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PRELIMINARY EVALUATION OF SPRAY CLEANING FOR USE BY NAVAL SHORE ACTIVITIES

BY

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U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California 93041

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PRELIMINARY EVALUATION OF SPRAY CLEANING FOR USE BY NAVAL SHORE ACTIVITIES

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Y-F020-03-05-002

Type B

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ABSTRACT

At Naval Activities, cleaning operations are a continuing effort in building maintenance, equipment maintenance, metal cleaning, sanitary cleaning, and other applications. The methods of cleaning vary from hand wiping to chemical and mechanical ~~techniques.~~ Spray cleaning, which is a relatively new technique, is not widely used ~~by the Navy~~, but since studies indicate that it has potential for reducing cleaning costs, a preliminary evaluation of the technique was made ~~by~~ NCEL.

A survey of nineteen Naval activities was conducted to determine the cleaning techniques presently in use, the cost of cleaning operations, and the cleaning operations which appeared to be suitable for spray cleaning. This survey indicated that spray cleaning of transportation and construction equipment had the greatest possibility for reducing costs of cleaning.

Tests made on spray cleaning equipment indicated that very high pressure spray units were effective in removing large quantities of mud, grease and oil. Medium and low pressure units were adequate for maintenance and pre-overhaul cleaning.

Recommendations are made to determine the most effective spray cleaning method for transportation and construction equipment, to compare it to the most effective cleaning method now in use, and to propose that the most efficient method be included in a cleaning manual.

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CONTENTS

INTRODUCTION

So many improvements have been made in cleaning equipment, materials and methods that it has been difficult for the various Naval shore activities to keep informed of the latest developments. Task Y-F020-03-05-001 was originated in FY-63 to investigate the latest methods and materials for (1) sanitary cleaning, (2) paint stripping, (3) steam cleaning, (4) metal cleaning, and (5) prepaint cleaning. The objective was to find methods for maximum cleaning efficiency at low cost, and the findings were to be used for improving specifications, operating manuals and instructions.

As a result of early investigations into steam cleaning,[1] alkaline spray cleaning was recognized as a method which might reduce cleaning costs in some areas. References 2 and 3 concluded that spray cleaning is a practical cleaning method not fully utilized in government maintenance programs, and that new compounds and equipment make this method attractive for effective and economical maintenance cleaning. A recommendation was made that a study be conducted to determine the present cleaning techniques being used and the current Navy-wide cost of specific cleaning practices which might be done more effectively by spray cleaning.

In FY-66, a study of cleaning techniques used and the determination of specific cleaning operations which could be done by spray cleaning were undertaken. This note reports on the results of (1) a survey of present cleaning operations including methods and costs, (2) the determination of operations which could be done by spray cleaning, and (3) an evaluation of spray cleaning equipment.

SPRAY CLEANERS AND STEAM CLEANERS

To clarify the terminology used in this report, the terms "spray" cleaner and "steam" cleaner will be defined and the differences between the two systems discussed.

Spray cleaners accomplish the cleaning process through a relatively high pressure liquid spray. Pressures vary from 100 psi to 8,500 psi and are usually obtained by positive displacement pumps. The cleaning medium may be either hot or cold and may be plain water or a water solution of a cleaning compound. Motive power for pumping the solution may be electric motors, internal combustion engines, air actuated pistons or hydraulically actuated pistons.

Steam cleaners use a steam jet to accomplish the cleaning. The high temperature (about 250°F) and the velocity of the jet are primarily responsible for the removal of unwanted substances. Chemical additives may also assist in the process. Steam cleaners are more complicated than spray cleaners as steam must be generated which involves a fuel supply, a burner, a heat exchanger and a hot gas exhaust; the hot spray nozzle may be a hazard. Steam cleaning equipment is simplified when electric steam generators are used. Some steam cleaners now being manufactured incorporate an arrangement for delivering high pressure liquid, thus the advantages of spray cleaning and steam cleaning are combined in a single machine.

CLEANING OPERATIONS IN USE

The five broad categories of cleaning with which Naval shore activities are concerned were found to be building maintenance, equipment maintenance, pre-paint cleaning, metal cleaning, and sanitary cleaning. An initial survey of Naval installations produced data on types of cleaning with which they were concerned and methods of cleaning presently used. Appendix A has six tables which list the various cleaning operations. Although the bulk of Navy cleaning is concerned with building and equipment maintenance, there is increased interest in pre-paint cleaning. Metal cleaning at most Naval establishments has only limited applications; sanitary cleaning is important in the prevention of the spread of disease by maintaining cleanliness.

SURVEY OF SPRAY CLEANING EQUIPMENT

A survey of spray cleaning equipment was made to determine the cleaning operations for which spray cleaning operations are suitable and to determine what types and variations of equipment are available. The results of the first determination are tabulated in Tables A-1 to A-6 inclusive of Appendix A in the column: "Spray Cleaning Applicable." Spray cleaning was found suitable for equipment maintenance cleaning, for cleaning engines before overhaul, and for cleaning garbage and trash receptacles and trucks. Other possible applications were cleaning of ventilation filters, tank cleaning, pre-paint cleaning, preservative removal and marine equipment cleaning. The primary considerations for determining if an item can be cleaned by spray cleaning are (1) the item must not be damaged by exposure to large quantities of water and (2) the item must be able to withstand the effects of the high pressure spray.

