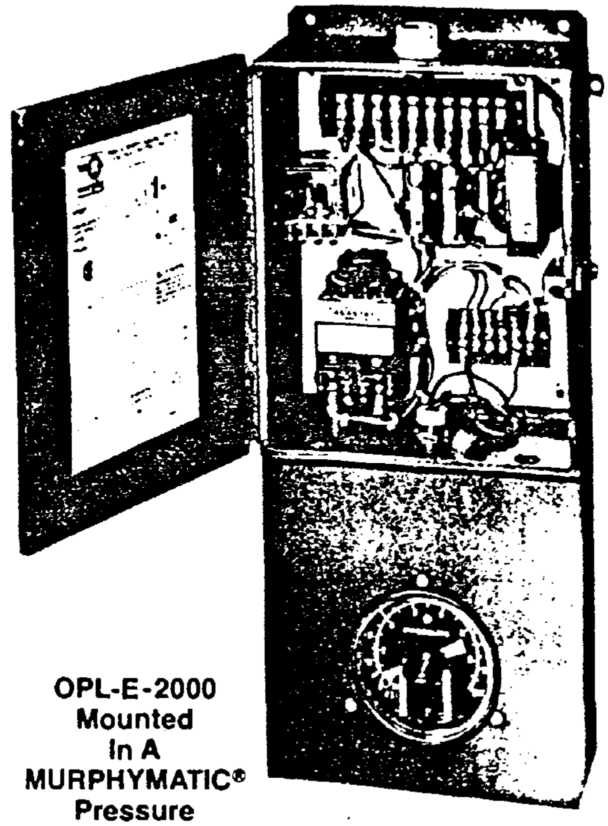
For corrosive environments, the OPL-F can be filled with an inert, non-toxic oil, then sealed. The oil dampens vibration/pulsation, reduces corrosion, suppresses contact arcing, and lubricates parts.



OPL-SA-1000
SEMI-AUTOMATIC LOCKOUT **SPECIFY: SA**

A manually actuated lockout replaces the low limit line switch. The push button on the limit knob automatically resets, to arm the low limit circuit, as the pointer lifts off the limit contact.

TYPICAL PANEL MOUNT INSTALLATION

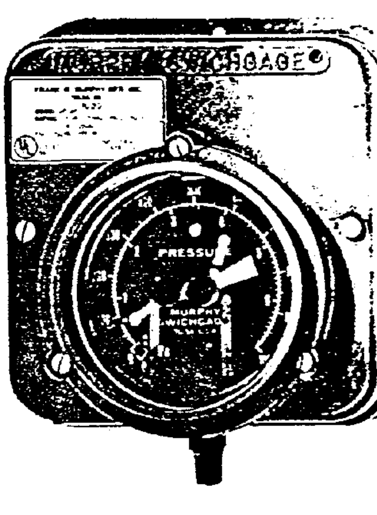


OPL-E-2000 Mounted In A MURPHYMATIC® Pressure Controller

See Bulletin PC-7119

OPL-BP: PRESSURE CONTROLLER

AIR COMPRESSORS — PUMPS



OPL-BP

The OPL-BP is designed to start and stop electric motor driven pumps, and air compressors. The pilot duty limit switches are connected to an internal control relay (10 A @ 120 VAC) for ON/OFF automation, either directly or through a motor starter.

As can be seen in the OPL-BP wiring diagram (see page opposite), when the SWICHGAGE® pointer touches the low contact, the magnetic latching relay RESETS (shipped in reset position). If pressure increases to the high contact, the relay SETS.

Once latched into either side, the relay will remain in that position until the opposite limit is met, even if a power outage occurs.

Example: Pumps are to be started at the low pressure limit and remain in operation until the high limit contact is made: wire the RESET side of the relay (low contact) to close a circuit and start the pumps; when the pressure rises to the high contact, the relay will SET and open the circuit to stop the pumps.

OPL Series Pressure SWICHGAGE® & MURPHYGAGE®

HOW TO ORDER

1. Select SWICHGAGE® or MURPHYGAGE®
2. Specify case type: standard or panel mount
3. Specify options
4. Specify Dial Range (your operating pressure should fall into the center 1/3 of the dial range)

EXAMPLE:

OPL—F —OS —0-2000 psi
1 2. 3. 4.

DUAL PRESSURE SCALES

Vacuum/psi	kPa/MPA	psi	MPa
30" vac-0 psi	—101 kPa-0 kPa	0-200 psi	0-1.38 MPa
30" vac-15 psi	—101 kPa-103 kPa	0-300 psi	0-2.07 MPa
30" vac-30 psi	—101 kPa-207 kPa	0-400 psi	0-2.76 MPa
30" vac-100 psi	—101 kPa-689 kPa	0-600 psi	0-4.14 MPa
30" vac-200 psi	—101 kPa-1.38 MPa	0-1000 psi	0-6.89 MPa
30" vac-300 psi	—101 kPa-2.07 MPa	0-1500 psi	0-10.3 MPa
0-15 psi	0-103 kPa	0-2000 psi	0-13.8 MPa
0-30 psi	0-207 kPa	0-3000 psi	0-20.7 MPa
0-60 psi	0-414 kPa	0-5000 psi*	0-34.5 MPa
0-100 psi	0-689 kPa	0-10,000 psi	0-68.9 MPa
0-160 psi	0-1.1 MPa	0-20,000 psi*	0-138 MPa

*OPL-BP above 5000 psi, and std. OPL's 30,000 thru 60,000 psi special order

OPTIONS LIST

Bourdon Tube: For ammonia service or other corrosive gases in gauges under 1000 psi (6.89 MPa), specify "SS tube"

Ungrounded Insulated Contacts: 1 A @ 125 VAC, order models with "C" designation.

Semi-Automatic Disconnect: Button with dust boot on low adjustment knob, manual disconnect will reset after sufficient pressure increase; specify "SA"

Pressure Line to Gauge Connection: Back Connect available for applications where std. Base Connect hinders; specify "Back Connect."

Bourdon Tube Stop: Allows 100% overpressure without damage to the tube or movement; specify "Bourdon Tube Stop"

Tamperproof Adjustment: Allen wrench adjust, specify "Tamperproof"

Oil Sealed: Flush case only in corrosive atmospheres add "OS" to F models

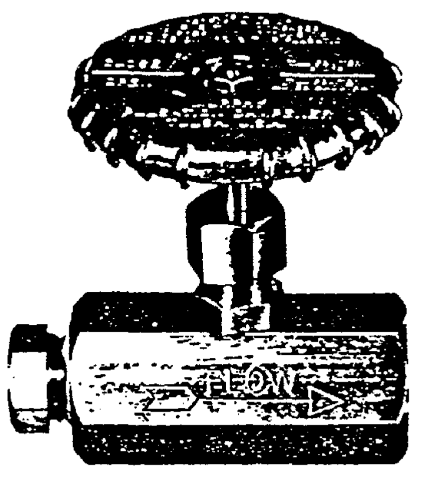
Controller: For latching relay start/stop order OPL-BP, see wiring diagram, available in ranges 30 in. hg (—101 kPa) thru 5000 psi (34.5 MPa)

CUSTOMER REPLACEABLE PARTS

05-00-0041 TUBE, MOVEMENT, DIAL & POINTER ASSEMBLY (SPECIFY RANGE)

05-00-0060 GLASS, RING & GASKET ASSEMBLY

See also bulletin 45-584



PD-8183

MURPHY PULSATION DAMPENERS

- Eliminate pointer contact flutter on pressure indicating SWICHGAGES®, which are subject to pulsating pressure from reciprocating pumps or compressors.
- Allow close high-low contact settings for more accurate pressure indication and equipment control.
- Decrease wear on SWICHGAGE® geared movement increasing the life of your instrument — by eliminating excessive strain and unnecessary pointer movement.
- See bulletin PD-6811

HOME OFFICE, TULSA - 74147, U.S.A.

FRANK W. murphy® MFR.

FRANK W. MURPHY MANUFACTURER 918/627-3550
P.O. Box 470248 Tulsa, Oklahoma 74147 TLX 492332
MURPHY SOUTHERN DIVISION 713/342-0297
P.O. Box 36968, Houston, Texas 77036 TLX 762829
FRANK W. MURPHY LIMITED (0202) 827723
22 Blackmoor Rd., Verwood, Dorset BH21 6AY England TLX 418384
MURPHEK PTY. LTD. 02/647-1977
215 Parramatta Road Auburn (NSW) Australia TLX 22574
MURPHY SAFETY SWITCH OF CALIFORNIA
P.O. Box 788 Palmdale, California 93550 805/272-4700

#850730 C M.A

Pressure SWICHGAGES®

The OPL is an accurate indicating guage, a high pressure switch and a low pressure switch. It is designed to initiate high-low pressure safety shutdown or start/stop signals.

The Murphy OPL has been applied to protecting and automating tasks on pumps, steam generators, air and gas compressors, etc. for over twenty years. Satisfactory service and trouble free operation throughout the world give the instrument proven reliability.

When a change in pressure occurs, this causes the instrument's pointer-contact to touch contacts at either end of your predetermined operating range. A circuit is completed and a signal can be sent to sound an alarm, flash a light, cause a switch or valve to open or close, signal the engine controller or relay to operate.

ADJUSTABLE CONTACTS

The OPL features fingertip adjustable contacts which allow you to 'dial' your 'operate or shutdown' pressure (thru 100% scale of the dial). These contacts are also gold flashed to resist corrosion from H_2S and other damaging gases.

OPL accuracy is better than 1% in the normal operating range and readings are indicated on a large, 41/2" dial. The instruments precision movement is actuated by a heavy duty bourdon tube.

INSTRUMENT ENCLOSURE

A Die-Cast Aluminum Enclosure sealed with long-life Neoprene gaskets protects the OPL from weather, dust, and other environmental hazards. The hinged cover provides easy access to the terminal block assembly for installation wiring and maintenance.

Also, a 1/2" conduit connection is provided with each instrument along with a 1/2" conduit knock-out on the backside of the enclosure for installation versatility. (For Explosion Proof enclosures see Murphy Bulletin EX-7038).

ADAPTABILITY

The OPL connects to Murphy Nerve Centers for automation of engines, motors, and valves and is also compatible with other installations. See the following Murphy bulletins for indicated applications:

OPERATE MAGNETIC SWITCHES ... M-Series (Magnetic Switches)

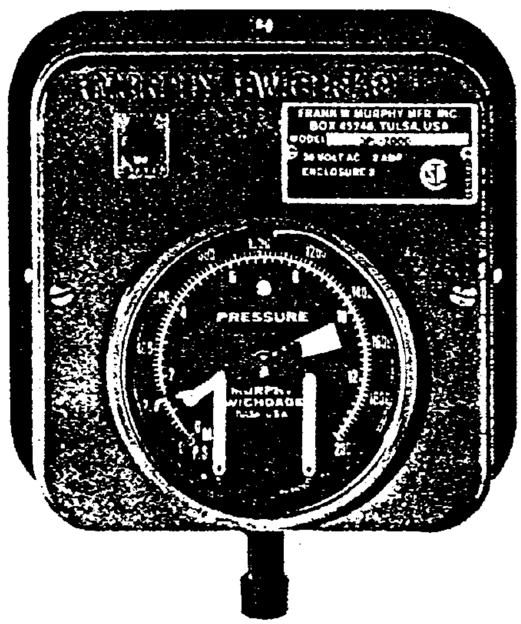
START & STOP ENGINES... A-Series (Murphymatic Engine Controllers)

START & STOP MOTORS... TR-Series (Transformer Relay Assemblies) or PC Series (OPL & TR-Series as a unitized package).

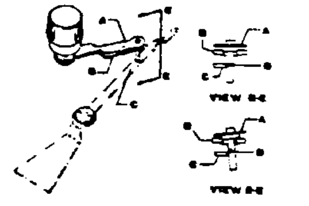
OPEN AND CLOSE VALVES... MV & SV-Series (Magnetic & Solenoid Valves)

OPL WARRANTY

Like all Murphy SWICHGAGES®, the OPL carries a full one year limited liability warranty against defective materials and workmanship. Should trouble occur, contact the Murphy Service department.



WIPING CONTACT



A. Contact Arm-Flex
B. Contact Arm
C. Pointer Contact
D. Initial Point of Contact

As the force of the pointer causes the Flexible Contact arm to "tilt," a wiping or scraping action takes place. This assures reliable contact as it clears away any film or corrosion which may have formed on the contact surfaces.

SPECIFICATIONS

CASE: Die-cast alluminum, weather and dust tight, with neoprene gaskets, hinged cover, 1/2" conduit connection RH side, and 1/2" knock-out back side.

CONTACTS: Indicating pointer-contact is nickel silver with fine silver contact area. Molded Lexan window assembly carries both high and low heavy silver contacts. All current carrying parts of contact assembly are gold plated.

CONTACT RATING: Standard OPL has S.P.D.T. with common ground. Adjustable differential. 2 amperes @ 30 volts AC resistive.

MOVEMENT: Geared movement with special link and spring to compensate for arrested movement of pointer contact in operation. Movements are bronze and stainless steel combination. Pointer-contact has recalibrating hub.

BOURDON TUBE: Bronze thru 1,000 PSI, stainless steel 2,000 PSI and up.

DIAL: 4 1/2" laminated Synthane. White figures silk screened on black background, reverse optional on special order.

PRESSURE CONNECTION: Lower male pipe thread 1/4" thru 1,000 PSI, 1/2" 2,000 PSI thru 20,000 PSI. Special order above 20,000 PSI.

ACCURACY: Exceeds ASA standard for Grade A gauges. Accuracy is better than 1% in operating range.

SHIPPING WEIGHT: 6 pounds. **DIMENSIONS:** 8 1/2" x 8 1/2" x 2 3/4".

IMPORTANT

A. Always select an instrument with twice the pressure range of your normally expected pressures. This will prevent bourdon tube fatigue, over pressures, distortion, give you the most accurate readings, and multiply the life of your instrument.

B. We recommend that the instrument be mounted *off* of vibrating machinery. Use shock mounts anywhere excessive vibration is present.

C. Pump pulsations, which will destroy geared movements on any pressure gauge, should be dampened out. Murphy pulsation dampeners give mircometer adjustment of pulsation dampening and act as a shutoff valve when required.

MODEL	PRESSURE RANGE
OPL-30V	30" vac-0 PSI
OPL-30V-15	30" vac-15 PSI
OPL-30V-30	30" vac-30 PSI
OPL-30V-100	30" vac-100 PSI
OPL-30V-200	30" vac-200 PSI
OPL-30V-300	30" vac-300 PSI
OPL-15	0-15 PSI
OPL-30	0-30 PSI
OPL-60	0-60 PSI
OPL-100	0-100 PSI
OPL-160	0-160 PSI
OPL-200	0-200 PSI
OPL-300	0-300 PSI
OPL-400	0-400 PSI
OPL-600	0-600 PSI
OPL-1000	0-1,000 PSI
OPL-2000	0-2,000 PSI
OPL-3000	0-3,000 PSI
OPL-5000	0-5,000 PSI
OPL-10000	0-10,000 PSI
OPL-20000	0-20,000 PSI

OPL-30,000 thru 60,000 PSI are made on special order only. Ask for prices, specifications and delivery.

OPTIONAL EXTRAS

Stainless Steel or Ammonia Service Tube for ranges *under* 2,000 PSI. Specify "Stainless Steel Tube" (stainless steel tubes are standard on 2,000 PSI and up). Stainless steel movement & link available on all pressure ranges. Specify "Stainless Steel Movement."

Oil Sealed Case for highly corrosive environment. Specifity "Oil Sealed" ("F" Case only).

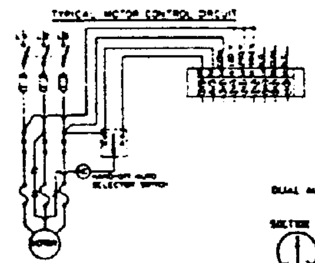
Ungrounded Insulated Contacts rated 1 amp @ 125 volt AC resistive. Specify "C".

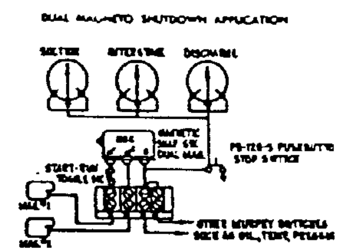
Bourdon Tube Stop allows 100% overpressure without damage to tube or movement. Specify "Bourdon Tube Stop."

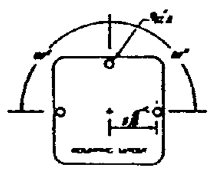
Dial with black figures printed on white background available on special order. Specify "Dial-White Background."

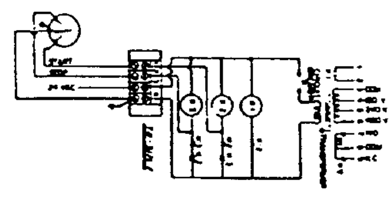
Tamperproof Contact Settings are available on special order. Adjustable with Allen head wrench. Specify "Tamperproof". (Not available in "C" Model).

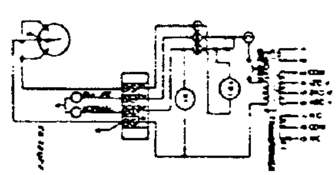
Pulsation Dampener. See bulletin for prices on sizes and materials.











Listed

The SteamGard™ System.

SOME COMMON QUESTIONS

Question:

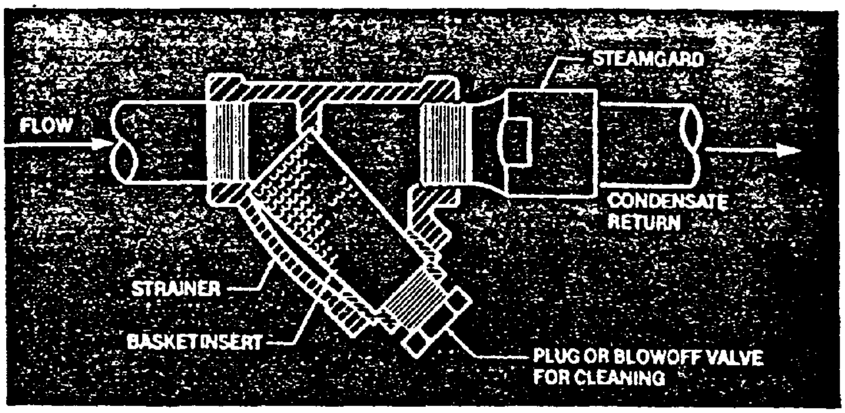
How does it work?

Answer:

STEAMGARD operates on the physics law known as two-phase flow. This means that steam and condensate are both fighting to pass through the same small orifice. The reason STEAMGARD works effectively is because much more condensate can pass through this orifice than steam.

This means that an orifice discharges fluid by volume. At 10 PSIG, one (1) pound of steam takes up close to 17 cubic feet. One cubic foot of condensate weighs over 59 pounds. This volume ratio means that our model SG-B-10 would discharge as follows:

Psi	Vs/Vw	Condensate/Hour
10	980	236#
50	380	521#
100	220	728#



The Steamgard™ System is a combination of a stainless steel condensate drain orifice, a special protective strainer assembly, and some very important applications engineering know-how rarely used when applying conventional steam traps.

The stainless steel drain, which comes in 25 nozzle configurations, ½ inch, ¾ inch and 1.0 inch pipe sizes (NPT, BSPT, or Welded) can handle steam pressures to 2000 PSI and condensate loads to more than 95,000 pounds per hour.

Question:

Where can STEAMGARD be used?

Answer:

STEAMGARD can be used on a variety of applications in many different types of facilities:

- Saturated steam distribution lines.
- Superheated steam distribution lines. (Up to 2000 PSIG and 950° F)
- Steam tracing.
- Tank heating.
- Radiators/convectors.
- Plating coils/degreasers/embossed coils.
- Steam heated dry cans/cylinders.
- Humidifiers.
- Flash tanks.
- Sterilization equipment.
- Cooking kettles.

STEAMGARD can also be used on applications that utilize a modulating steam control valve:

- Air heating coils.
- Shell/tube heat exchangers.
- Domestic water heating tanks.
- Instantaneous water heaters.
- Batch process tanks.
- Steam absorption coolers.
- Process heating equipment.

Question:

Won't STEAMGARD only work on *constant load applications?*

Answer:

If the conditions in a condensate system are **not** constant, STEAMGARD can still effectively discharge condensate while inhibiting excessive steam loss.

Let's look at a common example: STEAMGARD Model SG-B-10 can discharge 288 lbs. of condensate/hour at 15 PSI. If this same SG-B-10 sees only 144 lbs. of condensate/hour (50% of capacity) the steam loss is only 0.2 lbs./hour.

If this same SG-B-10 sees only 43 lbs. of condensate/hour (15% of capacity) the steam loss is still only 1.9 lbs./hour. This is still lower than the approximate 2 lbs./hour of live steam that an efficient steam trap will lose.

The above example illustrates how STEAMGARD can efficiently work on many applications that have varying condensate conditions without any means of steam control.

Question:

How can STEAMGARD operate on applications such as heat exchangers and heating coils when condensate loads fluctuate?

Answer:

Steam equipment which consumes large amounts of steam always requires some method of controlling the steam flow. One of the most common and energy efficient methods is the use of a pressure modulating steam control valve.

Our applications experience has proven that STEAMGARD will remove condensate quickly and completely with a very small amount of live steam loss on applications utilizing a modulating steam control valve.

Over a wide range of condensate/pressure variations, the orifice of the properly sized STEAMGARD will be occupied by condensate so that steam losses are usually too small to measure. Example: Steam absorption chillers, large convertors, air pre-heat coils.

It is important to realize that a conventional steam trap, with its own compensating mechanism, tends to complicate and defeat the modulating steam control which results in inefficiency and substantial steam losses.

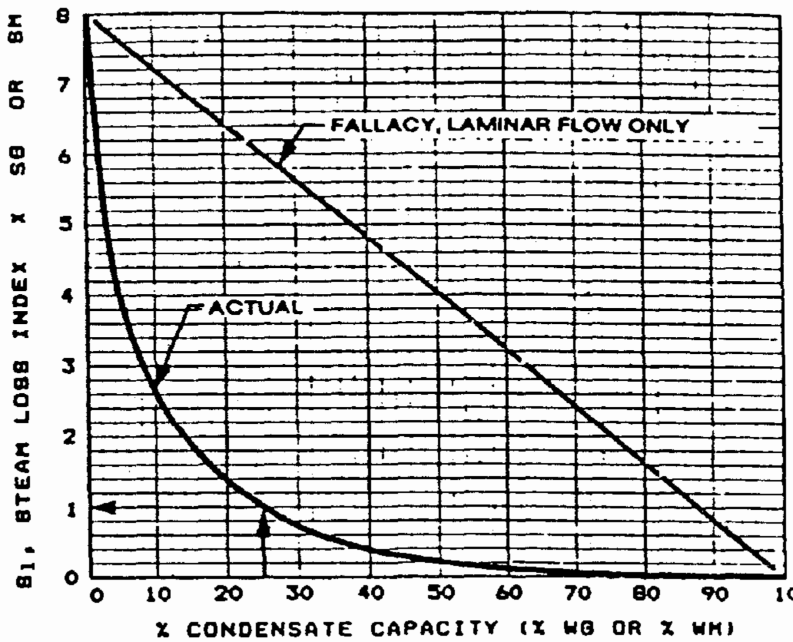
Question:

Won't STEAMGARD plug up if my system is dirty?

Answer:

Any type of steam trap can plug or hang up. STEAMGARD minimizes the plugging problem two ways:

The Figure shows the steam loss curve under partial loads. Using this curve and the capacity tables steam losses under any load conditions can be determined.



STEAM LOSSES UNDER PARTIAL LOADS.

1. The unit is to be installed in conjunction with a special 40 mesh stainless steel strainer insert. This insert is designed to trap any particles or contaminants before they reach the drain nozzle. This strainer should be blown down or cleaned as often as you would clean the strainers in front of your existing steam traps.

2. The drain nozzle in all STEAMGARD units is manufactured with a staged discharge. This design, which is totally different from the "simple" orifices found in many steam traps and orifice plates, facilitates the continual discharge of contaminants generally found in condensate.

   This continual discharge allows CO_2, air and non-condensables to be passed continually (unlike "sub-cooling" or "intermittent discharging" traps.)

Question:

How can STEAMGARD be used on a distribution line when ambient conditions change?

Answer:

STEAMGARD units are in service on outside distribution lines all over the world. Here's an example of how STEAMGARD would be applied on a distribution line that sees dramatic changes in ambient conditions.

A common outdoor distribution line may have the following characteristics:

- 8" IPS
- 1" Fiberglass insulation
- 300 Linear feet between drain points
- Distributing 150 PSIG steam
- 20°F Minimum ambient in winter
- 70°F Ambient in summer

When ambient is -20°F, this 8" line will generate 41 lbs. of condensate/hour. The STEAMGARD model recommended must be able to dischange a minimum of 41 lbs. of condensate/hour at 150 PSIG.

The model selected, SG-B-03, has a condensate capacity of 106 lbs./hour at 150 PSIG. The steam loss during -20°F conditions is **only** 0.28 lbs./hour.

This same 8" line at 90°F ambient will now generate 20 lbs. of condensate/hour. Our SG-B-03 still has a condensate capacity of 106 lbs./hour. How does this reduction in condensate affect steam loss?

The reduction in condensate load causes the steam loss to increase 0.62 lbs./hour. This "loss" is **significantly less** than steam loss figures stated by most steam trap manufacturers for their brand new traps.

Question:

Will STEAMGARD work on a vacuum return system?

Answer:

STEAMGARD is becoming a very popular replacement for steam traps on vacuum return systems for two reasons:

1. STEAMGARD cannot fail "open" like conventional steam traps usually do. This failure many times results in the introduction of an excessive amount of live steam into the vacuum return. This live steam will result in vacuum loss and sometimes in pump failure.

   By eliminating the excessive live steam losses inherent in conventional steam traps, STEAMGARD helps to maintain consistent condensate return temperatures and a level vacuum.

2. STEAMGARD'S continuous and complete condensate discharge will dramatically reduce heat up times in systems utilizing a vacuum return system.

Question:

Can STEAMGARD be applied in a return system that is experiencing back pressure problems?

Answer:

Let's look at our 150 PSIG distribution line example for an answer.

Our model SG-B-03 must be able to discharge a maximum of 41 lbs. condensate/hour under minimum ambient conditions. At 150 PSIG differential, this is no problem because the SG-B-03 has a capacity of 106 lbs. condensate/hour. If system back pressure increases as high as 80% (120 PSIG) the model SG-B-03 can **still** discharge 48 lbs. condensate/hour at the reduced pressure differential.

Question:

How does STEAMGARD vent air, CO_2 and other non-condensables?

Answer:

The continuous venting of air, CO_2 and other contaminants is an important requirement of any steam trap. The key to performing this vital function is continuous and complete condensate removal. Unlike many steam traps that operate "intermittently", STEAMGARD'S continuous discharge allows continuous air venting (even at low pressures).

STEAMGARD'S complete discharge also results in no "sub-cooling" of condensate. This "sub-cooling", which is a characteristic of many steam traps that introduce an upstream water seal, can cause dangerous CO_2 build-up. This CO_2 formation causes serious corrosion problems.

Question:

Won't a trap replacement program require a large number of different STEAMGARD models?

Answer:

Even though STEAMGARD must be sized for each specific application, our applications experience has proven that many large facilities require a surprisingly limited number of STEAMGARD models

A major midwestern refinery standardized on **two** different STEAMGARD models to complete a **300** trap conversion of its existing steam traps.

Question:

Won't it be difficult to select the correct STEAMGARD model sizes?

Answer:

Selecting the appropriate STEAMGARD models does require a certain basic knowledge of the lines and equipment to be trapped.

Early in STEAMGARD'S development, ERI realized that the majority of plant and facilities engineers do not have time to spend on sizing steam traps. Our engineers also realized that in order for STEAMGARD to operate more efficiently, the trap's proper sizing was imperative.

This need for proper sizing resulted in extensive research into the multitude of factors that effect the operation of STEAMGARD and steam traps.

1. **The STEAMGARD™ System Applications & Selection Guide**

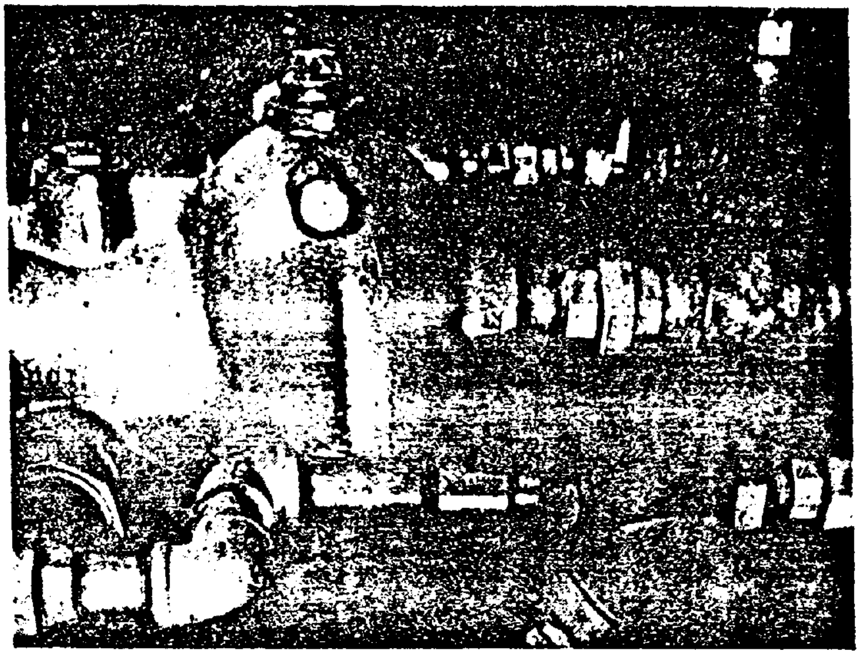
   This guide can assist the engineer in selecting STEAMGARD for applications where sizing information or condensate flow rates are available. The guide makes it simple to select a STEAMGARD model because safety factors are already included.

2. **The STEAMGARD™ System Field Sizing Survey**

   ERI and its field engineers can also assist customers in selecting STEAMGARD models through a field trap survey performed at the facility. Trained ERI field engineers will make a complete list of all existing traps that are to be replaced. They will also gather appropriate sizing information for each application.

The customer receives a computerized survey that lists:

- Location of existing steam traps by tag number.
- Working steam pressure.
- Sizing/applications information.
- STEAMGARD model selections.



In the installation above, The SteamGard System has replaced three steam traps. The remaining two traps are no longer used.

ENGINEERING RESOURCES, INC.
International Tower Building
8550 W. Bryn Mawr Ave.
Chicago, Illinois 60631
(312) 693-5500
Telex: 25-6259

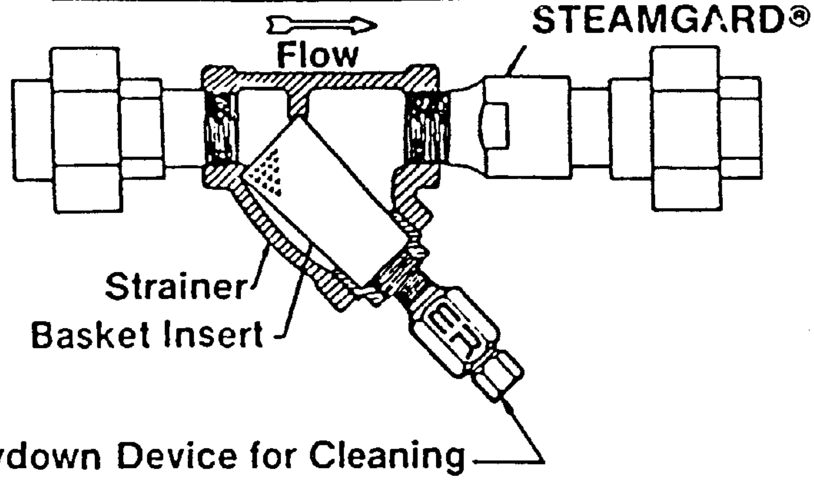
Contact your representative:

12/82

THE STEAMGARD SYSTEM®

SERVICE INSTRUCTIONS

Typical STEAMGARD® Assembly

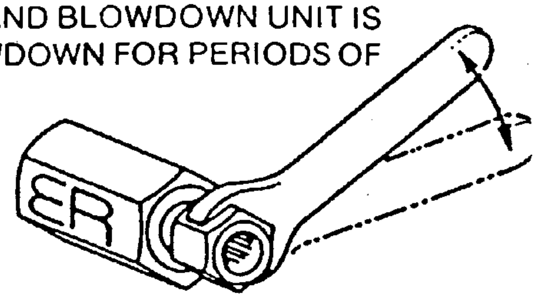


Blowdown Procedure

1. Wear safety glasses, protective clothing and gloves.
2. Position a bucket to receive debris from blowdown device and stand away from the direction of the flow from the blowdown device.
3. Open blowdown device three full turns.
4. Leave device open until debris is no longer present in flow (typically 10-15 seconds).
5. Close blowdown device with a *small* wrench. When device seats, give 15° turn to seal (equivalent to 30 ft.-lbs.; less than 1/16 turn). For units equipped with ball valves (available to handle up to 150 psig), open valve 1/4 turn (no wrench required).

CAUTION: IF STEAM IS HIGH PRESSURE AND BLOWDOWN UNIT IS IN A SMALL ENCLOSED SPACE ONLY BLOWDOWN FOR PERIODS OF 10 SECONDS OR LESS.

DO NOT OVER-TORQUE.
DAMAGE *WILL* RESULT.



IMPORTANT: AFTER INSTALLATION IT IS IMPORTANT TO PERFORM AN INITIAL STRAINER BLOWDOWN TO CLEAR THE LINE OF DIRT, METAL CHIPS, CORROSION BY—PRODUCTS, AND ACCUMULATED CONDENSATE BEFORE RETURNING TO NORMAL SERVICE. THE BLOWDOWN PROCEDURE SHOULD THEN BE REPEATED FOR EACH UNIT ON A BIANNUAL BASIS.

1-800-258-6771 ER inc. ENGINEERING RESOURCES, INC. Chicago
FOR SERVICE IN ILLINOIS CALL 1-800-826-1043

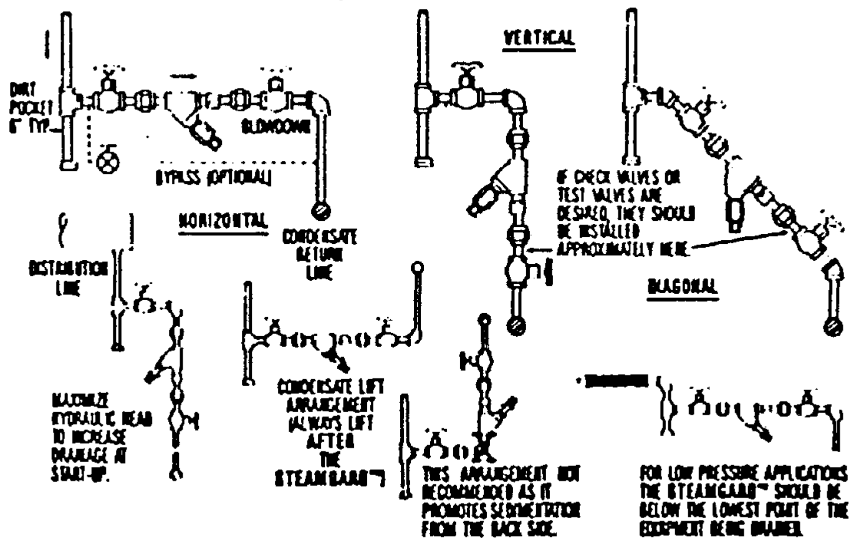
SEE OTHER SIDE FOR IMPORTANT WARRANTY INSTRUCTIONS

The SteamGard™ System
INSTALLATION INSTRUCTIONS

The SteamGard™ System requires no special orientation or leveling. The central device may be installed horizontal, vertical, diagonal or as shown below. The SteamGard™ System can replace existing traps which are physically much larger and may utilize larger pipe diameters. Bushings or reducers may be used as required to reduce pipe size down to SteamGard™ pipe size, keeping runs short.

THE STEAMGARD™ SYSTEM MUST BE INSTALLED WITH AN ERI APPROVED STRAINER AS REQUIRED UNDER WARRANTEE. EACH ERI STRAINER INCLUDES A CUSTOM 40 MESH STAINLESS STEEL BASKET INSERT, INSPECTED PRIOR TO SHIPMENT FOR INSTALLATION AND FIT.

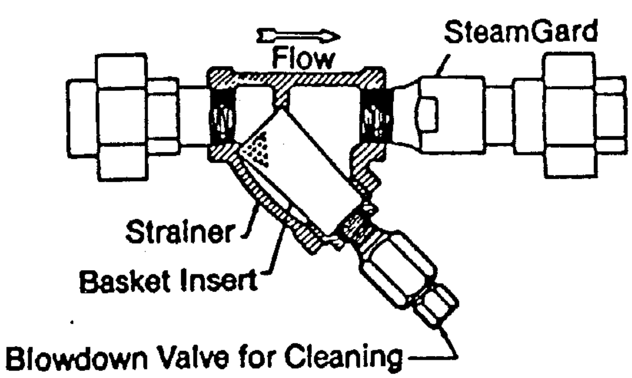
The SteamGard™ System requires no special orientation or leveling. The central device may be installed horizontal, vertical, diagonal or as shown below. The SteamGard™ System can replace existing traps which are physically much larger and may utilize larger pipe diameters. Bushings or reducers may be used as required to reduce pipe size down to SteamGard™ pipe size, keeping runs short.



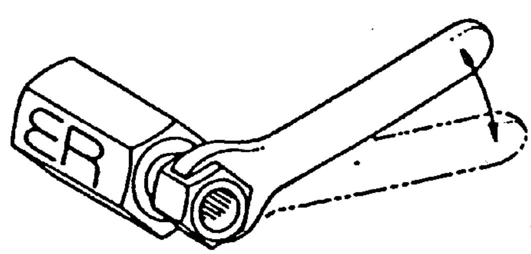
Notes: Piping the SteamGard™ to within reach of a man standing at ground level provides easy access and increased hydraulic head for improved drainage at start-up.

1-800-258-6771

Typical SteamGard Assembly



Blowdown Valve



Open blowdown valve three full turns. Close blowdown valve with a *small* wrench. When valve seats, give a 15° turn to seal. (Equivalent to 30 ft.-lbs.; less than 1/16 turn)

DO NOT OVER-TORQUE. DAMAGE *WILL* RESUL

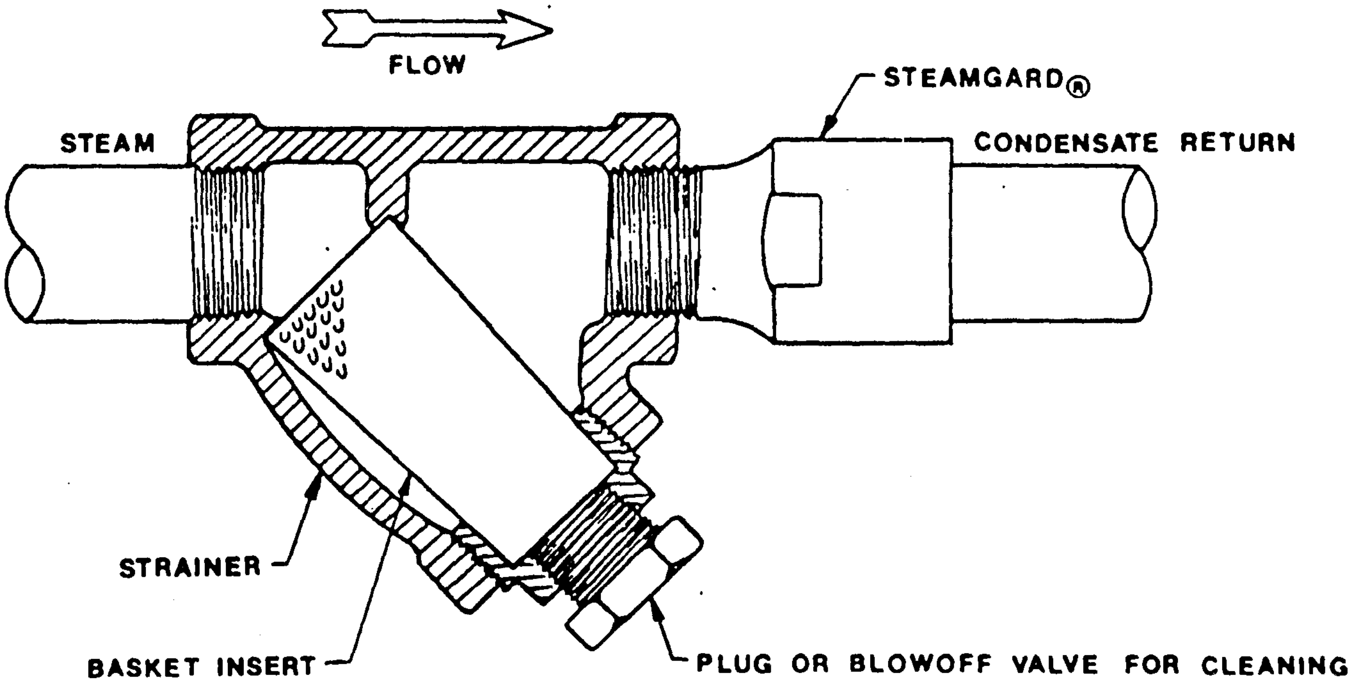
IMPORTANT: AFTER INSTALLATION IT IS IMPORTANT TO PERFORM AN INITIAL STRAINER BLOWDOWN TO CLEAR THE LINE OF DIRT, METAL CHIPS, CORROSION BY-PRODUCTS, AND ACCUMULATED CONDENSATE BEFORE RETURNING TO NORMAL SERVICE.

6	5	4	3	2	1

THIRD ANGLE PROJECTION

ENG NO
ENG STD 201

STEAMGARD® INSTALLATION INSTRUCTIONS



STEAMGARD® MUST BE INSTALLED DOWNSTREAM OF A "Y" STRAINER WITH A BASKET INSERT WITH 0.020" MAXIMUM OPENINGS (40 MESH)

REVISIONS

DIMENSION SHOWN METRIC/(INCH)
UNLESS OTHERWISE SPECIFIED
TOLERANCE: METRIC INCH
3 PLACES ±
2 PLACES ± ±
1 PLACE ±
ANGULAR °
DO NOT SCALE DRAWING

DRWG BY | CHK'D BY

TITLE
INSTALLATION

ER Inc.
ENGINEERING RESOURCES, INC.
International Tower Building

DATE
SHEET OF

ENG NO
ENG STD 201

APPENDIX 2-3

MATERIAL SAFETY DATA SHEET FOR NMP

BASF CORPORATION
3000 CONTINENTAL DRIVE
MT. OLIVE, NJ 07828
(201) 426-4671

Original Date: 12/21/1993
Revision Date: 06/07/1995

Emergency Telephone: (800) 424-9300 (CHEMTREC)
(800) 832-HELP (BASF Hotline)
BOTH NUMBERS ARE AVAILABLE DAYS, NIGHTS, WEEKENDS, & HOLIDAYS.

SECTION 1 - PRODUCT INFORMATION

NMP TECH
Product ID: NCI 597000
Common Chemical Name:
NMP TECHNICAL
Synonyms:
N-METHYLPYRROLIDONE TECHNICAL
Molecular Formula:
C(5)H(9)NO
Molecular Wt.: 99.1
Chemical Family: Cyclic Amines

SECTION 2 - INGREDIENTS

Chemical Name:	CAS	Amount
2-PYRROLIDINONE, 1-METHYL PEL/TLV NOT ESTABLISHED	872-50-4	> 97.8 %
WATER PEL/TLV NOT ESTABLISHED	7732-18-5	0.2 %
GAMMA BUTYROLACTONE PEL/TLV NOT ESTABLISHED	96-48-0	< 2.0 %

SECTION 3 - PHYSICAL PROPERTIES

Color:	Clear
Form/Appearance:	Liquid
Odor:	Amine
Odor Intensity:	Mild

	Typical	Low/High	U.O.M.
Specific Gravity:	NOT AVAILABLE		
Bulk Density:	1.028		G/CC
pH:		7.7- 8	SU
pH method:	100 G/L H2O		

	Typical	Low/High	Deg.	@	Pressure
Boiling Pt:	202		C	760	MM HG
Freezing Pt:	-25		C	760	MM HG
Decomp. Tmp:	NOT AVAILABLE				

Solubility in Water Description: Complete
Vapor Pressure: < 1 MILLIBARS @ 20 DEG. C

SECTION 3 - PHYSICAL PROPERTIES (cont)

	Typical	Low/High	U.O.M.	@ Temperature
Vapor Density (Air = 1):	3.4			

SECTION 4 - FIRE AND EXPLOSION DATA

	Typical	Low/High	Deg.	Method
Flash Point:	91		C	ASTM D9373
Autoignition:	270		C	DIN 51794
Flam. Limits:		1.3 - 9.5	%	

Extinguishing Media:
Use water fog, foam, CO2 or dry chemical extinguishing media.
Fire Fighting Procedures:
Firefighters should be equipped with self-contained breathing apparatus and turn out gear.
Unusual Hazards:
Low when exposed to heat or flames. It can react with oxidizing material.

SECTION 5 - HEALTH EFFECTS

Routes of entry for solids and liquids include eye and skin contact, ingestion and inhalation. Routes of entry for gases include inhalation and eye contact. Skin contact may be a route of entry for liquified gases.

Acute Overexposure Effects:
Contact with the liquid results in moderate eye irritation and may cause temporary corneal clouding. Skin contact results in mild irritation. Prolonged skin contact may result in redness and dermatitis.
Inhalation of the vapors of NMP may result in respiratory irritation. Accidental ingestion of the liquid causes gastric disturbances. Nausea and vomiting may result.
Chronic Overexposure Effects:
In animal studies in rats and mice, N-methylpyrrolidone (NMP) was embryotoxic by the oral and intraperitoneal routes at very high dose levels which were close to the LD(50). In a dermal exposure study with rats, NMP was only embryotoxic at the high dose level; this effect was attributed to maternal toxicity. Several inhalation studies in rats did not reveal any indication of maternal toxicity or embryotoxicity. In a 2 year inhalation study, NMP did not cause any life-shortening or carcinogenic effects in rats at 0.04 or 0.4 mg/l (10 and 100 ppm respectively)..
First Aid Procedures - Skin:
Wash affected areas with soap and water. Remove and launder contaminated clothing before reuse. If irritation develops, get medical attention.
First Aid Procedures - Eyes:
Immediately rinse eyes with running water for 15 minutes. If irritation develops, get medical attention.
First Aid Procedures - Ingestion:
If swallowed, dilute with water and immediately induce vomiting.

SECTION 5 - HEALTH EFFECTS (cont)

Never give fluids or induce vomiting if the victim is unconscious or having convulsions. Get immediate medical attention.

First Aid Procedures - Inhalation:

Move to fresh air. Aid in breathing, if necessary, and get immediate medical attention.

First Aid Procedures - Notes to Physicians:

Not applicable.

First Aid Procedures - Aggravated Medical Conditions:

No data is available which addresses medical conditions that are generally recognized as being aggravated by exposure to this product. Please refer to Section 5 (Effects of Overexposure) for effects observed in animals.

First Aid Procedures - Special Precautions:

Not applicable.

SECTION 6 - REACTIVITY DATA

Stability Data:

Stable

Incompatability:

Oxidizing reagents and strong acids.

Conditions/Hazards to Avoid:

See Reactivity - Incompatibility section.

Hazardous Decomposition/Polymerization:

Hazardous decomposition products: CO, CO_2 and NOx.
Polymerization: Does not occur.

Corrosive Properties:

Not corrosive.

Oxidizer Properties:

Not an oxidizer

SECTION 7 - PERSONAL PROTECTION

Clothing:

Manufacturer recommends the use of butyl rubber or FEP teflon gloves, coveralls, apron, and boots as necessary to prevent skin contact.

Eyes:

Chemical goggles; also wear a face shield if splashing hazard exists.

Respiration:

If vapors or mists are generated, wear a NIOSH/MSHA approved organic vapor/mist respirator or an air-supplied respirator as appropriate.

Ventilation:

Use local exhaust to control to recommended P.E.L.

Explosion Proofing:

See Section 4 - Fire and Explosion Data.

Other Personal Protection Data:

Eyewash fountains and safety showers must be easily accessible.
Shower after handling.

SECTION 8 - SPILL-LEAK/ENVIRONMENTAL

General:

Spills should be contained, solidified and placed in suitable containers for disposal in a licensed facility. This material is not

SECTION 8 - SPILL-LEAK/ENVIRONMENTAL (cont)

regulated by RCRA or CERCLA ("Superfund"). Wear appropriate respiratory protection and protective clothing and provide adequate ventilation during clean-up.

Waste Disposal:
Incinerate or bury in a licensed facility. Do not discharge into waterways or sewer systems without proper authority.

Container Disposal:
Dispose of in a licensed facility. Recommend crushing or other means to prevent unauthorized reuse.

Environmental Toxicity Test Data:
Elimination (method not specified) - > 90 PERCENT
Readily Biodegradable
Golden Orfe, static 96 hr LC50 - 4000 MG/L
Insignificant Hazard
Daphnia magna, 24 hr LC50 - > 1000 MG/L
Insignificant Hazard
Acute Algal Toxicity, 72 hr. EC/LC50 - > 500 MG/L
Practically Nontoxic
Toxicity to Bacteria - > 9000 MG/L
Insignificant Hazard
Biological Oxygen Demand, 5 day - 1,100 MG/L
TEST RATING NOT FOUND
Chemical Oxygen Demand - 1,600 MG/L
TEST RATING NOT FOUND

SECTION 9 - STORAGE AND HANDLING

General:
Avoid exposure to moisture; this product is hygroscopic.

Other Storage and Handling Data:
Consult other sections of this MSDS for information on reactivity and flammability.

SECTION 10 - REGULATORY INFORMATION

TSCA Inventory Status
Listed on Inventory: YES

SARA - 313 Listed Chemicals:
CAS: 872-50-4 AMOUNT: 97.8 %
NAME: 2-PYRROLIDINONE, 1-METHYL

RCRA Haz. Waste No.:
CERCLA: NO **Reportable Qty.: (If YES)**
NMP is subject to the reporting requirements of SARA Title III, Section 313 and 40CFR372.

Hazard Ratings:

	Health:	Fire:	Reactivity:	Special:
HMIS	1	2	0	NA

SECTION 11 - TRANSPORTATION INFORMATION

DOT Proper Shipping Name:
REFER TO BASF BILL OF LADING

SECTION 11 - TRANSPORTATION INFORMATION (cont)

DOT Technical Name:
REFER TO BASF BILL OF LADING
DOT Primary Hazard Class:
REFER TO BASF BILL OF LADING
DOT Secondary Hazard Class:
REFER TO BASF BILL OF LADING
DOT Label Required:
REFER TO BASF BILL OF LADING
DOT Placard Required:
REFER TO BASF BILL OF LADING
DOT Poison Constituent:
REFER TO BASF BILL OF LADING
BASF Commodity Codes: NA NA **UN/NA Code:** NONE **E/R Guide:**

Bill of Lading Description:
FOR THE MOST UP-TO-DATE D.O.T. SHIPPING DESCRIPTION, PLEASE REFER TO THE BASF BILL OF LADING!

