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Research Laboratory
Research Triangle Park NC 27711

Research and Development

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# Project Summary

# Transfer Efficiency of Improperly Maintained or Operated Spray Painting Equipment Sensitivity Studies

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**The U.S. Environmental Protection Agency initiated a research program to investigate the impact of common industrial operating and maintenance practices on the efficiency of spray painting systems.**

**Centec Consultants Inc. was contracted to conduct the research program. Assistance was also sought and received from representatives of the spray painting equipment manufacturing industry and users of spray painting equipment.**

**The results indicate strong directional responses in painting efficiency to certain common painting practices.**

***This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Introduction

Spray painting transfer efficiency (TE) is the percentage of paint solids deposited on a substrate compared to the total amount of paint solids sprayed at the substrate. Past research conducted by EPA has shown that certain operating and maintenance practices can drastically affect TE. This test program is designed to show the effects of defined operating and maintenance (O&M) parameters on TE.

Operating and maintenance parameters were selected for testing from information obtained through literature searches, industry contacts, service manuals, and technical bulletins.

Some of the identified parameters were considered qualitative; their value could be neither identified nor controlled quantitatively for a full range of values. Factors such as booth air velocity, fan air (shaping air), and electrode position were considered qualitative for the purposes of the test program. Qualitative factors were tested at a minimum of two levels. The remaining factors, considered quantitative, were tested at five levels. Examples of quantitative factors selected are:

- restricted air lines (measured by air pressure at gun),
- restricted paint lines (measured by paint pressure at gun),
- gun cleanliness (measured by percent of paint/air holes in air cap plugged), and
- voltage.

Using the selected O&M parameters, an experimental design was completed. A separate experimental design was developed for each type of spray equipment tested. The equipment tested included air atomized conventional, airless conventional, air atomized electrostatic, and airless electrostatic.

The test program was conducted in a fully equipped industrial spray painting laboratory. Graco, Inc., of Minneapolis, MN, provided their research laboratory for the testing phase of the program.

The data analysis techniques used explored first- and second-order system responses, as well as interaction between parameters. Regressions were developed to describe the response of TE to O&M factors for each equipment type. An error analysis was performed to determine the "lack of fit" of the models. Equations describing the system response for each of the four spray gun types with each of the two target types were developed using the Statistical Analysis System (SAS) of the SAS Institute, Inc.

## Operating and Maintenance Variables

During the initial phase of the project, industry representatives, consumers, and manufacturers of spray painting equipment identified 17 operating and maintenance variables considered important in achieving optimum operating efficiency for spray equipment. These variables are listed in Table 1.

*Table 1. Operating and Maintenance Variables for Air Atomized Conventional Spray Equipment*

| |
|---|
| *Atomizing air* |
| *Booth air rate* |
| *Booth configuration* |
| *Cure schedule (time, temperature)* |
| *Paint discharge technique* |
| *Equipment design* |
| *Flash off* |
| *Gun cleanliness* |
| *Gun condition* |
| *Gun-to-target distance* |
| *Operator error* |
| *Paint mass flow rate* |
| *Paint characteristics* |
| *Restricted air supply* |
| *Restricted paint supply* |
| *Shaping air (fan air)* |
| *Target configuration* |

Five of the 17 variables were selected for testing on the basis of the number of times they were identified by different sources, the anticipated size of their effect on TE, and the ability to simulate them within the prescribed test methodology. The five selected test variables were:

- restricted air lines,
- booth air rate,
- gun cleanliness,
- restricted paint lines, and
- fan (or horn) air.

## Experimental Design

An experimental design was developed to address the effects of each variable as completely as possible.

The major testing limitation was the number and types of simulation levels for each variable. Only two levels of linear air velocity (booth air rate) were possible in the test laboratory, three levels of fan air (sometimes called horn air or shaping air) were achievable, and five or more levels of the other variables could be simulated. Table 2 presents the type of variable (quantitative/qualitative) and levels accommodated in the experimental design.

A central composite experimental design was selected as the most thorough way to examine the effects of these factors with the fewest test runs. The experimental design was characterized by combining a fractional factorial design portion with a "star" portion, augmented by replicates.

## Conclusions

Air Atomized Conventional System (AAC) TE was most influenced by restricted air lines. Although the nature of the restriction for any given operation cannot be defined, the results do indicate the importance of maintenance for all paint lines to ensure the free flow of paint to the spray gun. The booth air rate was also determined to have a significant effect on painting efficiency, although not as strongly as restricted air lines.

Air Atomized Electrostatic System (AAE) TE was affected by the most variables. The most prominent effect was voltage, followed by restricted air lines and restricted paint lines. Booth air, gun cleanliness, fan air, and electrode position also had significant effects.

Airless Conventional System (ALC) TE was determined to be overwhelmingly affected by tip erosion.

Airless Electrostatic System (ALE) TE effects are similar to both the AAE and ALC systems: voltage and electrode position had the greatest effects, but effects of other factors were contingent on target configuration.

*Table 2. Experimental Variables Selected for Testing Air Atomized Conventional Spray Systems*

| *Factor ID* | *Factor Description* | *Quant./ Qual.* | *Number of Test Levels* |
|---|---|---|---|
| *A* | *Restricted atomizing air lines* | *Quant.* | *5* |
| *B* | *Booth air rate (linear velocity)* | *Quant.* | *2* |
| *C* | *Gun cleanliness* | *Qual.* | *5* |
| *D* | *Restricted paint lines* | *Quant.* | *5* |
| *E* | *Fan air (sometimes called horn air or shaping air)* | *Qual.* | *3* |

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*The complete report, entitled "Transfer Efficiency of Improperly Maintained or Operated Spray Painting Equipment Sensitivity Studies," (Order No. PB 86-108 271/AS; Cost: $16.95, subject to change) will be available only from:*
*National Technical Information Service*
*5285 Port Royal Road*
*Springfield, VA 22161*
*Telephone: 703-487-4650*
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