Spray equipment was found to differ in the pressures used, the volumes delivered, the power sources used, and the methods for mixing chemical additives. Classifying the equipment by operating pressures appeared to be most useful in making any comparisons of performance. Three ranges of operating pressures were arbitrarily established: "low" for pressures up to 500 psig; "intermediate" for pressures of 500 to 1,000 psig; and "high" for pressures above 1,000 psig. Along with these differences in pressures, other variables

included volume (from 1 to 35 gpm), power sources (electric motors, internal combustion engines, air or hydraulic pistons), and methods of mixing (internal and external).

In Appendix B, the various makes and models of spray cleaning equipment are tabulated.

SPRAY CLEANING EQUIPMENT EVALUATION

In order to make an evaluation of the cleaning effectiveness of spray cleaning equipment, the Laboratory conducted a series of cleaning operations with selected representative equipment and also witnessed demonstrations of cleaning with other spray equipment. For the Laboratory tests, four spray cleaning units were selected. One unit operated in the 0 to 500 psig range, two in the 500 to 1,000 psig range and one in the 1,000 to 8,500 psig range. The specific units selected were:

Name	Operating Pressure	Water Volume	Special Features
Kleen King	350-500 psig	3 gpm	Electric motor driven Electric controls
Graco Hydra Clean Bulldog 1,000	1,000 psig	4 gpm	Air piston actuated
Jet Kleen	1,000 psig	1.2 gpm	Electric motor driven
Partek Water Blaster	8,500 psig	8 to 12 gpm	Gasoline engine driven

Cleaning demonstrations with the following equipment were witnessed:

Name	Operating Pressure	Water Volume	Special Features
Speed Kleen	500 psig	2 gpm	Electric motor driven
Modern HOP	1,000 psig	4 gpm	Hydraulic piston Actuated
Aquablast 75	1,000-6,000 psig	8-12 gpm	Gasoline driven engine driven
Waterblaster	1,000-8,700 psig	12 gpm	Gasoline engine driven

Equipment Performance

"Partek" Water Blaster. This unit was operated with both a fan nozzle and a jet nozzle. Water flow and operating pressures are shown below.

Pressure (psig)	Flow (gpm) Fan	Jet
1,600	6.1	---
2,400	7.4	6.1
3,500	8.5	7.3
4,400	9.9	7.7
5,400	10.5	9.2
6,000	11.3	9.6

The "triplex" pump was water cooled and difficulties would be experienced if the cooling water flow was less than ½ gpm.

The high pressure spray (6,000 psig) was found to be excessive when used on wooden or concrete structures. The wood was splintered by the force of the spray and the concrete started to spall when the spray was used to remove paint from the concrete. At 3,000 to 4,500 psig, however, heavy deposits, marine growths, asphalt and heavy mud were removed satisfactorily. Protection required for the operator and accessories and techniques for effective cleaning are discussed in Appendix C, "Spray Cleaning Techniques and Safety Practices."

Graco Hydra Clean Bulldog 1,000 (Figure 1). This unit was operated with three different fan nozzles; one was a 25° fan and two were 40° fan nozzles rated at 1.5, 0.6 and 1.0 gpm at 40 psig respectively.

Waterflows and operating pressures are shown below:

Nozzle	Pressure psig	Flow gpm
2515	600	5.9
4006	900	2.8
4010	300	2.6
4010	500	3.3
4010	800	4.1

This unit was found to be very versatile because the pressure and volume could be controlled by regulating the air supply as well as by varying the sizes of the nozzles. A problem with icing of the pump may occur as expansion of the air causes the motor to get cold. The volume of air required for operation (100 scfm at 100 psi) may be difficult to obtain if the supply lines are too long or of too small diameter. Wheels added to the unit would make it easier to handle. The cleaning ability of this unit was improved appreciably when cleaning compounds were added to the water. The 1,000 psig spray of this unit was easier for the operator to work with than the higher pressure sprays, but the ability to clean by direct impingement was correspondingly reduced.

Goodall Jet Kleen (Figure 2). This unit was operated with three nozzles (numbered 50025, 15025 and 5004). The volumes of all three were about 1.25 gpm whereas the pressures were 1,000, 900 and 600 psig, respectively.

For cleaning automobile and truck bodies and engines, the Jet Kleen unit performed very well. By heating the water and adding cleaning compound the performance was improved over that obtained with plain cold water. The Jet Kleen unit has a control knob which governs the mixtures which are delivered; some difficulty was experienced during the "rinse" operation when soap solution leaked into the spray.

Britt Tech Kleen King (Figure 3). This unit operated in the "low" pressure range between 350 and 500 psig and delivered approximately 3 gpm. The cleaning results were about equal to those obtained with the Jet Kleen unit which used a smaller volume of water but at a higher pressure.