WHILE BASF CORPORATION BELIEVES THE DATA SET FORTH HEREIN ARE ACCURATE AS THE DATE HEREOF, BASF CORPORATION MAKES NO WARRANTY WITH RESPECT THERETO AND EXPRESSINGLY DISCLAIMS ALL LIABILITY FOR RELIANCE THEREON. SUCH DATA ARE OFFERED SOLELY FOR CONSIDERATION, INVESTIGATION, AND VERIFICATION.

END OF DATA SHEET

APPENDIX 2-4

BIODEGRADABILITY AND AQUATIC TOXICITY OF NMP

BIODEGRADABILITY AND AQUATIC TOXICITY

I. INTRODUCTION

Biodegradation refers to the biological (usually bacteria) catalyzed breakdown of organic chemicals. When dissolved oxygen is present as it typically is in a biologically healthy stream or river, the end products are carbon dioxide and water. In practice, complete oxidation is rare. More commonly, a partial breakdown occurs resulting in the formation of CO_2, H_2O, and metabolites.

Most chemicals will cause environmental damage if released untreated. The damage can take many forms depending on the chemical involved. Direct toxic effects may take the form of:

a. poisoning of aquatic species through short single dose exposure (acute toxicity)

b. poisoning of aquatic species due to persistent non-degraded toxicants (chronic toxicity)

c. poisoning of higher members of the food chain through bioaccumulation in aquatic species

Indirect toxic effects may take the form of:

a. oxygen demand overloading causing dissolved oxygen levels in the water to be depleted below levels needed by typical species of fish

b. high algal growth rates resulting in lake eutrophication

Prevention of future damage requires minimizing both the amount and toxicity of those wastewater discharges.

The need for treatment of chemicals prior to their release is obvious. In turn, this makes the need for a means of predicting the degree of treatment obvious. However, considering the wide range of circumstances that could be applicable, the form of the measurements needed to make these predictions is far from obvious. Our measurement, biodegradability, is not an absolute intrinsic property. Its value, and the method involved in determining that value, is dependent on the anticipated conditions which have necessitated the treatment. For example, a chemical which might be inadvertently released to a receiving water (a spill) would have different properties of interest than a chemical intentionally released to a wastewater treatment plant (aquatic toxicity vs. BOD). Similarly, the levels of treatment required and the ultimate efficiency of treatment achieved would differ as would the tests required to measure them.

II. MEASURES OF BIODEGRADABILITY

Biodegradability is a function of the type and amount of bacteria available, the structure of the chemical being treated, various environmental factors (oxygen, pH, etc.), and the contact time. Different treatment situations will involve different combinations of the above. Thus, it is understandable that many different types of tests exist.

Primary biodegradability was an early test method established to measure the loss of a particular property of interest (surface tension or foaming). This test used high concentrations of acclimated bacteria. Contact times are on the order of one day. Since only a small structural change is required in the test chemical to cause loss of a physical property, this type of test generally gives very extensive biodegradability even though most of the molecular makeup of that chemical remains untouched. For this reason, this type of test has fallen out of use.

The familiar BOD (Biological Oxygen Demand) test is an example of a respirometric (oxygen consumption) measurement of biodegradability. By measuring oxygen consumption, these tests provide a better indication of the extent of degradation of the chemical structure than does loss of a property of the chemical. These tests are often reported as percentages of theoretically complete oxidation (ThOD); accordingly, the biodegradability values are generally lower even though the extent of treatment may often be greater. This type of test varies in the conditions under which it is run, however, it is generally run with low concentrations of bacteria which may or may not be acclimated (adapted to the chemical) and contact times on the order of 1-5 days. The BOD test is the most commonly used test to describe wastewater treatment plant performance.

A third general type of test takes the respirometric test a step further by increasing the contact time to 30 days or longer (virtually insuring that the bacteria are acclimated). The objective of this test is to measure the ultimate biodegradability (greatest possible extent of degradation). This testing simulates the environmental fate of chemicals in a receiving water. The biodegradability values are usually higher than the shorter term BOD type tests.

Biodegradability can also be measured by monitoring other properties or descriptions of the test chemical. Chemical Oxygen Demand (COD) measures (for practical purposes) the complete oxidation of a chemical to CO_2 and H_2O. Thus, biodegradability measured by COD is generally lower than by any other test. The ratio of the BOD to COD gives the percentage of the molecule that can be biologically oxidized. A value of 0.3 or greater is considered good.

Total Organic Carbon (TOC) is sometimes used to describe a molecule. Values of biodegradability obtained by monitoring this parameter generally lie between BOD and COD values.

Obviously, it is essential that the test conditions be specified when citing biodegradability numbers. When comparing values from different sources it is vital to insure that the values are describing the same test.

III. MEASURES OF AQUATIC TOXICITY

The harmful effect of a chemical released into a receiving water is dependent on its concentration in that water. All chemicals are toxic if their concentration is high enough. Therefore, it is necessary to determine a "safe" concentration. The tests for doing this generally use various forms of aquatic life as indicators of toxicity. The values reported usually show the chemical concentration at which 50% of the test organisms would be expected to die. The common term for this is the LD-50. Because the life forms used in this testing vary greatly in their sensitivity to chemicals, the tests results also vary greatly. Again, it is important to specify the conditions used in the test and to make sure that conditions are identical when comparing values. In general, LD-50 values <10 ppm are considered toxic. Values between 10 and 100 ppm are somewhat toxic and values >100 ppm are "non-toxic."

IV. NMP BIODEGRADABILITY

River die-away tests were conducted by Chow & Ng (1). These tests simulate the fate of a compound in a receiving water. Using an initial concentration of 100 ppm NMP, they found 95% removal as measured by specific compound analysis and 45% removal as measured by COD. These determinations were conducted after two weeks exposure. The low COD removal compared to the specific compound removal indicates a high degree of molecular modification (probably nitrogen-carbonyl bond splitting) and a lesser amount of mineralization (conversion to CO_2 and H_2O). Thus, while the compound was no longer present as NMP, the compound was still present as modified fragments.

An additional test by the same people using a semi-continuous activated sludge system acclimated for five days showed 7 day biodegradability of 95% by specific analysis.

In similar tests, Matsui (2) used a semi-continuous system to measure TOC, COD, and specific compound (by GC) removals. These results all showed >92% removal (regardless of the parameter being measured) within 24 hours starting with concentrations ranging from 92 ppm to 210 ppm NMP.

Rowe and Tullos (3) studied biodegradability of NMP in acclimated and unacclimated, static and continuous flow, laboratory activated sludge systems. The tests were run at 300 and 1000 ppm of NMP; the continuous cells had an 18-hour hydraulic residence time. The results indicate that NMP was largely degraded (more than 98 percent destruction with 90 percent TOC reduction in the continuous cells), and that significant acclimation is easily achieved (more than 75 percent TOC reduction in 24 hours in unacclimated static tests).

Respirometric tests provided by BASF show a BOD-5 (acclimated) of 1.2 wt/wt. Compared to the Theoretical Oxygen Demand (ThOD = COD) of 2.18, this gives a BOD/COD ratio of 0.55 which is quite biodegradable.

As an indication of the impact of NMP on an activated sludge treatment system, the *Handbook of Environmental Data* (3) lists a no-effect level (LD-0) for NMP using the bacterium Pseudomonas as 5 g/1. This demonstrates that NMP is non-toxic to treatment systems even at fairly high concentrations. BASF AG tests indicate that activated sludge wastewater treatment systems will continue to function efficiently at NMP concentrations at least as high as 2000 ppm.

BOD tests conducted by BASF show that using unacclimated bacteria, NMP is biodegradable (BOD-5 = 0.76). However, acclimation significantly increased the biodegradability; BOD-5 = 1.15 wt/wt. Long term BOD tests show substantial biodegradability BOD-20 = 1.2 wt/wt.

All of the above tests show that in acclimated systems or systems that could acclimate during the normal contact time (as in the case of a spill to a receiving water), NMP is readily biodegradable. There are indications that in unacclimated, short contact time systems (single dose exposure in municipal treatment plants) NMP would not be significantly degraded.

V. AQUATIC TOXICITY

GAF data for various species of fish list the LC-50 as ranging from 832-3048 ppm. Even the lowest value is well within the "non-toxic" range.

VI. CONCLUSIONS

NMP is nearly non-toxic to most aquatic life and can be readily degraded by typical waste-water treatment plant organisms. It is, accordingly, an advantageous solvent to use whenever any possibility of discharge with an aqueous stream exists.

REFERENCES

(1) "The Biodegradation of N-Methyl-2-Pyrrolidone in Water by Sewage Bacteria," S. T. Chow and T. L. Ng, *Water Research, Vol. 17*, pp. 117-118 (1983).

(2) "Activated Sludge Degradability of Organic Substances in the Waste Water of the Kashima Petroleum and Petrochemical Industrial Complex in Japan," S. Matsui, T. Murakimi, T. Sasaki, Y. Hirose, and Y. Iguma, *Progress in Water Technology, Vol. 7*, Nos. 3/4, pp. 645-659 (1975).

(3) "Lube Solvents No Threat to Waste Treatment," E. H. Rowe and L. F. Tullos, Jr., *Hydrocarbon Processing, 59*, pp. 63-65 (October 1980).

(4) *Handbook of Environmental Data on Organic Chemicals.* 2nd Ed., Karel Verschueren, Van Nostrand, Reinhold Co., N.Y. 1983, p. 873.

SECTION 3:

DEMONSTRATION OF ALTERNATIVES FOR CLEANING PAINT APPLICATION EQUIPMENT

By:

J. M. Elion, J. B. Flanagan,
E. A. Hill, and J. H. Turner

ABSTRACT

The purpose of this project was to demonstrate on a full production scale a pollution prevention technology to replace methyl ethyl ketone (MEK) for cleaning the paint application equipment (pumps, hoses, and guns) at the Marine Corps Logistics Base (MCLB) in Albany, GA. The research was conducted by U.S. EPA with the the contractor services of Research Triangle Institute (RTI). Funding was provided by the Strategic Environmental Research and Development Program (SERDP).

This demonstration consisted of a preliminary screening to identify several possible solvent alternatives, testing to downselect the most effective cleaners, and finally full-scale demonstration at the MCLB.

The preliminary screening tested 65 alternative cleaners for their effect on fully cured single and plural component Chemical Agent Resistant Coatings (CARCs) and an epoxy primer. From these 65 alternatives, 5 cleaners were selected for further testing. These cleaners were tested for their compatibility with materials that would come in contact with the paints and the cleaner. The project researchers found no measurable weight gain or loss, pitting, or other signs of corrosion between any of the five cleaners or MEK and the four metals tested: aluminum, stainless steel, nickel, and brass. Material compatibility was also tested with four plastics (Teflon®, acetal, Nylon®, and Delrin®). Results showed slight weight changes in all coupons tested with the five cleaners and with MEK. Of the five cleaners, the two showing the least overall weight gain or loss for the four plastics were evaluated for paint removal efficiency in a laboratory setting. Overall, both of the cleaners were comparable to MEK for CARC, and both cleaners were better than MEK at removing the white primer.

Based on the test results, the blend of 40% propylene carbonate and 60% benzyl alcohol (PC/BA), by weight, was selected for demonstration at the base. Four barrels of this cleaner were shipped to the MCLB. MCLB used this cleaner as a direct replacement for MEK. No capital investment was required.

Use of this cleaner was monitored by weighing the amount of cleaner flushed through the system. The amounts of cleaner used for the initial prewash, the final wash, and the filter wash were recorded. The date and time at the start and finish of each step was also recorded.

PC/BA cleans green CARC from the pumps as well as MEK, and cleans epoxy primers from the pumps better than MEK. Advantages of using PC/BA are lowered inhalation hazard to workers, reduced cleaner use and reduced labor time for cleaning, and classification of the hazardous waste as non-RCRA regulated. The disadvantage is a higher cost for the PC/BA blend than for MEK. The higher cost may be offset by cleaner recovery and reclamation, and further waste reduction. The use of PC/BA significantly decreases downtime of the primer pumps. This substitution will reduce emissions from HAPs 21% from 1992 levels.

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ACRONYMS

APPCD	Air Pollution Prevention and Control Division
CAA	Clean Air Act
CARC	Chemical agent resistant coating
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DMA	Depot Maintenance Activity
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
HAP	Hazardous air pollutant
MCLB	Marine Corps Logistics Base
MEK	Methyl ethyl ketone
MSDS	Material Safety Data Sheet
P2	Pollution prevention
PC/BA	Propylene carbonate/benzyl alcohol
PP	Payback period
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
ROI	Return on investment
RTI	Research Triangle Institute
SARA	Superfund Amendments and Reauthorization Act
SERDP	Strategic Environmental Research and Development Program
VOC	Volatile organic compound

METRIC UNITS

English units have been included in the report to simplify communication with most of the intended readership and because they are the primary units used by the Marine Corps Logistics Base. The multiplying factors for converting from the English units to their metric equivalents are given in the table below.

METRIC CONVERSION FACTORS (Approximate)				
Symbol	*When You Know the Number of*	*Multiply By*	*To Find the Number of*	*Symbol*
LENGTH				
in	inches	2.54	cm	centimeters
VOLUME				
gal	gallons	3.79	liters	l
MASS				
lb	pounds	0.454	kilograms	kg
PRESSURE				
psi	pounds per square inch	6.89	kilopascals	kPa
TEMPERATURE				
°F	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Centigrade	°C
DENSITY				
lb/ft^3	pounds per cubic foot	16.0	kilograms per cubic meter	kg/m^3
FLOW				
cfm	cubic feet per minute	0.472	liters per second	l/sec

ACKNOWLEDGMENTS

The authors gratefully wish to acknowledge the following people at the MCLB, without whose cooperation and assistance this demonstration would not have been possible:

Steve Allan
Dave Baxter
Wayne Chauncey
Scott Clements
Clarence Clyde
Larry Fountain
John Gates
George Hagan
Duke Hellinger
Dave Hudson
Mark Joyner
Willie Walker

In addition, the authors acknowledge Tom Marquis of Huntsman Chemical for his assistance with the preliminary screening.

The authors would especially like to recognize the contribution of EPA and MCLB's Project Engineers J. Kaye Whitfield and Dan Gillum to this report. Their project oversight, guidance, direction, and technical assistance greatly contributed to this research demonstration.

NOTICES

QA/QC requirements apply to this project. Data are supported by QA/QC documentation as required by USEPA's QA Policy.

The use of trade names and company names in this section does not signify recommendation for use or endorsement by either the EPA or Research Triangle Institute.

3.1.0 INTRODUCTION

This section reports on the demonstration of solvent alternatives for cleaning paint application equipment (hereafter referred to as the "MEK alternatives demonstration"), performed at the Marine Corps Logistics Base in Albany, GA, with funding provided by the Stategic Environmental Research and Development Program (SERDP). It contains detailed descriptions of the technical evaluation, including the preliminary screening tests, and the operational evaluation conducted at the MCLB. Information regarding cost savings and estimated reductions in hazardous air emissions is contained in the Implementation Plan (Section 3.5.0).

3.1.1 Background

The demonstrations in this project were performed primarily at the Marine Corps Logistics Base (MCLB) in Albany, GA. This base carries out maintenance activities on a wide variety of equipment from small arms to tanks, trucks, and other vehicles. Much of the maintenance on the vehicles requires removing the existing paint prior to the repair procedures, and application of new paint once the maintenance has been performed. The processes for paint stripping, repainting, and cleaning of paint equipment release significant amounts of hazardous air pollutants (HAPs). By Executive Order 12856, the MCLB is required to reduce these air emissions by 50% from 1992 levels. The MCLB desires to accomplish this goal by implementing pollution prevention (P2) technologies.

The coatings used by the MCLB can be classified as polyurethane-based plural-component Chemical Agent Resistant Coatings (CARCs) and single-component CARCs, epoxy primers, and undercoatings. The four coatings used in this evaluation were dual-component green CARC (NSN 8010-01-160-6742); single-component tan CARC (NSN 8010-01-276-3640); undercoating (NSN 8030-01-127-3683); and epoxy primer (NSN 8010-001-193-0517). Material Safety Data Sheets for these four coatings are included in Appendix 3-1.

The MCLB primarily uses air-assisted airless spray systems to apply paint; cup sprayers are used for touch-up paint.

The current process used to remove the partially cured paint from the paint application equipment is to flush methyl ethyl ketone (MEK) through the equipment into an open bucket. When the MEK looks clean, the lines are flushed for three minutes or less with additional fresh solvent. The systems are cleaned at least twice daily; at the ends of the day shift and the night shift. The systems are also cleaned between color changes. The waste paint and MEK from the prewash is collected in a bucket that is later emptied into a hazardous waste barrel. The barrel is then disposed of as hazardous waste. The MEK from the final rinse is used for the next prewash cycle.

MEK needs to be replaced because it is a hazardous air pollutant and is one of seventeen toxic chemicals identified in the Environmental Protection Agency (EPA) 33/50 Program. The 33/50 Program is a voluntary pollution prevention initiative to reduce national pollution releases and off-site transfers. The seventeen toxic chemicals chosen were selected because they pose environmental and health concerns, are high-volume industrial chemicals, and may be reduced through pollution prevention technologies.

3.1.2 Objectives

The objective of this task was to demonstrate a process for cleaning the paint application equipment that would reduce the emissions of HAPs resulting from cleaning the paint application equipment. This objective was achieved by replacing the MEK with a less hazardous, less volatile solvent and a combination of work practices. These technologies and work practices were tested at a laboratory facility and then demonstrated on-site at the MCLB over a four-week period. The MCLB continued to use the new process after completion of the demonstration.

3.2.0 TECHNICAL EVALUATION OF ALTERNATIVES TO MEK

3.2.1 Preliminary Screening

The first step in finding a replacement solvent was to test the efficacy of a group of solvents that was most likely to be capable of removing the CARCs and primer. The list of capable solvents and solvent mixtures was narrowed to those that best met environmental, cost, and safety criteria. These criteria included high flash point, low vapor pressure, and removal of coatings at ambient use temperature.

Four aluminum 6 in. x 6 in. x 0.060 in. panels were sent to the MCLB, where they were each coated with one of four coatings: one-component Chemical Agent Resistant Coating (CARC), two-component CARC, epoxy primer, or undercoating. The panels were returned to RTI's laboratory. The panel coated with the undercoating arrived in poor condition and was not included in the preliminary screening. Each of the other panels was sheared into ½ in. x ½ in. squares. The square coupons were sent to Huntsman Specialty Chemical Corporation in Austin, TX, for preliminary screening tests.

Preliminary screening consisted of visual examination of the effect of different solvent formulations on the three coatings. Although the coatings cleaned at MCLB are usually uncured or only partially cured, the preliminary screening was conducted on fully cured coatings to ensure that a robust cleaner would be selected. Sixty-five different cleaners were tested. The cleaners were various proportions of propylene carbonate and other compounds, including methyl isoamyl ketone, n-methyl pyrrolidone (NMP), dibasic esters, and benzyl alcohol. A list of the sixty-five cleaners is provided in Table 3-1.

For each test, one test square coated with one-component CARC was placed in a test vial, one test square with two-component CARC was placed in another test vial, and one test square with epoxy primer was placed in a third test vial. Approximately 2 milliliters (ml) of the test blend was placed in each of the three vials. This was repeated for all sixty-five cleaners. MEK was also included to provide a baseline for comparison. Each coupon was visually inspected after twenty-four hours and again after forty-eight hours. The results are shown in Table 3-2. Samples were rated "L" for little or slight attack as evidenced by small pock marks or blisters in the coatings.

Samples were rated "M" for moderate attack as evidenced by wrinkling or blistering of the coating. Samples were rated "S" for severe attack, indicated by heavy blistering, wrinkling, or removal of the coating. No rating indicates no observed effect on the coating. MEK, the current cleaner, had no observed effect on the three coatings.

The photograph in Figure 3-1 shows a comparison of the *white primer* as coated and after severe attack following 48 hours immersion in one of the cleaners. The coating was heavily wrinkled on both sides. The photograph in Figure 3-2 shows a comparison of the *tan CARC* as coated, after moderate attack following 48 hours immersion in cleaner #2, and after severe attack following 48 hours immersion in cleaner #58. The coating was severely blistered on one side of the test square and completely removed from the other side. The photograph in Figure 3-3 shows a comparison of the *green CARC* as coated, following 48 hours immersion with no noticeable effect, and severe attack following 48 hours immersion. The coating shows a large blister.

TABLE 3-1. CLEANER BLENDS SCREENED AS ALTERNATIVES TO MEK
(Compositions Given by Weight Percent)

RTI #	PC	MIAK	NMP	DBE	DPM	N-AMYL ACETATE	BENZYL ALCOHOL	OTHER
1	25	25	50					
2	20		40					Diisobutyl ketone - 40
3	25		50			25		
4	20						80	
5	40						60	
6	25		50	25				
7	20		20	20	40			
8	20		40	20	20			
9	25		75					
10	25		25	25			25	
11	25			25			50	
12	20		30	50				
13	14		21	35			30	
14	8		12	20			60	
15	25		30	25	20			
16	17.5		21	17.5	14		30	
17	10		12	10	8		60	
18	25		15		20			Limonene - 40
19	17.5		10.5		14		30	Limonene - 28
20	10		6		8		60	Limonene - 16
21	28		35					Ethylene glycol butyl ether acetate - 37
22	19.6		24.5				30	Ethylene glycol butyl ether acetate - 25.9
23	11.2		14				60	Ethylene glycol butyl ether acetate - 14.8
24	24		35	5				Diacetone alcohol - 36
25	16.8		24.5	3.5			30	Diacetone alcohol - 25.2
26	9.6		14	2			60	Diacetone alcohol - 14.4
27	40		35	12				Methyl amyl acetate - 13
28	28		24.5	8.4			30	Methyl amyl acetate - 9.1
29	16		14	4.8			60	Methyl amyl acetate - 5.2
30	44		35	12				Isobutylisobutyrate - 9
31	30.8		24.5	8.4			30	Isobutylisobutyrate - 6.3

(continued)

(Table 3-1, continued)

32	17.6		14	4.8			60	Isobutylisobutyrate - 3.6
33	50		20	25				Limonene - 5
34	35		14	17.5			30	Limonene - 3.5
35	20		8	10			60	Limonene - 2
36	15.2		8	10.8			60	Tripropylene glycol - 6
37	26.6		14	11.2			30	2-Ethoxyl acetate - 18.2
38	15.2		8	6.4			60	2-Ethoxyl acetate - 10.4
39	49	7	20	24				
40	34.3	4.9	14	16.8			30	
41	19.6	2.8	8	9.6			60	
42	30		20	34				Ethylene glycol diacetate - 16
43	21		14	23.8			30	Ethylene glycol diacetate - 11.2
44	12		8	13.6			60	Ethylene glycol diacetate - 6.4
45	55			45				
46	38.5			31.5			30	
47	22			18			60	
48	10			19.2			60	γ-Butyrolactone - 10.8
49	18			17.2			60	Furfuryl alcohol - 4.8
50	32.2			29.4			30	Triethylene glycol - 8.4
51	18.4			16.8			60	Triethylene glycol - 4.8
52	28			28			30	Diethylene glycol butyl ether - 14
53	16			16			60	Diethylene glycol butyl ether - 8
54	17.5		17.5	17.5		17.5	30	
55	10		10	10		10	60	
56	13.3			13.3		13.3	60	
57	10	10	10	10			60	
58	13.3	13.3		13.3			60	
59	20	20	20	20		20		
60	14	14	14	14		14	30	
61	8	8	8	8		8	60	
62	17.5	17.5		17.5		17.5	30	
63	10	10		10		10	60	
64	33.3			33.3			33.3	
65	50		50					Texadd S-200

PC - Propylene carbonate
MIAK - Methyl isoamyl ketone
NMP - N-methyl Pyrrolidone
DBE - Dibasic esters
DPM - Dipropylene glycol methyl ether

TABLE 3-2. SUMMARY OF RESULTS OF PRELIMINARY SCREENING

Effects of cleaners on coatings after 24 and 48 hours.

	GREEN CARC		TAN CARC		WHITE EPOXY PRIMER	
Panel #	24 hours	48 hours	24 hours	48 hours	24 hours	48 hours
1	L	L	M	M	S	S
2					S	S
3	L	S	L	M	S	S
4	L	L	S	S	M	S
5			M	S	M	S
6	L	L	L	L	S	S
7	L	L	L	L	M	S
8	L	M	L	L	S	S
9	S	S	L	L	S	S
10					M	S
11			L	L	M	S
12	L	L		L	S	S
13	L	L			M	S
14				L	M	S
15				L	M	S
16				L	M	S
17				L	M	S
18	L	L	L	L	M	S
19					S	S
20			S	S	M	S
21				L	M	S
22				L	S	S
23	L	L		L	M	S
24				L	L	S
25				L	L	S
26	L	L		L	L	S
27	L	L			M	S
28	L	L		L	M	S
29	M	M	L	M	M	S
30		L			L	S
31					M	S
32			L	L		S
33						S
34					L	S
35			S	S	M	S
36					S	S
37			L	L	M	S
38			L	M	M	S
39				L	L	M
40				L	L	S

(continued)

(Table 3-2, continued)

41		M	S	S	S	S
42				L	L	L
43					M	S
44				L	S	S
45			L	L	L	L
46	L	M			L	M
47				L	S	S
48	L	S	M	S	S	S
49	L		S	S	S	S
50			L	L	L	M
51	L		L	L	S	S
52			L	L	L	S
53			L	L	S	S
54				L	M	S
55		S		L	S	S
56			M	S	L	M
57			L	L	M	S
58			S	S	S	S
59				L	S	S
60				L	S	S
61			L	M	S	S
62				L	S	S
63			S	S	M	S
64					M	M
65					M	M
MEK						

L - Little or slight effect
M - Moderate effect
S - Severe effect
Blank spaces indicate no observed effect

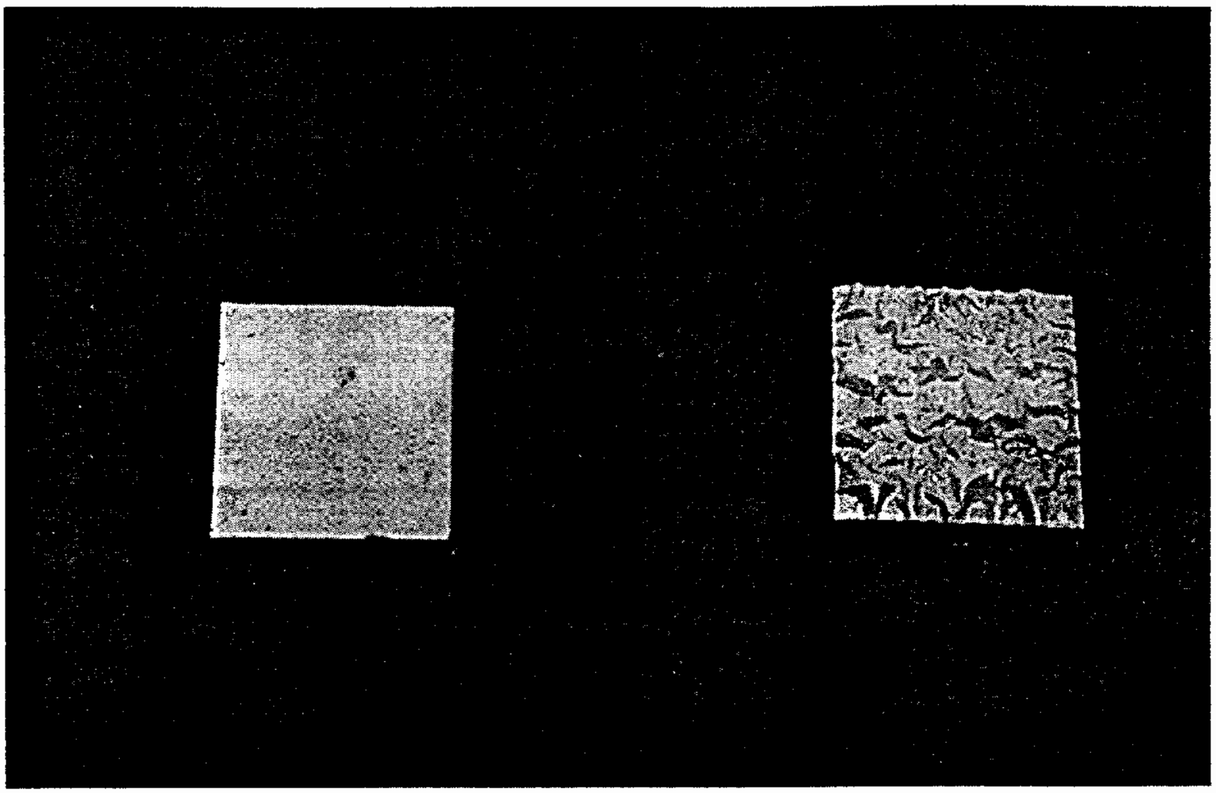


FIGURE 3-1. COMPARISON OF SCREENING RESULTS FOR WHITE PRIMER

Photograph shows test squares as coated and after severe attack following 48 hours immersion.

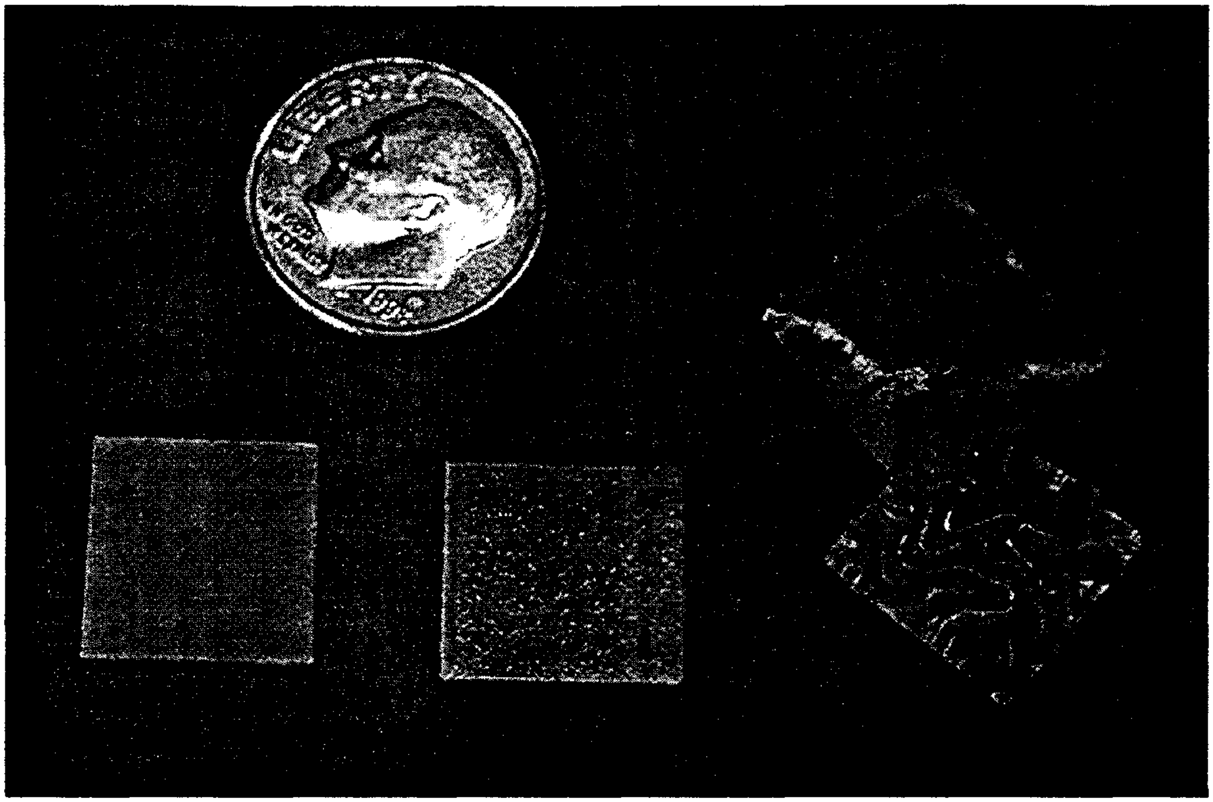


FIGURE 3-2. COMPARISON OF SCREENING RESULTS FOR TAN CARC

Photograph shows test squares as coated (on the left), after moderate attack following 48 hours immersion in cleaner #2 (in the middle), and after severe attack following 48 hours immersion in cleaner #58 (on the right). The coating is severely blistered on one side of the test square; the square directly above is the removed coating from the other side of the same test square.

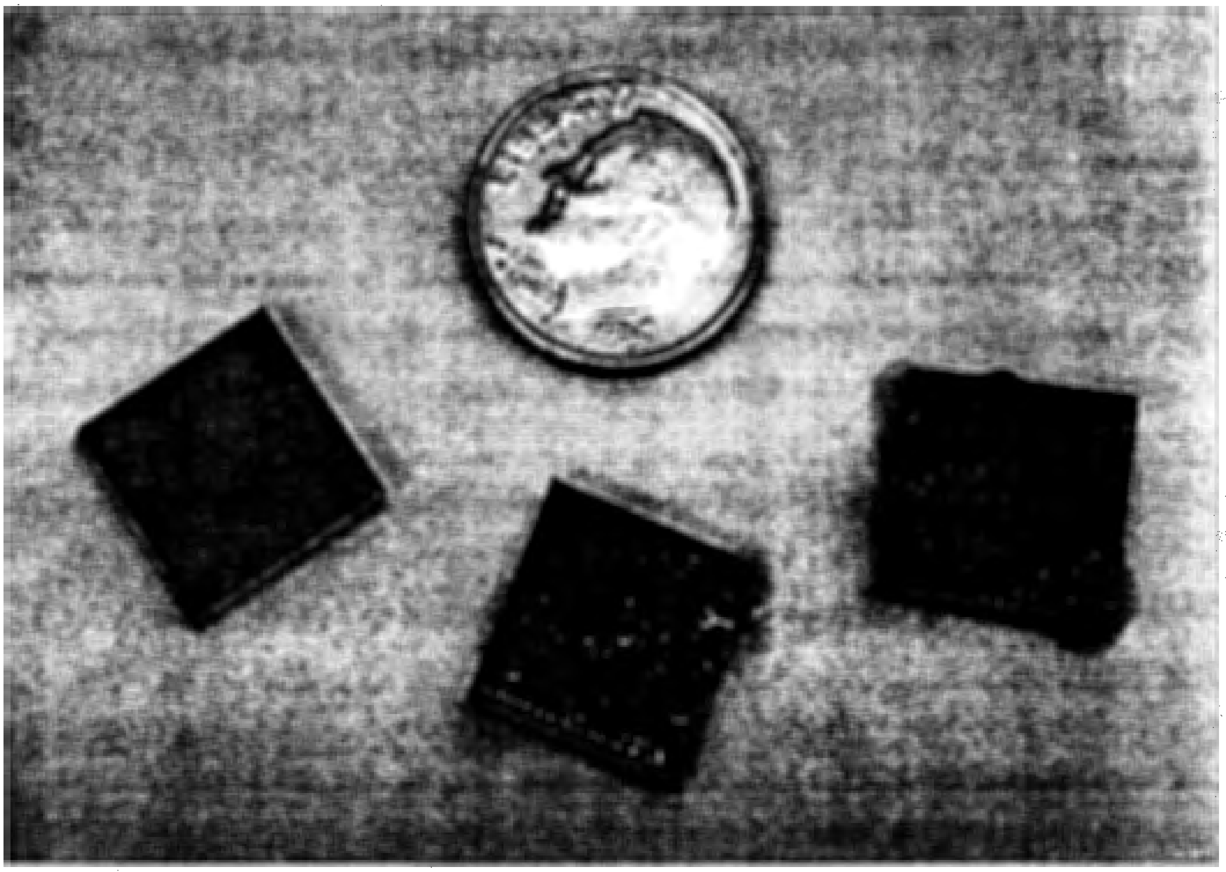


FIGURE 3-3. COMPARISON OF SCREENING RESULTS FOR GREEN CARC

Photograph shows test squares as coated (on the left), after slight attack following 48 hours immersion in cleaner #1 (in the middle), and after severe attack following 48 hours immersion in cleaner #3 (on the right).

Only one screening formulation, #48, severely attacked all three coatings after forty-eight hours. Three other formulations severely attacked two of the three coatings and moderately attacked the third. Based on the results of the screening study, five formulations were selected for further tests. Formulations with high percentages of n-methyl pyrrolidone (NMP) or benzyl alcohol appeared to have the highest solvency. For this reason, formulations #5 and #48 were chosen as likely candidates to replace MEK. Noting that the screening study with cured panels was a "worst-case" condition, formulation #64 was chosen to determine whether a formulation with a lower percentage of benzyl alcohol would prove effective. Formulation #65 was chosen to represent the propylene carbonate/NMP blends. Propylene carbonate (PC), as the common constituent, was also included for further testing, even though screening tests were not done with 100% PC.

Huntsman Specialty Chemical Corporation had Material Safety Data Sheets available for several of the screened cleaners, designating the formulations with letters or names instead of numbers. (Formulation #65 was selected over #3 and #9 because the MSDS was already available.)

These five formulations shown in Table 3-3 were used for materials compatibility testing and more cleaning tests. Half-gallon samples were submitted for further technical evaluation. The Material Safety Data Sheets for these are included in Appendix 3-2.

TABLE 3-3. CLEANERS SELECTED FOR TECHNICAL EVALUATION

Product	Formulation
Paint Remover H (RTI #64)	Propylene carbonate (33-1/3%) Dibasic esters (33-1/3%) Benzyl alcohol (33-1/3%)
Paint Remover L (RTI #5)	Propylene carbonate (40%) Benzyl alcohol (60%)
Paint Remover N (RTI #48)	Propylene carbonate (10%) Dibasic esters (19.2%) γ-Butyrolactone (10.8%) Benzyl alcohol (60%)
Texadd S-200 (RTI #65)	Propylene carbonate (50%) N-Methyl pyrrolidone (50%)
Propylene Carbonate	Propylene carbonate (100%)

3.2.2 Material Compatibility

The choices of materials for compatibility testing were based on wetted materials in the paint application pump systems then in use at the MCLB. The MCLB provided the instructions and parts list for the Graco plural component mixer manifold then in use to spray coatings. The manifold parts that would come in contact with the paint and paint cleaner included chrome alloy, 303 stainless steel, Delrin®, Nylon®, and Teflon®. The test materials chosen were aluminum, brass, nickel, 303 stainless steel, acetal, Delrin®, Nylon®, and Teflon®.

Test coupons measuring 3/4 in. by 2 in. by 1/8 in. thick were made for each material. Each coupon was weighed to the nearest 0.01 mg and the weight recorded. Replicate coupons of each material were placed in three separate test vials. Approximately 4 ml of cleaner were added to each vial, which covered about half the coupon. This allowed exposure of the coupon to the liquid phase, the liquid/vapor interface, and the vapor phase of each cleaner. Each vial was then capped and stored at room temperature. The test coupons were removed and weighed after one day immersion. They were returned to the cleaner vial and reweighed after three days immersion and again after seven days immersion. A fourth coupon, the control, was also reweighed to the nearest 0.01 mg after one day, three days, and seven days exposure to ambient conditions.

When the coupons were removed from a cleaner to be weighed, they were patted dry with absorbent towels for 60 seconds and then immediately weighed. Excessive contact with air and delays in weighing were avoided. Coupons were returned to their individual vials as soon as possible after weighing. Weight changes indicate loss of material or absorption of cleaner.

Visual examination of the test coupons during weighing indicated no pitting, flaking, discoloration. No signs of corrosion were visible on the metal coupons. No shape distortion was visible on the plastic coupons.

The results of the materials compatibility gravimetric testing are summarized in Table 3-4. The full experimental data are in Appendix 3-3. A comparison of the five cleaners and MEK is shown graphically in Figure 3-4. This figure shows only the plastics because, as can be seen from the data in Table 3-4, there was no significant change in the weights of any of the metals with any of the cleaners. The data in Figure 3-4 indicate that Teflon is the most stable of the plastics over the seven-day exposure. It absorbed a small percent of MEK, but not the other cleaners. Percent change for other cleaners are very close to the limits of detection for the method. The Delrin® absorbed the most cleaner for each of five cleaners and absorbed more MEK than any of the other cleaners. The acetal also absorbed a small percentage of cleaner, although not to the degree shown by the Delrin®. The data indicate that nylon lost a small weight percentage upon seven-day immersion to the five cleaners. Cleaner formulations L and N were chosen for further evaluation because they showed the least variation of weight gain/loss for the four plastics.

TABLE 3-4. PERCENT WEIGHT CHANGE OF MATERIALS IMMERSED 7 DAYS IN ALTERNATIVE CLEANERS

MATERIALS TESTED		CLEANERS					
		MEK	PC	L	H	N	T
Metals	Aluminum	-0.02	0.03	0.00	0.00	-0.01	-0.01
	Brass	-0.01	0.00	-0.01	-0.01	-0.02	-0.02
	Nickel	0.00	0.00	0.00	0.00	0.00	0.00
	Stainless Steel	-0.01	0.00	-0.01	-0.01	-0.01	0.00
Plastics	Teflon®	0.11	-0.02	-0.04	-0.04	-0.04	-0.03
	Delrin®	1.36	0.48	0.60	0.77	0.64	0.54
	Acetal	1.02	0.29	0.32	0.49	0.43	0.36
	Nylon®	0.13	-0.71	-0.13	-0.35	-0.19	-0.83
	CONTROLS†						
Metals	Aluminum	0.00	0.00	0.00	0.00	0.00	0.00
	Brass	0.00	0.00	0.00	0.00	0.00	0.00
	Nickel	0.00	0.00	0.00	0.00	0.00	0.00
	Stainless Steel	0.00	0.00	0.00	0.00	0.00	0.00
Plastics	Teflon®	0.00	0.00	0.00	0.00	0.00	0.00
	Delrin®	-0.04	-0.04	0.03	-0.01	-0.01	0.00
	Acetal	-0.02	-0.02	0.00	0.00	0.00	0.00
	Nylon®	-0.07	-0.07	0.05	-0.02	-0.02	0.01

† Controls not exposed to solvents

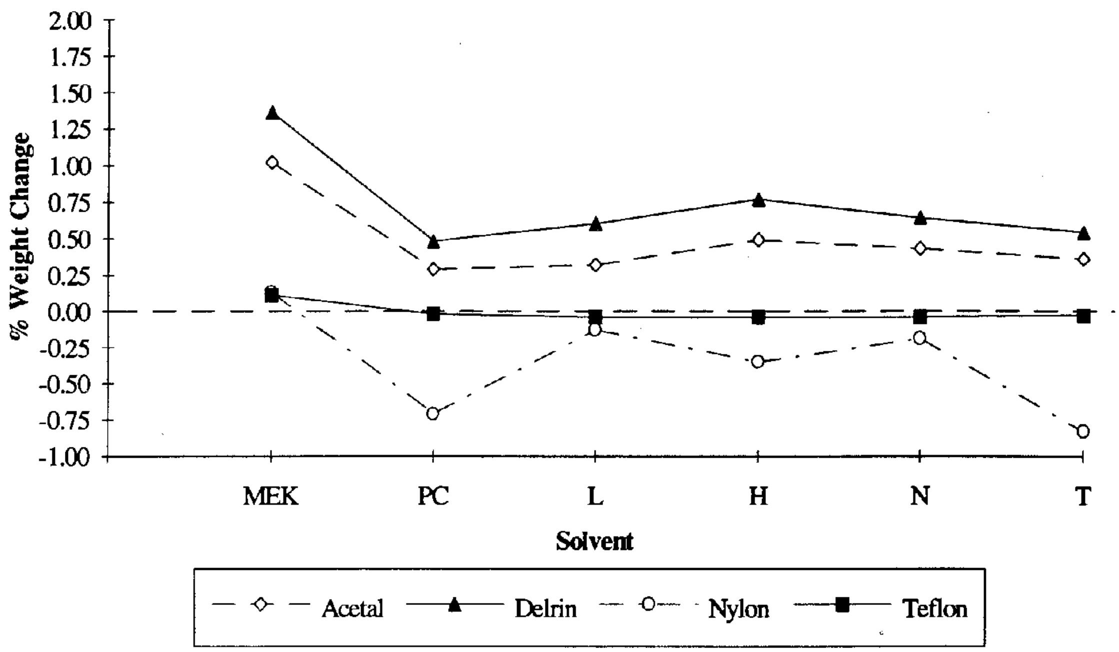


FIGURE 3-4. GRAVIMETRIC RESULTS OF MATERIALS COMPATIBILITY TESTS

3.2.3 Paint Removal Efficiency

Cleaners L (40% propylene carbonate/60% benzyl alcohol) and N (10% propylene carbonate/19.2% dibasic esters/10.8% γ-butyrolactone/60% benzyl alcohol), selected from the material compatibility study, were evaluated further for paint removal efficiency. MEK was used as a baseline for comparison.

In this test, cleaner was pumped through tubes that had been contaminated with the coatings in such a way as to simulate the way the hoses for the paint spray equipment are flushed at the MCLB. A small section of glass tubing was connected between two sections of hose to allow visual examination and gravimetric analysis of the paint removal by the cleaners. In this set of tests, paint was not allowed to cure before removal to more closely reproduce actual cleaning conditions at the MCLB.

The 3 in. long glass tubes had an inside diameter of 0.220 in. and an outside diameter of 0.375 in. All the tubes were precleaned and weighed to the nearest 0.01 mg to obtain $W_{initial}$. The paints were stirred before use. For the dual-component CARC and epoxy primer, the two components were mixed according to the manufacturer's instructions. Paint was applied to the interior of each glass tube using a cotton swab. The tubes were reweighed to the nearest 0.01 mg to obtain the coated weight, W_{coated}. The tubes were contaminated, reweighed, and cleaned one at a time to minimize paint curing. To clean, approximately 200 ml of the appropriate cleaner was flushed through each glass tube from a 50 psig pressure pot. The tubes were dried overnight and reweighed to the nearest 0.01 mg to obtain the cleaned weight, $W_{cleaned}$. Each paint was tested with three replicates and a control for each cleaner. The raw data are included in Appendix 3-4. The average paint removal efficiency was calculated as follows, for n=3:

$$Average\ Paint\ Removal\ Efficiency = \frac{Paint\ Removed}{Paint\ Applied} * 100$$

$$= \frac{\sum_{i=1}^{n} \left[\frac{(W_{coated_i} - W_{cleaned_i})}{(W_{coated_i} - W_{initial_i})} \right]}{n} * 100$$

The averaged data are summarized in Table 3-5. For each of the four coatings, the cleaners are listed in order of decreasing effectiveness. The same data are shown graphically in Figure 3-5. Overall cleaner performance was determined by averaging all samples for a given cleaner. Both of the cleaners were significantly better than MEK at removing the epoxy primer (white). Formulation L was nearly as effective at removing the dual-component CARC (green) as MEK. Neither of the two cleaners was as good at removing the single-component CARC (tan) or the undercoating (black) as MEK. Further discussions with the MCLB revealed that the black undercoating is thinned before applying and sometimes heated to reduce its viscosity. These factors would significantly effect its ability to be cleaned.

Although MEK is the current standard at the MCLB, it did not successfully remove all four coatings as expected. The MEK removed more of the tan CARC than of the other three coatings, but a residue was still visible on the glass tubes. Based upon visual examination, none of the three cleaners removed any noticeable amount of the black undercoating. The MEK did not remove any noticeable amount of the white epoxy primer; the two cleaners, L and N, removed most of the primer and left a faint residue behind.

Based on this data, formulation L, the blend of propylene carbonate and benzyl alcohol, was chosen for demonstration at the MCLB. The formulation is a custom-made blend with no commercial name. To avoid confusion, it will be referred to through the rest of this report as PC/BA (propylene carbonate/benzyl alcohol) rather than L.

TABLE 3-5. REMOVAL OF COATINGS FROM GLASS TUBES

Coating	*	Average Cleaning Efficiency (%)	Standard Deviation (%)
Black undercoating	MEK	76.49	16.76
	N	55.54	3.08
	L	53.39	17.24
Green CARC	MEK	99.58	0.7
	L	97.86	1.17
	N	96.76	1.55
Tan CARC	MEK	99.97	0.02
	L	82.21	8.56
	N	77.23	15.18
White primer	L	95.82	1.62
	N	90.23	5.3
	MEK	71.34	20.5

*Data are intentionally listed in order of decreasing cleaning efficiency for each coating

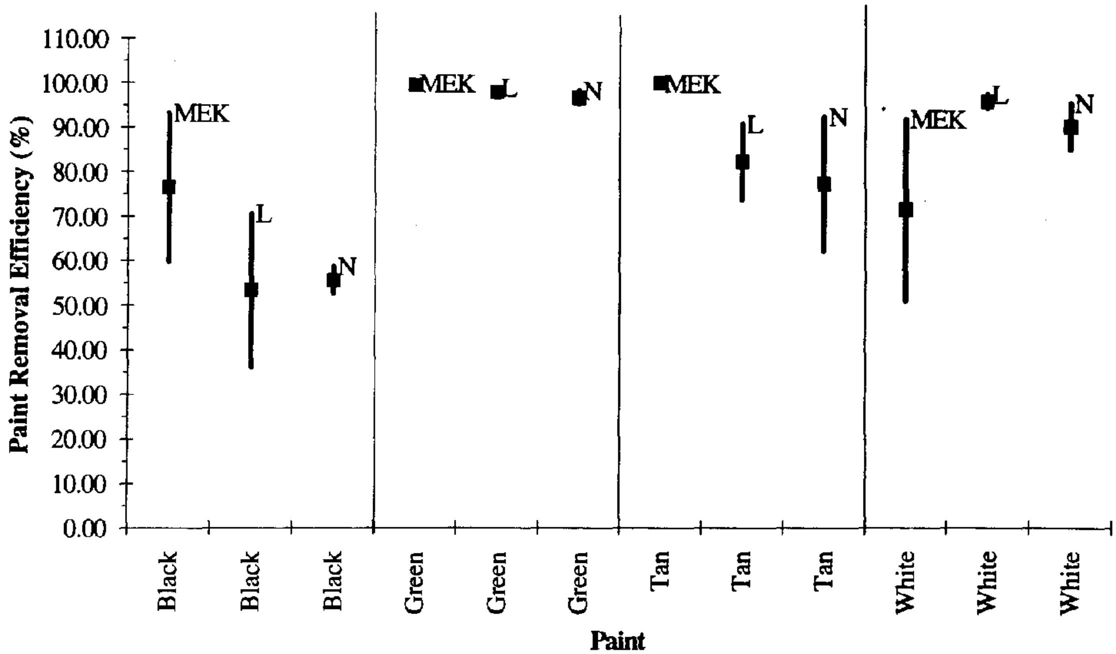


FIGURE 3-5. PAINT REMOVAL EFFICIENCY RESULTS OF MEK ALTERNATIVES

3.3.0 ON-SITE DEMONSTRATION OF ALTERNATIVE PAINT EQUIPMENT CLEANER PROPYLENE CARBONATE/BENZYL ALCOHOL

3.3.1 Current Process

More than 60,000 lbs. of MEK was purchased by the MCLB in 1992 for cleaning paint application equipment. Equipment is cleaned at the end of each shift and between color changes. Previously used solvent is flushed through the equipment following paint application to clean the hoses and guns of remaining paint as a prewash. The equipment is flushed with prewash solvent until no paint is visible in the wash effluent. The prewash is collected in a hazardous waste container which is later emptied into a hazardous waste barrel. The paint pickup tube then is placed in a container of fresh solvent for a final wash. Fresh solvent is flushed through the hoses and guns and collected in the prewash bucket. The pump filter is then backflushed with fresh solvent and the waste disposed of in the hazardous waste container. Finally, fresh solvent is recirculated through the system for several minutes.

In discussions with the area's Leadermen, it was learned that the cleaning process takes two operators using five gallons of MEK about fifteen to twenty minutes per paint spray system to clean the equipment. Data collected for verification indicate less MEK is actually used and the cleanup process takes less time.

3.3.2 Setup of Demonstration

Before the official on-site demonstration phase was started, a meeting was held with the MCLB painters to describe the test results and new cleaner, and answer any questions. The painters' main concerns were that the new cleaner would not remove the paint as well as MEK or that it would work so well that it would cause large chunks of paint to be released from the hoses that would plug the pumps and cause them to seize. Preliminary tests were conducted at the MCLB with the cooperation of the painters. The painters first sprayed a sample of the cleaner through the pumps to check that the cleaner could withstand the high pressures with no adverse reactions.

Next, three pumps were cleaned prior to the quantified portion of the demonstration. The first pump was located in Building 2200. The pump, a Graco Senator, had been flushed with

MEK and was considered clean by the operators. The area Leaderman placed a filter in line in one of the hoses to see if the new cleaner would cause sloughing of chunks of paint. About five gallons of PC/BA were continuously recirculated through the pump for about two hours. The PC/BA removed additional paint from the equipment, but there were no large chunks caught in the filter that might have caused the pump to seize up. Some paint residue was left on the main filter, and the in-line filters were clean. A catch sample taken from the bucket showed small green particles in suspension, which later settled. The cleaner warmed slightly when recirculated for over an hour and heated the pump slightly as well. The area Leaderman did not consider this a problem as the cleaning process generally takes less than half an hour. Air pressure of 45 psi was required to circulate the cleaner at the beginning of the test. Required air pressure increased to 60 psi after half an hour. At the end of the test, only 40 psi was required. The painters were pleased that the new cleaner was able to remove paint left behind by the MEK and that it broke down the old paint residue into small pieces that did not seize the pumps.

The second pump cleaned, also a Graco Senator, was located in Building 2222. It had recently been torn down, thoroughly cleaned, and rebuilt. The spray system was used for a single shift and then cleaned with PC/BA. The cleaning procedure was the same as that for cleaning with MEK. The dirty PC/BA from the first pump served as the prewash for the second pump. A final wash of fresh PC/BA was recirculated through the lines. Again, the cleaner removed the paint from the pump satisfactorily and did not cause any large clumps of paint to be released that might cause the pump to seize.

A third pump, a Graco 5-gallon model used only for spraying primer, was also cleaned with PC/BA. The cleaner dissolved the paint and flushed it completely. A catch sample taken from the waste container showed no settling or paint flakes; instead, the white primer appeared to dissolve completely.

The painters and the project's engineers were pleased with the results of these tests and proceeded to the full-scale demonstration of replacing MEK with PC/BA for cleaning the paint spray equipment.

3.3.3 Demonstration of Alternative Cleaner

The paint monitoring system used for the paint application demonstration was used to monitor the amount of cleaner and paint flushed through the system. The WI-130 Rate of Flow Monitor System is designed to monitor and display the rate of flow of paint and the amount of paint used from a scale using a Weigh-Tronix WI-130 indicator display. Accessories to the system included a tape printer, a remote Tare and Print push-button station, and a multiport controller. The remote displays used for the paint application demonstration were not used for this demonstration. The system was used for analysis purposes only and is not required to implement the new cleaner. The equipment used is listed in Table 3-6 and was purchased from J. A. King & Company in Greensboro, NC.

TABLE 3-6. EQUIPMENT USED TO MONITOR CLEANING OF PAINT APPLICATION EQUIPMENT

ITEM	*MODEL NO.*	*QTY.*
Base scale	Weigh-Tronix BSAO2020-200	2
Programmable controller	Weigh-Tronix Model WI-130 with: Extended memory 2-base interface Opto-22 Modules (2) Special Software Interface cable Multi-port controller	1
Tape printer	Weigh-Tronix Model WP-233	2
Remote tare and print push-button station	NA	1
Keyboard	Weigh-Tronix keyboard for WI-130	1
Interface cable to remote printer	NA	150 ft
25 lb. calibration weight	NA	2

The procedure for using the system is included in Appendix 3-5. The painters were trained in the new procedure during a site visit November 27-30, 1995. Because the software was designed for the paint application demonstration, the procedure for gathering cleaning data was adapted to fit the existing software. Upon start-up, the WI-130 prompted the painter to enter the following information:

"Enter Vehicle ID Number",
"Enter Vehicle Code",
"Enter Coating Code",
"Enter Your ID Number",
"Enter Partner's ID Number",
"Enter Target Amount",
"Enter Pounds per Gallon for Coating",
"Enter Scale".

For each entry, the previous value was displayed which the painter could accept by simply pressing <*Enter*> or replace by entering a new value. To collect the data for the cleaning, the vehicle ID and vehicle code were not relevant. Painters were instructed to accept the existing entry. For coating code, painters were instructed to enter P for primer coatings and C for CARCs. Painters were instructed to enter the shift for "Your ID Number" and identify the cleaning solvent, either MEK or PC/BA, for "Partner's ID Number". There was no prescribed target amount for cleaning, so painters accepted the existing entry. For pounds per gallon for coating, painters entered the pounds per gallon of the cleaner, 6.71 for MEK or 9.18 for PC/BA. This block of data, headed by the date and time, was printed whenever the painters pressed <*Print*>.

Collecting data did not interfere with the painters' ability to clean the equipment. The cleaning procedure is shown schematically in Figure 3-6. For the prewash, the painters placed the hazardous waste container on the scale and pressed <*Tare*> to zero the display. The painters continued the prewash as normal, with the paint pickup tube in the prewash container. The painters flushed the cleaner through the hoses and guns into the hazardous waste container on the scale until the cleaner was visibly free of paint. For the final wash, the painters switched the paint pickup tube from the prewash bucket to the final wash bucket. Then they replaced the hazardous waste container on the scale with the prewash bucket, and pressed <*Tare*>. The filter wash used fresh cleaner from the final wash bucket, but the waste was dumped into the hazardous waste container, not the prewash bucket. Some painters included the filter wash in the prewash by simply switching the paint pickup tube from the prewash bucket to the final wash and leaving the hazardous waste container on the scale. Other painters took the extra step of switching the prewash bucket with the hazardous waste container again and pressing <*Tare*>. Either was acceptable since it was the total amount used that was recorded. Painters printed the data block before and after the prewash, the final wash, and the filter wash, totaling the amount of cleaner flushed through the system.

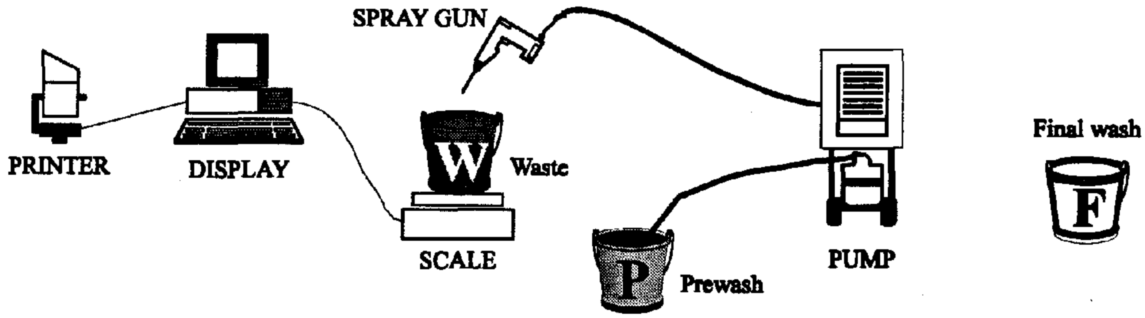
All data were collected from one booth in Building 2222. Both tan and green CARC are sprayed in this booth. However, during the course of data collection, only green CARC was used. The painters also continued to use PC/BA to clean the white epoxy primer from the Graco 5-gallon pumps.

The amount of PC/BA used to flush the Graco Senator clean of green CARC is shown in Table 3-7. The operators consider the Senator to be clean when no paint is visible in the wash solvent as it comes out of the spray gun. Because the printer included the date and time with each data block, it was also possible to determine how long the new cleaner took to flush the equipment. Some painters included the filter wash as part of the prewash, as described earlier. This is indicated by an asterisk in the filter wash column in Table 3-7. Cleaning data for the training sessions is included in averaging the amount of cleaner used to flush the equipment clean. However, the time for the training sessions is not included in the average for process time. The training sessions took longer than the normal cleaning procedure because time was taken to answer questions as they arose.

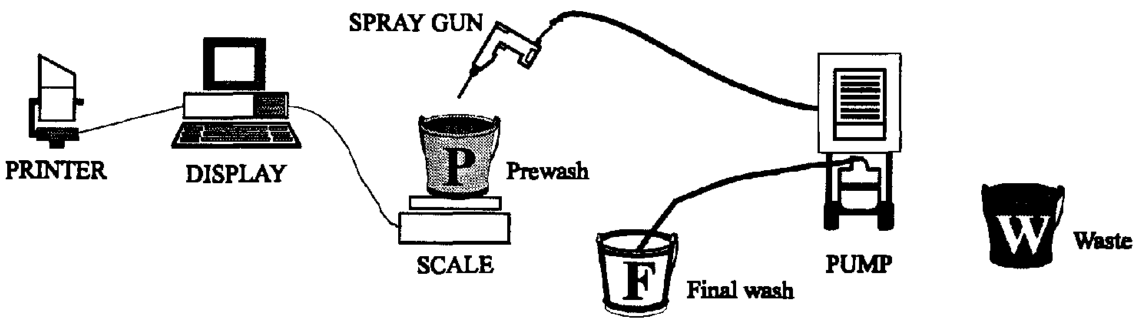
Although data were not collected for the Graco 5-gallon pump used only for spraying primer, the operators have used the blend to clean it since November 14, 1995.

The amount of MEK used to flush the Graco Senator clean of green CARC is shown in Table 3-8. As can be seen from the table, these data were collected after the completion of the demonstration. Although area Leadermen reported that the cleaning process takes two operators using five gallons of MEK about fifteen to twenty minutes per paint spray system to clean the equipment, data collected for verification indicate less MEK is actually used and the cleanup process takes less time. Because data for MEK usage were collected after the PC/BA demonstration, it is possible that the operators had gotten used to using less solvent and less time to clean the pumps. For this reason, the figures in Table 3-8 may be artificially low.

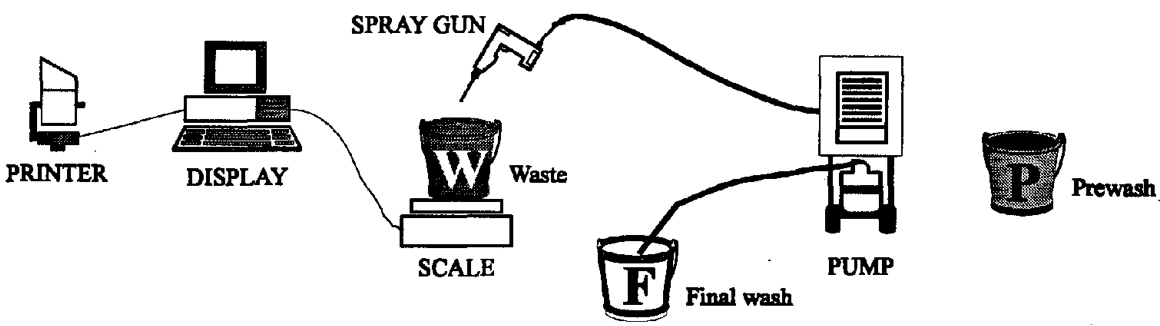
The values in Tables 3-7 and 3-8 form the basis of assumptions regarding usage in the economic analysis.



a. For prewash, paint pickup tube is placed in prewash bucket of used cleaner. Hazardous waste container is on scale.



b. For final wash, paint pickup tube is placed in final wash bucket of fresh cleaner. Prewash bucket is on scale.



c. For filter wash, paint pickup tube is placed in final wash bucket of fresh cleaner. Hazardous waste container is on scale.

FIGURE 3-6. SCHEMATIC FOR MONITORING CLEANING OF PAINT EQUIPMENT

TABLE 3-7. VOLUME AND TIME TO CLEAN EQUIPMENT WITH PC/BA

DATE	*START*	*STOP*	*PREWASH (gallons)*	*FINAL (gallons)*	*FILTER (gallons)*	*TOTAL (gallons)*	*ELAPSED TIME (h:mm:ss)*
11/28/95	3:21:03 PM	3:30:13 PM	0.90	0.65	*	1.55	0:09:10**
11/29/95	3:17:17 PM	3:26:38 PM	1.22	0.34	0.30	1.86	0:09:21**
11/30/95	3:26:08 PM	3:30:24 PM	1.45	0.27	*	1.72	0:04:16
12/05/95	3:33:31 PM	3:44:35 PM	0.86	1.16	*	2.02	0:11:04
12/13/95	3:23:51 PM	3:28:54 PM	1.00	0.62	0.29	1.91	0:05:03
12/14/95	10:26:35 AM	10:30:33 AM	1.21	0.97	0.57	2.75	0:03:58
12/14/95	3:25:43 PM	3:34:23 PM	0.83	0.59	0.56	1.98	0:08:40
12/15/95	11:32:28 AM	11:35:22 AM	1.24	0.69	0.72	2.65	0:02:54
					AVERAGE:	2.06	0:05:59
					STANDARD DEVIATION:	0.43	0:03:11

* Indicates filter wash was included with prewash

** Not included in average and standard deviation because the operators stopped to ask questions

TABLE 3-8. VOLUME AND TIME TO CLEAN EQUIPMENT WITH MEK

DATE	*START*	*STOP*	*PREWASH (gallons)*	*FINAL (gallons)*	*FILTER (gallons)*	*TOTAL (gallons)*	*ELAPSED TIME (h:mm:ss)*
12/19/95	3:23:09 PM	3:36:53 PM	1.19	0.34	0.95	2.47	0:13:44
12/20/95	3:18:59 PM	3:24:11 PM	1.15	0.53	1.17	2.85	0:05:12
12/21/95	3:17:51 PM	3:23:49 PM	1.27	0.57	0.46	2.30	0:05:58
03/06/96	4:34:35 PM	4:38:56 PM	1.75	0.98	0.48	3.21	0:04:21
03/06/96	9:22:07 AM	9:26:07 AM	1.34	0.60	0.50	2.44	0:04:00
03/06/96	1:06:22 PM	1:11:51 PM	1.41	0.72	0.52	2.65	0:05:29
03/07/96	4:27:56 PM	4:34:24 PM	1.60	1.41	0.57	3.57	0:06:28
					AVERAGE:	2.79	0:06:27
					STANDARD DEVIATION:	0.46	0:03:19

Feedback from the painters was generally positive. The painters reported that the new cleaner did not have an objectionable odor like MEK. They believed it removed the white primer from the Graco 5-gallon pumps much more effectively than MEK. They also believed that the "oily" nature of the PC/BA blend would reduce the binding that occurs when pumps are cleaned with MEK. The Senators still must be torn down approximately every two weeks; as paint builds up between the seals and packing, it causes the pump to seize up. However, the new cleaner was just as effective at cleaning the components of the torn-down pump as MEK. As of mid-March 1996, the MCLB reported that the Graco pump for primer has not required maintenance.

On the negative side, the operators were concerned about unknown health risks. They also did not like the fact that they cannot thin the CARCs with it. Material Safety Data Sheets (MSDSs) for the individual components of the blend were provided to the MCLB Safety and Health. These MSDSs were more detailed than the MSDS developed for the blend. (The MSDSs are included in Appendix 3-6; Safety issues are discussed in Section 3.5.3) The blend is not intended to be used as a thinning agent; it is to be used for cleaning only. The MCLB uses only approved thinning agents with CARC paints.

3.3.4 Regulations Affecting Alternative Cleaner

Replacing MEK with PC/BA decreases the burden of tracking and reporting for the MCLB. MEK is listed as a Hazardous Air Pollutant (HAP) under the Clean Air Act (CAA) Title III, section 112. Neither benzyl alcohol or propylene carbonate are classified as HAPs. Other regulations impacting the use of MEK are summarized in Table 3-9. Benzyl alcohol and propylene carbonate are not subject to these regulations.

TABLE 3-9. REGULATIONS IMPACTING THE USE OF MEK AND PC/BA

CAS	Chemical Name	Hazardous Substances CERCLA	Toxic Chemical SARA	RCRA Code	CAA, Title III Section 112
78-93-3	Methyl ethyl ketone	5,000 lbs.	313	U159	yes
100-51-6	Benzyl alcohol	Not listed	Not listed	Not listed	no
108-32-7	Propylene carbonate	Not listed	Not listed	Not listed	no

MEK is subject to reporting requirements under Title III of the Superfund Amendments and Reauthorization Act (SARA). Releases of CERCLA hazardous substances, in quantities equal or greater than their reportable quantity, are subject to reporting to the National Response Center under CERCLA. Such releases are also subject to state and local reporting under section 304 of SARA Title III. MEK is classified as a CERCLA hazardous substance; its reportable quantity is 5,000 lbs. Neither benzyl alcohol nor propylene carbonate are classified as CERCLA hazardous substances.

MEK is also classified as a toxic chemical under SARA Title III, section 313. Emissions, transfers, and waste management data of MEK must be reported annually as part of the community right-to-know provisions of SARA Title III. Neither benzyl alcohol nor propylene carbonate are classified reportable under SARA Title III, section 313.

Because MEK is flammable, it is classified as a RCRA hazardous waste. The hazardous waste RCRA code for MEK is indicated in Table 3-9. Neither benzyl alcohol nor propylene carbonate are subject to RCRA. Because the paint used at the MCLB is not RCRA-regulated either, the PC/BA-paint waste stream is not RCRA-regulated.

3.4.0 QUALITY ASSURANCE

3.4.1 Alternatives Evaluation Phase

Calibration and Standardization of Laboratory Balance: Evaluation of the alternative cleaners after the initial qualitative screening relied on data from a precision balance at the laboratory (Mettler Model AT261, Serial Number N71359). This balance is calibrated yearly by an outside service. The digital output of the balance is readable to the nearest 0.01 mg. The balance was leveled and zeroed before each weighing. Calibration was checked daily with a 1000.00 mg weight prior weighing samples.

Materials Compatibility: Materials coupons were weighed to the nearest 0.01 mg. Control coupons were weighed along with the experimental coupons used to assess the cleaners. A summary of weight changes for test coupons and control coupons is provided in Table 3-4. Control coupons were never wetted by cleaner. After weighing they were immediately returned to their container. For the metals and Teflon®, which show virtually no effects due to cleaner, the very small variability of the controls is comparable to the variability of the coupons. Control coupons for Delrin®, acetal, and Nylon® showed much greater weight changes than did the metals and Teflon®. Even for the plastics, however, the controls' weight changes were less than the weight changes for the cleaner-treated coupons. Changes in humidity could have contributed to some weight variability for the controls.

Paint Removal Efficiency: Table 3-5, which gave the removal effectiveness for several combinations of coatings and cleaners, shows individual standard deviations of up to about 20%. Assuming an average paint weight of approximately 8000 mg, a standard deviation of 20% corresponds to 1600 mg, which is much larger than the estimated error intrinsic in the balance. Most of the observed variability must be ascribed to real variations from a variety of causes. Controls were used during the removal efficiency assessments (see Appendix 3-4). These controls showed weight gains (no losses) between 0.01 and 0.33 mg. The controls' weight variations were negligible. Averaged over four different coatings, MEK has a slightly higher cleaning efficiency; however the differences between the cleaning efficiencies for the three cleaners reported in Table 3-5 are not statistically significant.

3.4.2 On-Site Demonstration

The primary Quality Assurance (QA) goal for the on-site portion of this project was to estimate and control the net error in the estimates of solvent usage for MEK and the MEK substitute. These estimates were derived from weighings taken with the Weigh-Tronix Flow Monitoring System model WI-130 that was installed at one paint booth. The chief sources of error, uncertainty, and variability included the following:

- errors in the balance - zero offset, nonlinearity, and instrument noise,
- ambient vibration and noise, and
- variability of amount paint used between cleanings.

The balance was set up at the site according to the manufacturer's specifications. This included assuring that the feet had solid support (concrete floor) and that the balance transducer was level. The accuracy and linearity of the electronic balance were assessed using a 25-pound weight supplied by the manufacturer. The accuracy and linearity of the balance were checked following setup of the scales at the MCLB by using the 25 lb. weight that had been independently checked at RTI's laboratory facilities. Accuracy and linearity were checked daily during site visits by the project's engineers throughout the demonstration period. The balance, as installed, was accurate within the resolution of the scale, and the linearity was also good.

Random noise experienced by the balance was evaluated in another task under this project. Approximately one hour's worth of data was acquired at one minute intervals from the balance while it was unused and there was no activity in the area. This provided an estimate of the scatter in data that may be attributed to the combined sources of noise affecting the balance. These included electrical and instrumental noise, as well as the effects of wind and ambient vibrations. The noise level was found to be approximately 0.02 gallons. This amount of noise is very small compared with the amount of cleaner typically used in a single cleaning.

The average amount of PC/BA used for six cleanings performed by the MCLB painters during the demonstration was 2.06 ± 0.43 gal. The uncertainty in this cleaner usage estimate is clearly dominated by operational variability rather than by instrumental accuracy and precision.

Prior to the start of the demonstration, area Leadermen reported that the cleaning process takes two operators about fifteen to twenty minutes and about 5 gallons of MEK per paint spray system. The average amount of MEK used for six cleanings performed by the MCLB painters was 2.79 ± 0.46 gallons; the time was about 6.5 minutes. The measured amounts were approximately half the estimated amounts. It is unclear, and cannot be determined, whether the Leadermen overestimated how much cleaner is actually used or whether the operators became used to using less cleaner over the course of the demonstration, resulting in lower figures. These two factors affect the accuracy of the usage numbers by as much as 50%.

3.5.0 IMPLEMENTATION PLAN

3.5.1 Equipment

Since the replacement cleaner was used as a direct substitute, capital investment required was minimal. A hand pump to fit on the 55-gallon drum was purchased. The pump was the same type as other hand pumps used at the MCLB. If available, one of these other hand pumps could have been used. Painters can pump from the drum into smaller 5-gallon buckets if desired.

3.5.2 Materials

The cleaner blend used in this demonstration is not available as a single commercial product. However, the components, propylene carbonate and benzyl alcohol, are commercially available. The product was ordered as a custom-made blend from a chemical products company, Eldorado Chemical Company, Inc., in San Antonio, TX. The company has assigned the product number ES-120 to this blend for identification purposes. It is likely that arrangements could be made with other vendors to blend the material. A list of chemical suppliers follows in Table 3-10.

TABLE 3-10. CHEMICAL SUPPLIERS FOR PC/BA

Alchem
5360 Tulane Drive
Atlanta, GA 30336
404-696-9202

American Industrial Chemical
1819 South Cobb Industrial Boulevard
Smyrna, GA 30082
770-434-8300

Baychem, Inc.
3200 Moon Station Road
Kennesaw, GA 30144
404-429-1405

Eldorado Chemical Company, Inc
PO Box 34837
San Antonio, TX 78265-4837
210-653-2060

The components, propylene carbonate and benzyl alcohol, can be purchased from other sources. Propylene carbonate typically costs about $0.90/lb and benzyl alcohol is normally $1.50/lb. At the time of demonstration, availability of benzyl alcohol was limited and the price was closer to $2.00/lb. No special expertise is required for blending. The formulation is a simple ratio by weight. The components may purchased separately and blended on-site.

3.5.3 Safety

The Material Safety Data Sheets for the components, propylene carbonate and benzyl alcohol, have been included in Appendix 3-6. These MSDSs are more detailed than the MSDS for the blend itself.

The cleaner is less toxic and has a much lower vapor pressure than MEK and so poses less of an inhalation hazard than MEK. However, proper ventilation is still necessary to prevent buildup of vapors. Also, lower vapor pressure means it will not evaporate quickly if accidentally splashed on skin. Gloves should be worn when handling the cleaner to prevent skin contact. Benzyl alcohol is a severe eye irritant. Safety glasses are necessary to prevent eye contact with the cleaner. Operators should also wash their hands before smoking or eating.

The MSDS for benzyl alcohol warns against mixing with isocyanates. Some of the CARCs contain isocyanates. This warning does not refer to any formation of hazardous compounds. The alcohol will affect the curing properties of the paint. Polyisocyanates consist of a polyol catalyzed by an isocyanate. Polyols have two or more OH (hydroxyl) functional groups, which serve as crosslinking sites, on the chain. The more functional groups available on the chain, the higher the crosslinking density and the better the chemical resistance. An alcohol such as benzyl alcohol, with only a single OH functional group, would act as a chain stopper because it has only one crosslinking site. A high proportion of alcohol would prevent the coating from fully crosslinking and achieving a full cure. For cleaning purposes, this is an advantage. However, the painters must discharge paint from the gun to flush the cleaner completely before painting vehicles.

3.5.4 Economic Analysis

One aspect of changing process operations for pollution prevention purposes is the effect on capital and annual cost. Pollution prevention changes are more likely to be embraced if these costs stay the same or decrease. The following sections provide measures of capital and annual costs for replacing MEK with PC/BA.

The methodology for estimating costs is taken from the EPA methods described in the OAQPS Control Cost Manual[1], which allows a convenient means of comparing different processes based on their annualized costs. Where actual costs are not known, factors applied to base equipment costs are used to estimate the remaining costs. These factors have been developed from a wide variety of sources associated with pollution control systems. The method provides a study estimate, which is intended to give a cost estimate within an accuracy range of

±30% of the actual cost when all the information affecting the costs is reasonable well known. This accuracy range is typical for EPA's estimates of pollution control systems when assessing cost impacts on existing or model facilities. Greater accuracy can be obtained with budget authorization estimates (±20%), definitive estimates (±10%), or contractor's estimates (±5%). Improved accuracy of the estimate is obtained only by improving the detailed knowledge of items that make up the estimate. In the present case, the firm costs obtained for most of the capital items could lead to a contractor's estimate if no assumptions were required for the remaining costs. However, unit costs, rates, and consumptions (listed in section 3.5.4.3) are not known with sufficient accuracy to go beyond a study estimate.

The estimates for cleaner substitution costing have only a few elements that must be considered.

3.5.4.1 OAQPS Control Cost Manual

Analysis of the costs associated with the pollution prevention project is performed such that comparisons can readily be made between competing processes. A consistent format for costing is used so that comparisons are valid. To be compatible with EPA usage, the format in this report is taken from the OAQPS Control Cost Manual as mentioned above. The methodology used in the manual divides costs into two major categories, capital costs and annual costs, as described below. For the economic analysis to be meaningful, it must include all elements associated with implementation of new technologies. An exception is the case in which no new capital costs are incurred. Capital and annual costs can be further subdivided into the categories shown below:

- Site preparation and buildings
- Equipment
- Emission controls
- Materials
- Energy and utility requirements
- Labor requirements, including training

- Waste disposal
- Special transportation costs (hazardous materials)
- Recovery credits
- Overheads and capital recovery
- Accommodation costs (for changes in use or behavior forced by the new technology).

Treatment of each of the cost elements is briefly described below. As used in the OAQPS Control Cost Manual, the first three items are capital costs, while the remainder are annual costs.

After all the cost elements are collected, they are presented as tables of capital and annual costs.

Capital Costs

Capital cost items are those requiring relatively large expenditures for land, buildings, and equipment expected to have a lifetime longer than a year (usually many years). Specific items are collected in the following paragraphs. For those cases in which explicit costs are not available, the factor method is used to estimate reasonable costs. Factors (as multipliers of the purchased equipment cost) are available in costing manuals or can be based on engineering judgement.

Site Preparation and Buildings: No site preparation (land clearing and leveling) or new buildings were required for the pollution prevention project.

Equipment and Emission Controls: Equipment costs include either new purchases (including add-ons) or modifications for existing items. Costs include installation. These costs are taken from invoices, vendor quotes, or other records where available, or are estimated from cost manual data.

Indirect Costs: Associated with purchase and installation of equipment are the indirect costs that include engineering, construction and field expense, contractor fees, start-up, performance tests, and contingencies. Not all of these items are required.

Annual Costs

Annual costs include expenditures for operating and maintenance labor and materials, utilities, and waste disposal. Indirect costs include overheads, administrative charges, property taxes (where applicable), insurance, and capital recovery. With the exception of overheads, the indirect annual costs are related to capital costs. The annual cost elements are described in the following paragraphs. The sum of the annual costs provides a total annual cost that is useful for comparison with other systems or technologies.

Materials: Materials include raw materials for operation, and maintenance materials for repairs and preventive maintenance. Costs and usage rates for materials are obtained from MCLB records, vendors, or estimates from MCLB or RTI project personnel.

Energy and Utility Requirements: Energy and utility usage rates are taken from MCLB records, project data, or estimates for the equipment or process being analyzed. Included for this project are electric power, steam, water, and compressed air.

Labor Requirements: As with materials, labor is divided into operating and maintenance categories. Operator labor hours are estimated from project records or from observation by project personnel. Maintenance labor hours are projected based on estimates of project personnel. Labor hours are also required for supervision and for training.

Waste Transportation and Disposal: Waste disposal costs include wastewater treatment, solid waste disposal, and hazardous waste treatment or disposal. Transportation costs are included in the waste disposal costs. Quantities are taken from MCLB records or are projected from project data.

Recovery Credits: Recycling of spent cleaners may provide money to offset costs of operation.

Overheads and Capital Recovery: General and administrative overheads, property tax, and insurance are taken from information provided by MCLB or from estimates by project personnel. Capital recovery charges are estimated from current EPA usage for interest rates; equipment lifetimes are based on engineering judgement.

Accommodation Costs: Identifiable costs are included here that are associated with a changeover to new technology.

3.5.4.2 Obtaining Cost Elements

Capital Costs

Because the factor method is dependent on base equipment costs for its capital cost accuracy, special care must be taken to record all of the individual items purchased. For the present work, each required item is purchased through RTI's purchasing department. All RTI purchases are posted on a computer operated accounting system that allows identification of each item associated with the project.

Annual Costs

Annual cost items are largely dependent on the labor, utility, and materials costs associated with operating a process and on recovery of capital. As with capital costs, accuracy of the annualized cost estimate depends on the accuracy of the information collected for these cost elements and also for the usage rates associated with the operating costs. Capital costs remain important in estimating annualized costs because most of the costs and the capital recovery cost depend on purchased equipment costs. For the present project, unavailability of some unit costs and usage rates may affect the accuracy (and the conclusions) of the economic analysis.

3.5.4.3 Unit Costs, Rates, and Assumptions for Economic Analysis

Unit costs and Rates Used Throughout Economic Analysis

The following unit costs and rates were used throughout the economic analysis. Sources for unit costs and rates are cited.

- Operating labor costs are $16.52/hr, taken and updated from the OAQPS Cost Control Manual, pp. 7-43, April 1991.
- Maintenance labor costs are $18.17/hr, taken and updated from the OAQPS Cost Control Manual, pp. 7-43, April 1991.
- Supervisory labor costs are 115% of operating labor costs, taken from the OAQPS Cost Control Manual, pp. 7-43, April 1991.

- Training costs are $33.04/hr based on twice the operating labor rate.
- Waste disposal costs for low-end wastes include $0.35/lb for transportation and $0.80/lb for disposal, based on interpolation from MCLB estimate.
- Waste disposal costs for high-end wastes include $0.35/lb for transportation and $1.80/lb for disposal, based on interpolation from MCLB estimate.
- Electricity costs $0.0709/kWh, cited in *Chemical Engineering*, January 1995.
- Compressed air costs $0.19/1,000 scfm from example problem in OAQPS Cost Control Manual, pp. 5-49 (April 1991). Updated with *Chemical Engineering* (CE) cost index.
- MEK costs $3.88/gal based on MCLB records for early 1995.
- The replacement cleaner PC/BA costs $12.60/gal based on the prices of the two components and assuming the MCLB blends the cleaner on-site.
- Permit charge of $25/ton for air emissions is not required, based on MCLB information.

Assumptions Used for PC/BA Cleaning

The following assumptions were used for cleaning with PC/BA.

- No new capital costs are incurred for switching to PC/BA.
- Actual time for cleaning is based on 0.10 hrs/cleaning x 1 cleaning/day x 2 operators/booth x 4 booths.
- Usage is 2.0 gallons PC/BA/cleaning.
- Maintenance hours are primarily for pumps; 0.5 hr/pump/month for 4 booths.
- Air consumption is 60% of the amount required for MEK based on shorter cleaning time.
- Waste disposal is based on 95% of the PC/BA going to disposal and 5 percent to evaporation. Low-end disposal charge applies.

Assumptions Used for Cleaning with MEK

The following assumptions were used for cleaning with MEK.

- No new capital costs are incurred for using MEK.
- Time for cleaning is based on 0.15 hrs/cleaning x 1 cleaning/day x 2 operators/booth x 4 booths, based on observation of area Leadermen.
- Annual usage based on average of neat MEK purchased over 3-year period.
- Maintenance hours are primarily for pumps; 1.0 hr/pump/month for 4 booths.
- Power usage is estimated at 0.4 kW for miscellaneous electrical loads.
- Air consumption is based on 22 scfm/gun x 2 guns/booth x 3.4 min/cleaning [when gun has air going through it] x 1 cleaning/day x 4 booths.
- Waste disposal is based on 25 percent of the MEK going to disposal and 75 percent to evaporation. High-end disposal charge applies.

3.5.4.4 Solvent Substitution

Results of Costing for Solvent Substitution

Table 3-11 shows the estimated annualized costs for using PC/BA as a replacement cleaning solvent for MEK. Because this is a direct substitution of one solvent for another, no capital costs are shown. The total amount is about $97,094/yr with the top three elements being the cost of the solvent, labor hours for using the solvent (including overheads), and disposal costs.

TABLE 3-11. ANNUALIZED COST ANALYSIS OF CLEANING WITH PC/BA

DIRECT ANNUAL COSTS, DC	
Operating Labor	
Operator *([0.8 hours/day]*[260 days/year]*[$16.52/hour])*	$3,436
Supervisor *(15% of operator)*	$515
Training *([4 hours/year/employee]*[$33.04/hour]*[32 employees])*	$4,229
Operating Materials	
PC/BA *([$12.60/gallon]*[4,160 gal/year])*	$52,416
Maintenance	
Labor *([0.0125 hours/day]*[260 days/year]*[$18.17/hour])*	$59
Material *(Equal to Maintenance Labor)*	$59
Utilities	
Electricity *([3.2 kW]*[$0.071/kWhour]*[23.3 hours/year])*	$5
Compressed air *([10560 scfm/hour]*[$0.19/1000 scfm]*[23.3 hours/year])*	$47
Waste Disposal *([13.63 tons/year]*[$2,300/ton])*	$31,349
Total Direct Cost, DC	*$92,115*
INDIRECT ANNUAL COSTS, IC	
Overhead (60% of sum of labor + maintenance materials)	$4,979
Administrative charges *TCI * 0.02*	$0
Property taxes *TCI * 0.01*	$0
Insurance *TCI * 0.01*	$0
Capital recovery *CRF*TCI (CRF=0.1424)*	$0
Total Indirect Costs, IC	*$4,979*
TOTAL ANNUAL COST, TAC (TAC = DC + IC)	**$97,094**

Comparison with Current Solvent

Table 3-12 shows the estimated annualized costs for using MEK as a cleaning solvent. Total annualized cost is about $93,947 or about 97 percent of the cost for PC/BA. The major costs elements are for the solvent and its disposal.

PC/BA is a less polluting cleaner, is as effective at cleaning, and reduces maintenance on pumps. However, because it costs over 3 times that of MEK, the annualized cost for PC/BA is higher than that of MEK. Returning the waste cleaner to the manufacturer for reclaiming, even at zero credit, would reduce the annualized cost of using PC/BA below that of MEK. Buying the PC/BA from a chemical supplier will cost almost 50% more than blending the cleaner on-site; these savings have been figured into the cost estimate. More cost savings could be realized by filtering and reusing the cleaner.

Other advantages of PC/BA are lower usage rate and lower disposal costs (lower quantities and lower unit cost). Reduced time for cleaning may also be indicative of long-term savings in equipment costs due to longer equipment life.

TABLE 3-12. ANNUALIZED COST ANALYSIS OF CLEANING WITH MEK

DIRECT ANNUAL COSTS, DC	
Operating Labor	
Operator *([1.2 hours/day]*[260 days/year]*[$16.52/hour])*	$5,154
Supervisor *(15% of operator)*	$773
Training *([4 hours/year/employee]*[$33.04/hour]*[32 employees])*	$4,229
Operating Materials	
MEK *([$3.88/gal]*[10,175 gal/year])*	$39,479
Maintenance	
Labor *([0.025 hours/day]*[260 days/year]*[$18.17/hour])*	$118
Material *(Equal to Maintenance Labor)*	$118
Utilities	
Electricity *([3.2 kW]*[$0.071/kWhour]*[38.9 hours/year])*	$9
Compressed air *([10560 scfm/hour]*[$0.19/1000 scfm]*[38.9 hours/year])*	$78
Waste Disposal *([8.78 tons/year]*[$4,300/ton])*	$37,754
Total Direct Cost, DC	*$87,712*
INDIRECT ANNUAL COSTS, IC	
Overhead (60% of sum of labor + maintenance materials)	$6,235
Administrative charges *TCI * 0.02*	$0
Property taxes *TCI * 0.01*	$0
Insurance *TCI * 0.01*	$0
Capital recovery *CRF*TCI (CRF=0.1424)*	$0
Total Indirect Costs, IC	*$6,235*
TOTAL ANNUAL COST, TAC (TAC = DC + IC)	**$93,947**

3.5.4.5 Return on Investment and Payback Period for Cleaning Solvent Replacement

Return on investment (ROI) and payback period (PP) are two common measures for estimating the profitability of a venture. Return on investment as used for this project is the average yearly profit divided by total capital investment, expressed as a percentage. The average yearly profit is taken as the difference in annualized cost between the existing process and its intended pollution prevention replacement.

Payback period is the total capital investment divided by the sum of profit (as used above) and depreciation of the pollution prevention equipment. For this project, the straight line depreciation method is used with a 5 percent salvage value. Depreciation is total capital investment minus salvage value, all divided by equipment life.

Because the replacement of one cleaning solvent with another requires no capital investment, neither ROI or PP can be estimated. However, one may compare the total annualized costs for the existing cleaner and for its pollution prevention replacement as given in the previous section.

3.6.0 DISCUSSION OF OBJECTIVE

As discussed previously, the MCLB is required to reduce emissions from hazardous air pollutants by 50% from 1992 levels. The MCLB provided a summary of their purchase history of toxic materials for 1992[2]. Table 3-13 shows the hazardous air pollutants from this list.

The MCLB has already replaced 1,1,1-trichloroethane vapor degreasers with aqueous parts washers. This change alone will reduce emissions from HAPs by 16%. By eliminating the MEK used for cleaning purposes, the MCLB can further reduce emissions from HAPs another 21%. The MCLB has also replaced methylene chloride with n-methyl pyrrolidone for immersion paint stripping, reducing emissions from HAPs an additional 11%. These three changes combined result in a reduction of emissions of 48%.

Five of the chemicals listed in Table 3-13 are components in paints and coatings used at the MCLB. The MCLB plans to replace solvent-borne CARCs with water-borne CARCs in 1996 to achieve over 50% reduction in emissions from HAPs.

TABLE 3-13. SUMMARY OF HAZARDOUS AIR POLLUTANTS BASED ON 1992 PURCHASE HISTORY

CONSTITUENT	*LBS.*	*USE*
1,1,1-trichloroethane	49,077	neat - degreaser
ethyl benzene	1,465	component - aircraft thinner
ethylene glycol	75,527	neat - antifreeze
methyl isobutyl ketone	613	component - paints
methyl ethyl ketone	89,787	63,810 lbs. neat for paint cleanup/remainder in paints
methylene chloride	33,700	component - paint stripper
toluene	18,533	component - paints
trivalent chromium	16,801	component - paints
xylene	16,600	component - paints

3.7.0 CONCLUSIONS

Based on this demonstration, the following conclusions may be drawn:

- PC/BA cleans green CARC from the pumps as well as MEK.
- PC/BA cleans epoxy primers from the pumps better than MEK.
- PC/BA removes additional paint from pumps previously cleaned with MEK.
- The inhalation hazard to workers is reduced with the use of PC/BA.
- The use of PC/BA neither increases or decreases downtime of the pumps used for applying CARC.
- The use of PC/BA decreases downtime of the pumps used for applying primer.
- The use of PC/BA does not cause clumps of paint to form, which could cause the pumps to seize.
- The raw material cost for the PC/BA blend is higher than for MEK. The higher cost may be offset by recovery and reclamation of the PC/BA.

Other advantages of PC/BA for the MCLB are

- replacing MEK with PC/BA will reduce the HAP emissions at MCLB by 21%, thus achieving over 40% of their overall goal with this one process change.
- PC/BA-paint waste generated at the MCLB is not RCRA regulated. (The waste may be subject to RCRA regulations if the paint contains high concentrations of metal pigments.)

- PC/BA is not subject to SARA Title III reporting, and is not a HAP under the CAA, Title III, section 112.
- PC/BA does not dry out the seals and packings of the pumps between maintenance as did MEK.

3.8.0 RECOMMENDATIONS

The first recommendation is to extend the use of this cleaner to the other paint booths. Also recommended is reclaimation of the used cleaner to extract the benzyl alcohol, the more expensive of the two components in the cleaner. MCLB has already taken steps in this direction by sending a gallon sample of the used solvent to Eldorado Chemical. It is not cost effective to reclaim the propylene carbonate.

Although MEK is used at the MCLB for both thinning and cleaning, the project's objective was in demonstrating a pollution prevention alternative, in this case PC/BA, for cleaning purposes only. Therefore, pursuing approval from the coatings manufacturer to thin with this cleaner is not recommended since thinning with this cleaner will adversely affect the curing properties of the coatings.

3.9.0 REFERENCES

1. OAQPS Control Cost Manual, EPA-450/3-90-006 (NTIS PB90-169954), January 1990.

2. Woodward, John. MCLB Albany, GA. Letter to Principal Director, Maintenance Directorate, dated June 14, 1993.

APPENDIX 3-1

Material Safety Data Sheets
for Coatings:

PRATT & LAMBERT 316-733-1361
Industrial Coatings Div.
P.O. Box 2153
Wichita, KS 67201

DOT EMERGENCY CHEMTEL (800)255-3924 (24hrs)
INFORMATION PHONE NO. 316-733-1361 (M-F 8 AM-5 PM CT)

CORPORATE CONTACT 716-873-6000 (M-F 8 AM-5 PM CT)

H.M.I.S.	
HEALTH	3*
FLAMMABILITY	3
REACTIVITY	0

These ratings should be used only as part of fully implemented H.M.I.S. program.

MATERIAL SAFETY DATA SHEET

SECTION I

PRODUCT CLASS GOVERNMENT SPEC. MAT — DATE OF PREPARATION 6/07/95

TRADE NAME COATING,ALIPH.POLYUR.TAN 686A, 33446 — MIL-C-53039A AM 2

MANUFACTURER CODE I.D. 705131 87

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENT	% BY WGT	CAS NO.	ALLOWABLE EXPOSURE LEVEL	PPM	MG/CU.M.	MPPCF	SKIN	SARA 313	VP mm Hg 20 DEG.
METHYL ISOBUTYL KETONE	10	108-10-1	TLV-TWA	50	205			X	16
			TLV-STEL	75	300				
			OSHA-PEL	100	410				
			OSHA-STEL	75	300				
			LFL 1.0 UFL 8.0						
SOLVENT NAPTHA,HEAVY AROMATIC	5	64742-94-5	NONE ESTABLISHED						
N-BUTYL ACETATE	5	123-86-4	TLV-TWA	150	710				10
			TLV-STEL	200	950				
			OSHA-PEL	150	710				
			OSHA-STEL	200	950				
			LFL 1.7 UFL 7.6						
ACETATE ESTER ALCOHOL	5	108419-32-5	NONE ESTABLISHED						
XYLENE	< 5	1330-20-7	TLV-TWA	100	435			X	5
			TLV-STEL	150	655				
			OSHA-PEL	100	435				
			OSHA-STEL	150	655				
			LFL 1.0 UFL 7.0						
TOLUENE	5	108-88-3	TLV-TWA	50	147		SKIN	X	22
			OSHA-PEL	100	375				
			OSHA-STEL	150	560				
			LFL 1.7 UFL 7.1						
SILICA, CRYSTALLINE-QUARTZ	< 1	14808-60-7	TLV-TWA		0.1000				
			OSHA-PEL		0.1000				
SILICA, CRYSTALLINE-CRISTOBALITE	10	14464-46-1	TLV-TWA		0.0500				
			OSHA-PEL		0.0500				
SILICA, AMORPHOUS-DIATOMACEOUS EARTH	5	68855-54-9	TLV-TWA		10				
			OSHA-PEL		6	20			
SILICA, CRYSTALLINE	5	14808-60-7	TLV-TWA		0.1000				
			OSHA-PEL		0.1000				
TITANIUM DIOXIDE	10	13463-67-7	TLV-TWA		10				
			OSHA-PEL		10				
ISOPHORONE DIISOCYANATE	< 5	4098-71-9	TLV-TWA	0.0050	0.0450		SKIN		1
			OSHA-PEL	0.0050	0.0200		SKIN		
DIBUTYL TIN DILAURATE	< 1	77-58-7	TLV-TWA		0.1000		SKIN		
			OSHA-PEL		0.1000				
POLYMERIC HEXAMETHYLENE DIISOCYANATE	25	28182-81-2	MFR		1				
SOLVENT NAPTHA , LIGHT AROMATIC	< 5	64742-95-6	NONE ESTABLISHED						
1,6 HEXANE METHYLENE DIISOCYANATE	<0.100	822-06-0	TLV-TWA	0.0050	0.0350				
			MFR	0.0050					

LFL = LOWER FLAMMABILITY LIMIT PERCENT
UFL = UPPER FLAMMABILITY LIMIT PERCENT
SKIN = SKIN ABSORPTION MUST BE CONSIDERED AS A ROUTE OF EXPOSURE
C-CEILING= ALLOW. EXPOSURE LEVEL SHOULD NOT BE EXCEEDED FOR ANY TIME PERIOD
MFR = MANUFACTURER RECOMMENDED EXPOSURE LIMIT
STEL = SHORT TERM EXPOSURE LIMIT

SECTION II - HAZARDOUS INGREDIENTS; (CONTINUED)

X-SARA 313 = CHEMICAL IS SUBJECT TO REPORTING REQUIREMENTS OF SECTION 313 OF TITLE III OF S.A.R.A. 40 CFR PART 372

SECTION III - HEALTH INFORMATION

EFFECTS OF SHORT TERM OVEREXPOSURE

SWALLOWING

May be fatal if swallowed.
Can cause gastrointestinal irritation, nausea, and vomiting. Aspiration of material into lung may cause chemical pneumonitis which can be fatal.

INHALATION

WARNING vapor and spray mist harmful. Overexposure may cause lung damage.
May cause lung irritation and allergic respiratory reaction. Effects may be permanent.
May cause respiratory sensitization (potential for allergic reaction).
May cause nose or throat irritation. High concentrations may cause acute central nervous system depression characterized by headaches, dizziness, nausea and confusion.

EYE

May cause severe eye irritation.

SKIN

Liquid material may be absorbed through the skin in harmful amounts.
Primary skin irritant.
May cause skin sensitization (allergic reaction).
May cause severe skin irritation.

EFFECTS OF REPEATED OVEREXPOSURE

Repeated and prolonged occupational overexposure to crystalline silica may cause silicosis, a progressively disabling lung disease.
Overexposure to xylene may cause injury to the liver, kidneys, and blood.
The OSHA Permissible Exposure Limit for amorphous silica is 20 Mppcf or

$$PEL = \frac{80mg/M3}{\%SiO2}$$

Repeated overexposure to toluene may cause liver damage.
Repeated exposure to diisocyanates may result in respiratory sensitization in some individuals. Respiratory sensitivity results in asthma-like symptoms on subsequent exposure at concentrations even below the TLV.
Prexisting respiratory conditions may be aggravated by exposure to crystalline silica.
Reports have associated prolonged and repeated occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal.

SIGNIFICANT LABORATORY DATA WITH POSSIBLE RELEVANCE TO HUMAN HEALTH.

Titanium dioxide IS NOT listed as a potential carcinogen by the National Toxicology Program, the International Agency for Research on Cancer, OSHA, or A.C.G.I.H. Titanium dioxide in a 24-month inhalation study with rats revealed a significant increase in benign and malignant lung tumors in the group exposed to 250mg/M3 respirable TiO2 dust. At lower exposure levels, this significant effect was not observed. The normal clearance mechanisms of the lungs may have been overwhelmed at the 250mg/M3 exposure level, and this may have contributed to the tumor formation. These results may not be directly relevant to the workplace where occupational exposure limits are observed. At the TLV the TiO2 manufacturer concludes that there is no significant hazard for man.
Toluene has been found to cause kidney, lung and spleen damage in laboratory animals.
Laboratory studies involving rats indicates that Methyl Isobutyl Ketone may damage the kidneys.
The International Agency for Research on Cancer considers crystalline silica to have limited evidence of carcinogenicity in humans and sufficient evidence in experimental animals (IARC Group 2A).

SECTION IV - FIRST AID AND EMERGENCY PROCEDURES

SWALLOWING

If swallowed do not induce vomiting. Call poison control center, hospital emergency room or physician immediately.

INHALATION

Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep warm and quiet. Get medical attention immediately.

EYE

Flush with large amounts of water, lifting upper and lower lids occasionally. Continue for at least 15 minutes. Get medical attention.

SKIN

Remove contaminated clothing. Wash affected area with soap and water. Obtain medical attention if irritation persists.

NOTES TO PHYSICIAN

Any treatment that might be required for overexposure should be directed at the control of symptoms and the clinical conditions.

SECTION V - PHYSICAL DATA

BOILING RANGE 210 DEG.F. (99 DEG.C.) TO 419 DEG.F.(215 DEG.C.)

VAPOR DENSITY than air. — **% VOLATILE BY VOLUME** 49

EVAPORATION RATE Slower than diethyl ether. — **VOC** 3.50 lb/gal less water & NFRS* 420 g/l less water CALCULATED

WEIGHT LB./GAL. 10.5 — **VOC** 6.89 lb/gal solids 827 g/l solids CALCULATED

SPECIFIC GRAVITY 1.3

SECTION V - PHYSICAL DATA; (CONTINUED)

All Physical data determined at 68 DEG. F. (20 DEG. C.) 760 mm Hg
* Negligibly Photochemically Reactive Materials
VOC values reported here are verified by ASTM method D-3960

SECTION VI - FIRE AND EXPLOSION DATA

NFPA FLAMMABILITY CLASSIFICATION FLAMMABLE LIQUID - CLASS IB

FLASHPOINT 40 DEG.F, (4 DEG.C,) CALCULATED

EXTINGUISHING MEDIA
Use NFPA Class B Fire extinguishers (carbon dioxide, all purpose dry chemical or alcohol foam) designed to extinguish flammable liquid fires. Polymer foam is preferred for large fires.