Some difficulty was experienced with this unit, too, in that soap leaked into the water during the "rinse" operation. The controls for this unit were conveniently located on the handle of the spray hand.

Speed Kleen. This unit operated at about 500 psig and was rated by the manufacturer at 2 gpm (not verified by NCEL) so that its performance should compare to the Kleen King unit. In a demonstration by the manufacturer, good performance was obtained in cleaning an automobile and an engine. Use of cleaning compound improved cleaning ability. The demonstration also included the cleaning of a very dirty, greasy galley floor with outstanding results.

Modern HOP. This unit was hydraulically powered and was rated by the manufacturer at 1,000 psig with 4 gpm volume, thus its performance would be expected to compare with the Graco Hydra-Clean. A switch controlled the selection of cleaning solution or plain water to be delivered to the spray head. Hydraulic power is obtained from a motor-driven pump; the water pump is driven by a hydraulic piston. Action and results were similar to those of the Graco unit, except for the absence of icing which resulted from air expansion in the Graco unit.

John Bean Aqua Blast 75 and American Water Blaster units were also demonstrated. These are very high pressure units and compare to the "Partek" unit. The "Water Blaster" unit delivered 14 gpm at about 8,500 psig. In a demonstration by the manufacturer, heavy mud was removed adequately from a bulldozer; in addition, a Naval shipyard has reported that the unit has been very successfully used in removing sea growth, and in cleaning of bilges and engine rooms of ships.*

Overall Evaluation

From the tests and demonstrations made to date, it has been found that the very high pressure spray units which deliver large volumes of water obtained good results where the removal of large quantities of mud, grease and oil was required. For general maintenance and pre-overhaul cleaning, both medium and low pressure cleaning units performed adequately depending on cleaning compound used and water temperature.

TRANSPORTATION AND CONSTRUCTION EQUIPMENT CLEANING

NCEL Survey

Inasmuch as analysis of the preliminary information on cleaning operations (Appendix A) and on spray equipment (Appendix B) indicated that spray equipment may be used in the cleaning of transportation and construction equipment with a good possibility for reducing the time required for the cleaning processes, a questionnaire (Appendix D) was sent to nineteen Naval Shore Facilities to determine the methods and materials used for cleaning operations and the time (man-hours) required for each operation.

Information on transportation and construction equipment cleaning obtained by the questionnaires is tabulated in Appendix E, Tables E-1, E-2 and E-3. As can be seen, there are wide variations in the time required to do certain operations. Some of the differences may be attributed to the cleaning methods used, but more detailed information must be obtained to eliminate the possibility that the scope of the work may also be different.

NCEL Tests

Simultaneously with the distribution of the questionnaires, the Laboratory conducted a series of tests by cleaning various items with several different models of cleaning equipment. Spray pressures, spray nozzles, detergent, and

*Personal communication from Mr. H. A. Moreley, Pearl Harbor Naval Shipyard, December 16, 1965.

water temperatures were varied during these tests. The results of the Laboratory tests on transportation equipment are contained in Appendix F, Table F-1.

Discussion of Results

When Tables E-1 and F-1 were compared, spray cleaning generally appeared to accomplish the same work in a shorter time. A direct comparison was not considered valid because of the way the operations were timed and because of the small number of units cleaned at the Laboratory by spray cleaning. However, the tendency was indicated for spray cleaning to be generally faster. In some cases, the reporting activities also used spray cleaning methods. The times for "Maintenance Cleaning" are compared below:

Item	Ave. Time	Min. Time	NCEL Test (Time in man-hours)
Automobiles, etc.	0.70	0.25	0.24
Trucks 1-10 tons	1.2	0.60	0.42
Trailers 10-20 tons	1.8	0.50	0.50
Buses 30-50 pass	1.8	0.50	0.38
Engines	1.1	0.50	0.25
Bulldozers	3.4	1.0	0.33
Graders	2.6	0.70	0.25
Cranes	4.7	1.0	2.0

MISCELLANEOUS CLEANING OPERATIONS

NCEL Survey

Information on miscellaneous cleaning operations also was obtained by the survey questionnaire from the nineteen Naval Activities. The cleaning of buildings and grounds, fences, walls and doors, windows, signs and some other items was not especially suitable for spray cleaning, but the information obtained in the questionnaire on cleaning venetian blinds, loading docks and ramps, conveyors, water and fuel tanks, chemical tanks and vats, garbage cans, garbage containers, (Dempster Dumpsters and similar items), ventilation filters and lawn and garden equipment was considered to be most pertinent to this study. Appendix G contains the results of the survey for cleaning these items.

Discussion of Results

Not all of the items listed have been cleaned by the Laboratory in the spray cleaning tests, and in other cases only one of the class has been cleaned. For comparison, however, the cleaning times were as follows:

Item	From Survey Ave. Time	From Survey Min. Time	NCEL Test Time (Time in man-hours)
Venetian Blinds	0.26	0.08	0.05
Garbage Cans	0.17	0.02	0.05-0.07
Garbage Containers	0.57	0.13	0.50
Ventilation Filters	0.12	0.03	0.05
Lawn Mowers	0.33	0.10	0.25

The "NCEL Test Times" indicated were the observed times for cleaning at the Laboratory and in most cases were close to or less than the minimum time required as reported by at least one activity. For garbage containers, the two Naval Activities which reported times of 0.13 and 0.17 man-hours both used spray cleaning with a chemical additive.