UNUSUAL FIRE AND EXPLOSION HAZARDS
During emergency conditions, overexposure to decompostion products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.
WARNING! FLAMMABLE.

SPECIAL FIRE FIGHTING PROCEDURES
Firefighters should wear self-contained breathing apparatus.
Water may be ineffective, but may be used to cool exposed containers to prevent pressure build-up and possible auto-ignition or explosion when exposed to extreme heat. If water is used, fog nozzles are preferable.

SECTION VII - REACTIVITY DATA

STABILITY
Normally stable.

CONDITIONS TO AVOID
Avoid excessive heat (>115 F (46 C) and sources of ignition.

INCOMPATABILITY (MATERIALS TO AVOID)
Strong acids or alkaline materials.
Oxidizing materials.

HAZARDOUS DECOMPOSITION PRODUCTS
Burning, including when heated by welding or cutting, will produce smoke, carbon monoxide and carbon dioxide.In addition, oxides of nitrogen may be generated.
The reaction of isocyanates with water may produce carbon dioxide gas which may result in container pressurization.

HAZARDOUS POLYMERIZATION
Will not occur

CONDITIONS TO AVOID
None known

SECTION VIII - ENVIRONMENTAL INFORMATION

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
The use of a NIOSH/MSHA approved, TC19C, air-supplied breathing apparatus may be required. Consult with a qualified occupational health and /or safety professional.
Wear respirators, eye, hand, and body protection appropriate for the size of the spill and the exposures encountered.
Keep spectators away. Eliminate all ignition sources (flames, hot surfaces, and sources of electrical, static or frictional sparks).
Dike and contain spill with inert material (e.g. sand, earth). Transfer liquids to covered metal containers for recovery or disposal, or remove with inert absorbent. Use only non-sparking tools. Place absorbent diking materials in covered metal containers for disposal. Prevent contamination of sewers, streams, and groundwater with spilled material or used absorbent.

WASTE DISPOSAL
Dispose in accordance with federal, state and local regulations.

RCRA CLASSIFICATION
This product, if discarded directly, would be classified a hazardous waste based on its ignitability characteristic, i.e. has a flash point of 140 deg. F (60 deg.C) or less. The proper RCRA classification would be D001.

ENVIRONMENTAL HAZARDS
None known

SECTION IX - PERSONAL PROTECTION INFORMATION

RESPIRATORY PROTECTION
Wear an appropriate properly fitted positive pressure air supplied respirator (TC 19C NIOSH/MSHA) while exposed. If not available, use a vapor particulate, (paint spray) respirator that respirator manufacturer recommends as effective for isocyanate vapors and mists. Wear the respirator for the whole time while mixing, spraying and untill vapors and mists are gone. Follow respirator manufacturer's directions for use.
Use positive pressure, air-supplied respirator, NIOSH schedule TC19C. Refer to OSHA 29 CFR 1910.134 " Respiratory Protection".

VENTILATION
Provide local exhaust ventilation in sufficient volume and pattern so as to maintain exposures below nusiance dust limits and permissible exposure limits which may be listed in Section II. Refer to Industrial Ventilation - A Manual for Recommended Practice - American Conference Of Governmentel Industrial Hygienists.

HAND PROTECTION
Wear appropriate impermeeble gloves.

EYE PROTECTION
Wear safety spectacles and chemical splash goggles (ANSI Z87.1 or

SECTION IX - PERSONAL PROTECTION INFORMATION: (CONTINUED)

EYE PROTECTION
equivalent).
OTHER PROTECTIVE EQUIPMENT
Eyewash facility, safety shower.
As required to prevent skin contact.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE
Do not store above 115 deg.F (46 deg.C) store large quantities in compliance with OSHA 29CFR1910.106.
OTHER PRECAUTIONS
Do not take internally. Close container after each use.
Do not breathe sanding dust.
This product should not be used by persons who have had chronic (long term) breathing problems or reactions to isocyanates. Do not breath vapor spray or mist. Do not get in eyes, on skin, or clothing. Wash thoroughly after handling. Keep away from heat sparks or flame. Use only with adequate ventilation.
Empty containers must not be washed and re-used for any purpose.
Containers should be grounded and bonded to the receiving container.
Do not weld, braze or cut on empty container.
Never use pressure to empty. Drum is not a pressure vessel.

SECTION XI - OTHER INFORMATION

THE INFORMATION CONTAINED HEREIN IS BASED ON DATA CONSIDERED TO BE ACCURATE. WHILE THE INFORMATION IS BELIEVED TO BE RELIABLE, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THIS DATA OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF. SINCE THE USE OF THIS INFORMATION AND THE CONDITIONS AND USE OF THIS PRODUCT ARE CONTROLLED BY THE USER, IT IS THE USER'S OBLIGATION TO DETERMINE THE CONDITIONS OF SAFE USE OF THE PRODUCT.
The Corporate Safety and Environmental Affairs Department is responsible for the preparation of this Material Safety Data Sheet.

RESEARCH TRIANGLE INSTITUTE
3040 CORNWALLIS RD.
RESEARCH TRIANGLE PARK NC
27709
ATTN: JENNI ELION

PRATT & LAMBERT   316-733-1361
Industrial Coatings Div.
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Wichita, KS 67201

DOT EMERGENCY CHEMTEL (800)255-3924 (24hrs)
INFORMATION PHONE NO. 316-733-1361 (M-F 8 AM-5 PM CT)

CORPORATE CONTACT   716-873-6000 (M-F 8 AM-5 PM CT)

H.M.I.S.	
HEALTH	2*
FLAMMABILITY	3
REACTIVITY	0

These ratings should be used only as part of fully implemented H.M.I.S. program.

MATERIAL SAFETY DATA SHEET

SECTION I

PRODUCT CLASS GOVERNMENT SPEC. MAT **DATE OF PREPARATION** 6/07/95

TRADE NAME COATING,POLYURETHANE GREEN 383,34094 MIL-C-46168DINTAM2

MANUFACTURER CODE I.D. 754217 87

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENT	% BY WGT	CAS NO.	ALLOWABLE EXPOSURE LEVEL	PPM	MG/CU.M.	MPPCF	SKIN	SARA 313	VP mm Hg 20 DEG
PROPYLENE GLYCOL METHYL ETHER ACETATE	20	108-65-6	NONE ESTABLISHED						2
XYLENE	< 5	1330-20-7	TLV-TWA	100	435			X	5
			TLV-STEL	150	655				
			OSHA-PEL	100	435				
			OSHA-STEL	150	655				
			LFL 1.0		UFL 7.0				
METHYL ETHYL KETONE	5	78-93-3	TLV-TWA	200	590			X	70
			TLV-STEL	300	885				
			OSHA-PEL	200	590				
			OSHA-STEL	300	885				
			LFL 2.0		UFL 10.0				
N-BUTYL ACETATE	5	123-86-4	TLV-TWA	150	710				10
			TLV-STEL	200	950				
			OSHA-PEL	150	710				
			OSHA-STEL	200	950				
			LFL 1.7		UFL 7.6				
SILICA, CRYSTALLINE-CRISTOBALITE	10	14464-46-1	TLV-TWA		0.0500				
			OSHA-PEL		0.0500				
SILICA, AMORPHOUS-DIATOMACEOUS EARTH	5	68855-54-9	TLV-TWA		10				
			OSHA-PEL		6	20			
SILICA, CRYSTALLINE-QUARTZ	< 1	14808-60-7	TLV-TWA		0.1000				
			OSHA-PEL		0.1000				
SILICA, CRYSTALLINE-TRIPOLI	< 1	1317-95-9	TLV-TWA		0.1000				
			OSHA-PEL		0.1000				
SILICA, CRYSTALLINE	15	14808-60-7	TLV-TWA		0.1000				
			OSHA-PEL		0.1000				
CHROMIUM III OXIDE	10	1308-38-9	TLV-TWA		0.5000			X	
			OSHA-PEL		0.5000				
TOLUENE	5	108-88-3	TLV-TWA	50	147		SKIN	X	22
			OSHA-PEL	100	375				
			OSHA-STEL	150	560				
			LFL 1.7		UFL 7.1				

LFL = LOWER FLAMMABILITY LIMIT PERCENT
UFL = UPPER FLAMMABILITY LIMIT PERCENT
SKIN = SKIN ABSORPTION MUST BE CONSIDERED AS A ROUTE OF EXPOSURE
C-CEILING= ALLOW. EXPOSURE LEVEL SHOULD NOT BE EXCEEDED FOR ANY TIME PERIOD
MFR = MANUFACTURER RECOMMENDED EXPOSURE LIMIT
STEL = SHORT TERM EXPOSURE LIMIT
X-SARA 313 = CHEMICAL IS SUBJECT TO REPORTING REQUIREMENTS OF SECTION 313 OF TITLE III OF S.A.R.A. 40 CFR PART 372

SECTION III - HEALTH INFORMATION

EFFECTS OF SHORT TERM OVEREXPOSURE

SWALLOWING

Can cause gastrointestinal irritation, nausea, and vomiting. Aspiration of material into lung may cause chemical pneumonitis which can be fatal.

INHALATION

May cause nose or throat irritation. High concentrations may cause acute central nervous system depression characterized by headaches, dizziness, nausea and confusion.

EYE

May cause severe eye irritation.

SECTION III - HEALTH INFORMATION; (CONTINUED)

SKIN
Liquid material may be absorbed through the skin in harmful amounts. May cause severe skin irritation.

EFFECTS OF REPEATED OVEREXPOSURE
Repeated and prolonged occupational overexposure to crystalline silica may cause silicosis, a progressively disabling lung disease.
Overexposure to xylene may cause injury to the liver, kidneys, and blood.
The OSHA Permissible Exposure Limit for amorphous silica is 20 Mppcf or PEL=_____80mg/M3_____
 %SiO2
Repeated overexposure to toluene may cause liver damage.
Prexisting respiratory conditions may be aggravated by exposure to crystalline silica.
Exposure to Methyl Ethyl Ketone may inhance the neurotoxicity of n-Hexane and Methyl-n-Butyl Ketone. This synergistic effect has resulted in peripheral neuropathy in humans.
Reports have associated prolonged and repeated occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal.

SIGNIFICANT LABORATORY DATA WITH POSSIBLE RELEVANCE TO HUMAN HEALTH.
Toluene has been found to cause kidney, lung and spleen damage in laboratory animals.
Laboratory studies involving rats indicate some evidence that Methyl Ethyl Ketone may be embryotoxic, fetotoxic and teratogenic.
The International Agency for Research on Cancer considers crystalline silica to have limited evidence of carcinogenicity in humans and sufficient evidence in experimental animals (IARC Group 2A).
The Chromium III Oxide supplier has concluded that Chromium III Oxide is not carcinogenic by OSHA definitions or by the evidence presented by the International Agency for Research on Cancer (IARC). (IARC has listed "Chromium and Certain Chromium Compounds" as Group 1 carcinogens.)

SECTION IV - FIRST AID AND EMERGENCY PROCEDURES

SWALLOWING
If swallowed do not induce vomiting. Call poison control center, hospital emergency room or physician immediately.

INHALATION
Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep warm and quiet. Get medical attention immediately.

EYE
Flush with large amounts of water, lifting upper and lower lids occasionally. Continue for at least 15 minutes. Get medical attention.

SKIN
Remove contaminated clothing. Wash affected area with soap and water. Obtain medical attention if irritation persists.

NOTES TO PHYSICIAN
Any treatment that might be required for overexposure should be directed at the control of symptoms and the clinical conditions.

SECTION V - PHYSICAL DATA

BOILING RANGE 175 DEG.F. (79 DEG.C.) TO 281 DEG.F.(138 DEG.C.)

VAPOR DENSITY than air. **% VOLATILE BY VOLUME** 61

EVAPORATION RATE Slower than diethyl ether. **VOC** 4.65 lb/gal less water & NPRS* 558 g/l less water CALCULATED

WEIGHT LB./GAL. 11.7 **VOC** 12.18 lb/gal solids 1462 g/l solids CALCULATED
SPECIFIC GRAVITY 1.4

All Physical data determined at 68 DEG. F. (20 DEG. C.) 760 mm Hg
* Negligibly Photochemically Reactive Materials
VOC values reported here are verified by ASTM method D-3960

SECTION VI - FIRE AND EXPLOSION DATA

NFPA FLAMMABILITY CLASSIFICATION FLAMMABLE LIQUID - CLASS IB

FLASHPOINT 24 DEG.F, (-4 DEG.C,) CALCULATED

EXTINGUISHING MEDIA
Use NFPA Class B fire extinguishers (carbon dioxide, all purpose dry chemical or alcohol foam) designed to extinguish flammable liquid fires. Polymer foam is preferred for large fires.

UNUSUAL FIRE AND EXPLOSION HAZARDS
During emergency conditions, overexposure to decompostion products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.
WARNING! FLAMMABLE.

SPECIAL FIRE FIGHTING PROCEDURES
Water may be ineffective, but may be used to cool exposed containers to prevent pressure build-up and possible auto-ignition or explosion when exposed to extreme heat. If water is used, fog nozzles are preferable.

SECTION VII - REACTIVITY DATA

STABILITY
Normally stable.

SECTION VII - REACTIVITY DATA; (CONTINUED)

CONDITIONS TO AVOID
Avoid excessive heat (>115 F (46 C) and sources of ignition.

INCOMPATABILITY (MATERIALS TO AVOID)
Strong acids or alkaline materials.
Oxidizing materials.

HAZARDOUS DECOMPOSITION PRODUCTS
Burning, including when heated by welding or cutting, will produce smoke, carbon monoxide and carbon dioxide.In addition, oxides of chromium may be generated.
Welding, brazing, or torch cutting materials coated with this product may produce metal oxides. Overexposure to these metal oxides may result in "Metal Fume Fever". Symptoms include a flu-like illness with fever, chills, and cough. An air purifying or supplied air respirator may be required depending upon levels of exposure. Consult a qualified health and safety professional.

HAZARDOUS POLYMERIZATION
Will not occur

CONDITIONS TO AVOID
None known

SECTION VIII - ENVIRONMENTAL INFORMATION

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
Keep spectators away. Eliminate all ignition sources (flames, hot surfaces, and sources of electrical, static or frictional sparks). Dike and contain spill with inert material (e.g. sand, earth). Transfer liquids to covered metal containers for recovery or disposal, or remove with inert absorbent. Use only non-sparking tools. Place absorbent diking materials in covered metal containers for disposal. Prevent contamination of sewers, streams, and groundwater with spilled material or used absorbent.

WASTE DISPOSAL
Dispose in accordance with federal, state and local regulations.

RCRA CLASSIFICATION
This product contains chromium. Waste residue of this product may qualify as hazardous waste (40 CFR Part 261.74- Characteristic of EP Toxicity). This product, if discarded directly, would be classified a hazardous waste based on its ignitability characteristic, i.e. has a flash point of 140 deg. F.(60 deg.C) or less. The proper RCRA classification would be D001.

ENVIRONMENTAL HAZARDS
None known

SECTION IX - PERSONAL PROTECTION INFORMATION

RESPIRATORY PROTECTION
Proper selection of respiratory protection depends upon many factors including duration/level of exposure and conditions of use. In general exposure to organic chemicals such as those contained in this product may not require the use of respiratory protection if used in well ventilated areas. In restricted ventilation areas a NIOSH approved chemical cartridge respirator may be required. Under certain conditions, such as spraying, a mechanical prefilter may also be required. In confined areas use a NIOSH/MSHA approved air supplied respirator. If the TLV's listed in Section II are exceeded use a properly fitted NIOSH/MSHA approved respirator with an appropriate protection factor. Refer to OSHA 29 CFR 1910.134 "Respiratory Protection", and "Respiratory Protection A Manual And Guideline, American Industrial Hygiene Assoc."

VENTILATION
Provide general dilution and local exhaust ventilation in sufficient volume and pattern to keep concentrations of hazardous ingredients listed in Section II below the lowest exposure limit stated. Remove decomposition products that are generated when welding, cutting, or brazing objects coated with this product. Refer to "Industrial Ventilation - A Manual of Recommended Practice " ACGIH .

HAND PROTECTION
Wear appropriate impermeable gloves (North- Silver Shield).

EYE PROTECTION
Wear safety spectacles.

OTHER PROTECTIVE EQUIPMENT
Not likely to be needed.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE
Do not store above 115 deg.F (46 deg.C) store large quantities in compliance with OSHA 29CFR1910.106.

OTHER PRECAUTIONS
Do not take internally. Close container after each use.
Do not breathe sanding dust.
Empty containers must not be washed and re-used for any purpose.
Containers should be grounded and bonded to the receiving container.
Do not weld, braze or cut on empty container.
Never use pressure to empty. Drum is not a pressure vessel.

SECTION XI - OTHER INFORMATION

SECTION XI - OTHER INFORMATION; (CONTINUED)

THE INFORMATION CONTAINED HEREIN IS BASED ON DATA CONSIDERED TO BE ACCURATE. WHILE THE INFORMATION IS BELIEVED TO BE RELIABLE, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THIS DATA OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF. SINCE THE USE OF THIS INFORMATION AND THE CONDITIONS AND USE OF THIS PRODUCT ARE CONTROLLED BY THE USER, IT IS THE USER'S OBLIGATION TO DETERMINE THE CONDITIONS OF SAFE USE OF THE PRODUCT.
The Corporate Safety and Environmental Affairs Department is responsible for the preparation of this Material Safety Data Sheet.

RESEARCH TRIANGLE INSTITUTE
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DOT EMERGENCY CHEMTEL (800)255-3924 (24hrs)
INFORMATION PHONE NO. 316-733-1361 (M-F 8 AM-5 PM CT)
CORPORATE CONTACT 716-873-6000 (M-F 8 AM-5 PM CT)

H.M.I.S.	
HEALTH	3
FLAMMABILITY	3
REACTIVITY	0

These ratings should be used only as part of fully implemented H.M.I.S. program.

MATERIAL SAFETY DATA SHEET

SECTION I

PRODUCT CLASS GOVERNMENT SPEC. MAT — DATE OF PREPARATION 6/07/95

TRADE NAME COATING,POLYURETHANE COMPONENT B TYPEII MIL-C-46168DINTAR2

MANUFACTURER CODE I.D. 754201 08

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENT	% BY WGT	CAS NO.		ALLOWABLE EXPOSURE LEVEL PPM	MG/CU.M.	MPPCF	SARA 313 SKIN	VP mm Hg 20 DEG.
N-BUTYL ACETATE	25	123-86-4	TLV-TWA	150	710			10
			TLV-STEL	200	950			
			OSHA-PEL	150	710			
			OSHA-STEL	200	950			
			LFL	1.7	UFL 7.6			
1,6 HEXANE METHYLENE DIISOCYANATE	< 1	822-06-0	TLV-TWA	0.0050	0.0350			
			MFR	0.0050				
POLYMERIC HEXAMETHYLENE DIISOCYANATE	75	28182-81-2	MFR		1			

LFL = LOWER FLAMMABILITY LIMIT PERCENT
UFL = UPPER FLAMMABILITY LIMIT PERCENT
SKIN = SKIN ABSORPTION MUST BE CONSIDERED AS A ROUTE OF EXPOSURE
C-CEILING= ALLOW. EXPOSURE LEVEL SHOULD NOT BE EXCEEDED FOR ANY TIME PERIOD
MFR = MANUFACTURER RECOMMENDED EXPOSURE LIMIT
STEL = SHORT TERM EXPOSURE LIMIT
X-SARA 313 = CHEMICAL IS SUBJECT TO REPORTING REQUIREMENTS OF SECTION 313 OF TITLE III OF S.A.R.A. 40 CFR PART 372

SECTION III - HEALTH INFORMATION

EFFECTS OF SHORT TERM OVEREXPOSURE

SWALLOWING
May be fatal if swallowed.
Can cause gastrointestinal irritation, nausea, and vomiting. Aspiration of material into lung may cause chemical pneumonitis which can be fatal.

INHALATION
WARNING vapor and spray mist harmful. Overexposure may cause lung damage. May cause lung irritation and allergic respiratory reaction. Effects may be permanent.
May cause respiratory sensitization (potential for allergic reaction).
May cause respiratory irritation.

EYE
May cause severe eye irritation.

SKIN
Primary skin irritant.
May cause skin sensitization (allergic reaction).
May cause skin irritation.

EFFECTS OF REPEATED OVEREXPOSURE
Repeated exposure to diisocyanates may result in respiratory sensitization in some individuals. Respiratory sensitivity results in asthma-like symptoms on subsequent exposure at concentrations even below the TLV. Reports have associated prolonged and repeated occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal.

SIGNIFICANT LABORATORY DATA WITH POSSIBLE RELEVANCE TO HUMAN HEALTH.
None currently known

SECTION IV - FIRST AID AND EMERGENCY PROCEDURES

SWALLOWING
If swallowed do not induce vomiting. Call poison control center, hospital emergency room or physician immediately.

INHALATION
Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep warm and quiet. Get medical attention immediately.

EYE
Flush with large amounts of water, lifting upper and lower lids occasionally. Continue for at least 15 minutes. Get medical attention.

SKIN
Remove contaminated clothing. Wash affected area with soap and water.

SECTION IV - FIRST AID AND EMERGENCY PROCEDURES; (CONTINUED)

SKIN
Obtain medical attention if irritation persists.
NOTES TO PHYSICIAN
Any treatment that might be required for overexposure should be directed at the control of symptoms and the clinical conditions.

SECTION V - PHYSICAL DATA

BOILING RANGE 260 DEG.F. (127 DEG.C.)

VAPOR DENSITY than air. **% VOLATILE BY VOLUME** 30

EVAPORATION RATE Slower than diethyl ether. **VOC** 2.21 lb/gal less water & NPRS* 265 g/l less water CALCULATED

WEIGHT LB./GAL. 8.8 SPECIFIC GRAVITY 1.1 **VOC** 3.16 lb/gal solids 379 g/l solids CALCULATED

All Physical data determined at 68 DEG. F. (20 DEG. C.) 760 mm Hg
* Negligibly Photochemically Reactive Materials
VOC values reported here are verified by ASTM method D-3960

SECTION VI - FIRE AND EXPLOSION DATA

NFPA FLAMMABILITY CLASSIFICATION FLAMMABLE LIQUID - CLASS IB

FLASHPOINT 72 DEG.F, (22 DEG.C,) CALCULATED
EXTINGUISHING MEDIA
Use NFPA Class B Fire extinguishers (carbon dioxide, all purpose dry chemical or alcohol foam) designed to extinguish flammable liquid fires. Polymer foam is preferred for large fires.
UNUSUAL FIRE AND EXPLOSION HAZARDS
During emergency conditions, overexposure to decompostion products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.
WARNING! FLAMMABLE.
SPECIAL FIRE FIGHTING PROCEDURES
Firefighters should wear self-contained breathing apparatus.
Water may be ineffective, but may be used to cool exposed containers to prevent pressure build-up and possible auto-ignition or explosion when exposed to extreme heat. If water is used, fog nozzles are preferable.

SECTION VII - REACTIVITY DATA

STABILITY
Normally stable.
CONDITIONS TO AVOID
Avoid excessive heat (>115 F (46 C) and sources of ignition.
INCOMPATABILITY (MATERIALS TO AVOID)
Strong acids or alkaline materials.
Oxidizing materials.
HAZARDOUS DECOMPOSITION PRODUCTS
Burning, including when heated by welding or cutting, will produce smoke, carbon monoxide and carbon dioxide.In addition, oxides of nitrogen may be generated.
The reaction of isocyanates with water may produce carbon dioxide gas which may result in container pressurization.
HAZARDOUS POLYMERIZATION
Will not occur
CONDITIONS TO AVOID
None known

SECTION VIII - ENVIRONMENTAL INFORMATION

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
The use of a NIOSH/MSHA approved, TC19C, air-supplied breathing apparatus may be required. Consult with a qualified occupational health and /or safety professional.
Keep spectators away. Eliminate all ignition sources (flames, hot surfaces, and sources of electrical, static or frictional sparks).
Dike and contain spill with inert material (e.g. sand, earth). Transfer liquids to covered metal containers for recovery or disposal, or remove with inert absorbent. Use only non-sparking tools. Place absorbent diking materials in covered metal containers for disposal. Prevent contamination of sewers, streams, and groundwater with spilled material or used absorbent.
WASTE DISPOSAL
Dispose in accordance with federal, state and local regulations.
RCRA CLASSIFICATION
This product, if discarded directly, would be classified a hazardous waste based on its ignitability characteristic, i.e. has a flash point of 140 deg. F.(60 deg.C) or less. The proper RCRA classification would be D001.
ENVIRONMENTAL HAZARDS
None known

SECTION IX - PERSONAL PROTECTION INFORMATION

RESPIRATORY PROTECTION
Wear an appropriate properly fitted positive pressure air supplied

SECTION IX - PERSONAL PROTECTION INFORMATION; (CONTINUED)

RESPIRATORY PROTECTION

respirator (TC 19C NIOSH/MSHA) while exposed. If not available, use a vapor particulate, (paint spray) respirator that respirator manufacturer recommends as effective for isocyanate vapors and mists. Wear the respirator for the whole time while mixing, spraying and untill vapors and mists are gone. Follow respirator manufacturer's directions for use.

VENTILATION

Use general dilution and local exhaust ventilation in sufficient volume and pattern to keep concentrations of hazardous ingredients listed in Section II below the lowest exposure limit stated. Fumes emitted while baking this product must be properly vented. Refer to "Industrial Ventilation a Manual of Recommended Practice"-ACGIH.

HAND PROTECTION

Wear appropriate impermeable gloves.

EYE PROTECTION

Wear safety spectacles and chemical splash goggles (ANSI Z87.1 or equilavent).

OTHER PROTECTIVE EQUIPMENT

As required to prevent skin contact.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

Do not store above 115 deg.F (46 deg.C) store large quantities in compliance with OSHA 29CFR1910.106.

OTHER PRECAUTIONS

Do not take internally. Close container after each use.
This product should not be used by persons who have had chronic (long term) breathing problems or reactions to isocyanates. Do not breath vapor spray or mist. Do not get in eyes, on skin, or clothing. Wash thoroughly after handling. Keep away from heat sparks or flame. Use only with adequate ventilation.
Empty containers must not be washed and re-used for any purpose.
Containers should be grounded and bonded to the receiving container.
Do not weld, braze or cut on empty container.
Never use pressure to empty. Drum is not a pressure vessel.

SECTION XI - OTHER INFORMATION

MISCELLANEOUS INFORMATION

This Urethane activatior is one part of a two component mixture. It is intended to be mixed with a base. The contents of this package must be blended with other components before the product can be used. Before opening the packages, be sure you understand the warning messages and labels of all components, since the mixture may have the hazards of all of its parts. Follow all applicable precautions.

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INFORMATION PHONE NO. 316-733-1361 (M-F 8 AM-5 PM CT)

CORPORATE CONTACT 716-873-6000 (M-F 8 AM-5 PM CT)

H.M.I.S.	
HEALTH	2*
FLAMMABILITY	3
REACTIVITY	0

These ratings should be used only as part of fully implemented H.M.I.S. program.

MATERIAL SAFETY DATA SHEET

SECTION I

PRODUCT CLASS GOVERNMENT SPEC. MAT **DATE OF PREPARATION** 6/07/95

TRADE NAME PRIMER,EPOXY CTG,CORRINHIB,LEAD & CHR FREEMIL-P-53022B TY I

MANUFACTURER CODE I.D. 724700 14

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENT	% BY WGT	CAS NO.		ALLOWABLE EXPOSURE LEVEL PPM	MG/CU.M.		MPPCF	SKIN	SARA 313	VP mm Hg 20 DEG.
TOLUENE	10	108-88-3	TLV-TWA	50	147			SKIN	X	22
			OSHA-PEL	100	375					
			OSHA-STEL	150	560					
			LFL	1.7	UFL	7.1				
DIGLYCIDYL ETHER OF BISPHENOL-A RESIN	25	25068-38-6		NONE ESTABLISHED						
TITANIUM DIOXIDE	20	13463-67-7	TLV-TWA		10					
			OSHA-PEL		10					
PROPYLENE GLYCOL MONOMETHYL ETHER	5	107-98-2	TLV-TWA	100	360					11
			TLV-STEL	150	540					
			OSHA-PEL	100	360					
			OSHA-STEL	150	540					
METHYL ETHYL KETONE	15	78-93-3	TLV-TWA	200	590				X	70
			TLV-STEL	300	885					
			OSHA-PEL	200	590					
			OSHA-STEL	300	885					
			LFL	2.0	UFL	10.0				
TALC	15	14807-96-6	TLV-TWA		2		15			
			OSHA-PEL		2		20			
SILICA, CRYSTALLINE	< 1	14808-60-7	TLV-TWA		0.1000					
			OSHA-PEL		0.1000					
N-BUTYL ALCOHOL	5	71-36-3	TLV-TWA	50	150	C		SKIN	X	6
			TLV-STEL	150	455			SKIN		
			OSHA-CEIL	50	150	C		SKIN		
			LFL	1.4	UFL	11.2				

LFL = LOWER FLAMMABILITY LIMIT PERCENT
UFL = UPPER FLAMMABILITY LIMIT PERCENT
SKIN = SKIN ABSORPTION MUST BE CONSIDERED AS A ROUTE OF EXPOSURE
C-CEILING= ALLOW. EXPOSURE LEVEL SHOULD NOT BE EXCEEDED FOR ANY TIME PERIOD
MFR = MANUFACTURER RECOMMENDED EXPOSURE LIMIT
STEL = SHORT TERM EXPOSURE LIMIT
X-SARA 313 = CHEMICAL IS SUBJECT TO REPORTING REQUIREMENTS OF SECTION 313 OF TITLE III OF S.A.R.A. 40 CFR PART 372

SECTION III - HEALTH INFORMATION

EFFECTS OF SHORT TERM OVEREXPOSURE

SWALLOWING

Can cause gastrointestinal irritation, nausea, and vomiting. Aspiration of material into lung may cause chemical pneumonitis which can be fatal.

INHALATION

May cause nose or throat irritation. High concentrations may cause acute central nervous system depression characterized by headaches, dizziness, nausea and confusion.

EYE

May cause severe eye irritation.

SKIN

Liquid material may be absorbed through the skin in harmful amounts.
May cause skin sensitization (allergic reaction).
May cause defatting and irritation of the skin.

EFFECTS OF REPEATED OVEREXPOSURE

Repeated and prolonged occupational overexposure to crystalline silica may cause silicosis, a progressively disabling lung disease.
Repeated overexposure to toluene may cause liver damage.
Repeated contact may cause dermatitis.
Prexisting respiratory conditions may be aggravated by exposure to

SECTION III - HEALTH INFORMATION; (CONTINUED)

EFFECTS OF REPEATED OVEREXPOSURE

crystalline silica.

Exposure to Methyl Ethyl Ketone may inhance the neurotoxicity of n-Hexane and Methyl-n-Butyl Ketone. This synergistic effect has resulted in peripheral neuropathy in humans.

Reports have associated prolonged and repeated occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal.

SIGNIFICANT LABORATORY DATA WITH POSSIBLE RELEVANCE TO HUMAN HEALTH.

Titanium dioxide IS NOT listed as a potential carcinogen by the National Toxicology Program, the International Agency for Research on Cancer, OSHA, or A.C.G.I.H. Titanium dioxide in a 24-month inhalation study with rats revealed a significant increase in benign and malignant lung tumors in the group exposed to 250mg/M3 respirable TiO2 dust. At lower exposure levels, this significant effect was not observed. The normal clearance mechanisms of the lungs may have been overwhelmed at the 250mg/M3 exposure level, and this may have contributed to the tumor formation. These results may not be directly relevant to the workplace where occupational exposure limits are observed. At the TLV the TiO2 manufacturer concludes that there is no significant hazard for man.

Toluene has been found to cause kidney, lung and spleen damage in laboratory animals.

Laboratory studies involving rats indicate some evidence that Methyl Ethyl Ketone may be embryotoxic, fetotoxic and teratogenic.

The International Agency for Research on Cancer considers crystalline silica to have limited evidence of carcinogenicity in humans and sufficient evidence in experimental animals (IARC Group 2A).

SECTION IV - FIRST AID AND EMERGENCY PROCEDURES

SWALLOWING

If swallowed do not induce vomiting. Call poison control center, hospital emergency room or physician immediately.

INHALATION

Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep warm and quiet. Get medical attention immediately.

EYE

Flush with large amounts of water, lifting upper and lower lids occasionally. Continue for at least 15 minutes. Get medical attention.

SKIN

Immediately flush the contaminated area with large amounts of water. Remove contaminated clothing as water is applied. Consult a physician.

NOTES TO PHYSICIAN

Any treatment that might be required for overexposure should be directed at the control of symptoms and the clinical conditions.

SECTION V - PHYSICAL DATA

BOILING RANGE 175 DEG.F. (79 DEG.C.) TO 248 DEG.F.(120 DEG.C.)

VAPOR DENSITY than air. **% VOLATILE BY VOLUME** 58

EVAPORATION RATE Slower than diethyl ether. **VOC** 4.03 lb/gal less water & NPRS* 484 g/l less water CALCULATED

WEIGHT LB./GAL. 10.9 **VOC** 9.76 lb/gal solids 1171 g/l solids CALCULATED
SPECIFIC GRAVITY 1.3

All Physical data determined at 68 DEG. F. (20 DEG. C.) 760 mm Hg
* Negligibly Photochemically Reactive Materials
VOC values reported here are verified by ASTM method D-3960

SECTION VI - FIRE AND EXPLOSION DATA

NFPA FLAMMABILITY CLASSIFICATION FLAMMABLE LIQUID - CLASS IB

FLASHPOINT 24 DEG.F, (-4 DEG.C,) CALCULATED

EXTINGUISHING MEDIA

Use NFPA Class B fire extinguishers (carbon dioxide, all purpose dry chemical or alcohol foam) designed to extinguish flammable liquid fires. Polymer foam is preferred for large fires.

UNUSUAL FIRE AND EXPLOSION HAZARDS

During emergency conditions, overexposure to decompostion products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.
WARNING! FLAMMABLE.

SPECIAL FIRE FIGHTING PROCEDURES

Water may be ineffective, but may be used to cool exposed containers to prevent pressure build-up and possible auto-ignition or explosion when exposed to extreme heat. If water is used, fog nozzles are preferable.

SECTION VII - REACTIVITY DATA

STABILITY

Hazardous polymerization may occur with the addition of excess hardener.

CONDITIONS TO AVOID

Avoid excessive heat (>115 F (46 C) and sources of ignition.

INCOMPATABILITY (MATERIALS TO AVOID)

Alkalis & Amines

SECTION VII - REACTIVITY DATA; (CONTINUED)

INCOMPATABILITY (MATERIALS TO AVOID)
Strong acids or alkaline materials.
Oxidizing materials.
Accelerators.

HAZARDOUS DECOMPOSITION PRODUCTS
Burning, including when heated by welding or cutting, will produce smoke, carbon monoxide and carbon dioxide.

HAZARDOUS POLYMERIZATION
Will not occur

CONDITIONS TO AVOID
None known

SECTION VIII - ENVIRONMENTAL INFORMATION

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
Keep spectators away. Eliminate all ignition sources (flames, hot surfaces, and sources of electrical, static or frictional sparks). Dike and contain spill with inert material (e.g. sand, earth). Transfer liquids to covered metal containers for recovery or disposal, or remove with inert absorbent. Use only non-sparking tools. Place absorbent diking materials in covered metal containers for disposal. Prevent contamination of sewers, streams, and groundwater with spilled material or used absorbent.

WASTE DISPOSAL
Dispose in accordance with federal, state and local regulations.

RCRA CLASSIFICATION
This product, if discarded directly, would be classified a hazardous waste based on its ignitability characteristic, i.e. has a flash point of 140 deg. F (60 deg.C) or less. The proper RCRA classification would be D001.

ENVIRONMENTAL HAZARDS
None known

SECTION IX - PERSONAL PROTECTION INFORMATION

RESPIRATORY PROTECTION
Proper selection of respiratory protection depends upon many factors including duration/level of exposure and conditions of use. In general exposure to organic chemicals such as those contained in this product may not require the use of respiratory protection if used in well ventilated areas. In restricted ventilation areas a NIOSH approved chemical cartridge respirator may be required. Under certain conditions, such as spraying, a mechanical prefilter may also be required. In confined areas use a NIOSH/MSHA approved air supplied respirator. If the TLV's listed in Section II are exceeded use a properly fitted NIOSH/MSHA approved respirator with an appropriate protection factor. Refer to OSHA 29 CFR 1910.134 "Respiratory Protection", and "Respiratory Protection A Manual And Guideline, American Industrial Hygiene Assoc."

VENTILATION
Provide local exhaust ventilation in sufficient volume and pattern so as to maintain exposures below nusiance dust limits and permissible exposure limits which may be listed in Section II. Refer to Industrial Ventilation - A Manual for Recommended Practice - American Conference Of Governmental Industrial Hygienists.

HAND PROTECTION
Solvent impermeable gloves are required for repeated or prolonged contact.

EYE PROTECTION
Wear safety spectacles and chemical splash goggles (ANSI Z87.1 or equivalent).

OTHER PROTECTIVE EQUIPMENT
Eyewash facility, safety shower.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE
Do not store above 115 degrees F (46 C).

OTHER PRECAUTIONS
Do not take internally. Close container after each use.
Keep away from children.
Do not breathe sanding dust.
Avoid skin contact.
Empty containers must not be washed and re-used for any purpose.
Containers should be grounded and bonded to the receiving container.
Do not weld, braze or cut on empty container.
Never use pressure to empty. Drum is not a pressure vessel.

SECTION XI - OTHER INFORMATION

MISCELLANEOUS INFORMATION

The contents of this package must be blended with other components before the product can be used. Any mixture of components will have the hazards of all components. Before opening the packages, read all warning labels. Follow all precautions.

THE INFORMATION CONTAINED HEREIN IS BASED ON DATA CONSIDERED TO BE

SECTION XI - OTHER INFORMATION; (CONTINUED)

ACCURATE. WHILE THE INFORMATION IS BELIEVED TO BE RELIABLE, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THIS DATA OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF. SINCE THE USE OF THIS INFORMATION AND THE CONDITIONS AND USE OF THIS PRODUCT ARE CONTROLLED BY THE USER, IT IS THE USER'S OBLIGATION TO DETERMINE THE CONDITIONS OF SAFE USE OF THE PRODUCT.
The Corporate Safety and Environmental Affairs Department is responsible for the preparation of this Material Safety Data Sheet.

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CORPORATE CONTACT 716-873-6000 (M-F 8 AM-5 PM CT)

H.M.I.S.	
HEALTH	3
FLAMMABILITY	3
REACTIVITY	0

These ratings should be used only as part of fully implemented H.M.I.S. program.

MATERIAL SAFETY DATA SHEET

SECTION I

PRODUCT CLASS GOVERNMENT SPEC. MAT

DATE OF PREPARATION 6/07/95

TRADE NAME PRIMER,EPOXY CTG,CORRINHIB,LEAD & CHR FREEMIL-P-53022B TY I

MANUFACTURER CODE I.D. 724701 28

SECTION II - HAZARDOUS INGREDIENTS

INGREDIENT	% BY WGT	CAS NO.		PPM	MG/CU.M.	ALLOWABLE EXPOSURE LEVEL	MPPCF	SKIN	SARA 313	VP mm Hg 20 DEG.
ALIPHATIC AMINE ADDUCT	25	31326-29-1	NONE ESTABLISHED							
N-BUTYL ALCOHOL	15	71-36-3	TLV-TWA	50	150	C		SKIN	X	6
			TLV-STEL	150	455			SKIN		
			OSHA-CEIL	50	150	C		SKIN		
			LFL 1.4		UFL 11.2					
PROPYLENE GLYCOL MONOMETHYL ETHER	50	107-98-2	TLV-TWA	100	360					11
			TLV-STEL	150	540					
			OSHA-PEL	100	360					
			OSHA-STEL	150	540					
TOLUENE	5	108-88-3	TLV-TWA	50	147			SKIN	X	22
			OSHA-PEL	100	375					
			OSHA-STEL	150	560					
			LFL 1.7		UFL 7.1					
DIETHYLENETRIAMINE	5	111-40-0	TLV-TWA	1	4			SKIN		1
			OSHA-PEL	1	4					
2-METHOXY-1-PROPANOL <	5	1589-47-5	NONE ESTABLISHED							
			LFL 1.5		UFL 10.9					

LFL = LOWER FLAMMABILITY LIMIT PERCENT
UFL = UPPER FLAMMABILITY LIMIT PERCENT
SKIN = SKIN ABSORPTION MUST BE CONSIDERED AS A ROUTE OF EXPOSURE
C-CEILING= ALLOW. EXPOSURE LEVEL SHOULD NOT BE EXCEEDED FOR ANY TIME PERIOD
MFR = MANUFACTURER RECOMMENDED EXPOSURE LIMIT
STEL = SHORT TERM EXPOSURE LIMIT
X-SARA 313 = CHEMICAL IS SUBJECT TO REPORTING REQUIREMENTS OF SECTION 313 OF TITLE III OF S.A.R.A. 40 CFR PART 372

SECTION III - HEALTH INFORMATION

EFFECTS OF SHORT TERM OVEREXPOSURE

SWALLOWING

Can cause gastrointestinal irritation, nausea, and vomiting. Aspiration of material into lung may cause chemical pneumonitis which can be fatal.

INHALATION

May cause respiratory sensitization (potential for allergic reaction).
May cause nose or throat irritation. High concentrations may cause acute central nervous system depression characterized by headaches, dizziness, nausea and confusion.

EYE

May cause severe eye irritation and corneal damage.

SKIN

Liquid material may be absorbed through the skin in harmful amounts.
May cause skin sensitization (allergic reaction).
May cause severe skin irritation.

EFFECTS OF REPEATED OVEREXPOSURE

Repeated overexposure to toluene may cause liver damage.
Repeated contact may cause dermatitis.
Reports have associated prolonged and repeated occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents may be harmful or fatal.

SIGNIFICANT LABORATORY DATA WITH POSSIBLE RELEVANCE TO HUMAN HEALTH.

Toluene has been found to cause kidney, lung and spleen damage in laboratory animals.

SECTION IV - FIRST AID AND EMERGENCY PROCEDURES

SWALLOWING

If swallowed do not induce vomiting. Give 1 or 2 glasses of water to dilute

SECTION IV - FIRST AID AND EMERGENCY PROCEDURES; (CONTINUED)

SWALLOWING
(Never give anyhting by mouth to an unconscious person). Call Poison Control Center, Hospital Emergency Room, or Physician immediately.
INHALATION
Remove to fresh air immediately. If breathing has stopped, give artificial respiration. Keep warm and quiet. Get medical attention immediately.
EYE
Flush with large amounts of water, lifting upper and lower lids occasionally. continue for at least 15 minutes. Get medical attention.
SKIN
Immediately flush the contaminated area with large amounts of water. Remove contaminated clothing as water is applied. Consult a physician.
NOTES TO PHYSICIAN
Any treatment that might be required for overexposure should be directed at the control of symptoms and the clinical conditions.

SECTION V - PHYSICAL DATA

BOILING RANGE 231 DEG.F. (111 DEG.C.) TO 405 DEG.F.(207 DEG.C.)

VAPOR DENSITY than air. **% VOLATILE BY VOLUME** 77

EVAPORATION RATE Slower than diethyl ether. **VOC** 5.65 lb/gal less water & NPRS* 678 g/l less water CALCULATED

WEIGHT LB./GAL. 8.0 SPECIFIC GRAVITY 1.0 **VOC** 25.27 lb/gal solids 3032 g/l solids CALCULATED

All Physical data determined at 68 DEG. F. (20 DEG. C.) 760 mm Hg
* Negligibly Photochemically Reactive Materials
VOC values reported here are verified by ASTM method D-3960

SECTION VI - FIRE AND EXPLOSION DATA

NFPA FLAMMABILITY CLASSIFICATION FLAMMABLE LIQUID - CLASS IB

FLASHPOINT 40 DEG.F, (4 DEG.C,) CALCULATED
EXTINGUISHING MEDIA
Use NFPA Class B fire extinguishers (carbon dioxide, all purpose dry chemical or alcohol foam) designed to extinguish flammable liquid fires. Polymer foam is preferred for large fires.
UNUSUAL FIRE AND EXPLOSION HAZARDS
During emergency conditions, overexposure to decompostion products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.
WARNING! FLAMMABLE.
SPECIAL FIRE FIGHTING PROCEDURES
Water may be ineffective, but may be used to cool exposed containers to prevent pressure build-up and possible auto-ignition or explosion when exposed to extreme heat. If water is used, fog nozzles are preferable.

SECTION VII - REACTIVITY DATA

STABILITY
Hazardous polymerization may occur with the addition of excess hardener.
CONDITIONS TO AVOID
Avoid excessive heat (>115 F (46 C) and sources of ignition.
INCOMPATABILITY (MATERIALS TO AVOID)
Strong acids or alkaline materials.
Oxidizing materials.
Accelerators.
HAZARDOUS DECOMPOSITION PRODUCTS
Burning, including when heated by welding or cutting, will produce smoke, carbon monoxide and carbon dioxide.
HAZARDOUS POLYMERIZATION
Will not occur
CONDITIONS TO AVOID
None known

SECTION VIII - ENVIRONMENTAL INFORMATION

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED
Keep spectators away. Eliminate all ignition sources (flames, hot surfaces, and sources of electrical, static or frictional sparks). Dike and contain spill with inert material (e.g. sand, earth). Transfer liquids to covered metal containers for recovery or disposal, or remove with inert absorbent. Use only non-sparking tools. Place absorbent diking materials in covered metal containers for disposal. Prevent contamination of sewers, streams, and groundwater with spilled material or used absorbent.
WASTE DISPOSAL
Dispose in accordance with federal, state and local regulations.
RCRA CLASSIFICATION
This product, if discarded directly, would be classified a hazardous waste based on its ignitability characteristic, i.e. has a flash point of 140 deg. F (60 deg.C) or less. The proper RCRA classification would be D001.
ENVIRONMENTAL HAZARDS
None known

SECTION IX - PERSONAL PROTECTION INFORMATION

RESPIRATORY PROTECTION
Proper selection of respiratory protection depends upon many factors

SECTION IX - PERSONAL PROTECTION INFORMATION (CONTINUED)

RESPIRATORY PROTECTION

including duration and level of exposure and conditions of use. In general exposure to organic chemicals such as those contained in this product may not require the use of respiratory protection if used in well ventilated areas. In areas of restricted ventilation a NIOSH approved organic vapor respirator may be required. Under certain conditions, such as spraying, a mechanical prefilter may also be required. In confined areas or in high exposure situations a NIOSH/MSHA approved air supplied respirator may be required. If the TLV's or PEL's listed in Section II are exceeded use a properly fitted NIOSH/MSHA approved respirator with an appropriate protection factor. Refer to OSHA 29 CFR 1910.134 "Respiratory Protection", and "Respiratory Protection a Manual and Guideline, American Industrial Hygiene Association".

VENTILATION

Provide general dilution and local exhaust ventilation in sufficient volume and pattern to keep concentrations of hazardous ingredients listed in Section II below the lowest exposure limit stated. Remove decomposition products that are generated when welding, cutting, or brazing objects coated with this product. Refer to "Industrial Ventilation - A Manual of Recommended Practice " ACGIH .

HAND PROTECTION

Solvent impermeable gloves are required for repeated or prolonged contact.

EYE PROTECTION

Wear safety glasses meeting the specifications of ANSI Z87.1 where no contact with the eye is anticipated. Chemical safety goggles meeting the specifications of ANSI Z87.1 sholud be worn whenever there is a possibilty of splashing or other contact with the eyes.

OTHER PROTECTIVE EQUIPMENT

Eyewash facility, safety shower.

SECTION X - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

Do not store above 115 degrees F (46 C).

OTHER PRECAUTIONS

Do not take internally. Close container after each use.
Keep away from children.
Avoid skin contact.
Empty containers must not be washed and re-used for any purpose.
Containers should be grounded and bonded to the receiving container.
Do not weld, braze or cut on empty container.
Never use pressure to empty. Drum is not a pressure vessel.

SECTION XI - OTHER INFORMATION

MISCELLANEOUS INFORMATION

The contents of this package must be blended with other components before the product can be used. Any mixture of components will have the hazards of all components. Before opening the packages, read all warning labels. Follow all precautions.

The Corporate Safety and Environmental Affairs Department is responsible for the preparation of this Material Safety Data Sheet.

RESEARCH TRIANGLE INSTITUTE
3040 CORNWALLIS RD.
RESEARCH TRIANGLE PARK NC
27709
ATTN: JENNI ELION

********** MATERIAL SAFETY DATA SHEET ************************************

ZPG Manufacturing
26500 Capitol avenue
Redford, Michigan 48239
24 Hour Emergency Contact: CHEMTREC 1-800-424-9300
Corporate Emergency Telephone: 1-313-937-0710 M-F 8:00 - 5:00
DUNS # 006-006-019

Canadian contact:
Ziebart Canada Inc.
150 Oakdale Avenue
Downsview, Ontario M3N 1W1
Emergency Telephone: 1-416-742-6613

********** SECTION 1 - PRODUCT IDENTIFICATION ****************************

PRODUCT NAME/NUMBER;.........XL5-G
FORMULA NUMBER;..............MB# 0140
CHEMICAL FAMILY;.............MIXTURE
CAS NUMBER;..................UNASSIGNED
HMIS: 2-2-1-H

********** SECTION 2 - HAZARDOUS INGREDIENTS *****************************

ALIPHATIC HYDROCARBONS (STODDARD SOLVENT). CAS # 8052-41-3
PERCENTAGE BY WEIGHT: 15-40.
PEL: 100 PPM. TLV: 100 PPM.
LISTED IN NTP, IARC or OSHA 1910(z): YES, OSHA Z-1-A, NOT CARCINOGENIC.