COST ANALYSIS OF SPRAY CLEANING OPERATIONS

A complete cost analysis must include: first cost of equipment, labor costs, costs of cleaning compounds and cost of power. As the spray cleaning tests have not yet been carried to a point where the most effective spray system and cleaning compound have been definitely established, only a partial analysis can be made at this time.

A tentative comparison was made between intermediate pressure spray cleaners and the small portable steam cleaning units which are carried in the Federal stock system under FSN 4940-865-4738. First costs were about equal if the spray cleaners are assumed to have a 3-year life expectancy and the steam cleaners a 5-year life expectancy. Labor costs for spray cleaners appear to be approximately 50% of labor costs for steam cleaners. Cost of spray cleaning compounds may be as small as 25% of costs of steam cleaning compound and power costs appear to be approximately equal.

Although this superficial study indicates that spray cleaning may be cheaper than steam cleaning, a more comprehensive study is required before a complete cost analysis can be made.

DISCUSSION

The cleaning operations presently conducted at the Naval Shore Establishments cover a wide range both in items cleaned and methods used. Spray cleaning involves large volumes of water or solution and is generally unsuitable for cleaning of building interiors where excessive water should be avoided. Spray cleaning of some interior fixtures is feasible, but only if the fixtures are removed from the building. With the possible exception of loading ramps and docks, cleaning of building exteriors is not generally suited to spray cleaning. Transportation equipment, construction equipment, marine equipment, some inside shop equipment and miscellaneous items (tanks, conveyors, lawn and garden equipment) were found to be cleanable with spray cleaners. Other possible uses for spray cleaners appear to be prepaint cleaning of equipment and machinery, and possibly of metal or masonry structures; degreasing, scale and rust removal from machinery and some other items; and sanitary cleaning of galley areas and garbage receptacles.

This study has indicated that spray cleaning may be more efficient in some applications than the methods now used, but it is yet to be proved that spray cleaning is the most efficient method in all cases.

The efficiency of any cleaning operation is dependent on several factors among which are: operator skill, the chemical additives, the solution temperature, the agitation (scrubbing action) and the time involved. In making a comparison between two cleaning methods, these factors should be considered and if possible, any prejudice on the part of the operator should be minimized. The results obtained from the survey of cleaning operations are considered to be only generally indicative of their effectiveness. Additional information on scope of the work involved and methods of computing the time required are needed for a comparison to be made. Similarly, spray cleaning operations must be done on a production basis before a valid comparison is possible.

Efficiency of cleaning operations can only be established by comparison and, therefore, may be highly dependent on personal judgement. To reduce the effect of personal judgement, an averaging system should be used with as large a sample (number of items cleaned) as possible.

Selection of proper equipment, chemical additives used and techniques used will be significant in the ultimate success of any cleaning processes. Costs of equipment, operating costs and costs of additives as well as operators time must be considered in making these selections.

CONCLUSIONS

Spray cleaning has been shown to be an effective method for cleaning transportation and construction equipment and is also effective in cleaning other items such as filter elements, conveyors and garbage containers. The most effective equipment for spray cleaning has not been established nor has

it been shown conclusively that spray cleaning is the most efficient method for any specific cleaning operation.

It has been shown that there is a wide variation in the times required to conduct certain cleaning operations using the present methods and that spray cleaning has promise of being equal to or better than the methods now in use. A more specific study of cleaning methods now used and a more conclusive comparison with spray cleaning must be made before the most effective method can be determined. From the information obtained in the cleaning survey, it appears that at some activities, from 50 to 75% reduction in time may be realized if the most efficient method of cleaning (not necessarily spray cleaning) is used.

Cleaning operations such as prepaint cleaning, grease, rust and scale removal and sanitary cleaning may be accomplished effectively by spray cleaning if suitable chemical additives are used. Further work will be required to verify that spray cleaning can be used in these applications and to determine the chemical additives which are required.

RECOMMENDATIONS

The following recommendations are made:

1. For each type and application of transportation or construction equipment, determine the spray cleaning equipment and solutions which will clean most efficiently.
2. Make a detailed cost comparison between the most efficient spray cleaning method and the most efficient cleaning method now in use (as determined by the survey).
3. When the most efficient cleaning methods have been determined, make recommendations for a manual for Cleaning Transportation and Construction Equipment.
4. For cleaning of other items by spray cleaning, determine that the number of items cleaned at any facility is large enough to warrant expenditure of further effort. Where such effort is warranted, follow recommendations 1, 2 and 3 above; where further effort is not considered warranted, make recommendations for inclusion in a cleaning manual information on cleaning methods presently in use and also on spray cleaning.
5. Continue with studies of the use of spray cleaning for metal cleaning, paint stripping and pre-paint cleaning.

REFERENCES

1. U. S. Naval Civil Engineering Laboratory. Technical Note N-611: Chemical cleaning materials and processes for BuDocks requirements, by C. Saturnino and W. R. Nehlsen. Port Hueneme, Calif., July 1964.

2. U. S. Naval Civil Engineering Laboratory. Technical Note N-665: Government and industrial use of the alkaline spray cleaning processes, by C. M. Saturnino and N. L. Drobny. Port Hueneme, Calif., December 1964.

3. U. S. Naval Civil Engineering Laboratory. Technical Note N-753: Essential features of alkaline spray cleaning studies, by LTJG Neil L. Drobny, CEC, USNR. Port Hueneme, Calif., July 1965.

Figure 1. Graco Hydra Clean

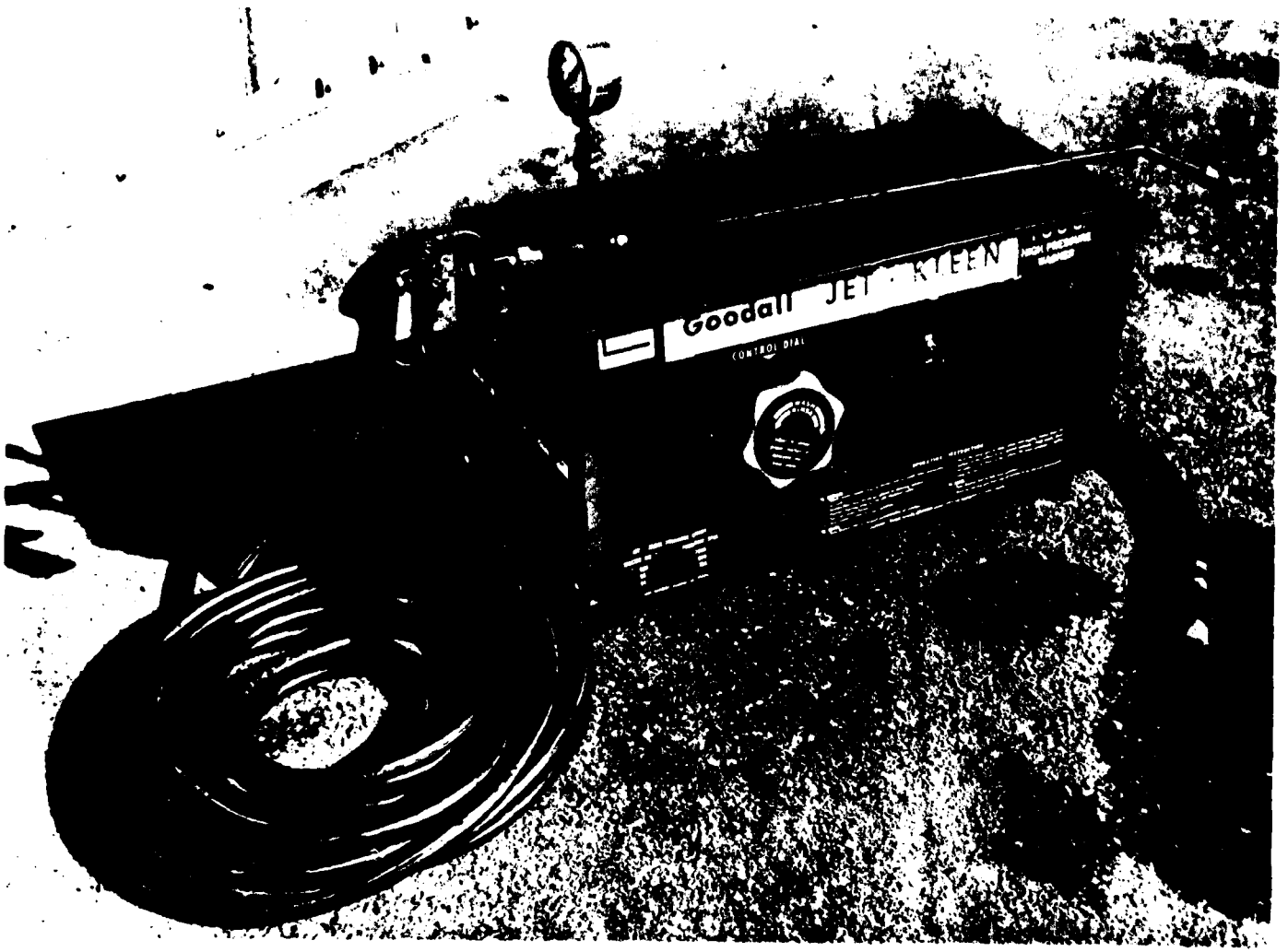

Figure 2. Goodall Jet Kleen

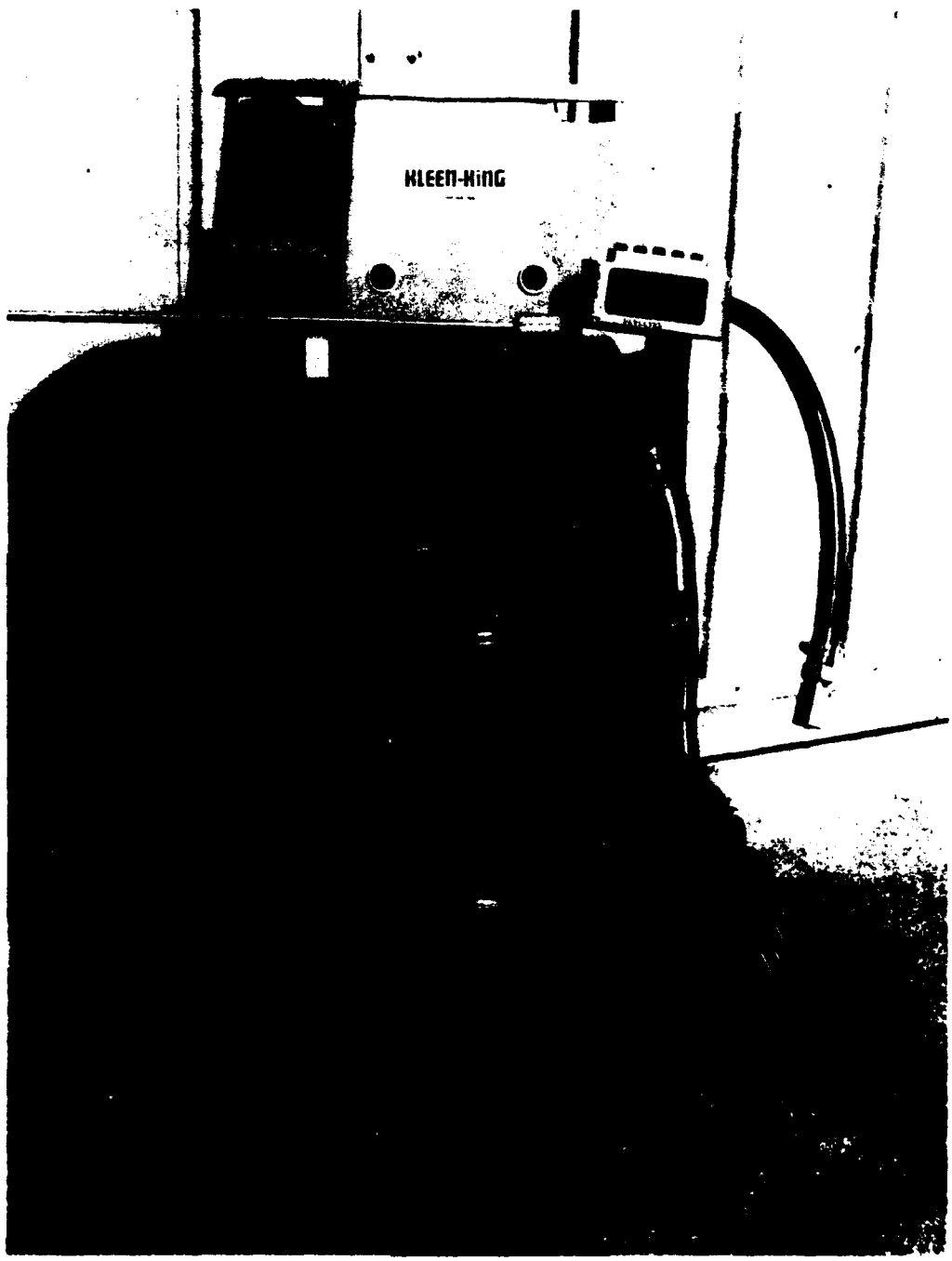

Figure 3. Britt Tech "Kleen King"

Appendix A

RESULTS OF SURVEY OF CURRENT CLEANING PRACTICES AT NAVAL SHORE ESTABLISHMENTS

Table A-1 Building Maintenance

Type of Buildings Considered:
Barracks, clubs (Officer's, CPO's, EM) garages, laboratories, office buildings, Post Exchanges, quarters (BOQ etc.), ships and warehouses

Table A-2 Equipment Maintenance

Types of Equipment Considered:
Transportation equipment, construction equipment, marine equipment, inside shop equipment, sewerage system components, tanks and misc. equipment

Table A-3 Pre-paint Cleaning

Applications Considered:
Cleaning of metal parts; cleaning of building interiors and exteriors

Table A-4 Degreasing, Scale and Rust Removal

Applications Considered:
Engines and parts during overhaul, ship hulls, pipes, etc., preservative removal, and descaling of watersides

Table A-5 Paint Stripping
Aircraft paint stripping only

Table A-6 Sanitary Cleaning

Applications Considered:
Galley areas, laundry, lavoratories, etc.