OXIDIZED ASPHALT. CAS # 64742-93-4
PERCENTAGE BY WEIGHT: 5-10.
PEL: 100 PPM. TLV: 100PPM.
LISTED IN NTP, IARC or OSHA 1910(z): NO

ALIPHATIC PETROLEUM DISTILLATES. CAS # 64742-53-6
PERCENTAGE BY WEIGHT: 1-5.
PEL: AS OIL MIST 5 MG/M3. TLV: AS OIL MIST 5 MG/M3.
LISTED IN NTP, IARC OR OSHA 1910(Z): NO

********** SECTION 3 - PHYSICAL DATA *************************************

PHYSICAL FORM:	LIQUID.
APPEARANCE AND ODOR:	BLACK WITH PETROLEUM ODOR.
pH:	NEUTRAL.
BOILING POINT; F (C):	>350 (>177).
FREEZING POINT; F (C):	32 (0).
VAPOR PRESSURE; (mm Hg):	<10.
VAPOR DENSITY; (AIR=1):	4.8
SOLUBILITY IN WATER:	SLIGHT.
SPECIFIC GRAVITY; (WATER=1):	0.9
EVAPORATION RATE; (BUAC=1):	0.2
PERCENT VOLATILES-VOLUME:	45.
PERCENT SOLIDS-WEIGHT:	61.
VOLATILE ORGANIC COMPOUNDS:	2.9 lb./gal. (minus water)

********** MATERIAL SAFETY DATA SHEET **

********** SECTION 4 - FIRE AND EXPLOSION DATA ***************************

AUTOIGNITION: F (C): >410 (>210)
FLASH POINT; F (C), METHOD: 101 (38), PMCC.
LOWER EXPLOSIVE LIMIT: 0.8%
UPPER EXPLOSIVE LIMIT: 6.0%
EXTINGUISHING MEDIA: FOAM, DRY CHEMICAL, WATER FOG, CO2.
SENSTIVE TO IMPACT: NO.
SENSTIVE TO STATIC DISCHARGE: NOT AVAILABLE.
HAZARDOUS COMBUSTION PRODUCTS: OXIDES OF CARBON, NITROGEN AND SULFUR.
FIRE FIGHTING PROCEDURES: USE SELF CONTAINED BREATHING APPARATUS. REMOVE ALL SOURCES OF IGNITION. COOL EXPOSED DRUMS WITH WATER SPRAY.
FIRE & EXPLOSION HAZARDS: VAPORS ARE HEAVIER THAN AIR AND MAY FLOW TO DISTANT IGNITION SOURCES.

********** SECTION 5 - REACTIVITY DATA ************************************

CHEMICAL STABILITY: YES.
MATERIALS TO AVOID: STRONG OXIDIZERS AND ACIDS.
HAZARDOUS DECOMPOSITION PRODUCTS: OXIDES OF CARBON, NITROGEN AND SULFUR.
HAZARDOUS POLYMERIZATION: WILL NOT OCCUR.

********** SECTION 6 - HEALTH HAZARD DATA ********************************

PRIMARY ROUTES OF ENTRY: INHALATION, SKIN CONTACT.
EFFECTS OF OVEREXPOSURE (ACUTE & CHRONIC): MILD DEPRESSION, CONVULSIONS AND LOSS OF CONSCIOUSNESS. SKIN CONTACT CAUSES BURNING, IRRITATION, DEFATTING AND DERMATITIS.
EXPOSURE LIMITS: PETROLEUM DISTILLATES: TLV 100 PPM.
PEL 100 PPM.
OXIDIZED ASPHALT FUMES: 5 MG/M3.
ALIPHATIC PETROLEUM DISTILLATES: PEL: 5 MG/M3 AS OIL MIST.
TLV: 5 MG/M3 AS OIL MIST.
IRRITANCY OF PRODUCT: EYE IRRITATION, DRAIZE TEST: MODERATE.
SENSITIZATION TO PRODUCT: NOT AVAILABLE.
CARCINOGEN: NO.
TERATOGEN: NO.
REPRODUCTIVE TOXICITY: NO.
MUTAGEN: NO.
SYNERGISTIC PRODUCTS: NOT APPLICABLE.

********** EMERGENCY AND FIRST AID PROCEDURES ***************************

SKIN CONTACT: REMOVE AND LAUNDER CONTAMINATED CLOTHING BEFORE REUSE. DISCARD SHOES IF SEVERLY CONTAMINATED. WASH SKIN WITH SOAP AND WATER.
EYES: FLUSH WITH WATER FOR 15 MINUTES LIFTING UPPER AND LOWER LIDS. CONTACT PHYSICIAN.
INHALATION: REMOVE TO FRESH AIR, GIVE OXYGEN IF BREATHING IS DIFFICULT. CONTACT PHYSICIAN.
INGESTION: DO NOT INDUCE VOMITING, GIVE WHITE MINERAL OIL. CONTACT PHYSICIAN. DO NOT ATTEMPT TO GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

********** MATERIAL SAFETY DATA SHEET **************************************

********** SECTION 6 - HEALTH HAZARD DATA (CONTINUED) *******************

********** TOXICOLOGY INFORMATION ***

PETROLEUM DISTILLATES: LD50, ORAL-RAT, >5 GM/KG.
LC50, 4 HOUR-RAT, >5500 MG/M3.

OXIDIZED ASPHALT: LD50, NOT AVAILABLE.
LC50, NOT AVAILABLE.

ALIPHATIC PETROLEUM DISTILLATES: LD50, NOT AVAILABLE.
LC50, NOT AVAILABLE.

********** SECTION 7 - SPILL OR LEAK PROCEDURES *************************

LEAK AND SPILL PROCEDURES: REMOVE ALL SOURCES OF IGNITION, PROVIDE ADEQUATE VENTILATION, ABSORB WITH VERMICULITE OR OTHER ABSORBENT.
WASTE DISPOSAL METHOD: REFER TO LOCAL, STATE AND FEDERAL EPA REGULATIONS.
CERCLA REPORTABLE QUANITY: NOT LISTED.
RCRA HAZARDOUS WASTE NO.: NONE (40 CFR 261.33).

********** SECTION 8 - PERSONAL PROTECTION INFORMATION ******************

RESPIRATORY PROTECTION: USE AIR PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGE >TLV IF LIMITS ARE EXCEEDED.
PROTECTIVE GLOVES: BUNA-N-RUBBER.
EYE PROTECTION: SAFETY GLASSES OR GOGGLES.
VENTILATION: EXPLOSION PROOF LOCAL EXHAUST IS RECOMMENDED. MAINTAIN ADEQUATE AIR TRANSFER VELOCITY TO REMOVE VAPORS.
CLOTHING REQUIREMENTS: STANDARD INDUSTRIAL HYGIENE SHOULD BE PRACTICED.
OTHER PROTECTIVE EQUIPMENT: BUNA-N-RUBBER APRON IS RECOMMENDED. EYE WASH AND SAFETY SHOWER IS SUGGESTED. WASH BEFORE EATING, DRINKING OR SMOKING.

********** SECTION 9 - SPECIAL PRECAUTIONS *******************************

STORAGE REQUIREMENTS: STORE IN COOL, WELL VENTILATED AREA AWAY FROM ALL SOURCES OF IGNITION.
HANDLING PROCEDURES: PREVENT PROLONGED/REPEATED SKIN CONTACT AND AVOID BREATHING VAPORS.

********** SECTION 10 - SHIPPING INFORMATION (HM-181) ******************

PROPER SHIPPING NAME: PETROLEUM DISTILLATES N.O.S.(STODDARD SOLVENT)
HAZARD CLASS/DIVISION: 3
UN MNUMBER: UN-1268
PACKING GROUP: III
LABELS REQUIRED: FLAMMABLE LIQUID (3.3)
CANADA: TOXIC "T" (D.2.B)
IMDG CODE: page 3375

XL5-G

********** MATERIAL SAFETY DATA SHEET **********************************

********** SECTION 11 - OTHER REGULATORY *******************************

TSCA: ALL COMPONENTS ARE ON THE TSCA INVENTORY.
SARA TITLE III, SECTION 313. THIS PRODUCT CONTAINS (OR IS) A TOXIC CHEMICAL FOR ROUTINE ANNUAL TOXIC CHEMICAL RELEASE REPORTING UNDER SECTION 313:

NONE.

SARA TITLE III, SECTIONS 311 AND 312. THIS PRODUCT CONTAINS A CHEMICAL SUBSTANCE THAT IS CONSIDERED, UNDER APPLICABLE DEFINITIONS, TO MEET THE FOLLOWING CATAGORIES:

A FIRE HAZARD.

********** SECTION 12 - PREPARATION ************************************

PREPARED BY:	GORDON POLIQUIN
TITLE:	LABORATORY MANAGER
CREATION DATE:	10-27-93
SUPERCEDES:	4-29-93
REASON FOR REVISION:	UP DATE SECTIONS 2, 10 AND 11.

ADDITIONAL INFORMATION

THE INFORMATION GIVEN AND THE RECOMMENDATIONS MADE HEREIN APPLY TO OUR PRODUCTS ALONE AND NOT COMBINED WITH OTHER PRODUCTS. SUCH ARE BASED ON OUR RESEARCH AND ON DATA FROM OTHER RELIBLE SOURCES AND ARE BELIEVED TO BE ACCURATE. NO GUARANTY OF ACCURACY IS MADE. IT IS THE PURCHASER'S RESPONSIBILITY BEFORE USING ANY PRODUCT TO VERIFY THIS DATA UNDER THEIR OWN OPERATING CONDITIONS AND TO DETERMINE WHETHER THE PRODUCT IS SUITABLE FOR THEIR PURPOSES. THE INFORMATION HEREIN IS PRESENTED IN GOOD FAITH AND BELIEVED TO BE ACCURATE AS OF THE EFFECTIVE DATE SHOWN ABOVE. HOWEVER, NO WARRENTY, EXPRESS OR IMPLIED, IS GIVEN. REGULATORY REQUIREMENTS ARE SUBJECT TO CHANGE AND MAY DIFFER FROM ONE LOCATION TO ANOTHER; IT IS THE BUYER'S RESPONSIBILITY TO ENSURE THAT IT'S ACTIVITIES COMPLY WITH FEDERAL, STATE OR PROVINCIAL, AND LOCAL LAWS. THE ABOVE INFORMATION IS MADE FOR THE PURPOSE OF COMPLYING WITH NUMEROUS FEDERAL, STATE OR PROVINCIAL, AND LOCAL LAWS AND REGULATIONS.

APPENDIX 3-2

Material Safety Data Sheets

for

MEK Alternatives:

Date Issued:	*06/12/95*
Date Created:	*06/01/95*

HUNTSMAN EXPERIMENTAL PRODUCT
MATERIAL SAFETY DATA SHEET

NOTE: This MSDS is valid for six months from the date of issue. Use, dispose of material or request new MSDS when six months has expired.

1. PRECAUTIONARY STATEMENT

WARNING! EXPERIMENTAL PRODUCT! IMPORTANT: The chemical, physical and toxicological properties of this experimental product have not been fully investigated, and its handling or use may be hazardous. EXERCISE DUE CARE.

NFPA Code:	Health *1*	Flammability *1*	Reactivity *0*	Special	-
HMIS Code:	Health *1*	Flammability *1*	Reactivity *0*	Protection	-

2. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Huntsman Corporation
Austin Research Laboratories
P.O. Box 15730
Austin, TX 78761

EMERGENCY CONTACT
Renée T. Bade (512) 483-0147 (Business hours)
Port Neches, TX (409) 727-0831 (24-hours)

ARL CODE:	*[ARL 9506-01]*
PRODUCT NAME:	**PAINT REMOVER FORMULATION H**
CHEMICAL NAME/CLASS:	*Solvent Mixture*

3. TRANSPORTATION AND OTHER REGULATORY INFORMATION

D.O.T.

Proper Shipping Name:	*Not Regulated*
Hazard Class:	*None*
Identification #:	*None*
Emergency Guide Response #:	*None*

O.S.H.A.

Component	Hazardous Characteristic(s)	CAS #	Range
Benzyl alcohol	*Irritating to skin and eyes (severe)* *No exposure limit established*	*000100-51-6*	*20-90*
Propylene carbonate	*None Known* *No exposure limit established*	*000108-32-7*	*5-40*
Dibasic Ester	*Flammable; Skin and eye irritant* *Admissible exposure limit 10 mg/m3 (8 hr TWA)*	*Mixture*	*5-40*

T.S.C.A.
Status: *Commercial*

ARL CODE:	*[ARL 9506-01]*	**Date Issued:**	*06/12/95*
PRODUCT NAME:	**PAINT REMOVER FORMULATION H**	**Date Created:**	*06/01/95*

4. FIRST AID MEASURES

Eye Contact

Flush eyes with plenty of water for at least 15 minutes: [X]
Get medical attention: [X]

Skin Contact

Wash skin with soap and water: [X]
Get medical attention: [X]

5. EXPOSURE CONTROLS/PERSONAL PROTECTION

The following personal protection is recommended:

Safety Glasses	[X]	Protective Apron	[X]
Chemical Goggles	[X]	Coveralls	[X]
Face Shield	[X]	Respirator/Hood	[X]
Gloves, Chemical Resistant	[X]	Supplied Air Mask (for large spills or confined spaces)	[X]

6. PHYSICAL AND CHEMICAL PROPERTIES

Color: *Light*	**Volatility:** *Low (< 100)*	**Water Solubility:** *Appreciable (> 10%)*
Odor: *Mild*	**Physical State:** *Mobile Liquid (< 100)*	
pH, 1% Solution: *6.9*	**Boiling Point, °F:** *> 95*	**Flash Point-Closed Cup, °F:** *213*
Density, g/ml: *1.07*	**Melting Point, °F:** *N.D.*	

7. STABILITY AND REACTIVITY

This material Reacts Violently with: (If others is checked below, see comments for details)

Air	[ ]	Heat	[ ]	Others	[X]
Water	[ ]	Strong Oxidizer	[ ]	None of These	[ ]

Comments:
This material reacts violently with [Strong acids, bases, oxidizers]

Hazardous Polymerizations: *Do Not Occur*

8. DISPOSAL CONSIDERATIONS

Contain spill. Avoid personal contact. Wipe up or absorb on suitable material for disposal. Dispose of unused material in a suitable manner.

R.C.R.A. Classification: *Not Regulated*

HUNTSMAN EXPERIMENTAL PRODUCT
MATERIAL SAFETY DATA SHEET

Date Issued: *06/12/95*
Date Created: *06/06/95*

NOTE: This MSDS is valid for six months from the date of issue. Use, dispose of material or request new MSDS when six months has expired.

1. PRECAUTIONARY STATEMENT

WARNING! EXPERIMENTAL PRODUCT! IMPORTANT: The chemical, physical and toxicological properties of this experimental product have not been fully investigated, and its handling or use may be hazardous. EXERCISE DUE CARE.

NFPA Code:	Health *1*	Flammability *1*	Reactivity *0*	Special -
HMIS Code:	Health *1*	Flammability *1*	Reactivity *0*	Protection -

2. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Huntsman Corporation
Austin Research Laboratories
P.O. Box 15730
Austin, TX 78761

EMERGENCY CONTACT
Renée T. Bade (512) 483-0147 (Business hour
Port Neches, TX (409) 727-0831 (24-hours)

ARL CODE: *[ARL 9506-05]*
PRODUCT NAME: **PAINT REMOVER FORMULATION L**
CHEMICAL NAME/CLASS: *Solvent Mixture*

3. TRANSPORTATION AND OTHER REGULATORY INFORMATION

D.O.T.

Proper Shipping Name: *Not Regulated*
Hazard Class: *None*
Identification #: *None*
Emergency Guide Response #: *None*

O.S.H.A.

Component	Hazardous Characteristic(s)	CAS #	Rang
Benzyl alcohol	*Irritating to skin and eyes (severe)* *No exposure limit established*	*000100-51-6*	*25-8*
Propylene carbonate	*None Known* *No exposure limit established*	*000108-32-7*	*15-7*

T.S.C.A.
Status: *Commercial*

ARL CODE:	*[ARL 9506-05]*	**Date Issued:**	*06/12/95*
PRODUCT NAME:	**PAINT REMOVER FORMULATION L**	**Date Created:**	*06/06/95*

4. FIRST AID MEASURES

Eye Contact

Flush eyes with plenty of water for at least 15 minutes: [X]
Get medical attention: [X]

Skin Contact

Wash skin with soap and water: [X]
Get medical attention: [X]

5. EXPOSURE CONTROLS/PERSONAL PROTECTION

The following personal protection is recommended:

Safety Glasses	[X]	Protective Apron	[X]
Chemical Goggles	[X]	Coveralls	[X]
Face Shield	[X]	Respirator/Hood	[X]
Gloves, Chemical Resistant	[X]	Supplied Air Mask (for large spills or confined spaces)	[X]

6. PHYSICAL AND CHEMICAL PROPERTIES

Color: *Light*	**Volatility:** *Low (< 100)*	**Water Solubility:** *Appreciable (> 10%)*
Odor: *Mild*	**Physical State:** *Mobile Liquid (< 100)*	
pH, 1% Solution: *6.8*	**Boiling Point, °F:** *> 95*	**Flash Point-Closed Cup, °F:** *213*
Density, g/ml: *1.10*	**Melting Point, °F:** *N.D.*	

7. STABILITY AND REACTIVITY

This material Reacts Violently with: (If others is checked below, see comments for details)

Air	[ ]	Heat	[ ]	Others	[X]
Water	[ ]	Strong Oxidizer	[ ]	None of These	[ ]

Comments:
This material reacts violently with [Strong acids, bases, oxidizers]

Hazardous Polymerizations: *Do Not Occur*

8. DISPOSAL CONSIDERATIONS

Contain spill. Avoid personal contact. Wipe up or absorb on suitable material for disposal. Dispose of unused material in a suitable manner.

R.C.R.A. Classification: *Not Regulated*

Date Issued: *06/12/95*
Date Created: *06/06/95*

HUNTSMAN EXPERIMENTAL PRODUCT
MATERIAL SAFETY DATA SHEET

NOTE: This MSDS is valid for six months from the date of issue. Use, dispose of material or request new MSDS when six months has expired.

1. PRECAUTIONARY STATEMENT

WARNING! EXPERIMENTAL PRODUCT! IMPORTANT: The chemical, physical and toxicological properties of this experimental product have not been fully investigated, and its handling or use may be hazardous. EXERCISE DUE CARE.

NFPA Code:	Health *1*	Flammability *1*	Reactivity *0*	Special -
HMIS Code:	Health *1*	Flammability *1*	Reactivity *0*	Protection -

2. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Huntsman Corporation
Austin Research Laboratories
P.O. Box 15730
Austin, TX 78761

EMERGENCY CONTACT
Renée T. Bade (512) 483-0147 (Business hours)
Port Neches, TX (409) 727-0831 (24-hours)

ARL CODE: *[ARL 9506-07]*
PRODUCT NAME: PAINT REMOVER FORMULATION N
CHEMICAL NAME/CLASS: *Solvent Mixture*

3. TRANSPORTATION AND OTHER REGULATORY INFORMATION

D.O.T.

Proper Shipping Name: *Not Regulated*
Hazard Class: *None*
Identification #: *None*
Emergency Guide Response #: *None*

O.S.H.A.

Component	Hazardous Characteristic(s)	CAS #	Range
Benzyl alcohol	*Irritating to skin and eyes (severe)* *No exposure limit established*	*000100-51-6*	*20-85*
Propylene carbonate	*None Known* *No exposure limit established*	*000108-32-7*	*5-25*
Dibasic Ester	*Flammable; Skin and eye irritant* *Admissible exposure limit 10 mg/m3 (8 hr TWA)*	*Mixture*	*5-25*
Butyrolactone, gamma	*May cause irritation* *No Exposure limit established*	*000096-48-0*	*5-25*

T.S.C.A.

Status: *Commercial*

4. FIRST AID MEASURES

Eye Contact

Flush eyes with plenty of water for at least 15 minutes: [X]
Get medical attention: [X]

Skin Contact

Wash skin with soap and water: [X]
Get medical attention: [X]

5. EXPOSURE CONTROLS/PERSONAL PROTECTION

The following personal protection is recommended:

Safety Glasses	[X]	Protective Apron	[X]
Chemical Goggles	[X]	Coveralls	[X]
Face Shield	[X]	Respirator/Hood	[X]
Gloves, Chemical Resistant	[X]	Supplied Air Mask (for large spills or confined spaces)	[X]

6. PHYSICAL AND CHEMICAL PROPERTIES

Color: *Light*	Volatility: *Low (< 100)*	Water Solubility: *Appreciable (> 10%)*
Odor: *Mild*	Physical State: *Mobile Liquid (< 100)*	
pH, 1% Solution: *6.9*	Boiling Point, °F: *> 95*	Flash Point-Closed Cup, °F: *209*
Density, g/ml: *1.07*	Melting Point, °F: *N.D.*	

7. STABILITY AND REACTIVITY

This material Reacts Violently with: (If others is checked below, see comments for details)

Air	[ ]	Heat	[ ]	Others	[X]
Water	[ ]	Strong Oxidizer	[ ]	None of These	[ ]

Comments:
This material reacts violently with [Strong acids, bases, oxidizers]

Hazardous Polymerizations: *Do Not Occur*

8. DISPOSAL CONSIDERATIONS

Contain spill. Avoid personal contact. Wipe up or absorb on suitable material for disposal. Dispose of unused material in a suitable manner.

R.C.R.A. Classification: *Not Regulated*

Date Issued:	*06/12/95*
Date Created:	*06/10/94*

HUNTSMAN EXPERIMENTAL PRODUCT MATERIAL SAFETY DATA SHEET

NOTE: This MSDS is valid for six months from the date of issue. Use, dispose of material or request new MSDS when six months has expired.

1. PRECAUTIONARY STATEMENT

WARNING! EXPERIMENTAL PRODUCT! IMPORTANT: The chemical, physical and toxicological properties of this experimental product have not been fully investigated, and its handling or use may be hazardous. EXERCISE DUE CARE.

NFPA Code:	Health *2*	Flammability *1*	Reactivity *0*	Special	-
HMIS Code:	Health *2*	Flammability *1*	Reactivity *0*	Protection	-

2. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Huntsman Corporation
Austin Research Laboratories
P.O. Box 15730
Austin, TX 78761

EMERGENCY CONTACT
Renée T. Bade (512) 483-0147 (Business hours)
Port Neches, TX (409) 727-0831 (24-hours)

ARL CODE:	*[ARL 9406-03]*
PRODUCT NAME:	**TEXADD S-200**
CHEMICAL NAME/CLASS:	*Solvent Mixture*

3. TRANSPORTATION AND OTHER REGULATORY INFORMATION

D.O.T.

Proper Shipping Name:	*Not Regulated*
Hazard Class:	*None*
Identification #:	*None*
Emergency Guide Response #:	*None*

O.S.H.A.

Component	Hazardous Characteristic(s)	CAS #	Range
Methyl-2-pyrrolidinone,1-	*Combustible;Eye (severe),skin/respiratory irritant* *No exposure limit established*	*000872-50-4*	*25-75*
Propylene carbonate	*None Known* *No exposure limit established*	*000108-32-7*	*25-75*

T.S.C.A.

Status: *Commercial*

ARL CODE:	*[ARL 9406-03]*	**Date Issued:**	*06/12/95*
PRODUCT NAME:	**TEXADD S-200**	**Date Created:**	*06/10/94*

4. FIRST AID MEASURES

Eye Contact

Flush eyes with plenty of water for at least 15 minutes: [X]
Get medical attention: [X]

Skin Contact

Wash skin with soap and water: [X]
Get medical attention: [ ]

5. EXPOSURE CONTROLS/PERSONAL PROTECTION

The following personal protection is recommended:

Safety Glasses	[X]	Protective Apron	[ ]
Chemical Goggles	[X]	Coveralls	[ ]
Face Shield	[X]	Respirator/Hood	[ ]
Gloves, Chemical Resistant	[ ]	Supplied Air Mask (for large spills or confined spaces)	[ ]

6. PHYSICAL AND CHEMICAL PROPERTIES

Color: *Colorless*	**Volatility:** *Low (< 100)*	**Water Solubility:** *Appreciable (> 10%)*
Odor: *Mild*	**Physical State:** *Mobile Liquid (< 100)*	
pH, 1% Solution: *~ 7*	**Boiling Point, °F:** *N.D.*	**Flash Point-Closed Cup, °F:** *200*
Density, g/ml: *1.10*	**Melting Point, °F:** *N.D.*	

7. STABILITY AND REACTIVITY

This material Reacts Violently with: (If others is checked below, see comments for details)

Air	[ ]	Heat	[ ]	Others	[X]
Water	[ ]	Strong Oxidizer	[X]	None of These	[ ]

Comments:
This material reacts violently with [Strong acids & bases]

Hazardous Polymerizations: *Do Not Occur*

8. DISPOSAL CONSIDERATIONS

Contain spill. Avoid personal contact. Wipe up or absorb on suitable material for disposal. Dispose of unused material in a suitable manner.

R.C.R.A. Classification: *Not Regulated*

JEFFSOL PC
HUNTSMAN CHEMICAL CO.
PRODUCT CODE: 75436
DATE ISSUED: 10-31-94 Supersedes: 07-01-94

MATERIAL SAFETY DATA SHEET

This MSDS was printed utilizing access to Huntsman's CD-ROM MSDS Database. Due to variations in printer dependent character styles, fonts and computer control codes, the appearance may differ from that of the centrally printed Huntsman MSDS.

NOTE: Read and understand Material Safety Data Sheet before handling or disposing of product.

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATERIAL IDENTITY
Product Code and Name:
75436 JEFFSOL PC
Chemical Name and/or Family or Description:
Alkylene carbonate

Manufacturer's Name and Address:
HUNTSMAN
P.O. Box 27707
Houston, TX 77227-7707

Telephone Numbers:

Transportation Emergency-Company	: (409) 727-0831
CHEMTREC	: (800) 424-9300
Health Emergency -Company	: (914) 831-3400
General MSDS Assistance	: (713) 235-6432
Technical Information	: (512) 459-6543

2. COMPOSITION/INFORMATION ON INGREDIENTS

THE CRITERIA FOR LISTING COMPONENTS IN THE COMPOSITION SECTION IS AS FOLLOWS: CARCINOGENS ARE LISTED WHEN PRESENT AT 0.1 % OR GREATER; COMPONENTS WHICH ARE OTHERWISE HAZARDOUS ACCORDING TO OSHA ARE LISTED WHEN PRESENT AT 1.0 % OR GREATER; NON-HAZARDOUS COMPONENTS ARE LISTED AT 3.0 % OR GREATER. THIS IS NOT INTENDED TO BE A COMPLETE COMPOSITIONAL DISCLOSURE. REFER TO SECTION 14 FOR APPLICABLE STATES' RIGHT TO KNOW AND OTHER REGULATORY INFORMATION.

Product and/or Component(s) Carcinogenic According to:

OSHA	IARC	NTP	OTHER	NONE
				X
-	-	-	-	-

Composition: (Sequence Number and Chemical Name)

Seq. Chemical Name	CAS Number	Range in %

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

2. COMPOSITION/INFORMATION ON INGREDIENTS (CONT)

01	* 1,3-dioxolan-2-one, methyl-	108-32-7	100.00

PRODUCT IS HAZARDOUS ACCORDING TO OSHA (1910.1200).
* COMPONENT IS HAZARDOUS ACCORDING TO OSHA.

Exposure Limits referenced by Sequence Number in the Composition Section

Seq.	Limit
None	

3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW
Appearance:
Colorless liquid
Odor:
Slight odor

WARNING STATEMENT

CAUTION ! MAY CAUSE EYE IRRITATION
ASPIRATION HAZARD IF SWALLOWED -
CAN ENTER LUNGS AND CAUSE DAMAGE
CONTAMINATION MAY RESULT IN DANGEROUS CO2 PRESSURE BUILD-UP

HMIS				NFPA			
Health:	1	Reactivity:	0	Health:	1	Reactivity:	0
Flammability:	1	Special	: -	Flammability:	1	Special	: -

POTENTIAL HEALTH EFFECTS

	EYE	SKIN	INHALATION	INGESTION
Primary Route of Exposure:	X	X	X	

EFFECTS OF OVEREXPOSURE
Acute:
Eyes:
May cause irritation, experienced as mild discomfort and seen as slight excess redness of the eye.

3. HAZARD IDENTIFICATION (CONT)

Skin:
Brief contact is not irritating. Prolonged contact, as with clothing wetted with material, may cause defatting of skin or irritation, seen as local redness with possible mild discomfort.

Other than the potential skin irritation effects noted above, acute (short term) adverse effects are not expected from brief skin contact; see other effects, below, and Section 11 for information regarding potential long term effects.

Inhalation:
Vapors or mist, in excess of permissible concentrations, or in unusually high concentrations generated from spraying, heating the material or as from exposure in poorly ventilated areas or confined spaces, may cause irritation of the nose and throat, headache, nausea, and drowsiness.

Ingestion:
If more than several mouthfuls are swallowed, abdominal discomfort, nausea, and diarrhea may occur. Aspiration may occur during swallowing or vomiting resulting in lung damage.

Sensitization Properties:
This product is not expected to be a human skin sensitizer based on animal data.

Chronic:
No adverse effects have been documented in humans as a result of chronic exposure. Section 11 may contain applicable animal data.

Medical Conditions Aggravated by Exposure:
There is no evidence that this product aggravates an existing medical condition.

Other Remarks:
None

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

4. FIRST AID MEASURES

Eyes:
Immediately flush eyes with plenty of water for at least 15 minutes. Hold eyelids apart while flushing to rinse entire surface of eye and lids with water. Get medical attention.

Skin:
Wash skin with plenty of soap and water for several minutes. Get medical attention if skin irritation develops or persists.

Ingestion:
If person is conscious and can swallow, give two glasses of water (16 oz.) but do not induce vomiting. If vomiting occurs, give fluids again. Have medical personnel determine if evacuation of stomach or induction of vomiting is necessary. Do not give anything by mouth to an unconscious or convulsing person.

Inhalation:
If irritation, headache, nausea, or drowsiness occurs, remove to fresh air. Get medical attention if breathing becomes difficult or respiratory irritation persists.

Other Instructions:
Aspiration of this product during induced emesis may result in severe lung injury. If evacuation of stomach is necessary, use method least likely to cause aspiration, such as gastric lavage after endotracheal intubation. Contact a Poison Center for additional treatment information.

5. FIRE-FIGHTING MEASURES

Ignition Temperature (degrees F):
Not determined.
Flash Point (degrees F):
275 (CC)
Flammable Limits (%):
Lower: 2.3
Upper: Not determined.

Recommended Fire Extinguishing Agents And Special Procedures:
Use water spray, dry chemical, foam, or carbon dioxide to extinguish flames. Use water spray to cool fire-exposed containers. Water or foam may cause frothing.

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

5. FIRE-FIGHTING MEASURES (CONT)

Unusual or Explosive Hazards:
None

Special Protective Equipment for Firefighters:
Wear full protective clothing and positive pressure breathing apparatus.

6. ACCIDENTAL RELEASE MEASURES (Transportation Spills: CHEMTREC (800)424-9300)

Procedures in Case of Accidental Release, Breakage or Leakage:
Contain spill if possible, contain with absorbent materials such as clay or soil, and shovel up. Avoid skin and eye contact.

If more than 10,000,000 pounds of product is spilled, then report spill according to SARA 304 and/or CERCLA 102(a) requirements, unless product qualifies for the petroleum exemption (CERCLA Section 101(14)).

7. HANDLING AND STORAGE

Precautions to be Taken in
Handling:
Minimum feasible handling temperatures should be maintained.

Storage:
Periods of exposure to high temperatures should be minimized. Water contamination should be avoided.
Alkyl carbonates may decompose in the presence of water, acids, bases, salts, or metal oxides such as common rust to cause a pressure build-up in processing or storage vessels. This may lead to rupture of the container.
Pressure-relief devices are recommended on such containers.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Protective Equipment (Type)
Eye/Face Protection:
Safety glasses, chemical type goggles, or face shield recommended to prevent eye contact.

N.D. - NOT DETERMINED	N.A. - NOT APPLICABLE	N.T. - NOT TESTED
< - LESS THAN	> - GREATER THAN	

8. EXPOSURE CONTROLS/PERSONAL PROTECTION (CONT)

Skin Protection:
Workers should wash exposed skin several times daily with soap and water. Soiled work clothing should be laundered or dry-cleaned.

Respiratory Protection:
Airborne concentrations should be kept to lowest levels possible. If vapor, mist or dust is generated and the occupational exposure limit of the product, or any component of the product, is exceeded, use appropriate NIOSH or MSHA approved air purifying or air supplied respirator after determining the airborne concentration of the contaminant. Air supplied respirators should always be worn when airborne concentration of the contaminant or oxygen content is unknown.

Ventilation:
Local exhaust ventilation recommended if generating vapor, dust, or mist. If exhaust ventilation is not available or inadequate, use MSHA or NIOSH approved respirator as appropriate.

Exposure Limit for Total Product:
None established for product.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:
Colorless liquid
Odor:
Slight odor

Boiling Point (degrees F):
468

Melting/Freezing point (degrees F):
-56

Specific Gravity (water=1):
1.203

pH of undiluted product:
7

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

PRODUCT CODE: 75436 **Date Issued: 10-31-9**
NAME: JEFFSOL PC **Supersedes: 07-01-9**

9. PHYSICAL AND CHEMICAL PROPERTIES (CONT)

Vapor Pressure:
.02 mmHg at 68.0

Viscosity:
1.6 cSt at 43.3 C

VOC Content:
Not determined.

Vapor Density (air=1):
3.5

Solubility in Water (%):
1 - 10

Other: None

10. STABILITY AND REACTIVITY

This Material Reacts Violently With:
(If Others is checked below, see comments for details)

Air	Water	Heat	Strong Oxidizers	Others	None of These
					X

Comments:
None

Products Evolved When Subjected to Heat or Combustion:
Toxic levels of carbon monoxide, carbon dioxide, irritating aldehydes and ketones may be formed on burning. Heating in air may produce irritating aldehydes, acids, and ketones.

Hazardous Polymerizations: DO NOT OCCUR

11. TOXICOLOGICAL INFORMATION

TOXICOLOGICAL INFORMATION(ANIMAL TOXICITY DATA)
Median Lethal Dose
Oral:
LD50 > 5.00 g/kg (rat) practically non-toxic

N.D. - NOT DETERMINED   N.A. - NOT APPLICABLE   N.T. - NOT TESTED
< - LESS THAN   > - GREATER THAN

11. TOXICOLOGICAL INFORMATION (CONT)

Inhalation:
Believed to be practically non-toxic
Dermal:
LD50 > 3.00 g/kg (rabbit) practically non-toxic
Irritation Index, Estimation of Irritation (Species)
Skin:
(Draize) .20 /8.0 (rabbit) no appreciable effect
Eyes:
(Draize) 12.50 /110 (rabbit) slightly irritating
Sensitization:
(Buehler) Negative - skin (guinea pig)
Other:
This product may contain residual (less than 100 ppm) concentrations of propylene oxide. There is evidence that propylene oxide causes tumors in laboratory animals.

12. DISPOSAL CONSIDERATIONS

Waste Disposal Methods
This product has been evaluated for RCRA characteristics and does not meet the criteria of a hazardous waste if discarded in its purchased form. Under RCRA, it is the responsibility of the user of the product to determine at the time of disposal, whether the product meets RCRA criteria for hazardous waste. This is because product uses, transformations, mixtures, processes, etc. may render the resulting materials hazardous.

Remarks
None

13. TRANSPORT INFORMATION

Transportation
DOT:
Proper Shipping Name:
Not regulated

IMDG:
Proper Shipping Name:
Not evaluated

13. TRANSPORT INFORMATION (CONT)

ICAO:
Proper Shipping Name:
Not evaluated

TDG:
Proper Shipping Name:
Not regulated

14. REGULATORY INFORMATION

Federal Regulations:
SARA Title III:
Section 302/304 Extremely Hazardous Substances

Seq.	Chemical Name	CAS Number	Range in %
01	Residual propylene oxide (typical)	75-56-9	0.001

Section 302/304 Extremely Hazardous Substances (CONT)

Seq.	TPQ	RQ
01	10000	100

Section 311 Hazardous Categorization:

Acute	Chronic	Fire	Pressure	Reactive	N/A
X					
-	-	-	-	-	-

Section 313 Toxic Chemical

Chemical Name	CAS Number	Concentration
None		

CERCLA 102(a)/DOT Hazardous Substances: (+ indicates DOT Hazardous Substance)

Seq.	Chemical Name	CAS Number	Range in %
01+	Residual propylene oxide (typical)	75-56-9	0.001

CERCLA/DOT Hazardous Substances (Sequence Numbers and RQ's):

Seq.	RQ
01+	100

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

14. REGULATORY INFORMATION (CONT)

TSCA Inventory Status:
This product is listed on the Toxic Substance Control Act (TSCA) Chemical Substance Inventory.

Other:
- None.

State Regulations:
California Proposition 65:
The following detectable components of this product are substances, or belong to classes of substances, known to the State of California to cause cancer and/or reproductive toxicity.

Chemical Name	CAS Number
Residual propylene oxide (typical)	75-56-9

States Right-to-know Regulations:

Chemical Name	State Right-to-know
None	

State list: CT (Connecticut), FL (Florida), IL (Illinois), MI (Michigan)
LA (Louisiana), MA (Massachusetts), NJ (New Jersey),
PA (Pennsylvania), RI (Rhode Island),

International Regulations:
Export Notification (TSCA-12b):
This product may be subject to export notification under TSCA section 12(b); contains:
Residual propylene oxide (typical)

WHMIS Classification:
Not regulated

Canada Inventory Status:
All components are listed on the Canadian Domestic Substance List (DSL).

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

14. REGULATORY INFORMATION (CONT)

EINECS Inventory Status:
All components are listed on the European Inventory of Existing Chemical Substances (EINECS).

Australia Inventory Status:
All components are listed on the Australian Inventory of Chemical Substances (ACIS).

Japan Inventory Status:
All components are listed on the Japanese MITI inventory.

15. ENVIRONMENTAL INFORMATION

Aquatic Toxicity:
Not determined.

Mobility:
Not determined.

Persistence and Biodegradability:
Not determined.

Potential to Bioaccumulate:
Not determined.

Remarks:
None

16. OTHER INFORMATION

Propoxylated products may contain residual amounts of free propylene oxide. Residual propylene oxide can accumulate in the container headspace and be released into the ambient environment. This process is enhanced when the product is agitated, as during tank car loading and unloading, and blending operations. There is evidence that propylene oxide causes tumors in laboratory animals. The OSHA and ACGIH eight-hour time weighted average exposure limits are both 20 ppm. The Huntsman internal standard is 10 ppm for an eight-hour time weighted average exposure.

16. OTHER INFORMATION (CONT)

THE INFORMATION CONTAINED HEREIN IS BELIEVED TO BE ACCURATE. IT IS PROVIDED INDEPENDENTLY OF ANY SALE OF THE PRODUCT FOR PURPOSE OF HAZARD COMMUNICATION AS PART OF HUNTSMAN'S PRODUCT SAFETY PROGRAM. IT IS NOT INTENDED TO CONSTITUTE PERFORMANCE INFORMATION CONCERNING THE PRODUCT. NO EXPRESS WARRANTY, OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE WITH RESPECT TO THE PRODUCT OR THE INFORMATION CONTAINED HEREIN. DATA SHEETS ARE AVAILABLE FOR ALL HUNTSMAN PRODUCTS. YOU ARE URGED TO OBTAIN DATA SHEETS FOR ALL HUNTSMAN PRODUCTS YOU BUY, PROCESS, USE OR DISTRIBUTE AND YOU ARE ENCOURAGED AND REQUESTED TO ADVISE THOSE WHO MAY COME IN CONTACT WITH SUCH PRODUCTS OF THE INFORMATION CONTAINED HEREIN.

TO DETERMINE APPLICABILITY OR EFFECT OF ANT LAW OR REGULATION WITH RESPECT TO THE PRODUCT, USER SHOULD CONSULT HIS LEGAL ADVISOR OR THE APPROPRIATE GOVERNMENT AGENCY. HUNTSMAN DOES NOT UNDERTAKE TO FURNISH ADVICE ON SUCH MATTERS.

Date: 10-31-94 New X Revised, Supersedes: 07-01-94

Inquiries regarding MSDS should be directed to:
Huntsman
Coordinator, Product Safety
P.O. Box 27707
Houston, TX 77227-7707

PLEASE SEE NEXT PAGE FOR PRODUCT LABEL

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

PRODUCT CODE: 75436 Date Issued: 10-31-9
NAME: JEFFSOL PC Supersedes: 07-01-9

17. PRODUCT LABEL

READ AND UNDERSTAND MATERIAL SAFETY DATA SHEET BEFORE HANDLING OR DISPOSING OF PRODUCT. THIS LABEL COMPLIES WITH THE REQUIREMENTS OF THE OSHA HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200) FOR USE IN THE WORKPLACE. THIS LABEL IS NOT INTENDED TO BE USED WITH PACKAGING INTENDED FOR SALE TO CONSUMERS AND MAY NOT CONFORM WITH THE REQUIREMENTS OF THE CONSUMER PRODUCT SAFETY ACT OR OTHER RELATED REGULATORY REQUIREMENTS.

75436 JEFFSOL PC

WARNING STATEMENT

CAUTION ! MAY CAUSE EYE IRRITATION
ASPIRATION HAZARD IF SWALLOWED -
CAN ENTER LUNGS AND CAUSE DAMAGE
CONTAMINATION MAY RESULT IN DANGEROUS CO2 PRESSURE BUILD-UP

PRECAUTIONARY MEASURES

- -Avoid prolonged breathing of vapor, mist, or gas.
- -Avoid contact with eyes.
- -Keep container closed.
- -Wash thoroughly after handling.

FIRST AID

Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes. Hold eyelids apart while flushing to rinse entire surface of eye and lids with water. Get medical attention.

Skin Contact:
Wash skin with plenty of soap and water for several minutes. Get medical attention if skin irritation develops or persists.

Ingestion:
If person is conscious and can swallow, give two glasses of water (16 oz.) but do not induce vomiting. If vomiting occurs, give fluids again. Have medical personnel determine if evacuation of stomach or induction of vomiting is necessary. Do not give anything by mouth to an unconscious or convulsing person.

Inhalation:
If irritation, headache, nausea, or drowsiness occurs, remove to fresh air. Get medical attention if breathing becomes difficult or respiratory irritation persists.

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

17. PRODUCT LABEL (CONT)

Note to Physician:
Aspiration of this product during induced emesis may result in severe lung injury. If evacuation of stomach is necessary, use method least likely to cause aspiration, such as gastric lavage after endotracheal intubation. Contact a Poison Center for additional treatment information.

FIRE

In case of fire, use water spray, dry chemical, foam or carbon dioxide. Water may cause frothing. Use water spray to cool fire-exposed containers.

If more than 10,000,000 pounds of product is spilled, then report spill according to SARA 304 and/or CERCLA 102(a) requirements, unless product qualifies for the petroleum exemption (CERCLA Section 101(14)).

	Chemical Name	CAS Number	Range in %
*	1,3-dioxolan-2-one, methyl-	108-32-7	100.00

PRODUCT IS HAZARDOUS ACCORDING TO OSHA (1910.1200).
* COMPONENT IS HAZARDOUS ACCORDING TO OSHA.

Pennsylvania Special Hazardous Substance(s)	CAS Number	Range in %
None		

HMIS				NFPA			
Health:	1	Reactivity:	0	Health:	1	Reactivity:	0
Flammability:	1	Special	: -	Flammability:	1	Special	: -

Transportation
DOT:
Proper Shipping Name:
Not regulated

PRODUCT CODE: 75436 **Date Issued: 10-31-94**
NAME: JEFFSOL PC **Supersedes: 07-01-94**

17. PRODUCT LABEL (CONT)

CAUTION: Misuse of empty containers can be hazardous. Empty containers can be hazardous if used to store toxic, flammable, or reactive materials. Cutting or welding of empty containers might cause fire, explosion or toxic fumes from residues. Do not pressurize or expose to open flame or heat. Keep container closed and drum bungs in place.

Manufacturer's Name and Address:
HUNTSMAN
P.O. Box 27707
Houston, TX 77227-7707

TRANSPORTATION EMERGENCY	Company:	(409) 727-0831
	CHEMTREC:	(800) 424-9300
HEALTH EMERGENCY	Company:	(914) 831-3400

J.T. Baker
A Division of Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865
24-Hour Emergency Telephone 908-859-2151
National Response Center 800-424-8802
Chemtrec 800-424-9300

National Response in Canada
CANUTEC 613-996-6666
Outside U.S. and Canada
Chemtrec 202-483-7616

MATERIAL SAFETY DATA SHEET
FICHE SIGNALÉTIQUE
HOJAS DE DATOS DE SEGURIDAD

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers are to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.
All non-emergency questions should be directed to Customer Service (1-800-JTBAKER) for assistance.

Mallinckrodt Baker, Inc., 222 Red School Lane, Phillipsburg, NJ 08865

SECTION I - PRODUCT IDENTIFICATION

Product Name:	Methyl Ethyl Ketone
Common Synonyms:	2-Butanone; MEK; Ethyl Methyl Ketone; Methyl Acetone
Chemical Family:	Ketones
Formula:	$CH_3COCH_2CH_3$
Formula Wt.:	72.11
CAS No.:	78-93-3
NIOSH/RTECS No.:	EL6475000
Product Use:	Laboratory Reagent
Product Codes:	5385,9323,9214,9319,5808,Q531,9211

PRECAUTIONARY LABELING

BAKER SAF-T-DATA* System

HEALTH	FLAMMABILITY	REACTIVITY	CONTACT
2	4	2	2
MODERATE	EXTREME	MODERATE	MODERATE

Laboratory Protective Equipment

U.S. Precautionary Labeling

DANGER!

CAUSES IRRITATION. EXTREMELY FLAMMABLE. HARMFUL IF SWALLOWED OR INHALED. LABORATORY TEST RESULTS INDICATE MATERIAL MAY BE TERATOGENIC.
Keep away from heat, sparks, flame. Avoid contact with eyes, skin, clothing. Avoid breathing vapor. Keep in tightly closed container. Use with adequate ventilation. Wash thoroughly after handling. In case of fire, use alcohol foam, dry chemical, carbon dioxide - water may be ineffective. In case of spill, soak up with sand or earth. Flush spill area with water.

PRECAUTIONARY LABELING (CONTINUED)

International Labeling

Highly flammable.
Keep container in a well-ventilated place. Keep away from sources of ignition - No smoking. Do not breathe vapor. Take precautionary measures against static discharges.

SAF-T-DATA* Storage Color Code: Red (flammable)

SECTION II - COMPONENTS

Component	CAS No.	Weight %	OSHA/PEL	ACGIH/TLV
Methyl Ethyl Ketone	78-93-3	99-100	200 ppm	200 ppm

SECTION III - PHYSICAL DATA

Boiling Point: 80°C (176°F) (at 760 mm Hg)

Vapor Pressure (mmHg): 78 (20°C)

Melting Point: -87°C (-124°F) (at 760 mm Hg)

Vapor Density (air=1): 2.5

Specific Gravity: 0.81 (H_2O=1)

Evaporation Rate: 5.7 (Butyl Acetate = 1)

Solubility(H_2O): Appreciable (>10%)

% Volatiles by Volume: 100 (21°C)

pH: N/A

Odor Threshold (ppm): N/A

Physical State: Liquid

Coefficient Water/Oil Distribution: N/A

Appearance & Odor: Clear, colorless liquid. Ketone-like odor.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point (Closed Cup): -6°C (20°F) NFPA 704M Rating: 1-3-0

Autoignition Temperature: 403°C (759°F)

Flammable Limits: Upper - 11.4 % Lower - 1.8 %

Fire Extinguishing Media

Use alcohol foam, dry chemical or carbon dioxide. (Water may be ineffective.)

Special Fire-Fighting Procedures

Firefighters should wear proper protective equipment and self-contained breathing apparatus with full facepiece operated in positive pressure mode. Move containers from fire area if it can be done without risk. Use water to keep fire-exposed containers cool.

Unusual Fire & Explosion Hazards

Vapors may flow along surfaces to distant ignition sources and flash back. Closed containers exposed to heat may explode. Contact with strong oxidizers may cause fire.

Toxic Gases Produced

carbon monoxide, carbon dioxide

Explosion Data-Sensitivity to Mechanical Impact

None identified.

Explosion Data-Sensitivity to Static Discharge

None identified.

SECTION V - HEALTH HAZARD DATA

Threshold Limit Value (TLV/TWA): 590 mg/m^3 (200 ppm)

Short-Term Exposure Limit (STEL): 885 mg/m^3 (300 ppm)

Permissible Exposure Limit (PEL): 590 mg/m^3 (200 ppm)

Toxicity of components

Oral Rat LD_{50} for Methyl Ethyl Ketone 2737 mg/kg

SECTION V - HEALTH HAZARD DATA (CONTINUED)

Intraperitoneal Mouse LD_{50} for Methyl Ethyl Ketone	616	mg/kg
Skin Rabbit LD_{50} for Methyl Ethyl Ketone	13	g/kg

Carcinogenicity: NTP: No IARC: No Z List: No OSHA Reg: No

Carcinogenicity
None identified.

Reproductive Effects
Tests on laboratory animals indicate material may be teratogenic.

Effects of Overexposure

INHALATION: headache, nausea, vomiting, dizziness, drowsiness, irritation of upper respiratory tract, unconsciousness

SKIN CONTACT: irritation, prolonged contact may cause dermatitis

EYE CONTACT: irritation, may cause temporary corneal damage

SKIN ABSORPTION: none identified

INGESTION: headache, nausea, vomiting, dizziness, gastrointestinal irritation, central nervous system depression

CHRONIC EFFECTS: central nervous system depression

Target Organs
nasal septum, lungs, eyes, skin, mucous membranes, in animals: liver, kidneys, lungs, spleen, brain

Medical Conditions Generally Aggravated by Exposure
respiratory system disease, skin disorders

Primary Routes of Entry
inhalation, ingestion, eye contact, skin contact

Emergency and First Aid Procedures

INGESTION: CALL A PHYSICIAN. If swallowed, do NOT induce vomiting.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Prompt action is essential.

SECTION V - HEALTH HAZARD DATA (CONTINUED)

SKIN CONTACT: In case of contact, flush skin with water.

EYE CONTACT: In case of eye contact, immediately flush with plenty of water for at least 15 minutes.

SARA/TITLE III HAZARD CATEGORIES and LISTS

Acute: Yes Chronic: Yes Flammability: Yes Pressure: No Reactivity: No

Extremely Hazardous Substance:	No	
CERCLA Hazardous Substance:	Yes	Contains Methyl ethyl ketone (RQ = 1 LB)
SARA 313 Toxic Chemicals:	Yes	Contains Methyl Ethyl Ketone
Generic Class:		Generic Class Removed from CFR: 7/1/91
TSCA Inventory:	Yes	

SECTION VI - REACTIVITY DATA

Stability: Stable Hazardous Polymerization: Will not occur

Conditions to Avoid: heat, flame, other sources of ignition

Incompatibles: strong oxidizing agents, strong bases, caustics, mineral acids, amines and ammonia, halogens, plastics, rubber

Decomposition Products: carbon monoxide, carbon dioxide

SECTION VII - SPILL & DISPOSAL PROCEDURES

Steps to be Taken in the Event of a Spill or Discharge

Wear self-contained breathing apparatus and full protective clothing. Shut off ignition sources; no flares, smoking or flames in area. Stop leak if you can do so without risk. Use water spray to reduce vapors. Take up with sand or other non-combustible absorbent material and place into container for later disposal. Flush area with water.

J. T. Baker SOLUSORB® solvent adsorbent is recommended for spills of this product.

SECTION VII - SPILL & DISPOSAL PROCEDURES (CONTINUED)

<u>Disposal Procedure</u>
Dispose in accordance with all applicable federal, state, and local environmental regulations.

EPA Hazardous Waste Number: U159 (Toxic Waste)

SECTION VIII - INDUSTRIAL PROTECTIVE EQUIPMENT

Ventilation: Use general or local exhaust ventilation to meet TLV requirements.

Respiratory Protection: Respiratory protection required if airborne concentration exceeds TLV. At concentrations up to 1000 ppm, a chemical cartridge respirator with organic vapor cartridge is recommended. Above this level, a self-contained breathing apparatus is recommended.

Eye/Skin Protection: Safety goggles, uniform, apron, butyl rubbergloves are recommended.