Table A-1. Building Maintenance Cleaning Practices

Cleaning Application	Substances to be Removed	Current Method	Spray Cleaning Applicable	Remarks
BUILDING INTERIOR				Note 1
Air conditioners, ex. filters	dust, grease	not reported	not likely	
Blinds, venetian	dust, grease	hose off	yes	can be spray cleaned if removed
Doors		hand wipe	no	
Ducts and diffusers	dirt, dust, grease	hand vacuum	not likely	
Filters, kitchen & ventilation	dirt, grease, exhaust fumes	steam clean or vapor degreasing	possible	can be spray cleaned if removed. Note 2
Floors, corridors, stairs	dirt, dust, heelmarks	handmop, floor machine	no	
Hoppers, vats, etc.	chemicals, food, grease	hand scrub	possible	remove to spray clean
Piping	dirt, dust, grease		not likely	
Screens & screen doors			possible	
Walls & ceilings	dirt, fumes, etc.	paint over	no	
Windows	dirt, fumes, etc.	hand wash	no	
BUILDING EXTERIOR				
Handrails	dirt, etc.	hand scrub	no	
Piping	dirt, etc.	not cleaned	no	
Ramps, loading docks	dirt, food, grease, chemicals, mud, etc.	hose off	possible	
Roof	dirt, dust, salt spray	not cleaned	no	
Stairways	dirt, etc.	hand mop	no	
Walls	dirt, dust, salt spray, fumes	not cleaned	no	
Windows	dirt, fumes, etc.	hand wash	no	
AREAS ADJACENT TO BLDGS.				
Bridges, overpasses		not cleaned	no	
Driveways, walkways	dirt, grease, oil, etc.	hand/machine sweep	no	
Fences	mud, rust, etc.	not cleaned	no	
Parking areas	mud, rust, etc.	machine sweep	no	
Signs, traffic, building	dirt, fumes, etc.	not cleaned or hand wiped	no	

NOTE: 1. Spray cleaning inside buildings is not generally suitable because of excessive water or high pressure which may damage flooring, woodwork or wallboard.

2. Because of the generation of aerosols, spray cleaning must not be done in galley areas unelss food processing is suspended.

Table A-2. Equipment Maintenance Cleaning Practices

Cleaning Application	Substances to be Removed	Current Method	Spray Cleaning Applicable	Remarks
TRANSPORTATION EQUIPMENT				
Cars, buses	road dirt, bugs, tar, mud, grease, salt spray, exhaust deposits	water & detergent wash, steam clean, heavy dirt & grease	yes	
Trucks, trailers	road dirt, bugs, tar, mud, salt spray, grease, exhaust deposits	same as above	yes	
Train locomotives & cars	dirt, grease, exhaust deposits	steam clean, water wash	yes	
Aircraft	dirt, grease, exhaust deposits	hand wash, spray clean	yes	
CONSTRUCTION EQUIPMENT				
Bulldozers, cranes, graders, shovels, earth movers and lift trucks	heavy mud, grease, salt spray	water & detergent for light dirt, steam clean heavy dirt, etc.	yes	
Drill rigs, ditchers, rock crushers	heavy mud, grease, salt spray	hand clean tracks daily	yes	
Paving machinery	hardened asphalt	hand chip hardened asphalt	yes	
MARINE EQUIPMENT				
Boats, ships, barges	sea growth, rust, exhaust deposits	sandblast during overhaul	possible	
Decks	same as above	same as above	possible	
Exhaust stacks	"	"	possible	
Booms & rigging	"	"	possible	
Hull surfaces	"	"	possible	
INSIDE SHOP EQUIPMENT				
Lathes, drill presses, etc.	oil, grease, metal chips, rust etc.	Wipe down and air blow	no	washing or spraying not recommended
Fork lifts	dirt, oil, grease	steam clean	yes	
Vats, hoppers, chemical tanks	chemical deposits, scale, rust	steam clean, hand scrape	yes	

Table A-2. Equipment Maintenance Cleaning Practices (cont'd)

Cleaning Application	Substances to be Removed	Current Method	Spray Cleaning Applicable	Remarks
SEWER SYSTEM				
Storm sewer	silt & debris from heavy rains	hand clean	no	
Sewer pipes	compacted grease, soaps, roots	chemical clean, "Roto-rooter"	no	
TANKS				
Water, potable	algae	hose down	possible	
Water, other	algae	hose down	possible	
Fuel	algae, dirt, water	water hose down	possible	
Swimming pools	algea, dirt, leaves	scrape & brush by hand	possible	
MISCELLANEOUS				
Conveyer belts & tables	rust, dirt, etc.	no report	possible	
Hand tools	rust, dirt, etc.	no report	not likely	
Lawn & garden equipment	grass, dirt, rust	no report	yes	
Printing presses	ink, etc.	no report	not likely	
Tunnels (traffic)	exhaust fumes	not cleaned	possible	

Table A-3. Pre-Paint Cleaning Practices

Cleaning Application	Substances to be Removed	Current Method	Spray Cleaning Applicable	Remarks
METAL PARTS				
Equipment & machinery	grease, mud, oil, salt spray exhaust deposits, loose paint	steam clean plus sanding	possible	
Parts after fabricating	grease, preservatives, drawing compounds	dip or soak in chemical solution	possible	
Parts prior to electroplat	oil, rust	dip in acid, electrostatic	no	
Parts prior to heat treating		dip in chemical solution, vapor degreasing	possible	
Pre-packaging cleaning	fingerprints dust, oil, grease	dip tank or vapor degrease	no	
BUILDING INTERIORS				
All surfaces	cooking fumes, hand prints, heel marks	hand wash, squeeze and stick, sand	no	pressure & water a problem in building interiors
BUILDING EXTERIORS				
Wood surfaces	salt spray, loose paint, exhaust deposit, corrosion, alkalai deposits, bird droppings	flame, sand blast sand, wire brush, (or none)	no	
Metal surfaces	same as above	sandblast (or none)	possible	
Stucco surfaces	same as wood surfaces	none	no	
Masonry surfaces	same as wood surfaces	scrape, wirebrush, (or none)	possible	
Concrete surfaces	same as wood surfaces	seldom painted	possible	