SECTION IX - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA* Storage Color Code: Red (flammable)

<u>Storage Requirements</u>
Keep container tightly closed. Store in a cool, dry, well-ventilated, flammable liquid storage area. Isolate from incompatible materials.

<u>Special Precautions</u>
Bond and ground containers when transferring liquid.

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

<u>Domestic (D.O.T.)</u>

Proper Shipping Name: Ethyl Methyl Ketone
Hazard Class: 3
UN/NA: UN1193 Reportable Quantity: 5000 LBS. Packaging Group: II

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION (CONTINUED)

Labels: 3 FLAMMABLE LIQUID
Regulatory References: 49CFR 172.101

International (I.M.O.)

Proper Shipping Name: Ethyl methyl ketone
Hazard Class: 3.2 I.M.O. Page: 3226
UN: UN1193 Marine Pollutants: No Packaging Group: II
Labels: 3 FLAMMABLE LIQUID
Regulatory References: 49CFR PART 176; IMDG Code

AIR (I.C.A.O.)

Proper Shipping Name: Ethyl methyl ketone
Hazard Class: 3
UN: UN1193 Packaging Group: II
Labels: 3 FLAMMABLE LIQUID
Regulatory References: 49CFR PART 175; ICAO=== We believe the transportation data and references contained herein to be factual and the opinion of qualified experts. The data is meant as a guide to the overall classification of the product and is not package size specific, nor should it be taken as a warranty or representation for which the company assumes legal responsibility.=== The information is offered solely for your consideration, investigation, and verification. Any use of the information must be determined by the user to be in accordance with applicable Federal, State, and Local laws and regulations. See shipper requirements 49CFR 171.2, Certification 172.204, and employee training 49 CFR 173.1(b).

U.S. Customs Harmonization Number: 29141200007

NOTE: When handling liquid products, secondary protective containers must be used for carrying.
-N/A = Not Applicable, or not Available; -N/E = Not Established

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Approved by Quality Assurance Department.

APPENDIX 3-3

Materials Compatibility Data

	MEK	*06/13/95*	*06/14/95*	*06/16/95*	*06/20/95*
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	*wt. in mg.*	*wt. in mg.*	*wt. in mg.*
M Al 1	Aluminum 2024-T3	2269.91	2269.57	2269.56	2269.55
M Al 2	Aluminum 2024-T3	2217.87	2217.59	2217.57	2217.55
M Al 3	Aluminum 2024-T3	2292.73	2292.33	2292.27	2292.27
M Br 1	Brass CDA-360	6341.98	6341.43	6341.40	6341.54
M Br 2	Brass CDA-360	5895.79	5895.16	5895.17	5895.26
M Br 3	Brass CDA-360	6002.47	6001.75	6001.73	6001.71
M Ni 1	Nickel N-200	6892.23	6891.88	6891.89	6891.90
M Ni 2	Nickel N-200	6912.86	6912.51	6912.52	6912.47
M Ni 3	Nickel N-200	6920.14	6919.93	6919.91	6919.89
M SS 1	Stainless Steel 303	6184.46	6184.04	6183.98	6183.96
M SS 2	Stainless Steel 303	5934.49	5934.16	5934.08	5934.09
M SS 3	Stainless Steel 303	5995.94	5995.58	5995.51	5995.53
M Ac 1	Acetal	1345.22	1350.14	1353.86	1358.87
M Ac 2	Acetal	1344.27	1349.12	1352.84	1357.98
M Ac 3	Acetal	1343.91	1348.79	1352.43	1357.54
M Bu 1	Buna-N	496.44	1090	1093	944
M Bu 2	Buna-N	494.40	1089	1088	1031
M Bu 3	Buna-N	492.26	1079	1094	1063
M De 1	Delrin	1391.71	1397.79	1403.11	1410.44
M De 2	Delrin	1388.78	1394.76	1399.99	1407.53
M De 3	Delrin	1383.26	1389.53	1394.87	1402.43
M Ny 1	Nylon	539.68	539.77	539.80	540.49
M Ny 2	Nylon	539.63	539.67	539.74	540.25
M Ny 3	Nylon	540.63	540.72	540.79	541.30
M Te 1	Teflon	1062.24	1062.61	1062.83	1063.32
M Te 2	Teflon	1045.33	1045.90	1046.16	1046.63
M Te 3	Teflon	1057.82	1058.19	1058.43	1058.88

	Jeffsol PC	*06/13/95*	*06/14/95*	*06/16/95*	*06/20/95*
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	*wt. in mg.*	*wt. in mg.*	*wt. in mg.*
J Al 1	Aluminum 2024-T3	2212.98	2213.95	2213.24	2213.56
J Al 2	Aluminum 2024-T3	2196.45	2197.29	2197.24	2196.94
J Al 3	Aluminum 2024-T3	2177.06	2178.33	2177.56	2177.82
J Br 1	Brass CDA-360	5937.62	5938.03	5938.16	5937.76
J Br 2	Brass CDA-360	5922.00	5922.11	5922.17	5921.55
J Br 3	Brass CDA-360	5860.88	5860.92	5860.98	5860.57
J Ni 1	Nickel N-200	6949.88	6950.34	6949.92	6949.77
J Ni 2	Nickel N-200	7055.87	7056.44	7055.91	7055.97
J Ni 3	Nickel N-200	7166.33	7167.18	7166.41	7166.45
J SS 1	Stainless Steel 303	6028.70	6029.78	6028.62	6028.52
J SS 2	Stainless Steel 303	6203.53	6204.41	6203.79	6203.36
J SS 3	Stainless Steel 303	6123.63	6124.09	6123.69	6123.62
J Ac 1	Acetal	1345.13	1346.53	1347.15	1348.81
J Ac 2	Acetal	1347.90	1348.93	1350.51	1351.77
J Ac 3	Acetal	1344.67	1345.82	1347.32	1348.95
J Bu 1	Buna-N	494.84	705.09	736.00	742.98
J Bu 2	Buna-N	490.39	673.81	705.61	727.77
J Bu 3	Buna-N	493.71	702.99	736.13	745.32
J De 1	Delrin	1396.08	1398.04	1400.22	1402.85
J De 2	Delrin	1389.87	1392.31	1393.84	1396.10
J De 3	Delrin	1386.56	1388.52	1390.23	1393.79
J Ny 1	Nylon	538.62	537.08	535.47	534.58
J Ny 2	Nylon	540.59	538.87	537.34	536.39
J Ny 3	Nylon	539.80	539.07	536.69	536.48
J Te 1	Teflon	1047.52	1047.44	1047.41	1047.32
J Te 2	Teflon	1048.35	1048.21	1048.17	1048.13
J Te 3	Teflon	1054.54	1054.61	1054.39	1054.33

	Formulation L	*06/20/95*	*06/21/95*	*06/23/95*	*06/27/95*
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	*wt. in mg.*	*wt. in mg.*	*wt. in mg.*
L Al 1	Aluminum 2024-T3	2169.93	2170.01	2169.91	2169.91
L Al 2	Aluminum 2024-T3	2155.42	2155.50	2155.50	2155.49
L Al 3	Aluminum 2024-T3	2170.59	2170.83	2170.56	2170.79
L Br 1	Brass CDA-360	5831.69	5831.45	5830.90	5830.73
L Br 2	Brass CDA-360	6111.42	6111.20	6110.84	6110.64
L Br 3	Brass CDA-360	6062.17	6061.79	6061.92	6061.60
L Ni 1	Nickel N-200	7089.95	7090.32	7089.95	7089.88
L Ni 2	Nickel N-200	6991.14	6991.79	6991.18	6991.25
L Ni 3	Nickel N-200	7055.13	7055.28	7055.21	7055.23
L SS 1	Stainless Steel 303	6052.28	6052.18	6052.27	6052.06
L SS 2	Stainless Steel 303	6059.85	6059.76	6059.84	6059.60
L SS 3	Stainless Steel 303	6118.70	6118.22	6118.25	6117.96
L Ac 1	Acetal	1346.40	1347.73	1349.52	1350.81
L Ac 2	Acetal	1345.79	1347.09	1348.94	1350.65
L Ac 3	Acetal	1347.96	1349.59	1350.61	1351.74
L Bu 1	Buna-N	493.95	1116.15	1140.38	1168.63
L Bu 2	Buna-N	491.69	1093.85	1114.71	1133.41
L Bu 3	Buna-N	490.31	1082.21	1111.37	1136.57
L De 1	Delrin	1384.56	1387.13	1390.17	1393.02
L De 2	Delrin	1391.07	1394.12	1396.23	1399.28
L De 3	Delrin	1387.28	1390.04	1392.43	1395.76
L Ny 1	Nylon	539.04	538.20	538.15	538.39
L Ny 2	Nylon	540.12	539.25	539.21	539.61
L Ny 3	Nylon	538.82	538.02	537.76	537.87
L Te 1	Teflon	1032.15	1032.21	1031.98	1031.86
L Te 2	Teflon	1072.55	1072.25	1072.09	1072.02
L Te 3	Teflon	1057.08	1056.73	1056.62	1056.64

	Formulation H	*07/10/95*	*07/11/95*	*07/13/95*	*07/17/95*
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	*wt. in mg.*	*wt. in mg.*	*wt. in mg.*
H Al 1	Aluminum 2024-T3	2107.26	2107.11	2107.53	2106.99
H Al 2	Aluminum 2024-T3	2169.12	2169.61	2169.44	2169.05
H Al 3	Aluminum 2024-T3	2137.46	2137.86	2137.38	2137.66
H Br 1	Brass CDA-360	6593.77	6593.76	6593.08	6593.02
H Br 2	Brass CDA-360	5894.67	5894.66	5894.51	5894.23
H Br 3	Brass CDA-360	6113.29	6113.15	6112.99	6112.37
H Ni 1	Nickel N-200	7147.23	7147.03	7147.55	7147.01
H Ni 2	Nickel N-200	7089.52	7089.69	7089.59	7089.07
H Ni 3	Nickel N-200	7232.69	7232.68	7232.34	7232.58
H SS 1	Stainless Steel 303	6533.04	6533.41	6533.00	6532.81
H SS 2	Stainless Steel 303	6210.44	6210.19	6209.76	6209.69
H SS 3	Stainless Steel 303	6471.20	6471.58	6471.61	6470.92
H Ac 1	Acetal	1312.74	1315.36	1316.72	1319.53
H Ac 2	Acetal	1314.82	1317.61	1319.35	1321.40
H Ac 3	Acetal	1314.25	1316.16	1318.44	1320.00
H Bu 1	Buna-N	485.84	1005.87	1017.19	1028.20
H Bu 2	Buna-N	488.34	1027.32	1038.38	1046.79
H Bu 3	Buna-N	487.20	1074.64	1087.36	1090.16
H De 1	Delrin	1347.90	1351.90	1355.56	1357.65
H De 2	Delrin	1344.22	1348.99	1351.61	1355.32
H De 3	Delrin	1343.45	1347.11	1349.12	1353.59
H Ny 1	Nylon	533.88	532.95	532.09	531.84
H Ny 2	Nylon	536.97	535.96	535.76	535.18
H Ny 3	Nylon	536.01	535.07	534.59	534.21
H Te 1	Teflon	1044.42	1044.27	1044.24	1044.09
H Te 2	Teflon	1039.69	1039.59	1039.41	1039.24
H Te 3	Teflon	1029.32	1029.11	1029.10	1028.86

	Formulation N	*07/10/95*	*07/11/95*	*07/13/95*	*07/17/95*
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	***wt. in mg.***	***wt. in mg.***	***wt. in mg.***
N Al 1	Aluminum 2024-T3	2110.35	2110.71	2110.53	2110.11
N Al 2	Aluminum 2024-T3	2177.07	2177.33	2176.90	2176.78
N Al 3	Aluminum 2024-T3	2182.24	2182.33	2182.62	2182.17
N Br 1	Brass CDA-360	6498.09	6498.53	6498.22	6498.18
N Br 2	Brass CDA-360	6667.59	6667.23	6666.81	6666.29
N Br 3	Brass CDA-360	6607.79	6605.93	6606.55	6605.80
N Ni 1	Nickel N-200	7033.92	7034.14	7034.24	7033.91
N Ni 2	Nickel N-200	6970.80	6970.72	6970.95	6970.75
N Ni 3	Nickel N-200	7231.63	7231.71	7231.34	7231.18
N SS 1	Stainless Steel 303	5911.88	5911.73	5911.74	5911.30
N SS 2	Stainless Steel 303	6439.00	6438.81	6438.83	6438.69
N SS 3	Stainless Steel 303	6199.77	6199.17	6199.16	6198.90
N Ac 1	Acetal	1311.75	1313.55	1314.99	1317.02
N Ac 2	Acetal	1315.26	1317.13	1319.12	1321.36
N Ac 3	Acetal	1316.80	1319.13	1320.51	1322.56
N Bu 1	Buna-N	487.83	1090.62	1102.24	1131.51
N Bu 2	Buna-N	485.82	1066.59	1074.96	1085.58
N Bu 3	Buna-N	489.13	1059.95	1075.69	1100.87
N De 1	Delrin	1349.63	1352.41	1354.46	1357.53
N De 2	Delrin	1348.82	1351.56	1354.17	1357.30
N De 3	Delrin	1349.39	1352.78	1355.40	1358.94
N Ny 1	Nylon	536.92	536.48	536.20	536.21
N Ny 2	Nylon	535.93	534.75	535.13	534.73
N Ny 3	Nylon	538.74	537.76	537.74	537.60
N Te 1	Teflon	1041.37	1040.97	1041.09	1040.90
N Te 2	Teflon	1047.88	1047.99	1047.85	1047.62
N Te 3	Teflon	1024.41	1023.87	1023.93	1023.90

	Formulation T	*07/11/95*	*07/12/95*	*07/14/95*	*07/18/95*
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	*wt. in mg.*	*wt. in mg.*	*wt. in mg.*
T Al 1	Aluminum 2024-T3	2165.68	2165.71	2166.49	2165.91
T Al 2	Aluminum 2024-T3	2144.62	2144.67	2144.90	2144.37
T Al 3	Aluminum 2024-T3	2184.48	2184.65	2184.02	2184.14
T Br 1	Brass CDA-360	6344.78	6343.06	6342.85	6342.82
T Br 2	Brass CDA-360	6414.84	6413.34	6413.28	6413.29
T Br 3	Brass CDA-360	6569.35	6568.48	6568.32	6568.42
T Ni 1	Nickel N-200	7295.98	7295.39	7295.70	7295.61
T Ni 2	Nickel N-200	7148.85	7148.67	7148.66	7148.75
T Ni 3	Nickel N-200	7280.80	7280.09	7280.25	7280.75
T SS 1	Stainless Steel 303	6402.90	6402.89	6402.62	6402.86
T SS 2	Stainless Steel 303	6202.52	6202.56	6202.61	6202.46
T SS 3	Stainless Steel 303	6424.69	6424.61	6424.40	6424.76
T Ac 1	Acetal	1346.60	1347.88	1349.86	1351.13
T Ac 2	Acetal	1341.75	1342.99	1344.30	1346.69
T Ac 3	Acetal	1313.94	1315.89	1316.44	1318.76
T Bu 1	Buna-N	494.42	1039.18	1050.67	1055.26
T Bu 2	Buna-N	488.19	831.89	874.83	917.76
T Bu 3	Buna-N	493.46	1047.04	1048.42	1064.07
T De 1	Delrin	1380.05	1382.45	1384.86	1387.70
T De 2	Delrin	1392.24	1394.45	1396.75	1399.42
T De 3	Delrin	1344.21	1347.26	1349.13	1351.73
T Ny 1	Nylon	540.77	538.88	537.68	536.35
T Ny 2	Nylon	532.49	530.60	529.50	528.13
T Ny 3	Nylon	541.86	539.96	538.60	537.20
T Te 1	Teflon	1066.00	1065.76	1065.63	1065.62
T Te 2	Teflon	1075.42	1075.33	1075.21	1075.13
T Te 3	Teflon	1040.25	1039.95	1039.94	1039.90

	Control/MEK & PC	06/13/95	06/14/95	06/16/95	06/20/95
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	*wt. in mg.*	*wt. in mg.*	*wt. in mg.*
Control	Aluminum 2024-T3	2145.25	2145.24	2145.22	2145.21
Control	Brass CDA-360	6247.96	6247.94	6247.93	6247.95
Control	Nickel N-200	7128.72	7128.67	7128.67	7128.68
Control	Stainless Steel 303	6089.26	6089.24	6089.22	6089.23
Control	Acetal	1345.32	1345.06	1344.87	1345.02
Control	Buna-N	494.46	493.93	493.81	494.07
Control	Delrin	1390.61	1390.24	1389.98	1390.11
Control	Nylon	539.34	539.05	538.84	538.98
Control	Teflon	1052.90	1052.91	1052.90	1052.90

	Control/L	06/20/95	06/21/95	06/23/95	06/27/95
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	*wt. in mg.*	*wt. in mg.*	*wt. in mg.*
Control	Aluminum 2024-T3	2145.23	2145.22	2145.25	2145.22
Control	Brass CDA-360	6247.93	6247.96	6247.96	6247.93
Control	Nickel N-200	7128.68	7128.68	7128.68	7128.64
Control	Stainless Steel 303	6089.21	6089.25	6089.21	6089.22
Control	Acetal	1345.04	1345.07	1345.00	1345.10
Control	Buna-N	494.10	494.12	494.03	494.19
Control	Delrin	1390.15	1390.25	1390.27	1390.52
Control	Nylon	539.05	539.09	539.09	539.31
Control	Teflon	1052.91	1052.92	1052.90	1052.87

	Control/H & N	*07/10/95*	*07/11/95*	*07/13/95*	*07/17/95*
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	***wt. in mg.***	***wt. in mg.***	***wt. in mg.***
Control	Aluminum 2024-T3	2145.27	2145.29	2145.27	2145.26
Control	Brass CDA-360	6247.96	6247.97	6247.99	6247.98
Control	Nickel N-200	7128.71	7128.74	7128.69	7128.73
Control	Stainless Steel 303	6089.27	6089.30	6089.25	6089.28
Control	Acetal	1345.22	1345.16	1345.12	1345.18
Control	Buna-N	494.06	494.00	494.00	494.07
Control	Delrin	1390.68	1390.61	1390.59	1390.56
Control	Nylon	539.64	539.55	539.51	539.54
Control	Teflon	1052.88	1052.88	1052.91	1052.86

	Control/T	*07/11/95*	*07/12/95*	*07/14/95*	*07/18/95*
ID	***Description***	***Initial***	***Day 1***	***Day 3***	***Day 7***
		wt. in mg.	***wt. in mg.***	***wt. in mg.***	***wt. in mg.***
Control	Aluminum 2024-T3	2145.29	2145.27	2145.25	2145.27
Control	Brass CDA-360	6247.97	6247.98	6247.93	6247.93
Control	Nickel N-200	7128.74	7128.75	7128.72	7128.66
Control	Stainless Steel 303	6089.30	6089.29	6089.28	6089.22
Control	Acetal	1345.16	1345.18	1345.12	1345.12
Control	Buna-N	494.00	494.04	493.99	494.10
Control	Delrin	1390.61	1390.62	1390.51	1390.55
Control	Nylon	539.55	539.53	539.47	539.58
Control	Teflon	1052.88	1052.9	1052.88	1052.90

APPENDIX 3-4

Paint Removal Efficiency Data

TWO-COMPONENT CARC -- GREEN						
					PAINT	PAINT
		INITIAL	WET	CLEANED	BEFORE	AFTER
ID	SOLVENT	*wt in mg*	*wt in mg*	*wt in mg*	*wt in mg*	*wt in mg*
14	MEK	8061.88	8149.77	8061.88	87.89	0.00
15	MEK	8095.64	8181.37	8095.66	85.73	0.02
16	MEK	7983.40	8027.22	7983.94	43.82	0.54
17	MEK Control	8060.08	N/A	8060.10	0.00	0.02
18	L	8057.87	8137.92	8059.75	80.05	1.88
19	L	8070.20	8124.57	8071.94	54.37	1.74
20	L	8097.01	8152.74	8097.50	55.73	0.49
21	L Control	8076.72	N/A	8076.96	0.00	0.24
22	N	8070.81	8156.68	8073.87	85.87	3.06
23	N	8062.56	8130.33	8065.68	67.77	3.12
24	N	8142.22	8231.40	8143.61	89.18	1.39
25	N Control	8061.39	N/A	8061.60	0.00	0.21

ONE-COMPONENT CARC -- TAN						
					PAINT	PAINT
		INITIAL	WET	CLEANED	BEFORE	AFTER
ID	SOLVENT	*wt in mg*	*wt in mg*	*wt in mg*	*wt in mg*	*wt in mg*
1	MEK	7975.70	8199.39	7975.80	223.69	0.10
2	MEK	8031.68	9369.07	8031.87	1337.39	0.19
3	MEK	8043.32	8416.92	8043.46	373.60	0.14
4	MEK Control	8067.88	N/A	8067.96	0.00	0.08
5	L	8057.25	8354.50	8080.76	297.25	23.51
6	L	8075.43	8388.38	8147.39	312.95	71.96
7	L	8102.38	8597.67	8213.66	495.29	111.28
8	L Control	8112.67	N/A	8112.84	0.00	0.17
9	N	8084.93	8464.34	8209.27	379.41	124.34
10	N	8071.87	8342.84	8086.26	270.97	14.39
11	N	8070.94	8330.69	8149.47	259.75	78.53
12	N Control	8092.03	N/A	8092.13	0.00	0.10

UNDERCOATING -- BLACK						
					PAINT	PAINT
		INITIAL	WET	CLEANED	BEFORE	AFTER
ID	SOLVENT	*wt in mg*	*wt in mg*	*wt in mg*	*wt in mg*	*wt in mg*
37	MEK	8126.27	8264.72	8132.12	138.45	5.85
38	MEK	8071.24	8245.67	8131.53	174.43	60.29
39	MEK	8082.17	8300.06	8151.33	217.89	69.16
40	MEK Control	8149.84	N/A	8149.94	0.00	0.10
41	L	8037.06	8228.86	8092.49	191.80	55.43
42	L	8126.90	8340.46	8228.52	213.56	101.62
43	L	8126.65	8267.33	8215.76	140.68	89.11
44	L Control	8033.35	N/A	8033.48	0.00	0.13
45	N	8030.66	8211.59	8112.63	180.93	81.97
46	N	8078.82	8262.86	8165.37	184.04	86.55
47	N	8062.38	8316.23	8166.57	253.85	104.19
48	N Control	8045.29	N/A	8045.54	0.00	0.25

PRIMER -- WHITE						
					PAINT	PAINT
		INITIAL	WET	CLEANED	BEFORE	AFTER
ID	SOLVENT	*wt in mg*	*wt in mg*	*wt in mg*	*wt in mg*	*wt in mg*
13	MEK	8120.73	8176.69	8143.08	55.96	22.35
26	MEK	8056.55	8091.84	8071.03	35.29	14.48
27	MEK	8063.29	8116.32	8065.94	53.03	2.65
28	MEK Control	8087.34	N/A	8087.35	0.00	0.01
29	L	8088.85	8135.84	8090.79	46.99	1.94
30	L	8020.50	8070.73	8021.80	50.23	1.30
31	L	8057.06	8112.09	8060.27	55.03	3.21
32	L Control	8038.15	N/A	8038.48	0.00	0.33
33	N	8061.28	8107.00	8063.87	45.72	2.59
34	N	8054.80	8094.55	8057.94	39.75	3.14
35	N	8103.35	8138.64	8108.91	35.29	5.56
36	N Control	8146.49	N/A	8146.62	0.00	0.13

APPENDIX 3-5

Procedure for Monitoring Cleaning Use

CLEANING PAINT EQUIPMENT

* *Use keyboard for data entry.*
* *Make sure printer is on! (Red light will glow.)*

1) Press <**F1**> (Start)
2) Enter data when prompted by display:

Display Prompt	*Code*	*Operator entry*
Vehicle ID	(VID)	Press <**ENTER**>.
Vehicle Code	(V)	Press <**ENTER**>.
Coating Code	(C)	Enter **P** (Primer) or **C** (CARC), press <**ENTER**>.
Your ID	(P1)	Enter **1** (1st shift) or **2** (2nd shift), press <**ENTER**>.
Partner ID	(P2)	Enter **MEK** (ketone) or **L** (L), press <**ENTER**>.
Target Amount	(T)	Press <**ENTER**>.
Pounds per gallon		Enter **6.71** for ketone or **9.18** for L, press <**ENTER**>.
Scale	(SCL)	Enter **1** (outside) or **2** (inside), press <**ENTER**>.

3) Screen will prompt "Start Flow Monitor?" Press <**F5**> (Yes)

* The bucket used to collect the cleaner as it is flushed from the hoses and guns is the solvent catch bucket. Depending on the wash, it may be the hazardous waste bucket, the prewash bucket, or the final wash bucket. The solvent catch bucket is what goes on the scale!

PREWASH

4) Place solvent catch bucket on scale.
5) Press <**TARE**> (yellow button on remote box).
6) Press <**PRINT**> (blue button on remote box).
7) Clean equipment.
8) When equipment is ready for next step, press <**PRINT**>.

FINAL WASH

9) Repeat steps 4, 5, 6, 7, & 8.

FILTER WASH

10) Repeat steps 4, 5, 6, 7, & 8.
11) To stop, press <**F1**> (Stop); then <**F5**> (Yes).
12) When all data has printed, give data strip to Leaderman.

* *Data will print every thirty seconds continuously starting at Step 3.*
* *Total weight for cleaning will be negative.* ***This is OK!***

IMPORTANT: DO NOT HIT <**TARE**> WHILE CLEANING!!

To Correct Errors During Data Entry (Step 2):
Use <**Backspace**> for current entry.
Use <**Escape**> <**Escape**>

APPENDIX 3-6

Material Safety Data Sheets

for

Benzyl Alcohol and Propylene Carbonate

PRODUCT: BENZYL ALCOHOL

ORDER NO: 136970
PROD NO : 500585

HUNTSMAN CORPORATION
7114 NORTH LAMAR BLVD

AUSTIN ,TX 787612310

VAN WATERS & ROGERS INC. , SUBSIDIARY OF UNIVAR (206)889-3400
6100 CARILLON POINT , KIRKLAND , WA 98033

---------------------------- EMERGENCY ASSISTANCE ------------------------

FOR EMERGENCY ASSISTANCE INVOLVING CHEMICALS CALL - CHEMTREC
(800)424-9300

****
PRODUCT IDENTIFICATION
****

PRODUCT NAME: BENZYL ALCOHOL

MSDS #: P1525VS

DATE ISSUED: 1-1-94

ISSUED BY: 008547

****
MANUFACTURER'S MSDS
****

****
I PRODUCT INFORMATION
****

CHEMICAL NAME:	BENZYL ALCOHOL
SYNONYM(S):	Alpha hydroxy toluene, Phenylmethanol
CHEMICAL FAMILY:	Aromatic alcohol
MOLECULAR FORMULA:	C6H5CH2OH (C7H8O)
MOLECULAR WEIGHT:	108.14
CAS REG NO:	100-51-6

REPORT NUMBER: 703 VAN WATERS & ROGERS INC. PAGE: 0
MSDS NO: P1525V6 MATERIAL SAFETY DATA SHEET
EFFECTIVE DATE: 03/31/94 VERSION: 0

PRODUCT: BENZYL ALCOHOL

ORDER NO: 136970
PROD NO : 500585

****

II SUMMARY OF HAZARDS

****

WARNING
CAUSES EYE IRRITATION - IS A SEVERE EYE IRRITANT
EXPOSURE TO VAPORS MAY CAUSE HEADACHE, DIZZINESS, AND NAUSEA
OVER-EXPOSURE MAY CAUSE CENTRAL NERVOUS SYSTEM DEPRESSION
MAY CAUSE SKIN IRRITATION
HARMFUL IF SWALLOWED

****

III PHYSICAL PROPERTIES

****

APPEARANCE and ODOR: Colorless liquid with an aromatic odor.
BOILING POINT: 401 Deg. F (205 Deg. C)
MELTING POINT: +4.5 Deg. F (-15.3 Deg. C)
VAPOR PRESSURE: < 0.1 mm Hg @ 20 Deg. C (68 Deg. F)
SPECIFIC GRAVITY: 1.045 @ 77 Deg. F (H_2O = 1)
WEIGHT PER GALLON: 8.7#
VAPOR DENSITY: 3.7 (Air = 1)
SOLUBILITY IN WATER: Moderate (approx. 4-5%)
% VOLATILE: 100
EVAPORATION RATE: <0.01 (Butyl acetate = 1)

****

IV FIRE AND EXPLOSION HAZARD INFORMATION

****

FLASH POINT (TCC): 210 Deg. F (98.9 Deg. C)

FLAMMABLE LIMITS: Not determined

AUTOIGNITION TEMP: 817 Deg. F (436 Deg. C)

DECOMPOSITION TEMP: Not determined

FIRE and EXPLOSION HAZARDS: Decomposition under fire conditions will generat carbon monoxide and may generate other toxic vapors.

FIRE FIGHTING INFORMATION: Use CO_2, foam, or dry chemical to extinguish fire Water can be used to cool a fire, but for extinguishment, foam or dry chemic are preferred. Avoid spreading liquid and fire by water flooding. Wear self-contained, positive pressure breathing apparatus and full firefighting protective clothing. Use water to keep containers cool.

PRODUCT: BENZYL ALCOHOL

ORDER NO: 136970
PROD NO : 500585

****
V HAZARD RATINGS FOR BENZYL ALCOHOL
****

NFPA	HEALTH	2	HMIS	HEALTH	2
HAZARD	FLAMMABILITY	1	RATINGS	FLAMMABILITY	1
RATINGS	REACTIVITY	0	(NPCA & NAPIM)	REACTIVITY	0

****
VI HEALTH HAZARD INFORMATION
****

LD50 (ORAL RAT): 1230 mg/kg

THRESHOLD LIMIT VALUE (TLV): TLV has not been established by the ACGIH.

CARCINOGEN (IARC/NTP/29CFR): No

NOTE: Health studies have shown that exposures to chemicals pose potential health risks which may vary from person to person. Exposures to liquids, vapors, mists, or fumes should always be minimized.

ACUTE HEALTH HAZARDS:

Inhalation: Inhalation of concentrated vapor may irritate the nose and thro Overexposure to vapors causes headache, vertigo, nausea, vomiting, and diarrhea. Over-exposure can cause central nervous system depression.

Eye Contact: Causes eye irritation. Is a severe eye irritant.

Skin Contact: May cause skin irritation.

Ingestion: Harmful if swallowed. See LD50 data.

CHRONIC HEALTH HAZARDS:
Prolonged contact may cause defatting of the skin.
No other chronic health hazard information is available.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: None known

EMERGENCY FIRST AID:

Inhalation: If overcome by exposure, remove to fresh air immediately. Give oxygen or artificial respiration as needed. Get immediate medical attention.

Eye Contact: In case of eye contact, flush eyes with plenty of water for at least 15 minutes. Get immediate medical attention.

PRODUCT: BENZYL ALCOHOL

ORDER NO: 136970
PROD NO : 500585

Skin Contact: In case of skin contact, flush skin with plenty of water. Remo contaminated clothing. Call a physician if irritation develops. Wash clothin before reuse.

Ingestion: If swallowed, call a physician immediately. Induce vomiting only advice of medical personnel. Never give anything by mouth to an unconscious person.

VII PROTECTIVE EQUIPMENT AND EXPOSURE CONTROL METHODS

Use with adequate local exhaust ventilation. In confined or enclosed spaces, use NIOSH approved respiratory protection. Use chemical resistant apron, gloves, and other impervious clothing to avoid skin contact.

Use splash goggles and face shield when eye contact may occur. Provide safet shower, equipped with an eye wash fountain in the immediate vicinity of any potential exposure. Use good personal hygiene practices. Wash hands before eating, drinking, or smoking, or using toilet facilities. Promptly remove contaminated clothing and wash thoroughly before reuse.

VIII REACTIVITY DATA

STABILITY: Stable

HAZARDOUS POLYMERIZATION: Will not occur.

INCOMPATIBLE MATERIALS: Alcohols can react violently in contact with strong oxidizing agents, isocyanates, acetaldehyde, LiAl4, aluminum alkyl compounds and strong mineral acids.

HAZARDOUS DECOMPOSITION PRODUCTS: Incomplete combustion will produce carbon monoxide and other potentially toxic and/or poisonous vapors.

IX SPILL OR LEAK PROCEDURES

Remove sources of ignition, stop release, and provide adequate ventilation. Prevent flow to sewer and public waters. Recover free product, if possible. Cover spill with inert, non-combustible absorbent material and remove to disposal container. Report spill as per regulatory requirements.

Leaking drum should be emptied or placed into an oversized (recovery) drum.

PRODUCT: BENZYL ALCOHOL

ORDER NO: 136970
PROD NO : 500585

****

X WASTE DISPOSAL

****

Disposal must be made in accordance with applicable governmental regulation. Do not contaminate any streams, lakes, or ponds.

****

XI ADDITIONAL PRECAUTIONS

****

Partially filled drums should be blanketed with nitrogen to avoid product being slowly oxidized to benzaldehyde.

Since benzyl alcohol is an excellent solvent, contact with plastics other t fluorinated polymers or polypropylene should be avoided.

Store as a NFPA Class III B liquid. Keep fire and sparks away from drums. Since empty containers retain product residue, do not cut, drill, grind, or weld on or near the container until it is thoroughly cleaned.

Isolate, vent, drain, wash and purge systems or equipment before maintenance or repair. Remove all ignition sources. Check atmosphere for explosiveness & oxygen deficiencies. Use adequate personal protective equipment. Comply with regulations governing confined space entry.

****

XII OSHA/SARA TITLE III/TSCA INFORMATION

****

We have evaluated Benzyl Alcohol using the criteria in OSHA's Hazard Communication Rule (29 CFR 1910.1200). Benzyl Alcohol is considered hazardou under the OSHA Standard.

Benzyl Alcohol is not listed as an Extremely Hazardous Substance under Secti 302 of SARA Title III.

As a OSHA hazardous substance, Benzyl Alcohol is subject to the reporting requirements of Sections 311 or 312 of SARA Title III.

Benzyl Alcohol does not contain ingredients (at a level of 1% or more) on th List of Toxic Chemicals in Section 313 of SARA Title III.

Benzyl Alcohol is included in the current TSCA Inventory List.

****

XII TRANSPORTATION INFORMATION

PRODUCT: BENZYL ALCOHOL

ORDER NO: 136770
PROD NO : 500585

****

Benzyl Alcohol is NOT regulated as a hazardous material under the regulatio
of the United States Department of Transportation.

------------------------------ FOR ADDITIONAL INFORMATION ------------------------------

CONTACT: MSDS COORDINATOR VAN WATERS & ROGERS INC.
DURING BUSINESS HOURS, PACIFIC TIME (206)889-3400

06/14/95 16:52 PRODUCT: 500585 CUST NO: 333244 ORDER NO: 1369?

------------------------------ NOTICE ------------------------------

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*** E N D O F M S D S ***

JEFFSOL PC
HUNTSMAN CHEMICAL CO.
PRODUCT CODE: 75436
DATE ISSUED: 10-31-94 **Supersedes: 07-01-94**

MATERIAL SAFETY DATA SHEET

This MSDS was printed utilizing access to Huntsman's CD-ROM MSDS Database. Due to variations in printer dependent character styles, fonts and computer control codes, the appearance may differ from that of the centrally printed Huntsman MSDS.

NOTE: Read and understand Material Safety Data Sheet before handling or disposing of product.

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATERIAL IDENTITY
Product Code and Name:
75436 JEFFSOL PC
Chemical Name and/or Family or Description:
Alkylene carbonate

Manufacturer's Name and Address:
HUNTSMAN
P.O. Box 27707
Houston, TX 77227-7707

Telephone Numbers:

Transportation Emergency-Company		: (409) 727-0831
	CHEMTREC	: (800) 424-9300
Health Emergency	-Company	: (914) 831-3400
General MSDS Assistance		: (713) 235-6432
Technical Information		: (512) 459-6543

2. COMPOSITION/INFORMATION ON INGREDIENTS

THE CRITERIA FOR LISTING COMPONENTS IN THE COMPOSITION SECTION IS AS FOLLOWS: CARCINOGENS ARE LISTED WHEN PRESENT AT 0.1 % OR GREATER; COMPONENTS WHICH ARE OTHERWISE HAZARDOUS ACCORDING TO OSHA ARE LISTED WHEN PRESENT AT 1.0 % OR GREATER; NON-HAZARDOUS COMPONENTS ARE LISTED AT 3.0 % OR GREATER. THIS IS NOT INTENDED TO BE A COMPLETE COMPOSITIONAL DISCLOSURE. REFER TO SECTION 14 FOR APPLICABLE STATES' RIGHT TO KNOW AND OTHER REGULATORY INFORMATION.

Product and/or Component(s) Carcinogenic According to:

OSHA	IARC	NTP	OTHER	NONE
				X
-	-	-	-	-

Composition: (Sequence Number and Chemical Name)

Seq. Chemical Name	CAS Number	Range in %

N.D. - NOT DETERMINED **N.A. - NOT APPLICABLE** **N.T. - NOT TESTED**
< - LESS THAN **> - GREATER THAN**

2. COMPOSITION/INFORMATION ON INGREDIENTS (CONT)

01	* 1,3-dioxolan-2-one, methyl-	108-32-7	100.00

PRODUCT IS HAZARDOUS ACCORDING TO OSHA (1910.1200).
* COMPONENT IS HAZARDOUS ACCORDING TO OSHA.

Exposure Limits referenced by Sequence Number in the Composition Section

Seq.	Limit
None	

3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW
Appearance:
Colorless liquid
Odor:
Slight odor

WARNING STATEMENT

CAUTION ! MAY CAUSE EYE IRRITATION
ASPIRATION HAZARD IF SWALLOWED -
CAN ENTER LUNGS AND CAUSE DAMAGE
CONTAMINATION MAY RESULT IN DANGEROUS CO2 PRESSURE BUILD-UP

HMIS				NFPA			
Health:	1	Reactivity:	0	Health:	1	Reactivity:	0
Flammability:	1	Special	: -	Flammability:	1	Special	: -

POTENTIAL HEALTH EFFECTS

	EYE	SKIN	INHALATION	INGESTION
Primary Route of Exposure:	X	X	X	

EFFECTS OF OVEREXPOSURE
Acute:
Eyes:
May cause irritation, experienced as mild discomfort and seen as slight excess redness of the eye.

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

3. HAZARD IDENTIFICATION (CONT)

Skin:
Brief contact is not irritating. Prolonged contact, as with clothing wetted with material, may cause defatting of skin or irritation, seen as local redness with possible mild discomfort.

Other than the potential skin irritation effects noted above, acute (short term) adverse effects are not expected from brief skin contact; see other effects, below, and Section 11 for information regarding potential long term effects.

Inhalation:
Vapors or mist, in excess of permissible concentrations, or in unusually high concentrations generated from spraying, heating the material or as from exposure in poorly ventilated areas or confined spaces, may cause irritation of the nose and throat, headache, nausea, and drowsiness.

Ingestion:
If more than several mouthfuls are swallowed, abdominal discomfort, nausea, and diarrhea may occur. Aspiration may occur during swallowing or vomiting resulting in lung damage.

Sensitization Properties:
This product is not expected to be a human skin sensitizer based on animal data.

Chronic:
No adverse effects have been documented in humans as a result of chronic exposure. Section 11 may contain applicable animal data.

Medical Conditions Aggravated by Exposure:
There is no evidence that this product aggravates an existing medical condition.

Other Remarks:
None

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

4. FIRST AID MEASURES

Eyes:
Immediately flush eyes with plenty of water for at least 15 minutes. Hold eyelids apart while flushing to rinse entire surface of eye and lids with water. Get medical attention.

Skin:
Wash skin with plenty of soap and water for several minutes. Get medical attention if skin irritation develops or persists.

Ingestion:
If person is conscious and can swallow, give two glasses of water (16 oz.) but do not induce vomiting. If vomiting occurs, give fluids again. Have medical personnel determine if evacuation of stomach or induction of vomiting is necessary. Do not give anything by mouth to an unconscious or convulsing person.

Inhalation:
If irritation, headache, nausea, or drowsiness occurs, remove to fresh air. Get medical attention if breathing becomes difficult or respiratory irritation persists.

Other Instructions:
Aspiration of this product during induced emesis may result in severe lung injury. If evacuation of stomach is necessary, use method least likely to cause aspiration, such as gastric lavage after endotracheal intubation. Contact a Poison Center for additional treatment information.

5. FIRE-FIGHTING MEASURES

Ignition Temperature (degrees F):
Not determined.
Flash Point (degrees F):
275 (CC)
Flammable Limits (%):
Lower: 2.3
Upper: Not determined.

Recommended Fire Extinguishing Agents And Special Procedures:
Use water spray, dry chemical, foam, or carbon dioxide to extinguish flames. Use water spray to cool fire-exposed containers. Water or foam may cause frothing.

PRODUCT CODE: 75436
NAME: JEFFSOL PC

5. FIRE-FIGHTING MEASURES (CONT)

Unusual or Explosive Hazards:
None

Special Protective Equipment for Firefighters:
Wear full protective clothing and positive pressure breathing apparatus.

6. ACCIDENTAL RELEASE MEASURES (Transportation Spills: CHEMTREC (800)424-9300)

Procedures in Case of Accidental Release, Breakage or Leakage:
Contain spill if possible, contain with absorbent materials such as clay or soil, and shovel up. Avoid skin and eye contact.

If more than 10,000,000 pounds of product is spilled, then report spill according to SARA 304 and/or CERCLA 102(a) requirements, unless product qualifies for the petroleum exemption (CERCLA Section 101(14)).

7. HANDLING AND STORAGE

Precautions to be Taken in
Handling:
Minimum feasible handling temperatures should be maintained.

Storage:
Periods of exposure to high temperatures should be minimized. Water contamination should be avoided.
Alkyl carbonates may decompose in the presence of water, acids, bases, salts, or metal oxides such as common rust to cause a pressure build-up in processing or storage vessels. This may lead to rupture of the container. Pressure-relief devices are recommended on such containers.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Protective Equipment (Type)
Eye/Face Protection:
Safety glasses, chemical type goggles, or face shield recommended to prevent eye contact.

PRODUCT CODE: 75436 Date Issued: 10-31-94
NAME: JEFFSOL PC Supersedes: 07-01-94

8. EXPOSURE CONTROLS/PERSONAL PROTECTION (CONT)

Skin Protection:
Workers should wash exposed skin several times daily with soap and water. Soiled work clothing should be laundered or dry-cleaned.

Respiratory Protection:
Airborne concentrations should be kept to lowest levels possible. If vapor, mist or dust is generated and the occupational exposure limit of the product, or any component of the product, is exceeded, use appropriate NIOSH or MSHA approved air purifying or air supplied respirator after determining the airborne concentration of the contaminant. Air supplied respirators should always be worn when airborne concentration of the contaminant or oxygen content is unknown.

Ventilation:
Local exhaust ventilation recommended if generating vapor, dust, or mist. If exhaust ventilation is not available or inadequate, use MSHA or NIOSH approved respirator as appropriate.

Exposure Limit for Total Product:
None established for product.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:
Colorless liquid
Odor:
Slight odor

Boiling Point (degrees F):
468

Melting/Freezing point (degrees F):
-56

Specific Gravity (water=1):
1.203

pH of undiluted product:
7

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

9. PHYSICAL AND CHEMICAL PROPERTIES (CONT)

Vapor Pressure:
.02 mmHg at 68.0

Viscosity:
1.6 cSt at 43.3 C

VOC Content:
Not determined.

Vapor Density (air=1):
3.5

Solubility in Water (%):
1 - 10

Other: None

10. STABILITY AND REACTIVITY

This Material Reacts Violently With:
(If Others is checked below, see comments for details)

Air	Water	Heat	Strong Oxidizers	Others	None of These
					X

Comments:
None

Products Evolved When Subjected to Heat or Combustion:
Toxic levels of carbon monoxide, carbon dioxide, irritating aldehydes and ketones may be formed on burning. Heating in air may produce irritating aldehydes, acids, and ketones.

Hazardous Polymerizations: DO NOT OCCUR

11. TOXICOLOGICAL INFORMATION

TOXICOLOGICAL INFORMATION(ANIMAL TOXICITY DATA)
Median Lethal Dose
Oral:
LD50 > 5.00 g/kg (rat) practically non-toxic

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

11. TOXICOLOGICAL INFORMATION (CONT)

Inhalation:
Believed to be practically non-toxic
Dermal:
LD50 > 3.00 g/kg (rabbit) practically non-toxic
Irritation Index, Estimation of Irritation (Species)
Skin:
(Draize) .20 /8.0 (rabbit) no appreciable effect
Eyes:
(Draize) 12.50 /110 (rabbit) slightly irritating
Sensitization:
(Buehler) Negative - skin (guinea pig)
Other:
This product may contain residual (less than 100 ppm) concentrations of propylene oxide. There is evidence that propylene oxide causes tumors in laboratory animals.

12. DISPOSAL CONSIDERATIONS

Waste Disposal Methods
This product has been evaluated for RCRA characteristics and does not meet the criteria of a hazardous waste if discarded in its purchased form. Under RCRA, it is the responsibility of the user of the product to determine at the time of disposal, whether the product meets RCRA criteria for hazardous waste. This is because product uses, transformations, mixtures, processes, etc. may render the resulting materials hazardous.

Remarks
None

13. TRANSPORT INFORMATION

Transportation
DOT:
Proper Shipping Name:
Not regulated

IMDG:
Proper Shipping Name:
Not evaluated

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

13. TRANSPORT INFORMATION (CONT)

ICAO:
Proper Shipping Name:
Not evaluated

TDG:
Proper Shipping Name:
Not regulated

14. REGULATORY INFORMATION

Federal Regulations:
SARA Title III:
Section 302/304 Extremely Hazardous Substances

Seq.	Chemical Name	CAS Number	Range in %
01	Residual propylene oxide (typical)	75-56-9	0.001

Section 302/304 Extremely Hazardous Substances (CONT)

Seq.	TPQ	RQ
01	10000	100

Section 311 Hazardous Categorization:

Acute	Chronic	Fire	Pressure	Reactive	N/A
X					

Section 313 Toxic Chemical

Chemical Name	CAS Number	Concentration
None		

CERCLA 102(a)/DOT Hazardous Substances: (+ indicates DOT Hazardous Substance)

Seq.	Chemical Name	CAS Number	Range in %
01+	Residual propylene oxide (typical)	75-56-9	0.001

CERCLA/DOT Hazardous Substances (Sequence Numbers and RQ's):

Seq.	RQ
01+	100

N.D. - NOT DETERMINED
N.A. - NOT APPLICABLE
N.T. - NOT TESTED
< - LESS THAN
> - GREATER THAN

14. REGULATORY INFORMATION (CONT)

TSCA Inventory Status:
This product is listed on the Toxic Substance Control Act (TSCA) Chemical Substance Inventory.

Other:
None.

State Regulations:
California Proposition 65:
The following detectable components of this product are substances, or belong to classes of substances, known to the State of California to cause cancer and/or reproductive toxicity.

Chemical Name	CAS Number
Residual propylene oxide (typical)	75-56-9

States Right-to-know Regulations:

Chemical Name	State Right-to-know
None	

State list: CT (Connecticut), FL (Florida), IL (Illinois), MI (Michigan)
LA (Louisiana), MA (Massachusetts), NJ (New Jersey),
PA (Pennsylvania), RI (Rhode Island),

International Regulations:
Export Notification (TSCA-12b):
This product may be subject to export notification under TSCA section 12(b); contains:
Residual propylene oxide (typical)

WHMIS Classification:
Not regulated

Canada Inventory Status:
All components are listed on the Canadian Domestic Substance List (DSL).

N.D. - NOT DETERMINED N.A. - NOT APPLICABLE N.T. - NOT TESTED
< - LESS THAN > - GREATER THAN

14. REGULATORY INFORMATION (CONT)

EINECS Inventory Status:
All components are listed on the European Inventory of Existing Chemical Substances (EINECS).

Australia Inventory Status:
All components are listed on the Australian Inventory of Chemical Substances (ACIS).

Japan Inventory Status:
All components are listed on the Japanese MITI inventory.

15. ENVIRONMENTAL INFORMATION

Aquatic Toxicity:
Not determined.

Mobility:
Not determined.

Persistence and Biodegradability:
Not determined.

Potential to Bioaccumulate:
Not determined.

Remarks:
None

16. OTHER INFORMATION

Propoxylated products may contain residual amounts of free propylene oxide. Residual propylene oxide can accumulate in the container headspace and be released into the ambient environment. This process is enhanced when the product is agitated, as during tank car loading and unloading, and blending operations. There is evidence that propylene oxide causes tumors in laboratory animals. The OSHA and ACGIH eight-hour time weighted average exposure limits are both 20 ppm. The Huntsman internal standard is 10 ppm for an eight-hour time weighted average exposure.

16. OTHER INFORMATION (CONT)

THE INFORMATION CONTAINED HEREIN IS BELIEVED TO BE ACCURATE. IT IS PROVIDED INDEPENDENTLY OF ANY SALE OF THE PRODUCT FOR PURPOSE OF HAZARD COMMUNICATION AS PART OF HUNTSMAN'S PRODUCT SAFETY PROGRAM. IT IS NOT INTENDED TO CONSTITUTE PERFORMANCE INFORMATION CONCERNING THE PRODUCT. NO EXPRESS WARRANTY, OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE WITH RESPECT TO THE PRODUCT OR THE INFORMATION CONTAINED HEREIN. DATA SHEETS ARE AVAILABLE FOR ALL HUNTSMAN PRODUCTS. YOU ARE URGED TO OBTAIN DATA SHEETS FOR ALL HUNTSMAN PRODUCTS YOU BUY, PROCESS, USE OR DISTRIBUTE AND YOU ARE ENCOURAGED AND REQUESTED TO ADVISE THOSE WHO MAY COME IN CONTACT WITH SUCH PRODUCTS OF THE INFORMATION CONTAINED HEREIN.

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Date: 10-31-94 New X Revised, Supersedes: 07-01-94

Inquiries regarding MSDS should be directed to:
Huntsman
Coordinator, Product Safety
P.O. Box 27707
Houston, TX 77227-7707

PLEASE SEE NEXT PAGE FOR PRODUCT LABEL

N.D. - NOT DETERMINED
N.A. - NOT APPLICABLE
N.T. - NOT TESTED
< - LESS THAN
> - GREATER THAN

PRODUCT CODE: 75436 **Date Issued: 10-31-9**
NAME: JEFFSOL PC **Supersedes: 07-01-9**

17. PRODUCT LABEL

READ AND UNDERSTAND MATERIAL SAFETY DATA SHEET BEFORE HANDLING OR DISPOSING OF PRODUCT. THIS LABEL COMPLIES WITH THE REQUIREMENTS OF THE OSHA HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200) FOR USE IN THE WORKPLACE. THIS LABEL IS NOT INTENDED TO BE USED WITH PACKAGING INTENDED FOR SALE TO CONSUMERS AND MAY NOT CONFORM WITH THE REQUIREMENTS OF THE CONSUMER PRODUCT SAFETY ACT OR OTHER RELATED REGULATORY REQUIREMENTS.

75436 JEFFSOL PC

WARNING STATEMENT

CAUTION ! MAY CAUSE EYE IRRITATION
ASPIRATION HAZARD IF SWALLOWED -
CAN ENTER LUNGS AND CAUSE DAMAGE
CONTAMINATION MAY RESULT IN DANGEROUS CO2 PRESSURE BUILD-UP

PRECAUTIONARY MEASURES

-Avoid prolonged breathing of vapor, mist, or gas.
-Avoid contact with eyes.
-Keep container closed.
-Wash thoroughly after handling.

FIRST AID

Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes. Hold eyelids apart while flushing to rinse entire surface of eye and lids with water. Get medical attention.
Skin Contact:
Wash skin with plenty of soap and water for several minutes. Get medical attention if skin irritation develops or persists.
Ingestion:
If person is conscious and can swallow, give two glasses of water (16 oz.) but do not induce vomiting. If vomiting occurs, give fluids again. Have medical personnel determine if evacuation of stomach or induction of vomiting is necessary. Do not give anything by mouth to an unconscious or convulsing person.
Inhalation:
If irritation, headache, nausea, or drowsiness occurs, remove to fresh air. Get medical attention if breathing becomes difficult or respiratory irritation persists.

17. PRODUCT LABEL (CONT)

Note to Physician:
Aspiration of this product during induced emesis may result in severe lung injury. If evacuation of stomach is necessary, use method least likely to cause aspiration, such as gastric lavage after endotracheal intubation. Contact a Poison Center for additional treatment information.

FIRE

In case of fire, use water spray, dry chemical, foam or carbon dioxide. Water may cause frothing. Use water spray to cool fire-exposed containers.

If more than 10,000,000 pounds of product is spilled, then report spill according to SARA 304 and/or CERCLA 102(a) requirements, unless product qualifies for the petroleum exemption (CERCLA Section 101(14)).

	Chemical Name	CAS Number	Range in %
*	1,3-dioxolan-2-one, methyl-	108-32-7	100.00

PRODUCT IS HAZARDOUS ACCORDING TO OSHA (1910.1200).
* COMPONENT IS HAZARDOUS ACCORDING TO OSHA.

Pennsylvania Special Hazardous Substance(s)	CAS Number	Range in %
None		

HMIS				NFPA			
Health:	1	Reactivity:	0	Health:	1	Reactivity:	0
Flammability:	1	Special	: -	Flammability:	1	Special	: -

Transportation
DOT:
Proper Shipping Name:
Not regulated

N.D. - NOT DETERMINED
N.A. - NOT APPLICABLE
N.T. - NOT TESTED
< - LESS THAN
> - GREATER THAN

17. PRODUCT LABEL (CONT)

CAUTION: Misuse of empty containers can be hazardous. Empty containers can be hazardous if used to store toxic, flammable, or reactive materials. Cutting or welding of empty containers might cause fire, explosion or toxic fumes from residues. Do not pressurize or expose to open flame or heat. Keep container closed and drum bungs in place.

Manufacturer's Name and Address:
HUNTSMAN
P.O. Box 27707
Houston, TX 77227-7707

TRANSPORTATION EMERGENCY	Company:	(409) 727-0831
	CHEMTREC:	(800) 424-9300
HEALTH EMERGENCY	Company:	(914) 831-3400

SECTION 4:

EVALUATION OF INNOVATIVE PAINT APPLICATION TECHNOLOGY

By:

J. T. Hanley, J. B. Flanagan,
J. M. Elion, J. H. Turner, and E. A. Hill

ABSTRACT

This section describes the procedures and findings of a pollution prevention demonstration performed at the Marine Corps Logistics Base (MCLB) in Albany, GA. The research was performed by U.S. EPA with the contractor services of Research Triangle Institute (RTI). Funding was provided by the Strategic Environmental Research and Development Program (SERDP). The test location was the paint booth located in Building #2222 at the MCLB. The measurements were performed during December 1995.

The objective was to determine if the amount of paint required to coat a vehicle could be reduced by providing the painters with a real time readout of how much paint they have used. The study began with the design, specification, purchase, and installation of a paint monitoring system in one of the MCLB's paint booths. The system monitored paint use gravimetrically by continuously measuring the weight of the 5-gallon paint pot that held the paint pumped to the spray guns. The system included programmable digital scales, a small printer, and large remote displays visible from within the paint booth. The displays continuously showed the cumulative amount of paint used, beginning at zero at the start of a painting job.

The initial portion of the test period was devoted to baseline or control measurements taken "without feedback" of paint consumption information. During this period, the displays were not visible to the painters while they were in the booth. After sufficient baseline information had been gathered, the displays were installed in the booth and the painters were instructed in how the displays could be used to control their usage rate. "Target" levels for High Mobility Multipurpose Wheeled Vehicles (HMMWVs) and 5-ton trucks were set based on the lowest usage during the baseline period.

The system proved to work reliably, and paint usage measurements were obtained on a total of nineteen vehicles; ten HMMWVs, five 5-ton cargo trucks, and four other vehicles. The measurements show that, for one set of identical vehicles (the ten HMMWVs), paint consumption differed by up to 30% between the highest and lowest vehicles. This indicates that a potential for significant reductions may exist. However, during the brief study period, no statistically significant decrease in paint usage was seen between the baseline (without feedback) and the experimental (with feedback) portions of the demonstration. This may be due to the short duration of the demonstration and to the presence of monitoring personnel at the paint booth during the baseline period. However, the system could still provide reductions in paint usage and other benefits when used in combination with other strategies such as mixing only the amount needed for each vehicle rather than the current practice of mixing paint in multiples of five gallons. The system could also be used to assist in training new employees, and to assess the impact of equipment inspection and maintenance practices on paint consumption.

The recommendation is that the MCLB continue to collect paint usage data for a period of several months to determine if measurable reductions in paint usage are realized after the staff become accustomed to the equipment.

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ACRONYMS

APPCD	Air Pollution Prevention and Control Division
CAA	Clean Air Act
CARC	Chemical agent resistant coating
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DMA	Depot Maintenance Activity
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
LED	Light emitting diode
HMMWV	High mobility multipurpose wheeled vehicle
HAP	Hazardous air pollutant
MCLB	Marine Corps Logistics Base
MEK	Methyl ethyl ketone
MSDS	Material Safety Data Sheet
P2	Pollution prevention
PP	Payback period
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
ROI	Return on investment
RTI	Research Triangle Institute
SARA	Superfund Amendments and Reauthorization Act
SERDP	Strategic Environmental Research and Development Program
ULV	Ultra low volume (spray gun)
VOC	Volatile organic compound

METRIC UNITS

English units have been included in the report to simplify communication with most of the intended readership and because they are the primary units used by the Marine Corps Logistics Base. The multiplying factors for converting from the English units to their metric equivalents are given in the table below.

METRIC CONVERSION FACTORS (Approximate)				
Symbol	*When You Know the Number of*	*Multiply By*	*To Find the Number of*	*Symbol*
LENGTH				
in	inches	2.54	cm	centimeters
VOLUME				
gal	gallons	3.79	liters	l
MASS				
lb	pounds	0.454	kilograms	kg
PRESSURE				
psi	pounds per square inch	6.89	kilopascals	kPa
TEMPERATURE				
°F	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Centigrade	°C
DENSITY				
lb/ft^3	pounds per cubic foot	16.0	kilograms per cubic meter	kg/m^3
FLOW				
cfm	cubic feet per minute	0.472	liters per second	l/sec

ACKNOWLEDGMENTS

The authors gratefully wish to acknowledge the following people at the MCLB, without whose cooperation and assistance this demonstration would not have been possible:

Steve Allan
Dave Baxter
Wayne Chauncey
Scott Clements
Clarence Clyde
Larry Fountain
John Gates
George Hagan
Duke Hellinger
Dave Hudson
Mark Joyner
Willie Walker

The authors would especially like to recognize the contribution of EPA and MCLB's Project Engineers J. Kaye Whitfield and Dan Gillum to this report. Their project oversight, guidance, direction, and technical assistance greatly contributed to this research demonstration.

NOTICES

QA/QC requirements apply to this project. Data are supported by QA/QC documentation as required by USEPA's policy.

The use of trade names and company names in this section does not signify recommendation for use or endorsement by either the EPA or Research Triangle Institute.

4.1.0 INTRODUCTION

This section reports on the demonstration of an innovative paint application technology performed at the Marine Corps Logistics Base (MCLB) in Albany, GA. It contains detailed descriptions of the technical evaluation, including baseline and operational tests conducted at the MCLB. Information regarding potential cost savings and estimated reductions in hazardous air emissions is contained in the Implementation Plan (Section 4.5.0).

4.1.1 Background

This document describes the procedures and findings of a pollution prevention demonstration performed at the MCLB. The test location was the paint booth located in Building #2222 at the MCLB. The measurements were performed during December 1995.

The pollution prevention technology demonstration research was performed by:

1) U. S. Environmental Protection Agency (EPA), Air Pollution Prevention and Control Division (APPCD), Research Triangle Park, NC
2) Research Triangle Institute (RTI), Research Triangle Park, NC
3) MCLB, Albany, GA

The EPA/APPCD initiated this project with funding from the Strategic Environmental Research and Development Program (SERDP) and provided guidance throughout its duration. The on-site demonstration was conducted in which the alternative paint application process was demonstrated in a production environment. RTI provided contractor services (e.g.coordinated the project, provided technical expertise for the design and implementation of the demonstration), and reported to the EPA Project Officer. The primary responsibility of the MCLB was to support the demonstration by providing the facilities and staff for carrying out the demonstration. The MCLB technical representative supervised the project at the site and served as a contact person with EPA and RTI.

The MCLB carries out maintenance activities on a wide variety of equipment from small arms to tanks, trucks, and other vehicles. Much of the maintenance on the vehicles requires removal of existing paint prior to the repair procedures and application of new paint once the maintenance has been performed. The processes for paint stripping, repainting, and cleaning of paint application equipment release significant amounts of hazardous air pollutants (HAPs). By executive Order 12856, the MCLB is required to reduce these air emissions by 50% from 1992 levels. The MCLB desires to accomplish this goal by implementing pollution prevention (P2) technologies.

The demonstration performed at the MCLB was based on previous scoping studies carried out in collaboration with the EPA and the MCLB. The scoping study for the spray paint application was performed under a cooperative agreement with the EPA/APPCD.

4.1.2 Objectives

The specific objectives of this task were to:

- select, procure, install, and demonstrate a paint flow monitoring system in one paint booth at the MCLB;
- determine whether the paint flow monitoring system could provide reliable, continuous operation when used with the MCLB's paint coatings and solvents, and when used in the MCLB's physical environment (heat, electronic noise, handling by painters, etc.);
- measure the amount of paint used as a function of vehicle type, painter, and coating; and
- acquire and analyze data to determine whether providing the painters and their managers with real-time monitoring information would lead to reduced paint use during the demonstration.

In defining the specific task objectives, it was important to note that MCLB is a high production repair facility for military vehicles and operated on a tight schedule. Although the MCLB provided valuable assistance and cooperation with the study, the demonstration activities could not significantly interfere with or slow their work schedule. As a result, several important test parameters could not be controlled and regulated to produce the most statistically efficient experimental design. These parameters included the number and types of vehicles painted, assignment of painters to the test booth, and the type of coating applied. The objectives of this task were formed with these limitations in mind.

(Note: an initial project objective, to evaluate an innovative paint pumping device, the ultra low volume (ULV) system, proved inappropriate for the MCLB Chemical Agent Resistant Coatings (CARC) coatings during preliminary trials by the manufacturer and was not evaluated further. A summary of these findings is presented in Appendix 4-1.)

The MCLB is planning to implement another P2 technology for paint application, a paint dispensing system. This system will allow quantities of less than the standard 5-gallon "kit" to be mixed. This should have the beneficial environmental effects of reducing air pollution and solid/hazardous waste disposal, as well as reducing the cost of paint consumed. This planned P2 technology will work well in combination with the weighing system, which can provide quantitative data about the amount of paint that needs to be dispensed to cover each type of vehicle. The weighing system could also be used to document the reduction in paint usage.

4.2.0 TECHNICAL EVALUATION

4.2.1 Introduction

Reducing the amount of paint sprayed is the primary method available to the MCLB to reduce HAP air emissions from its paint booths. The MCLB has no VOC control devices on the paint booth exhaust; only particulate paint arresters. Consequently, 100% of the VOC originally in the paint (including added thinner) is emitted to the atmosphere. Paint that is discarded without being sprayed is sent to a disposal contractor. The solvent content of the discarded waste paint is not included in air emissions from the MCLB paint booths.

Prior to this study, the MCLB painters and managers had only crude estimates of how much paint was being sprayed to coat a given type of vehicle. For example, the amount of paint needed to paint a HMMWV (High Mobility Multipurpose wheeled Vehicle) was estimated to range from 3 to 5 gallons. This estimate was based on the observation that the painters usually use less than a 5-gallon kit to paint one HMMWV. (At the MCLB, paint is dispensed in 5-gallon quantities or, for two-component paints, in 5-gallon "kits.") Similarly, it was estimated that about 5 to 8 gallons were needed for a 5-ton truck, based on the painters needing two 5 gallon kits to complete the job. This crude level of measure was insufficient to accurately quantify how much paint was being used prior to making the measurements described in this report.

The MCLB already knew from prior short-term training sessions that painters would be more careful not to waste paint when they were being observed by a supervisor. For example, wasteful practices such as spraying at too great a working distance, spraying at too high a pressure, and applying excessively thick coatings were reduced while painters were under close supervision. It was anticipated that feedback provided by the paint flow monitor would provide the same effects as "supervision and training" of the painters so that these benefits could be extended over the long term. Acquiring an accurate means for measuring the amount of paint sprayed was the first step towards quantifying, controlling, and reducing it.

4.2.2 Equipment Evaluation and Selection

This task began with selection and installation of a suitable paint monitoring device. After a period of investigation, project engineers found that measuring devices based on direct in-line flow measurement would not be practical. This conclusion was based on the highly abrasive qualities of the CARC and because of the probability of caking and fouling within any in-line devices contacting catalyzed resins. As a consequence, a continuous readout scale was used as the primary measurement device. This scale, the Weigh-Tronix Model BSAO2020-200 with associated readout, printer, and control units, was capable of displaying and recording both the total weight of a paint container and the rate of paint usage. Since the measuring device never contacted the CARC, there was no possibility of abrasion as with the in-line flow rate measuring devices first considered. The presence of dried paint on the weighing surface is also not a concern because the weighing pan is tared at the beginning of each painting session.

The Weigh-Tronix device was configured with two large light-emitting diode (LED) readout panels so that the painters could continuously see both the amount of paint used and a preselected "goal" or target for the vehicle. One of the key questions to be answered during the demonstration was whether access to this information would enable the painters to reduce the amount used to paint a particular type of vehicle. This was done by comparing the amount of paint used for vehicles of the same type with and without the displays. Other potential applications for controlling and reducing paint use with the displays will be discussed below.

The availability of quantitative usage information may also enable the painters to complete vehicles of the same type with a high degree of consistency in total paint usage. If so, it should be possible to mix only the predetermined amount of paint needed for each type of vehicle. Paint usage, corresponding VOC emissions, and wasted paint would thus be reduced to the absolute minimum achievable without additional controls.

4.2.3 Measurement Procedure

A schematic diagram of the spray painting and measurement equipment setup is provided in Figure 4-1. Immediately prior to beginning paint spraying of the vehicle, the scale was reset to zero by pressing the "tare" and "print" buttons. After painting was completed, the amount of paint used was directly read off the paint monitor and was printed on the tape. If additional paint was needed during a job, the print button was pressed before adding paint. After the addition of paint, the tare and print buttons were again pressed. Finally, after each vehicle was completed, the print button was pressed a final time. This procedure was used throughout the demonstration period. The full procedure for using the scale is provided in Appendix 4-2, which is a replica of the instructions posted at the spray booth.

As part of this procedure, data specific to each painting job were entered by the painter and recorded on the printer. These data included vehicle identification number, vehicle type, painter ID numbers, and coating type. There was also an option to print at a user specified interval to provide a continuous record of paint usage. The printer was used in this way during the baseline period to record 1-minute weight data. Operation of the printer was independent of the LED displays.

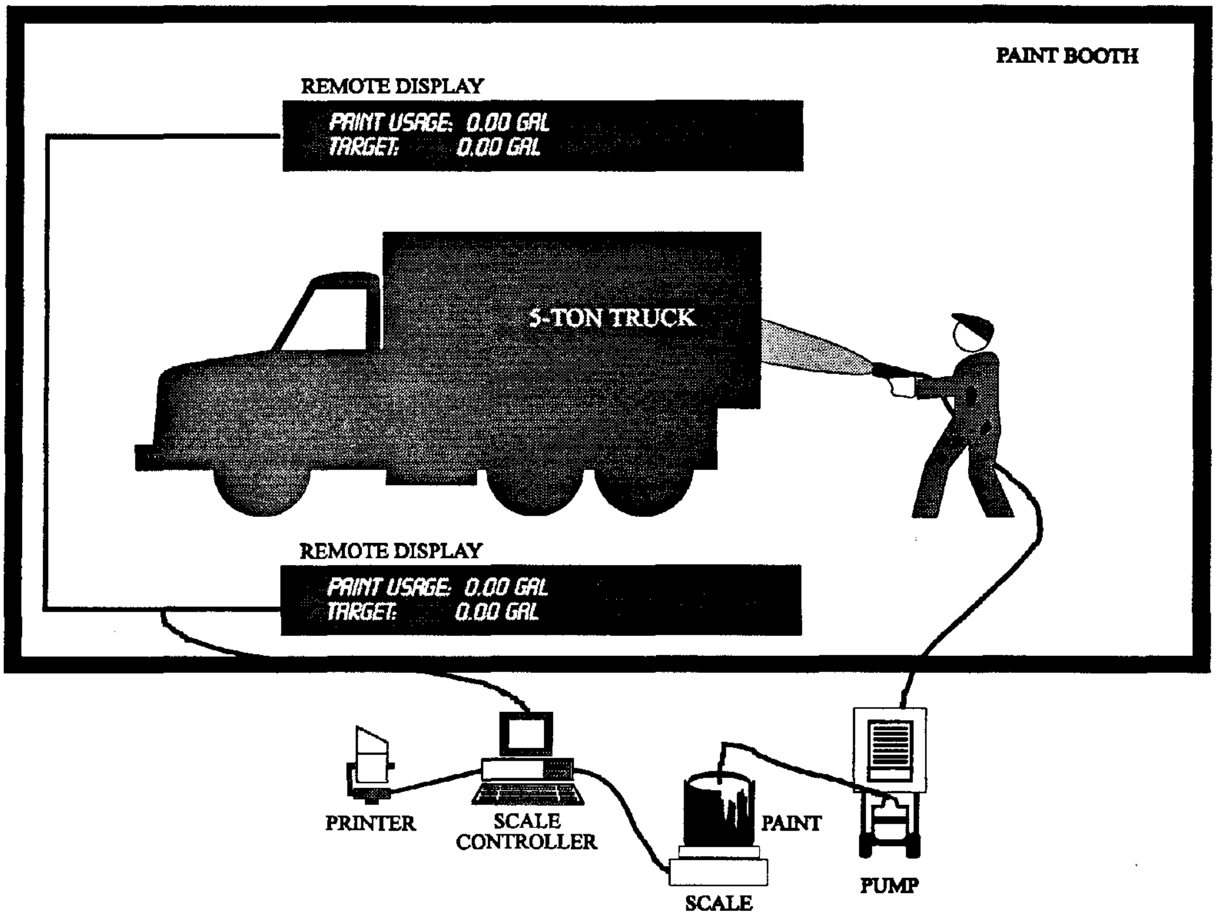

FIGURE 4-1. SCHEMATIC OF PAINT MONITORING SYSTEM (NOT TO SCALE)
The remote displays were located on the side walls of the paint booth.

4.2.4 Evaluation of Paint Use Reduction

Due to changes in the schedule while the project was under way, on-site testing was limited to two weeks. It was nevertheless possible to obtain limited statistics for paint consumption with and without access to the paint use monitor.

It is important to note that even without feedback, the painters knew that paint consumption was being measured. Knowing this, they may have been more careful in their painting even during the baseline portion of the study conducted "without feedback." Thus, the consumption measurements "without feedback" should not be considered as completely representative of paint consumption prior to this project. While it would have been interesting to measure paint consumption without the painters knowledge, such an approach was deemed inappropriate and impractical for this study.

4.2.5 Test Variables

This study involved three independent variables: painter(s), type of vehicle, and whether feedback of paint use information was given to the painters. Only one type of coating, green 2-component CARC, was used for the demonstration. The independent and dependent variables are discussed below and are summarized in Table 4-1.

- Painters: Two painters work simultaneously in the booth using the same paint source. One or both may be spraying at any given time. The MCLB has approximately 30 painters on staff; five different painters participated in this study. Painters were scheduled randomly throughout the test period.
- Type of Vehicles: The study focused on the most frequently painted types of vehicles at the MCLB which were HMMWVs and 5-ton trucks. For each of these, however, there were several different body configurations. To the extent possible, the exact body configuration was noted for each vehicle painted. For each type, vehicles were considered "identical" so long as there was no discernible difference that would affect the surface area to be painted.
- Coatings: While the MCLB uses several different coatings, only 2-component green CARC was used during the demonstration. After the two components were mixed, the

- CARC was thinned with methyl ethyl ketone (MEK) in the ratio of 1 part MEK to 5 parts CARC.
- Feedback: The study involves two levels of information feedback to the painters defined as:
    - "Without feedback": For the first half of the study, the flow monitor readings were known only to the attending project technician. This information was not given to the painter. It is important to note that even without feedback, the painters knew that their paint usage was being monitored. Because of this, they may have been more careful in their painting, which might result in a slight low bias in the results taken without feedback. MCLB supervisors have stated that painters tended to use less paint when they were under direct supervision.
    - "With feedback": During the second half of the testing, a real-time readout of cumulative paint use was readily visible to the painter. The painters could also see the target level for the vehicles on the display. Painters were trained in the use of the flow monitor and were informed of the importance to the MCLB that the amount of paint sprayed be reduced.

TABLE 4-1. PROJECT VARIABLES.

VARIABLES		*LEVELS*
Independent Variables	Painter	5 total painters during demonstration period, randomly assigned from a pool of 20-30 painters
	Type of Vehicle	1) HMMWV 2) 5-Ton Truck 3) all other*
	Type of Coating	2-Component green CARC only
	Feedback	1) Painter receives no feedback. 2) Painter receives real time data on paint consumption and a target level for the vehicle
Dependent Variables	Volume of Paint Sprayed	Data obtained as a function of painter, vehicle type, coating, and feedback.

*Other vehicle types included a tractor-trailer cab, a mobile power unit, and small utility equipment.

4.2.6 Data Reduction, Validation, and Reporting

It was planned that paint use data with and without feedback would be compiled based on several independent variables including: painter, type of vehicle, and type of coating. Due to the compression of the demonstration schedule and the consequent paucity of data, it was necessary to limit the test to just two types of vehicles and one type of coating. The identity of the painters was not used as a variable in the evaluation because there was insufficient data to draw a reliable correlation between painter ID and paint usage. In addition, painters worked in pairs which varied from day to day.

Percent reduction in paint use for a particular vehicle type is calculated using the following equation:

$$\%\ \text{Reduction} = 100 \cdot \frac{V_b - V_a}{V_b}$$

where: V_b = the average volume of paint used without feedback, and

V_a = the average volume of paint used with feedback.

To compute the statistical significance of the differences between means, Student's t-test was used.

4.3.0 DEMONSTRATION OF INNOVATIVE PAINT APPLICATION TECHNOLOGY

4.3.1 Baseline Data

Between December 4 and December 13, 1995, the paint monitoring equipment was installed and functioning, but the displays were not installed. This period was used to acquire data "without feedback". During the baseline period several complete vehicles were painted while the printer recorded at 1-minute intervals. Several graphs of paint consumption vs. time for these vehicles are shown in Figures 4-2 through 4-9. These graphs document the performance of the monitoring equipment and show events and interruptions that occur during typical painting sessions. Appendix 4-3 provides the net paint consumption data for all vehicles painted during the demonstration period, both with and without feedback.

Figure 4-2 shows data for the first vehicle painted after the scale was installed. This figure illustrates features of a typical painting session:

- The initial slope of paint volume vs. time ("2 painters") was higher than near the end of the job, when only one painter was spraying paint.
- The areas indicated as "Noise" were the result of opening and closing the door to the paint booth and moving the plastic sheet covering the paint reservoir and scale. These movements caused vibrations and changes in pressure that affected the scale's readout. This type of noise was not seen in any subsequent vehicles because the plastic tarp covering the equipment was moved away from the scale. A linear regression was used to estimate the amount of paint used up to the first point noted "Paint Added." It was not necessary to use linear regression for any subsequent vehicles because the source of this noise had been eliminated.
- After the first paint addition there appeared to be about 1-2 minutes of additional noise, followed by about five minutes of painting. The balance was not tared after this paint addition.
- More paint was added, which caused the indicated weight to go below the original baseline. This was because the paint reservoir was heavier than it was when the original tare was done.
- A second tare was then done, which restored the baseline to 0.00 gallons.
- The final, relatively uninterrupted section of the curve was a period during which one painter did touch up and detail work, while the other painter assisted with taping and masking. This accounts for the lower slope for this section of the curve compared to the first section.

The total paint used, 5.49 gallons, was calculated as the total of the segments indicated. Because of noise in the signal, this total has an estimated uncertainty of about 0.3 gallons.

Figure 4-3 shows the raw data for the second vehicle painted, the tractor unit from a large truck. The high level of noise observed in the previous job (Figure 4-1) was not seen in this or any subsequent paint jobs. The time axis is shown as elapsed time from the beginning of the job. The segment below the baseline is probably due to either adding paint without taring, or taring the scale before it had stabilized. In either case, the calculation of the total is not compromised; the 0.14 gallons is included in the total of 5.74 gallons.

Figures 4-4 and 4-5 show the cumulative consumption, 6.45 gal., for an MK-48 power unit (a large truck-like vehicle). Figure 4-4 is the raw data as recorded on the printout, and Figure 4-5 shows cumulative paint usage calculated by joining the individual segments end-to-end. The time axes for these figures show elapsed time from the beginning of the job. During the long segment marked "Meeting," the painters were away from the booth. The printer tape continued to run, which allowed data on random variability (low level "noise") in the signal to be captured. This low-level noise is thought to be due to the vibration of the stirring motor, electronic noise, etc., and is likely to be present in all the data. This noise is much smaller in magnitude than the areas marked "Noise" in Figure 4-2, because it has a different source (see discussion above). There also appeared to be a slight slope, which may be due to evaporation of the high-volatility solvent. This segment is analyzed further in Section 4.4.0 of this report.

Figures 4-6 through 4-9 illustrate the variation in time, application rate, and total paint used for four HMMWVs. The amount of paint used "without feedback" varied from 1.66 to 2.70 gallons. The time required to paint these identical vehicles ranged from about 20 to about 40 minutes. To facilitate comparison, Figures 4-6 through 4-9 are plotted on the same time scale. Reasons for the differences in painting times were not recorded, but are most likely related to the number of painters working at a given time, the paint flow rate, the amount of detail work needed by a particular vehicle, etc. Note that the slope of paint usage changes on all four graphs at around minutes 17-21. The rate of paint use slows significantly; perhaps only touch-up occurs after this point. It is noteworthy that on Test 6, the HMMWV with highest paint usage, the painters continued using paint at the lower rate for another twenty minutes, using approximately an additional half-gallon paint. It would be well worth the effort to find out what activities take place during these two distinct rates of paint usage.

Table 4-2 provides the total paint consumption figures for vehicles painted "without feedback." Trials 1 and 13, both 5-ton trucks, had to be rejected for data analysis because their undercarriages had already been painted before they entered the booth. Consequently, their results were not representative of other 5-ton trucks which received full paint jobs. The data tape for Trial 11 indicated that the balance was not tared properly when paint was added. This error is thought to be relatively small compared to the total variability of the measurements; consequently, the data for Trial 11 were not rejected from the data analysis.

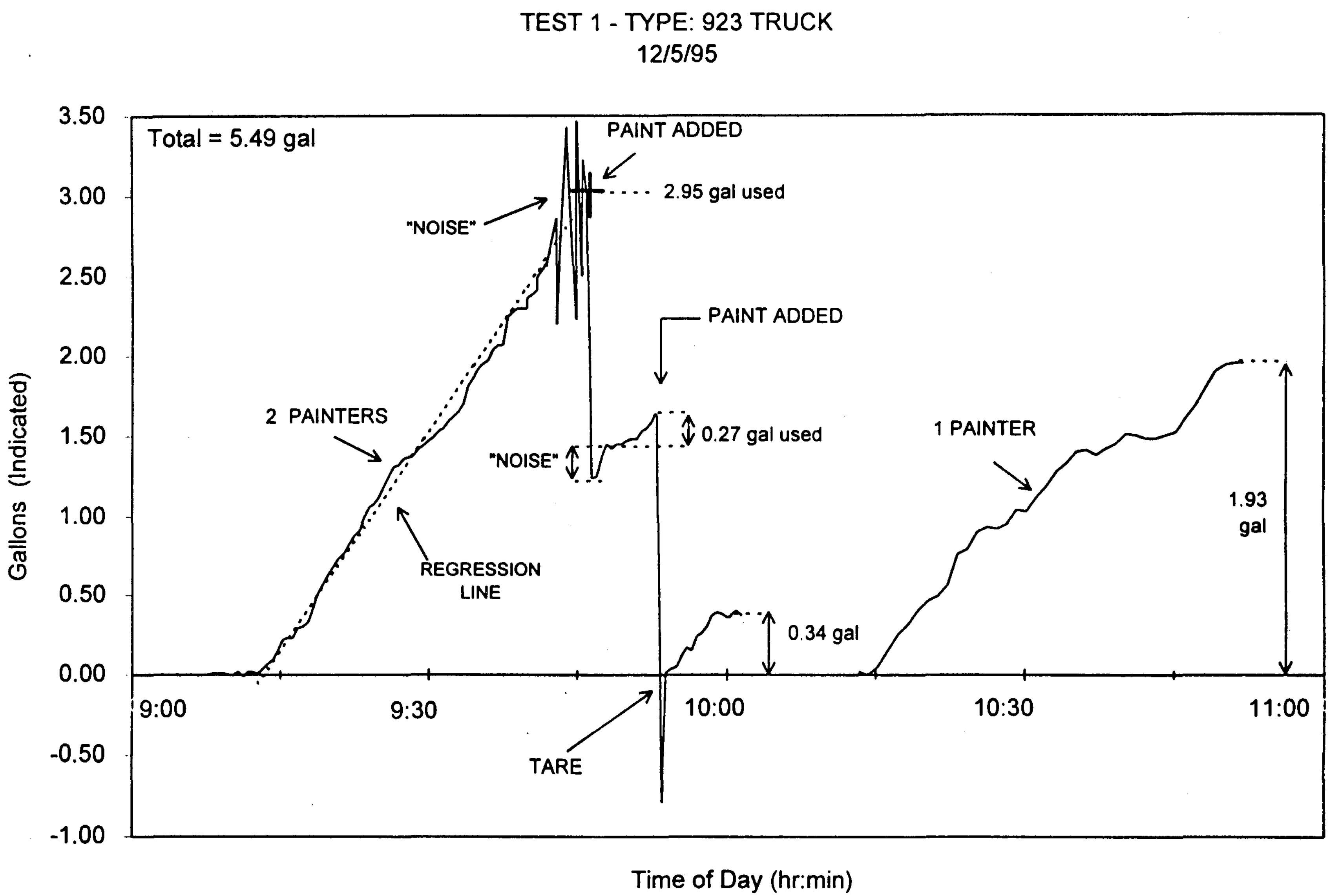

FIGURE 4-2. PAINT CONSUMPTION FOR TEST 1.

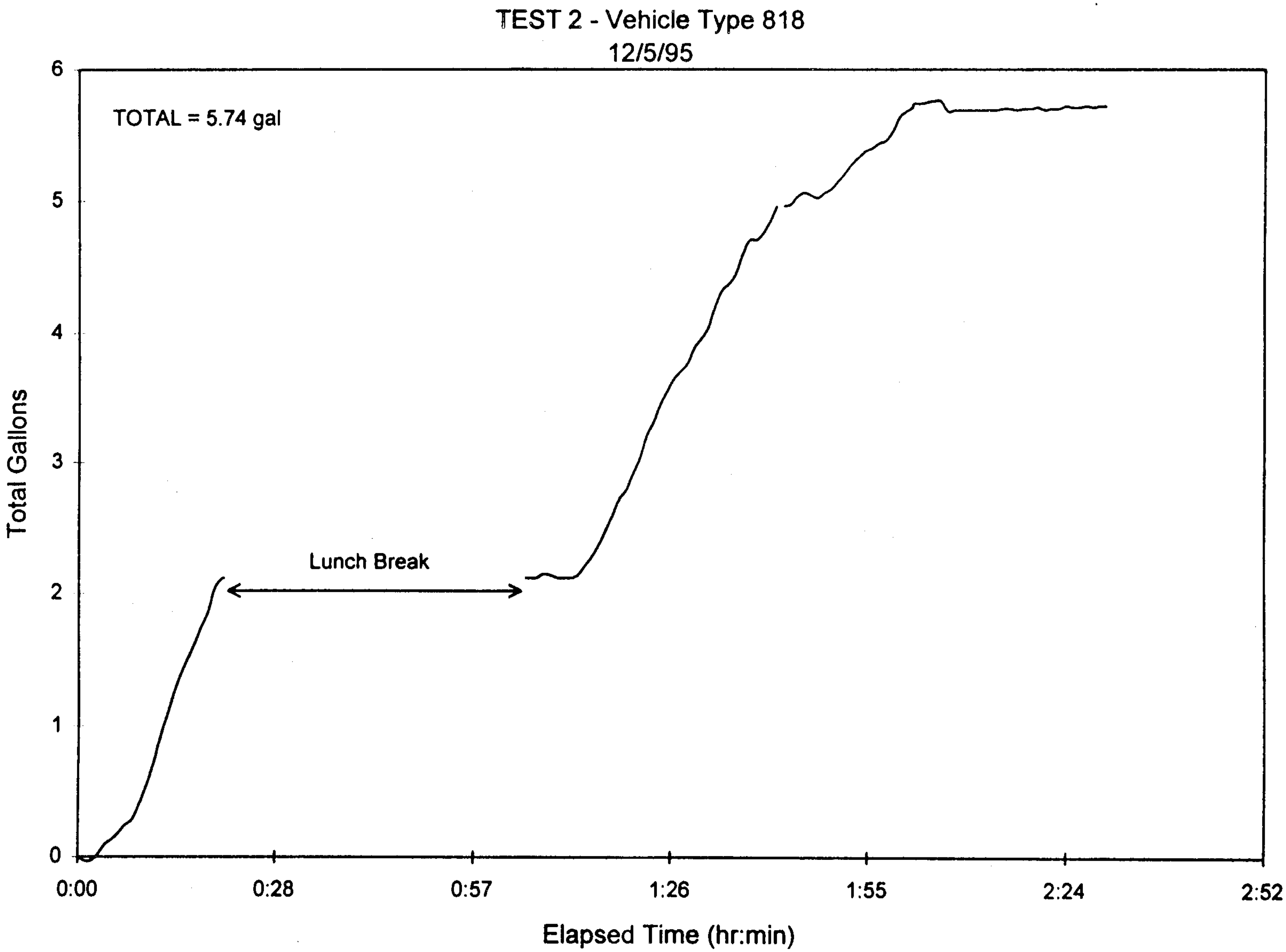

FIGURE 4-3. PAINT CONSUMPTION FOR TEST 2.

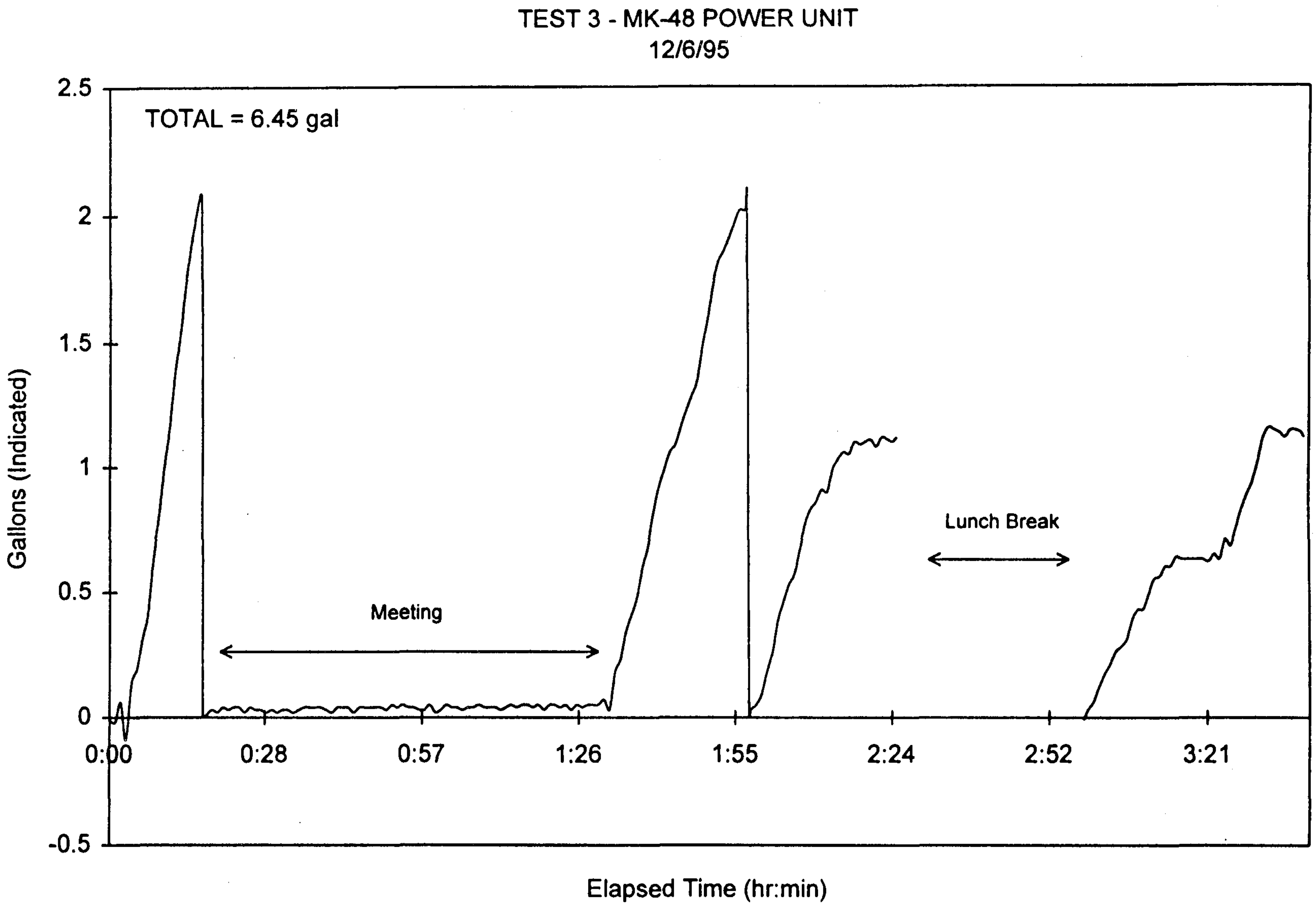

FIGURE 4-4. PAINT CONSUMPTION FOR TEST 3.

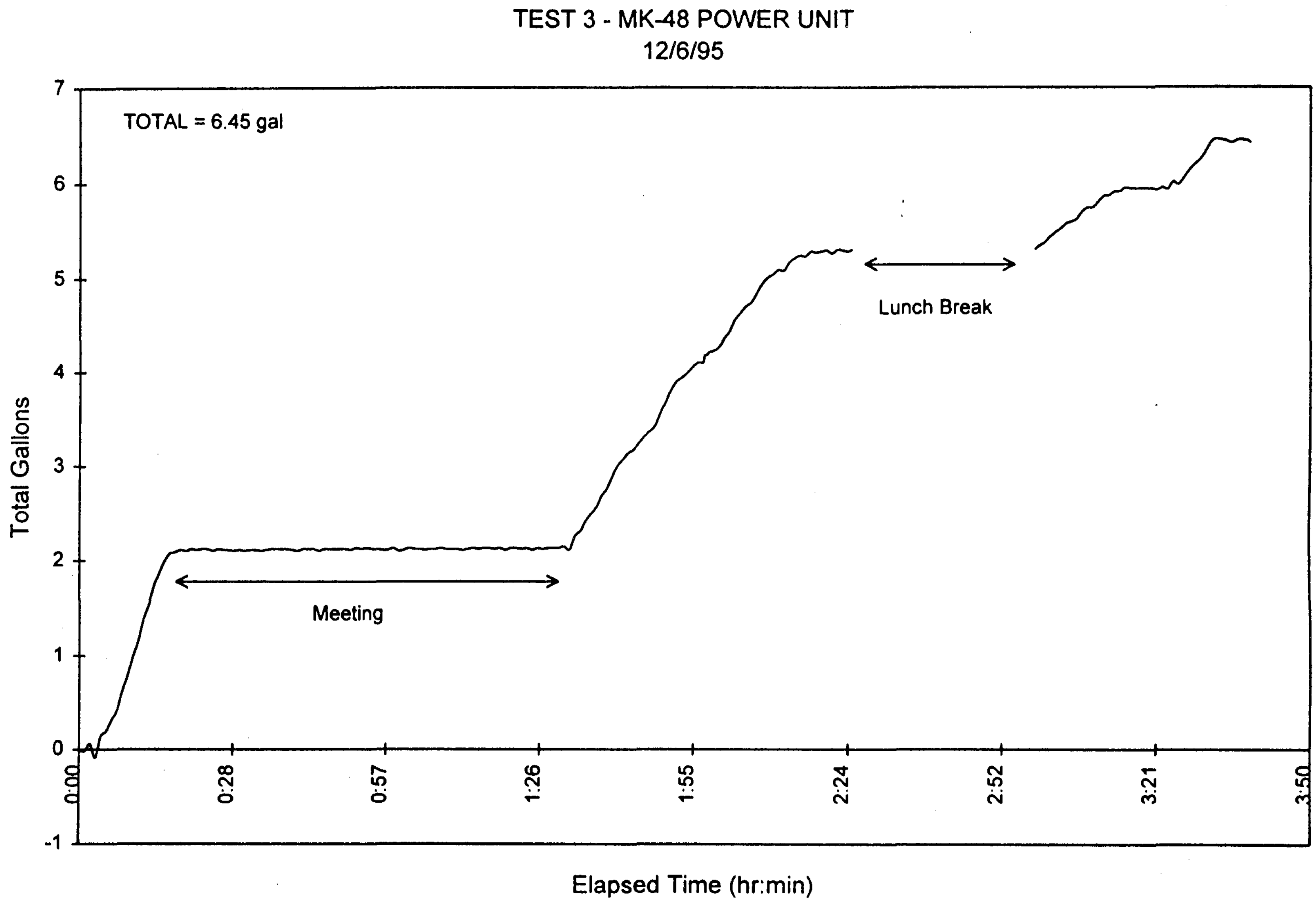

FIGURE 4-5. CUMULATIVE PAINT CONSUMPTION, TEST 3.

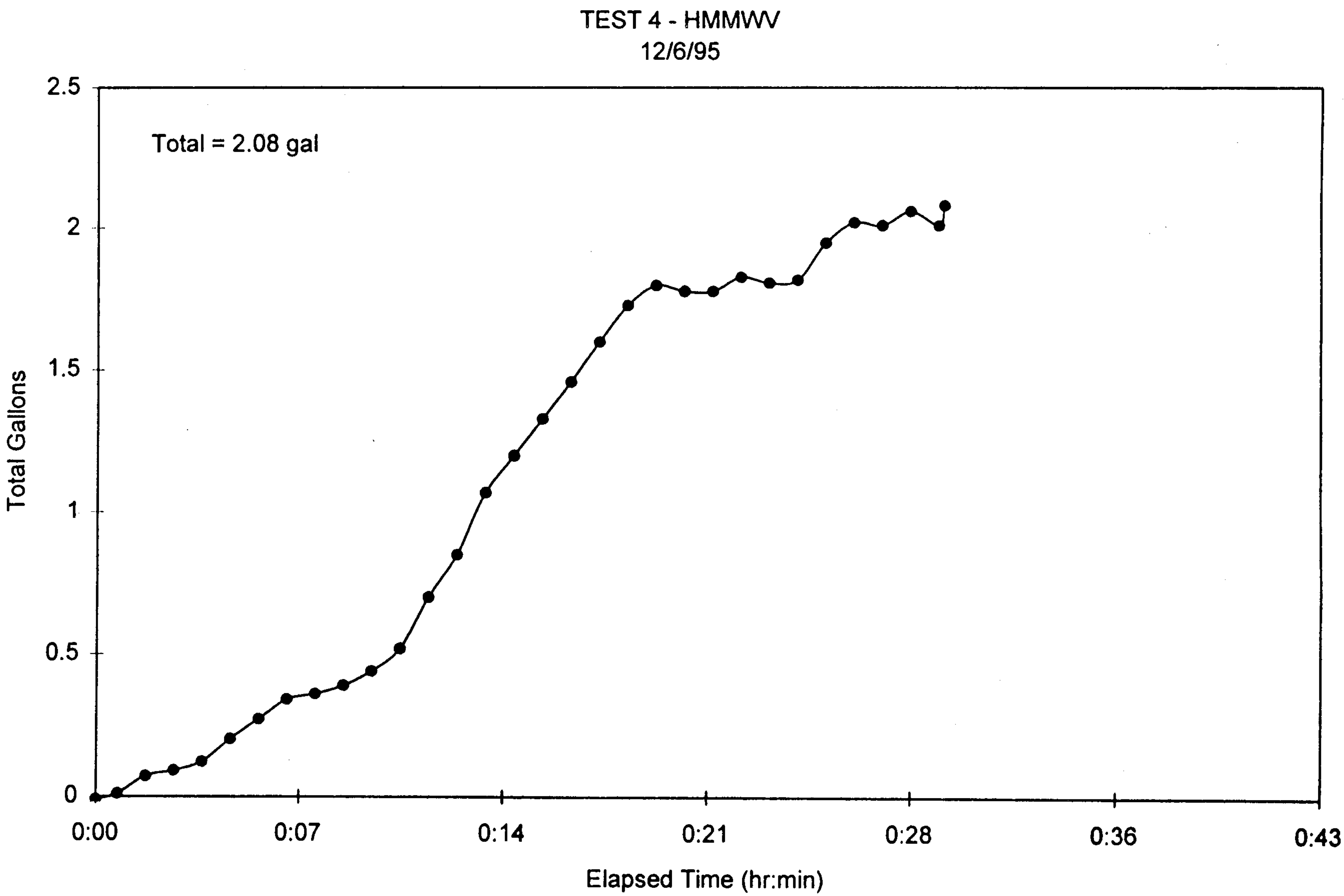

FIGURE 4-6. CUMULATIVE PAINT CONSUMPTION, TEST 4.

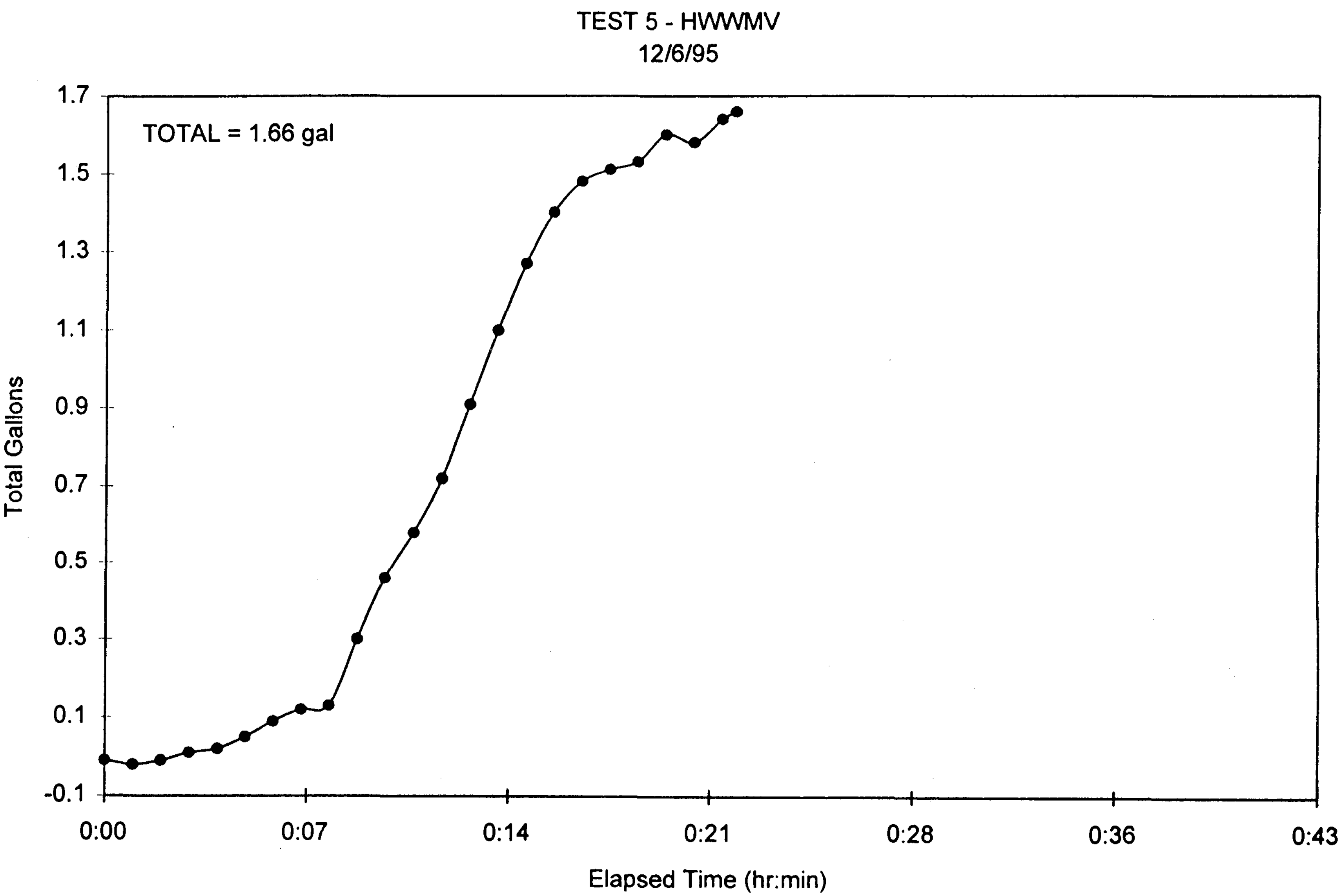

FIGURE 4-7. CUMULATIVE PAINT CONSUMPTION, TEST 5.

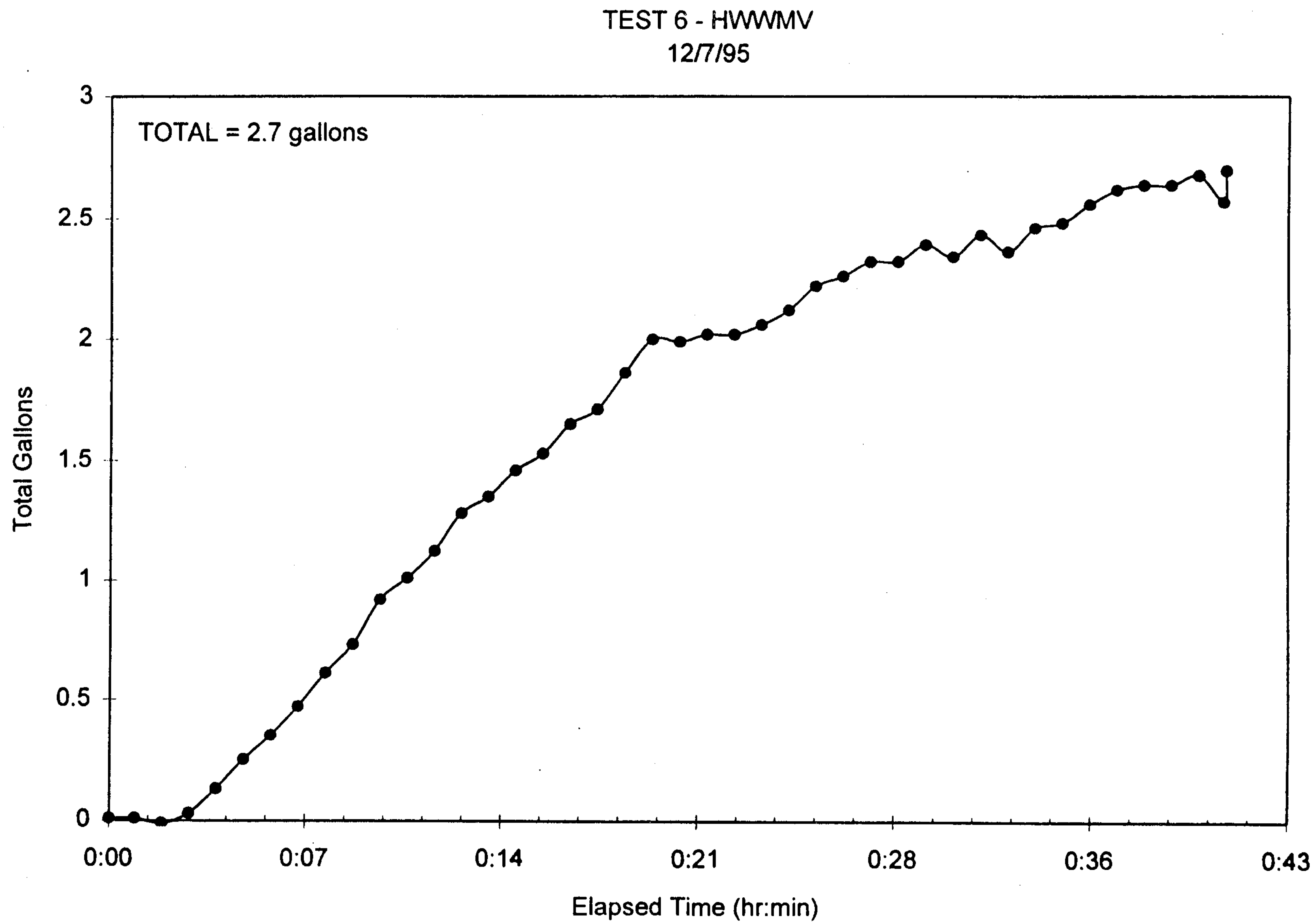

FIGURE 4-8. CUMULATIVE PAINT CONSUMPTION, TEST 6.

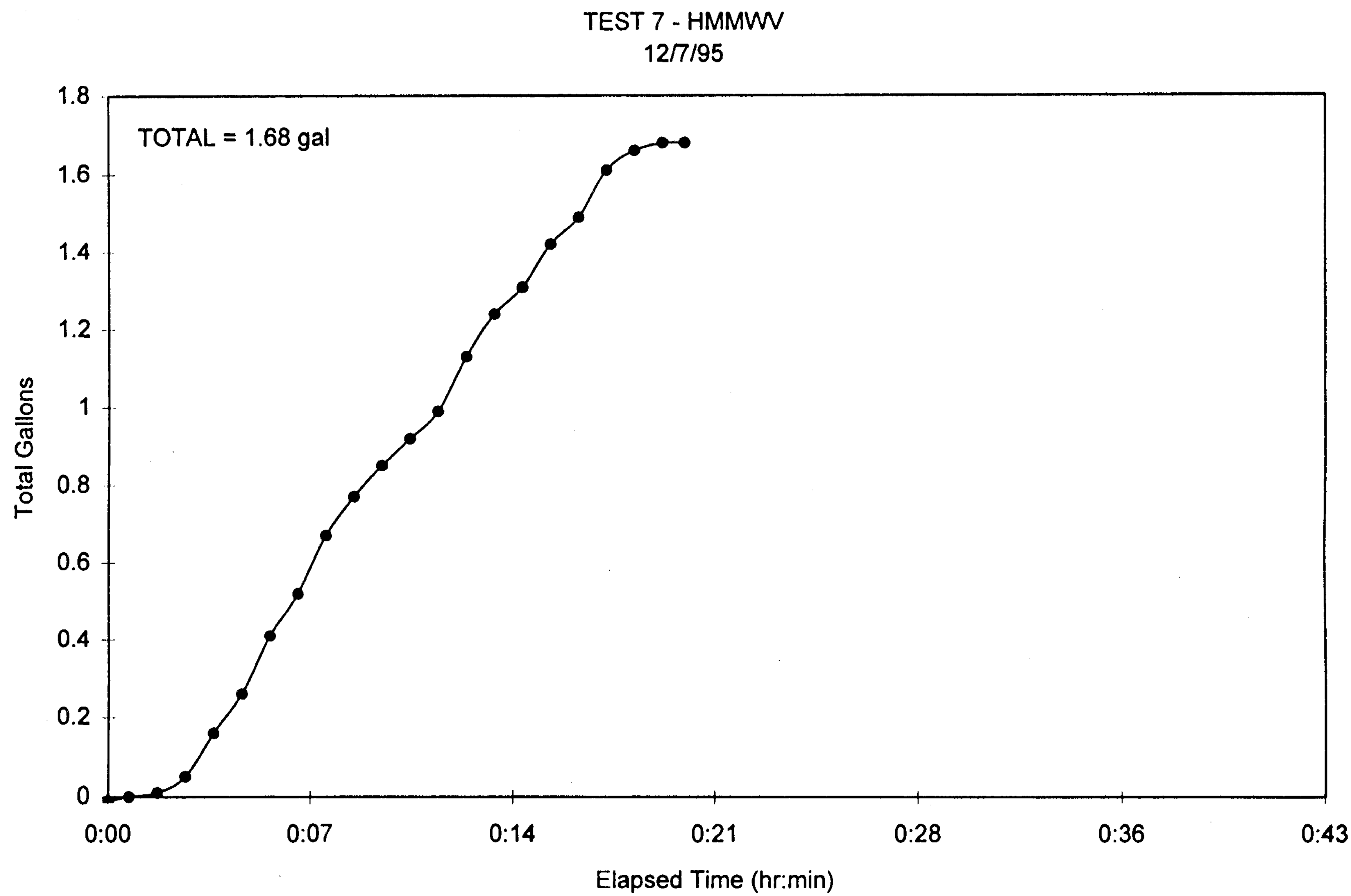

FIGURE 4-9. CUMULATIVE PAINT CONSUMPTION, TEST 7.

TABLE 4-2. PAINT CONSUMPTION DATA "WITHOUT FEEDBACK"

DATE	*TEST NUMBER*	*VEHICLE TYPE*	*TOTAL (gal)*
12/5	1	5-ton Truck	5.49*
12/5	2	818 - Cab	5.74
12/6	3	Power Unit	6.45
12/6	4	HMMWV	2.08
12/6	5	HMMWV	1.66
12/7	6	HMMWV	2.7
12/7	7	HMMWV	1.68
12/7	8	HMMWV	2.04
12/7	9	5-ton Truck	7.16
12/11	10	HMMWV	1.82
12/12	11	HMMWV	1.92†
12/13	12	5-ton Truck	5.84
12/13	13	5-ton Truck	4.1*

*Undercarriage not done.
†Tare not recorded (estimated).

4.3.2 Demonstration Data With Feedback

The second part of the demonstration period began on December 14, the first full day of activities after the remote displays had been installed in the booth. These displays were mounted on the walls parallel to the long axis of the paint booth at a height of about seven feet. This mounting allowed adequate visibility for the painters to refer to them frequently. The research technician, Mr. K. David Carter, Jr, who was on-site at the time, instructed the painters to try and minimize paint usage without sacrificing the quality of the paint job. He also alerted the inspector to the change in process and asked to be notified of any increases in problems with the paint quality. No increase in problems was reported. Target values for total paint usage were chosen for two vehicle types for which multiple data sets had been acquired, the HMMWVs and the 5-ton Trucks.

With prior information on paint requirements by vehicle type, low, but achievable, target levels were set for how much paint should be used to paint a given vehicle. The exact value of the initial target levels was not critical; their purpose was to raise awareness of paint usage and to give the painters a goal. They were, however, intended to be relatively low values that would require minimal waste to achieve. The target amount for the HMMWVs was set at 1.7 gallons, and the target for the trucks was 6.2 gallons. (These target values may be adjusted when more consumption data have been collected.) During the demonstration, there was no penalty for painters exceeding the target level. It was hoped that self-motivation, knowledge that the supervisor would also see the results, and an atmosphere of friendly competition among the painters would motivate them to do their best to meet the target levels.

The need to add paint to the reservoir bucket during a painting session for a single vehicle had not been anticipated when the weight display program was developed. Adding paint during a job causes the displayed "total" to be offset by the amount of paint added and, upon re-taring, to return to zero. To account for this during the demonstration, after a refilling and taring step, the project's attending technician quickly computed a new target level (by subtracting the displayed "total"value before adding paint and re-taring from the "target") and told the painters verbally what the new target level was.

Because of the difficulty of tracking the target value under the current setup, it is recommended that a software change be made within the WI-130 controller to allow for a "refill" operation without loss of the currently displayed "total", or to change the painting procedure to allow filling the paint pot with enough paint to complete the entire job. The recommended programming change can be performed by the vendor.

Paint consumption data during this phase were recorded only when the painter pressed the "print" button, as instructed in the procedure sheet shown in Appendix 4-2. As a result, one-minute data were not printed out after the displays were installed. Consequently, no graphs of paint consumption are provided for paint consumption "with feedback." Summarized paint consumption data for the feedback period are provided in Table 4-3.

TABLE 4-3. PAINT CONSUMPTION DATA "WITH FEEDBACK"

DATE	*TEST NUMBER*	*VEHICLE TYPE*	*TOTAL (gal)*
12/14/95	14	5-ton Truck	5.76
12/14/95	15	5-ton Truck	6.56
12/15/95	16	5-ton Truck	7.53
12/15/95	17	HMMWV	2.04
12/15/95	18	HMMWV	2.04
12/15/95	19	HMMWV	2.08

4.3.3 Data Evaluation and Discussion

Table 4-4 summarizes the measurement results. The raw data from which Table 4-4 was derived are presented in Appendix 4-3. Paint use for a total of ten HMMWVs (seven without feedback, three with feedback) and five 5-ton trucks (two without feedback, three with feedback) was obtained. Overall, paint use with and without feedback (i.e., use of the displays to show paint use) were not significantly different between the two data sets. Reduced variability was seen for the HMMWVs with feedback, however with such a small number of trials (n=3), this could be an artifact.

The data show that paint use ranged widely, even for similar vehicles. For the HMMWVs, paint use ranged from 1.66 to 2.70 gallons; for the 5-ton trucks the range was from 5.76 to 7.53 gallons. The presence or absence of user feedback did not significantly reduce the amount of paint used during the testing period. The minimum value observed for the HMMWVs was 17% below the HMMWV mean. The minimum value observed for 5-ton trucks was 27% below the corresponding mean.

The large ranges in the amount of paint required to coat similar vehicles are difficult to explain. Potential causes include the skill and experience of the painters, and the preparation and detail work required by each vehicle. Significant variability was seen even for identical vehicles painted by the same team of painters. Thus, the skill and experience of the painters is not the whole explanation for the variability.

Target values shown in Table 4-4 were chosen based on the consumption values achieved during the tests without feedback. For the HMMWVs, the target value was chosen to equal the lowest value observed in seven trials without feedback. This was rounded to the nearest 0.1 gal. for a target of 1.7 gal. For the 5-ton trucks, only two preliminary observations were available on which to base the target value. After some discussion, a target value of 6.2 gallons was chosen, which is slightly below the average for the two trials without feedback. Selecting the target value for the 5-ton trucks was complicated by the following factors: the small number of previous measurements (2); the relative complexity of this type of vehicle; and a concern that the smaller of the two previous measurements might have been an anomaly. One subsequent trial with feedback (5.76 gal.) was lower than both the target (6.2 gal.) and the minimum value observed without feedback (5.84 gal.). This indicates that the target for the 5-ton trucks could have been set lower.

There was some concern that reduced paint usage might result in thin, inadequate coatings. However, all vehicles are inspected after painting as a normal part of the MCLB's procedures, and no problems of this nature were found during the demonstration period.

Longer term use of the paint monitoring system (several months versus the 2 weeks of this demonstration), with continued encouragement to the painters to strive for lower paint use values, may show that a reduction in the mean paint use and/or reduction in variability can be achieved. It is recommended, therefore, that the MCLB continue to operate the paint monitoring system to determine if long term reductions can be achieved.

TABLE 4-4. STATISTICAL DATA SUMMARY

Vehicle Type	N[a]	Average (gal.)	Std. Deviation (gal.)	Rel. Std. Deviation[b] (percent)	Min. (gal.)	Max. (gal.)	Target (gal.)
Without Feedback							
HMMWV	7	1.99	0.35	17.84%	1.66	2.7	--
5-ton Truck	2[c]	6.5	0.93	14.36%	5.84	7.16	--
With Feedback							
HMMWV	3	2.05	0.02	1.12%	2.04	2.08	1.7
5-ton Truck	3	6.62	0.89	13.40%	5.76	7.53	6.2

Notes:
a - Number of vehicles painted for each condition.
b - Relative standard deviation is the standard deviation divided by the average, expressed as a percent.
c - Two additional 5-ton trucks were painted but are not included in the statistics because they were "partial" jobs -- i.e., the undercarriage had already been painted. Only 5-ton trucks receiving a complete paint job are included in the statistics.

4.4.0 QUALITY ASSURANCE

The primary Quality Assurance (QA) goal for the on-site portion of this project was to estimate and control errors in paint consumption measurements. These measurements were done with the Weigh-Tronix Flow Monitoring System that was installed at one paint booth. The chief sources of error, uncertainty, and variability include the following:

- errors in the balance - zero offset, nonlinearity, and instrument noise
- ambient vibration and noise

The balance was set up at the site according to the manufacturer's specifications. This included assuring that the feet had solid support (concrete floor) and that the balance transducer was level. The accuracy and linearity of the electronic balance were assessed using a 25-pound weight supplied by the manufacturer. The weight had been independently checked in a laboratory before the on-site portion of this task. Calibration check data are shown in Table 4-5.

TABLE 4-5. ON SITE CALIBRATION CHECK DATA FOR PAINT SCALE.

Location:	MCLB Paint Booth
Operator:	David Carter (RTI)
Date:	December 15, 1995
Empty Pan (after TARE)	0.00 lbs.
With 25 lb. Weight	24.99 lbs.
With paint can	23.86 lbs.
Paint can + 25 lb. Weight	48.86 lbs.

These data show that the balance, as installed, was accurate within the resolution of the scale and that linearity was also acceptable.

Internal Quality Assurance (QA) was provided by Dr. James Flanagan of RTI's Center for Environmental Measurements and Quality Assurance. Dr. Flanagan helped prepare the QA Project Plan and visited the MCLB site twice to review the project.

As was discussed in Section 4.3.1, random noise experienced by the balance was recorded while the system was not being used and the area was quiet. These data are shown in

Figure 4-10, plotted on a greatly expanded scale. Approximately one hour's worth of data was acquired at one minute intervals. This provides an estimate of the data scatter that can be attributed to the combined sources of noise affecting the balance. These include electrical and instrumental noise, vibrations from the stirring motor, and the effects of wind and ambient vibrations. The background noise level was found to be approximately 0.02 gallons. This amount of noise is very small compared with the variability between the amount of paint used to paint identical vehicles. The slope of 0.43 gal/day indicates that some weight loss may be occurring due to solvent evaporation. This rate of weight loss is insignificant in the period of time over which most vehicles are painted. For example, during a relatively long 3-hour job, the weight loss would be only about 0.05 gallons.

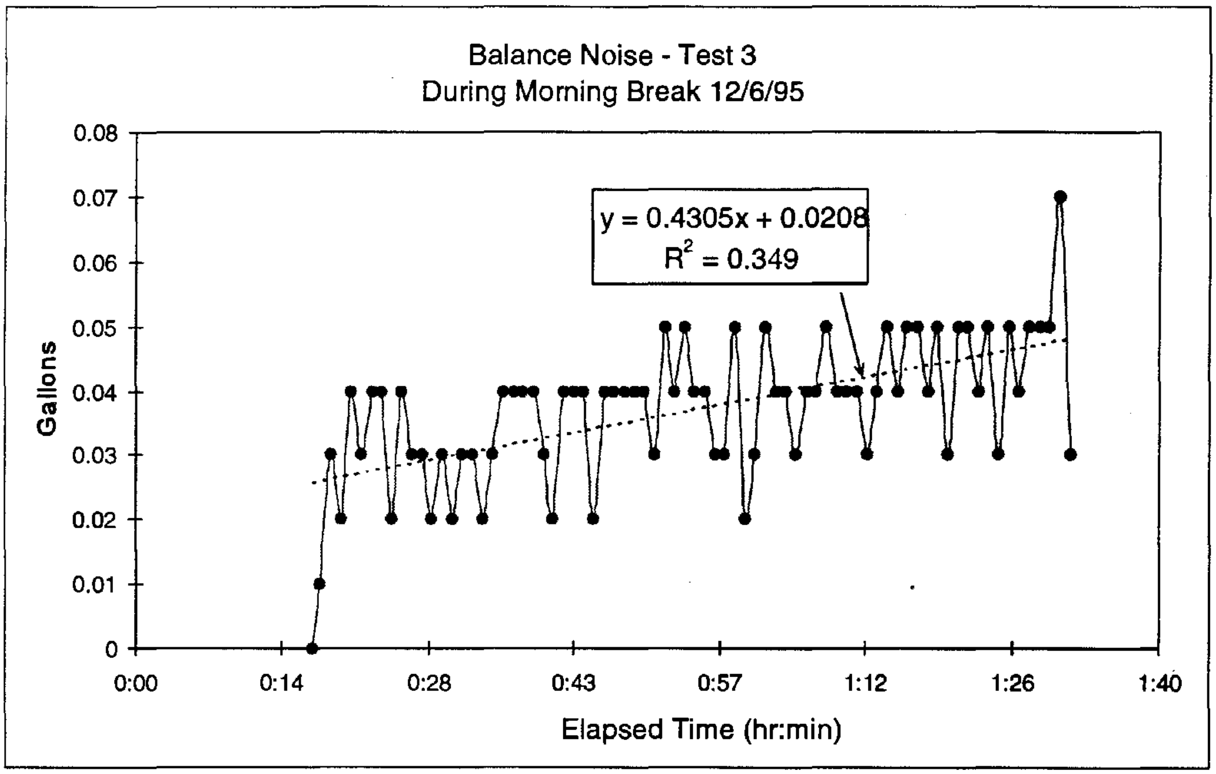

FIGURE 4-10. RANDOM NOISE IN PAINT CONSUMPTION DATA.

4.5.0 IMPLEMENTATION PLAN

4.5.1 Equipment

Table 4-6 lists the equipment comprising the paint monitoring system. The system consists of two scales (one for inside the booth and one for outside the booth to match the MCLB's painting practices), a control unit with keyboard, two remote displays mounted in opposite side walls of the paint booth, a local tape printer, a remote tape printer for installation in the supervisors office, a print and tare push-button station outside the booth, and a print and tare push-button station inside the booth. Note that all of the equipment that is within the booth must be rated for the hazardous environment use and be installed by qualified electricians.

The entire paint monitoring system was purchased through a single commercial vendor (J. A. King & Company, Inc., Garner, NC). Using one vendor to help design and provide the system had the important advantage that the vendor was responsible for ensuring that all components worked together as intended. Prior to delivery, the vendor set up and tested the system at his facility. The system was also set up and tested prior to delivery to the MCLB.

4.5.2 Installation of the Monitoring System at the MCLB

Installation of the system involved the following activities:

1. Cutting and installing two windows in the paint booth; one on each side wall. The opening needed to be at least 29"W x 8"H to allow full viewing of the remote displays. The height of the displays is approximately 6-8 ft above the floor so as to be readily visible to the painters and to avoid excessive overspray accumulation on the window.
2. Providing explosion-proof hook ups for the remote print and tare switch located in the paint booth. (These are low voltage signal lines.)
3. Locating a small table near the paint booth door for the WI-130 controller, keyboard and tape printer.
4. Running interconnecting low voltage cables from the WI-130 to the printers and displays.
5. Installing the scale immediately outside the paint booth door.

6. Running extensions cords to operate the scale, printers, and displays. The system operates on 110V at roughly 1000W.

TABLE 4-6. EQUIPMENT FOR THE PAINT MONITORING SYSTEM

ITEM	*MODEL NO.*	*QTY.*
Base scale	Weigh-Tronix BSAO2020-200	2
Programmable controller	Weigh-Tronix Model WI-130 with: Extended memory 2-base interface Opto-22 Modules (2) Special Software Interface cable Multi-port controller	1
Explosion proof barrier box	NA	1
Cable between barrier box and base	NA	25 ft
Tape printer	Weigh-Tronix Model WP-233	2
Remote displays	Model M1000	2
Remote tare and print push-button station	NA	1
Explosion proof tare and print station	NA	1
Keyboard	Weigh-Tronix keyboard for WI-130	1
Interface cable to remote printer	NA	150 ft
Interface cable to remote display	NA	25 ft
Interface cable to remote display	NA	100 ft
25 lb. calibration weight	NA	2

4.5.3 Safety

Because paint booths contain potentially explosive vapors (paint solvents), all of the electronic equipment within the booth must be rated for hazardous environment use and be installed by qualified electricians. All electrical wiring for the demonstration was installed by qualified MCLB electricians.

4.5.4 Economic Analysis

One aspect of changing process operations for pollution prevention purposes is the effect on capital and annual costs. Pollution prevention changes are more likely to be embraced if these costs stay the same or decrease. The following sections provide measures of capital and annual costs for installing weighing systems to allow painters to monitor their paint usage.

The methodology for estimating costs is taken from the EPA methods described in the OAQPS Control Cost Manual[2], which allows a convenient means of comparing different processes based on their annualized costs. Where actual costs are not known, factors applied to base equipment costs are used to estimate the remaining costs. These factors have been developed from a wide variety of sources associated with pollution control systems.

The method for estimating costs used here provides a "study" estimate, which is intended to give a cost estimate within an accuracy range of ±30% of the actual cost when all the information affecting the costs is reasonably well known. This accuracy range is typical for EPA's estimates of pollution control systems when assessing cost impacts on existing or model facilities. Greater accuracy can be obtained with "budget authorization" estimates (±20%), "definitive" estimates (± 10%), or "contractors'" estimates (± 5%). Improved accuracy of the estimate is obtained only by improving the detailed knowledge of items that make up the estimate (and by spending more time and money in preparing it). In the present case, the firm costs obtained for most of the capital items could lead to a contractors' estimate if no assumptions were required for the remaining costs. For the present work there are relatively few elements that must be considered for paint application costing; however, several of these cost elements are not known with sufficient accuracy to go beyond a "study" estimate.

4.5.4.1 OAQPS Control Cost Manual

Analysis of the costs associated with this pollution prevention project is performed such that comparisons can readily be made between competing processes. A consistent format for costing is used so that comparisons are valid. To be compatible with EPA usage, the format in this report is taken from the OAQPS Control Cost Manual cited above. This methodology divides costs into two major categories, capital costs and annual costs. For the cost analysis to be meaningful, it must include all elements associated with implementation of new technologies. An exception is the case in which no new capital costs are incurred. Capital and annual costs can be further subdivided into the categories shown below:

- Site preparation and buildings
- Equipment
- Emission controls
- Materials
- Energy and utility requirements
- Labor requirements, including training
- Waste disposal
- Special transportation costs (hazardous materials)
- Recovery credits
- Overheads and capital recovery
- Accommodation costs (for changes in use or behavior forced by the new technology).

Treatment of each of the cost elements is briefly described below. As used in the OAQPS Control Cost Manual, the first three items are capital costs, while the remainder are annual costs. After all the cost elements are collected, they are presented as tables of capital and annual costs.

Capital Costs

Capital cost items are those requiring relatively large expenditures for land, buildings, and equipment expected to have a lifetime longer than a year (usually many years). Specific items are collected in the following paragraphs. For those cases in which explicit costs are not available, the factor method is used to estimate reasonable costs. Factors (as multipliers of the purchased equipment cost) are available in costing manuals or can be based on engineering judgement.

Site Preparation and Buildings: No site preparation (land clearing and leveling) or new buildings were required for this pollution prevention project.

Equipment and Emission Controls: Equipment costs include either new purchases (including add-ons) or modifications for existing items. Costs include installation. These costs are taken from invoices, vendor quotes, or other records where available, or are estimated from cost manual data.

Indirect Costs: Associated with purchase and installation of equipment are the indirect costs that include engineering, construction and field expense, contractor fees, start-up, performance tests, and contingencies. Not all of these items are required.

Annual Costs

Annual costs include expenditures for operating and maintenance, labor and materials, utilities, and waste disposal. Indirect costs include overheads, administrative charges, property taxes (where applicable), insurance, and capital recovery. With the exception of overheads, the indirect annual costs are related to capital costs. The annual cost elements are described in the following paragraphs. The sum of the annual costs provides a total annual cost that is useful for comparison with other systems or technologies.

Materials: Materials include raw materials for operation, and maintenance materials for repairs and preventive maintenance. Costs and usage rates for materials are obtained from MCLB records, vendors, or estimates from MCLB or RTI project personnel.

Energy and Utility Requirements: Energy and utility usage rates are taken from MCLB records, project data, or estimates for the equipment or process being analyzed. Considered for this project are electric power, steam, water, and compressed air.

Labor Requirements: As with materials, labor is divided into operating and maintenance categories. Operator labor hours are estimated from project records or from observation by project personnel. Maintenance labor hours are projected based on estimates of project personnel. Labor hours are also required for supervision and for training.

Waste Transportation and Disposal: Waste disposal costs include wastewater treatment, solid waste disposal, and hazardous waste treatment or disposal. Transportation costs are included in the waste disposal costs. Quantities are taken from MCLB records or are projected from project data.

Recovery Credits: Recycling of spent solvents may provide money to offset costs of operation.

Overheads and Capital Recovery: General and administrative overheads, property tax, and insurance are taken from information provided by the MCLB or from estimates by project personnel. Capital recovery charges are estimated from current EPA usage for interest rates; equipment lifetimes are based on engineering judgement.

Accommodation Costs: Identifiable costs are included here that are associated with a changeover to new technology.

4.5.4.2 Obtaining Cost Elements

Capital Costs

Because the factor method is dependent on base equipment costs for its capital cost accuracy, special care must be taken to record all of the individual items purchased. For the present work, each required item is purchased through RTI's purchasing department. All RTI purchases are posted on a computer operated accounting system that allows identification of each item associated with the project.

Annual Costs

Annual cost items are largely dependent on the labor, utility, and materials costs associated with operating a process and on recovery of capital. As with capital costs, accuracy of the annualized cost estimate depends on the accuracy of the information collected for these cost elements and also for the usage rates associated with the operating costs. Capital costs remain important in estimating annualized costs because most of the costs and the capital recovery cost depend on purchased equipment costs. For the present project, unavailability of some unit costs and usage rates may affect the accuracy (and the conclusions) of the cost analysis.

4.5.4.3 Unit Costs, Rates, and Assumptions

The following cost analysis is based on an assumed reduction of 20% in paint spray usage due to implementation of the paint monitoring system. While the data collected during the short demonstration period showed no significant change between *average* paint use with and without the monitoring system, the measurements do show that paint usage has considerable variability, even among identical vehicles. Thus, the 20% reduction value appears to be a reasonable goal for long term reductions, since it is well within the range of normal variability. It is recommended that the MCLB continue to use the monitoring system to collect long-term data to determine if actual reductions are realized. For example, a 20% reduction in paint for a HMMWV would amount to about 0.4 gal. This would be a reduction from the current average of around 2.0 gal. to 1.6 gal., which was nearly met in several tests. An overall 20% reduction would only require that this level be achieved consistently, rather than as a consequence of random variation. A further justification for a projected reduction of at least 20% is the MCLB's planned introduction of a paint dispensing system. This system would allow only the needed amount of paint to be mixed. This would minimize the air emissions attributable to unused paint, as well as the procurement and disposal costs for the unused paint. As discussed elsewhere in this report, data generated by the weighing system will be valuable in setting the amount of paint to be dispensed by the new system, as well as for documenting the reduction in paint consumption.

Unit Costs and Rates Used Throughout Economic Analysis

The following unit costs and rates were used throughout the economic analysis.

- Operating labor costs were $16.52/hr, taken from the OAQPS Control Cost Manual, pp. 7-43, April 1991.
- Maintenance labor costs were $18.17/hr, taken from the OAQPS Control Cost Manual, pp. 7-43, April 1991.
- Supervisory labor costs were 115% of operating labor costs, taken from the OAQPS Control Cost Manual, pp. 7-43, April 1991.
- Training costs were $33.04/hr based on twice the operating labor rate.
- Waste disposal costs for low-end wastes included $0.35/lb for transportation and $.80/lb for disposal, based on interpolation from the MCLB estimate.
- Waste disposal costs for high-end wastes included 0.35/lb for transportation and $1.80/lb for disposal, based on interpolation from the MCLB estimate.
- Electricity costs were $0.0709/kWh, cited in *Chemical Engineering*, January 1995.
- Compressed air costs were $0.19/1,000 scfm from example problem in OAQPS Control Cost Manual, pp. 5-49 (April 1991). Updated with *Chemical Engineering* (CE) cost index.
- Wastewater disposal or treatment costs were $4.75/1,000 gal updated from OAQPS Control Cost Manual, pp. 9-51, July 1992.
- Paint cost was an average of $4.76/lb based on the MCLB estimate.
- State air emission fee of $25/ton was required for hazardous air emissions, based on MCLB information.

Assumptions Used for Paint Application without Scales

The following assumptions were used for paint application without scales.

- No new capital equipment was required for painting without scales.
- Actual painting times was estimated at 3 hrs/day for each painter, 2 painters/booth, 4 booths in operation.
- Paint usage was estimated at an average of 3.1 5-gal kits/day for each of 4 booths, 5 shifts/week, 52 weeks/yr. Paint specific gravity is 1.26.
- Power usage was estimated at 1 kW for miscellaneous electrical loads.
- Air consumption was based on 2 guns x 22 scfm/gun x 26.4 minutes usage/hr.
- Waste disposal was based on a total of 11 gal/day waste paint plus replacement of ventilation system filters at the rate of 4/wk, 52 wks/yr, 3 lb/filter. Low-end disposal charge applies.

Assumptions Used for Paint Application with Scales

The following assumptions were used for paint application with scales.

- Capital costs were included for the paint weighing system and associated instrumentation. All direct installation costs were lumped under handling, erection, and electrical. Construction and field expense were included under installation costs. Engineering costs were estimated for 40 hours at $25/hr x 1.6 for overhead.
- Actual painting time was the same as for application without scales, but 0.4 hrs/day was added for tending to the weighing system. The effect of the scales on actual time spent spraying is unknown. Although less paint would be sprayed, any time savings might be offset by observing the readout unit and by increased attention to detail that would be required. Therefore, no reduction was assumed in actual time spent spraying paint.
- For paint consumption it was assumed that 20 % less paint is sprayed compared to the previous method and that 10 % fewer kits are used. Charges for printer paper and pens were included with paint consumption costs.

- Maintenance costs were included for the paint weighing system.
- Power usage was estimated at 1 kW for miscellaneous electrical loads plus 1 kW for instrumentation.
- Air consumption was based on 2 guns, 22 scfm, and 22 min/hr usage (vs 26.4 min/hr for the previous method).
- Waste disposal was based on 12 gal/day waste paint plus replacement of ventilation system filters at the rate of 2/wk, 52 wks/yr, 3 lb/filter. Less paint was assumed to be sprayed, but more paint went to waste because the paint is mixed in discrete batches of 5 gallons. At the same time, the overspray load on the ventilation system was reduced. Low-end disposal charge applies.

4.5.4.4 Paint Application Monitoring

Results of Costing for Paint Application Monitoring

Tables 4-7 and 4-8 show capital and annual costs for purchasing, installing, and using the weighing equipment and instrumentations intended to reduce paint usage. Capital costs are primarily for the scales and displays used to show the painters their rate of application. Direct and indirect installation costs are largely for handling and erection and for engineering. Estimated total capital investment is $22,161.

Estimated annualized costs are about $1.03 million, three fourths of which is for the paint. Labor and waste disposal are about 14 % of the costs.

Discussion of Paint Application Results

The pollution prevention aspects of this task are aimed at equipment to reduce paint usage (and improve coating quality). The purchased equipment and its annualization are a minor portion of the total costs used in the analysis. However, with savings expected in both paint usage and painting labor, these large costs are also included in the analysis. Greater accuracy would be obtained with more operating time and examination of data.

TABLE 4-7. CAPITAL COSTS FOR PAINT APPLICATION WITH FLOW MONITORING

DIRECT COSTS		
Purchased Equipment Costs		
System with controls		$17,150
Instrumentation (if not included in controls)		$858
Sales Taxes		$0
Freight		$200
Purchased Equipment Cost, PEC		*$18,208*
Direct Installation Costs		
Foundations and supports		$0
Handling and erection		$1,057
Electrical		$750
Piping		$0
Insulation for ductwork		$0
Painting		$0
Direct Installation Costs		*$1,807*
Site Preparation	*as required,*	
Buildings	*as required,*	
Total Direct Cost		*$20,015*
INDIRECT COSTS (INSTALLATION)		
Engineering		$1,600
Construction and Field Expense		$0
Contractor Fees		$0
Start-up		$0
Performance Test		$0
Contingencies		$546
Total Indirect Costs, IC		*$2,146*
TOTAL CAPITAL INVESTMENT, TCI		**$22,161**

TABLE 4-8. ANNUALIZED COST ANALYSIS FOR PAINT APPLICATION WITH FLOW MONITORING

DIRECT ANNUAL COSTS, DC		
Operating Labor		
Operator *([24.4 hours/day]*[260 days/year]*[$16.52/hour])*		$104,803
Supervisor *(15% of operator)*		$15,720
Training *([8 hours/year/employee]*[$33.04/hour]*[32 employees])*		$8,458
Operating Materials		
Paint *([$4.76/pound]*[163,734 pounds/year])*		$779,374
Maintenance		
Labor *([0.4 hours/day]*[260 days/year]*[$18.17 hour])*		$1,890
Material *(Equal to $150/year)*		$150
Utilities		
Electricity *([2.0 kW]*[$0.071/kWhour]*[2080 hours/year])*		$295
Compressed air *([3870 scfm/hour]*[$0.19/1000 scfm]*[2080 hours/year])*		$1529
Waste Disposal *([16.53 tons/year]*[$2,300/ton])*		$38,019
	Total Direct Cost, DC	*$950,238*
INDIRECT ANNUAL COSTS, IC		
Overhead (60% of sum of labor + maintenance materials)		$78,613
Administrative charges	*TCI * 0.02*	$443
Property taxes	*TCI * 0.01*	$222
Insurance	*TCI * 0.01*	$222
Capital recovery	*CRF*TCI (CRF=0.2439)*	$5,405
	Total Indirect Costs, IC	*$84,905*
	TOTAL ANNUAL COST, TAC (TAC = DC + IC)	**$1,035,143**

Comparison with Current Application Method

Table 4-9 shows the estimated annualized costs for the current paint application method, i.e., without an objective system for measuring and indicating paint usage during application. Because the current system requires no change, no capital costs are charged. The annualized costs are $1.097 million or about 6% more than for the new system. Table 4-10 compares the costs for the two application methods. As with the new system, the major costs are in paint usage and labor.

TABLE 4-9. ANNUALIZED COST ANALYSIS FOR PAINT APPLICATION WITHOUT FLOW MONITORING

DIRECT ANNUAL COSTS, DC	
Operating Labor	
Operator *([24 hours/day]*[260 days/year]*[$16.52/hour])*	$103,085
Supervisor *(15% of operator)*	$15,463
Training *([8 hours/year/employee]*[$33.04/hour]*[32 employees])*	$8,458
Operating Materials	
Paints *([$4.76/pound]*[180,108 pounds/year])*	$857,314
Maintenance	
Labor *([0 hours/day]*[260 days/year]*[$18.17/hour])*	$0
Material *(Equal to Maintenance Labor)*	$0
Utilities	
Electricity *([1.0 kW]*[$0.071/kWhour]*[2080 hours/year])*	$148
Compressed air *([4260 scfm/hour]*[$0.19/1000 scfm]*[2080 hours/year])*	$1,684
Waste Disposal *([15.16 tons/year]*[$2,300/ton])*	$34,868
Total Direct Cost, DC	*$1,021,020*
INDIRECT ANNUAL COSTS, IC	
Overhead (60% of sum of labor + maintenance materials)	$76,204
Administrative charges *TCI * 0.02*	$0
Property taxes *TCI * 0.01*	$0
Insurance *TCI * 0.01*	$0
Capital recovery *CRF*TCI (CRF=0.2439)*	$0
Total Indirect Costs, IC	$76,204
TOTAL ANNUAL COST, TAC (TAC = DC + IC)	**$1,097,224**

TABLE 4-10. SUMMARY COMPARISON OF PAINTING WITH AND WITHOUT FLOW MONITORING

PAINTING METHOD	*CAPITAL COSTS*	*ANNUALIZED COSTS*
Without Flow Monitoring	$0	$1,097,224
With Flow Monitoring	$22,161	$1,035,143

The major long-term saving with the new system is due to the reduction in paint required. The assumed reduction in paint sprayed is about 20%. Because mixed paint is prepared in discrete quantities (5-gal kits) rather than being used as needed, the 20% reduction in sprayed paint is assumed to result in a 10% reduction in the number of kits required. Waste disposal increases a small amount because of the shift to less paint sprayed and resultant increased wastage from some of the 5-gallon kits. Labor hours are also reduced because of the more efficient usage of paint; fewer passes are required to coat a given surface. A further benefit of the scales might be better and more uniform coverage, resulting in less rework due to overly thick coatings. However, this benefit remains to be verified. A reduction in labor hours is used for this analysis, but in practice, the savings would more likely result in higher productivity.

4.5.4.5 Return on Investment and Payback Period for Paint Application

Return on investment (ROI) and payback period (PP) are two common measures for estimating the profitability of a venture. Return on investment as used for this project is the average yearly profit divided by total capital investment, expressed as a percentage. The average yearly profit is taken as the difference in annualized cost between the existing process and its intended pollution prevention replacement.

Payback period is the total capital investment divided by the sum of profit (as used above) and depreciation of the pollution prevention equipment. For this project, the straight line depreciation method is used with a 5% salvage value. Depreciation is total capital investment minus salvage value, all divided by equipment life. For paint application with a weighing system, ROI is found from:

$$ROI = \frac{TAC_{no\ scales} - TAC_{scales}}{TCI_{scales}} * 100$$

$$= \frac{61{,}081}{22{,}161} * 100$$

$$= 280\%$$

and PP is found from:

$$PP = \frac{TCI_{scales}}{\left(TAC_{no\ scales} - TAC_{scales} + \dfrac{TCI_{scales} - 0.05 * TCI_{scales}}{20}\right)}$$

$$= \frac{22,161}{\left(61,181 + \dfrac{22,161 - 1,108}{20}\right)}$$

$$= 0.4\ years$$

These values, which require verification from further measurements of paint usage with the weighing system, are highly encouraging. There is apparently a large economic incentive to convert to the pollution prevention method of paint application.

4.6.0 CONCLUSIONS

The program has successfully demonstrated that very accurate and precise measurements of paint usage by vehicle can be made using this system. As a result, the MCLB now has reliable information about the amount of paint needed for two common vehicle types and the means for developing additional data about other vehicle types.

There was no demonstrated decrease in mean paint usage immediately after the displays were installed. However, results of the paint use measurements must be viewed in light of the limited time available for the demonstration. The demonstration period included six days of data acquisition without feedback and two days with feedback. Within this period, only five of the approximate twenty-five MCLB painters were included in the measurements. Thus, the data base both in terms of the number of vehicles painted and the number of painters monitored is very limited. Within these limitations, the specific conclusions drawn from this study are:

1) The gravimetrically-based paint monitoring system proved to be a reliable and accurate means of monitoring paint use.
2) The amount of paint (two-component green CARC) sprayed to cover ten HMMWVs, five 5-ton trucks, and several other vehicles was recorded. HMMWVs required from 1.66 to 2.70 gallons. The 5-ton trucks required from 5.76 to 7.53 gallons.
3) During the demonstration period, no reduction in mean paint usage was observed after use of display units to provide feedback to the painters.
4) Relative to the mean values for the combined (with and without feedback) data sets, the minimum observed values were 17% below the mean for the HMMWVs and 27% below the mean for the 5-ton trucks. These figures indicate that a reduction in emissions of approximately 20% should be achievable if average paint usage could routinely be kept near the observed minimums. Also, the MCLB's planned use of a paint dispensing system to allow dispensing only the amount of paint needed, as opposed to the current practice of dispensing in discrete 5-gallon kits, is expected to further reduce air emissions through reduced paint usage.
5) Based on an economic analysis, a cost savings of approximately $62,081 per year would be realized if a 20% reduction in paint usage could be achieved. Given the estimated $22,161 capital cost to purchase and install the system, this yields a relatively short payback period of approximately 0.4 years.

4.7.0 RECOMMENDATIONS

Although a reduction in mean paint usage was not measured, significant variations were measured in the amount of paint sprayed to coat identical vehicles. This indicates the potential for significant reductions in paint use with continued use of the paint monitoring system. Therefore, the following recommendations are presented:

1) Continued use of the paint monitoring system and continued collection of the paint use data by vehicle type is the first recommendation. After a period of several months, an evaluation of these data would determine if measurable reductions in mean paint usage were realized. During this several month period, it is recommended that relatively low

target values be used and that the painters be encouraged to try to stay at or below the target levels.

2) A modification of the paint monitoring system and/or painting practices would allow the system to display the accumulated total per job regardless of refilling of the paint bucket. (The need to add paint during a single job was not anticipated when the display unit was programmed.) This could be accomplished by a software change within the WI-130 controller (performed by the vendor) to allow for a "refill" operation without loss of the currently displayed "total," or through the use of a larger paint pot that could hold the entire amount needed to paint the vehicle.

3) Continued investigation of complementary technologies for pollution reduction including a paint dispensing system that is capable of mixing quantities of paint in less than 5 gallon increments is recommended. The combination of the two technologies (weighing and dispensing) should provide better reduction than either technology alone.

During the demonstration, it appeared that in addition to reducing the amount of paint sprayed through operator awareness of application rate and target value, there are other ways in which the paint monitoring system could be used to reduce emissions. Some of these are as follows:

F Training - With the weighing system, new painters can learn to apply uniform coatings without using too much or too little paint by comparing their usage with the historical data for the vehicle type.

F Equipment Maintenance and Setup - The ability to measure paint consumption can be used to assess whether equipment maintenance and setup have any effect on paint consumption. To do this, the MCLB personnel would have to record information such as the condition of the nozzle, air pressure, etc., and make correlations with the amount of paint used. Optimizing the equipment configuration may provide an opportunity for significant emission reductions.

F Verification of other pollution reduction strategies including the paint dispensing system. The weighing system demonstrated on this project can provide data that can be used for determining the amount of paint to be mixed for each vehicle type. Used in conjunction with such a technology, the weighing system can provide documentation of pollution reduction.

The MCLB may wish to consider these areas for further investigation and implementation.

4.8.0 REFERENCES

1. OAQPS Control Cost Manual, EPA-450/3-90-006 (NTIS PB90-169954), January 1990.

APPENDIX 4-1

EVALUATION OF ULV PAINT DELIVERY SYSTEM

An initial project objective to evaluate an innovative paint pumping device (the ULV system) proved inappropriate for the MCLB's CARC coatings during preliminary trials by the manufacturer and was not evaluated further. A summary of these findings are presented in this appendix.

Introduction

The ultra low volume (ULV) system, manufactured by Air Compliance Technology, Greensboro, GA, is a paint delivery system designed to improve the performance of **airless** spray guns. It is different from conventional high-pressure paint systems in that rather than using a piston pump to pump the paint to high pressure, it uses a nitrogen-pressurized floating piston to pressurize paint in a high-pressure-capacity container.

Improved performance is obtained primarily because the ULV system allows airless spraying at a lower paint pressure than airless (500-800 psi for ULV versus 1500 - 2000 psi for conventional airless). For all types of spray painting, a significant amount of room air is entrained into the paint plume due to the aerodynamic drag of the particles. Due to the high fluid pressures associated with conventional airless spraying (1500 to 2000 psi), the spray particles have a relatively velocity that results in a very turbulent, violent entrainment of air that reduces transfer efficiency. By reducing the pressure to the 500 - 800 psi range, the velocity of the particles is reduced and the entrained air is not nearly as turbulent or violent and thus, transfer efficiency is increased.

Also, according to the ULV manufacturer, at the higher pressures of conventional airless systems, the speed of the paint spray droplets through the air promotes evaporation of the solvent carriers creating an undesirable dry film. The ULV system, by using lower paint pressures, reduces this effect.

A secondary benefit of the ULV system is a smoother delivery of paint (i.e., no pulsations in flow) which can result in a more uniform coating thickness.

Utility of ULV for Spraying MCLB's Coatings

Preliminary trials by the ULV manufacturer (Table 4-1-1) showed that, without thinning, a ULV airless system could not spray the MCLB's CARC or primer coatings acceptably.

Discussion

The MCLB uses air-assisted airless for the majority of painting, and some conventional guns for touch up work. The MCLB does not use airless systems. The benefits of air-assisted airless relative to conventional airless are very similar to those provided by using ULV on airless systems, reduced paint pressure, softer spray, higher transfer efficiency. Air-assisted airless allows the paint pressure to be reduced to the 500 - 800 psi range because the air-assist helps in the atomization of the paint and distribution of the particles within the plume. At these lower pressures, if air-assist were not used the spray pattern would have unacceptable "heavy edges".

The MCLB has already obtained most of the benefit that the ULV system would provide because the MCLB uses air-assisted airless. The ULV system could be used with the air-assisted airless guns to provide a smoother paint delivery but this is not likely to be lead to significant reductions in the amount of paint sprayed for vehicle painting. It is estimated that at least 75% of the benefit of ULV comes from the reduced pressure and no more than 25% from smoother paint delivery. Thus, while some benefit may be achieved from the smooth delivery, it is not likely to be significant.

TABLE 4-1-1. SUMMARY OF ULV TRIALS WITH MILITARY COATINGS

Coating	Was an Attempt Made To Spray This Coating With The ULV System? (Indicate Yes or No)	Was The Coating Successfully Sprayed With The ULV System? (Indicate Yes or No)	Comments
2-component CARC	YES	NO	*
1-component CARC	YES	NO (Better)	*
Primer	YES	NO (Close)	
Undercoating	NO		

* During testing, the ULV manufacturer noted that higher pressures (700 to 800 psi) caused compaction of the material in the lines and on strainer and filter screens. 500 psi or less eliminates this clogging effect. All above materials were sprayed with the ULV System. The spray pattern was unacceptable, having heavy "crows feet" or heavy edges.

APPENDIX 4-2

PAINTING PROCEDURE INSTRUCTION SHEET

**Use keyboard for data entry.*

**Make sure printer is on! (Red light will glow.)*

1) Press <**F1**> (Start)
2) Enter data when prompted by display:

Display Prompt	Operator Entry
Vehicle ID	enter 6-digit ID number, press <**ENTER**>
Vehicle Code	enter 3-digit code (like 923), press <**ENTER**>
Coating Code	enter **P** (primer) or C (CARC), press <**ENTER**>
Your ID	enter your badge number, press <**ENTER**>
Partner ID	enter partner's badge number, press <**ENTER**>
Target Amount	enter gallons of paint needed, press <**ENTER**>
Pounds per gallon	enter **11.1** for CARC, press <**ENTER**>
Scale	enter **1** (outside) or **2** (inside), press <**ENTER**>

3) Screen will prompt "Start Flow Monitor?" Press <**F5**> (Yes).
4) Place solvent catch bucket on scale. Place the stirring motor and paint tube in the bucket as usual.
5) Press <**TARE**> (yellow button on remote box).
6) Press <**PRINT**> (blue button on remote box).
7) If more paint is needed:
    - A) press <**PRINT**>
    - B) pour paint into bucket on scale
    - C) press <**TARE**>
    - D) press <**PRINT**> again
8) When equipment is finished, press <**PRINT**>.
9) To stop, press <**F1**> (Stop); then <**F5**> (Yes).
10) When all data has printed, give data strip to Leaderman.

IMPORTANT: DO NOT HIT <**TARE**> EXCEPT AFTER PAINT IS ADDED TO BUCKET!

To Correct Errors During Data Entry (Step 2):

Use <**Backspace**> for current entry.

Use <**Escape**><**Escape**> after <**Enter**> has been pressed. This will return you to Step 1.

APPENDIX 4-3

SUMMARY DATA FOR PAINT DEMONSTRATION

TEST #	*PAINTERS*	*DATE*	*DISPLAY*	*VEHICLE TYPE*	*AMOUNT (gal)*	*NOTES*
1	6261, 8938	12/5	No	923 - Truck	5.49	Underside not done
2	6261, 8938	12/5	No	818 - Cab	5.74	
3	6261, 8209	12/6	No	MK-48 - Power	6.45	
4	6261, 8209	12/6	No	HMMWV	2.08	
5	6261, 8209	12/7	No	HMMWV	1.66	
6	8938, 7478	12/7	No	HMMWV	2.7	
7	8938, 7478	12/7	No	HMMWV	1.68	
8	8938, 7478	12/7	No	HMMWV	2.04	
9	8938, 7478	12/8	No	5-ton Truck	7.16	
		12/8	No	misc.	--	Touch up only
10	8938,6261	12/11	No	HMMWV	1.82	
11	8938,6261	12/12	No	HMMWV	1.92	TARE not recorded
12	8938,9791	12/13	No	927 - Truck	5.84	
13	8938,9791	12/13	No	813 - Truck	4.1	Underside not done
14	8938,6261	12/14	Yes	813 - Truck	5.76	
15	8938,7478	12/14	Yes	923 - Truck	6.56	
16	8938,7478	12/14-15	Yes	813 - Truck	7.53	Across days
17	8938,7478	12/15	Yes	HMMWV	2.04	
18	8938,7478	12/15	Yes	HMMWV	2.04	
19	8938;7478	12/15	Yes	HMMWV	2.08	