Table A-4. Degreasing, Scale and Rust Removal Practices

Cleaning Application	Substances to be Removed	Current Method	Spray Cleaning Applicable	Remarks
Engines, before overhaul	mud, grease, carbon, oil	steam clean	yes	
Engine parts during overhaul	carbon, grease, oil	soft grit blast, spray, soak w/solvent	possible	
Ship hulls (metal)	rust, scale, barnacles, etc.	sand blast, water wash	no	sea growth can be removed by spray cleaning
Welded assemblies from welding ship	flux, grease, oil, dirt	hand chip, wire brush	no	
Pipes	scale, rust, mud, grease, oil	sand blast, hand scrape	no	
Pontoons	rust, salt, scale, sea growth	sand blast, water wash brush	possible	
Tanks inside, outside	rust, scale, etc.	steam clean and sand blast	possible	
Preservative removal from all equipment	preservatives, grease	vapor degreaser, steam	possible	
Descaling of watersides of surface condensers, water coolers, washing machines	hard scale	acid soak or water treatment	no	
Material for fabricating shops	scale, rust, grease, dirt	not cleaned	no	

Table A-5. Paint Stripping Practices

Cleaning Application	Substances to be Removed	Current Method	Spray Cleaning Applicable	Remarks
Aircraft	paint	hand application of stripping compound	possible	

Table A-6. Sanitary Cleaning Practices

Cleaning Application	Substances to be Removed	Current Method	Spray Cleaning Applicable	Remarks
GALLEY AREA				
Carts & racks	food	hand scrub or wipe w/detergent solution	possible	Note 1
Floor, walls & ceilings	food, grease, dirt, dust	same as above	no	see Note 1 for Table A-1
Food prep. equipment	food, grease	same as above	possible	
Food storage areas	food, grease	same as above	possible	Note 1
Garbage cans	food, grease, dirt	steam	yes	
Pots, pans	food, grease	hand scrub or wipe w/detergent solution	no	
Refrigerators, walk-in	food, grease, dirt	same as above	possible	Note 1
Tables, chairs	food, grease, dirt	same as above	no	
LAUNDRY AREA				
Carts, hangars, racks	dust, dirt	hand clean	possible	
Cleaning equipment	no report	hand clean	no	
Floors and walls	dust, dirt	hand scrub	no	see Note 1 for Table A-1
LAVATORIES				
Floors and walls	dirt, dust, soap, scum etc.	hand scrub	no	see Note 1 for Table A-1
Showers	dirt, sand, hair oil, soap scum, hard water deposit	hand scrub	no	
Toilets	same as above	hand scrub	no	
Wash basins	dirt, soap, scum deposits	hand scrub	no	
MISCELLANEOUS				
Garbage trucks and Dempster Dumpsters	food, grease, mud, dirt, chemicals	steam	yes	
Shopping & laundry carts	food, grease, oil	hand clean	yes	

NOTE 1: Aerosols generated by spray cleaning make it mandatory that no food, either in storage or in preparation, be exposed during the cleaning operation.

Appendix B

TABULATION OF SPRAY CLEANING EQUIPMENT

Table B-1. Low Pressure (less than 500 psi) Spray Cleaning Equipment

Trade Name	Manufacturer	Operating Press (psi)	Volume GPM	Power Source	Mixing	Other Characteristic	Cost Range	Remarks
Aqua Blast Mark III	John Beam Div., Food Mach'y Corp.	100	12	Electric	Internal	Rinses		Delux-w/tank on wheels Portable-55 gal drum mounted
Aqua Matic	Siesbring Mfg. Co.	0 - 600	2	Electric	Internal	Rinses	Less than $300	Also listed under B-2 "Intermediate Pressure"
Cleen Bee Electric Hydro	Gray Co. Inc. (Graco)	400	2	Electric	External		$300-500	See Wyandotte Topper Electric
Hydra-Cleen 200	Gray Co. Inc. (Graco)	200	0.72-1.72	Air	External		$300-500	Drum-mounted (See Wyandotte #1)
Jenny Multi-Job Washers	Homestead Valve Co.	250 - 300	1-4GPM Steam 2-8GPM Water	Oil Fired Electric	External	Rinses Degreases	$300-500	Wash & rinse at 250 psi clear & degrease at 300 psi
Malsbary-Washall 400	Malsbary Mfg. Co.	400	2	Electric	Internal	Rinses Heats	$300-500	
Electro-Magic 300	Electronics Inc.	100 (Air Supp)		Air	External	Rinses	Less than $300	Pressurized tank on air supply
Tysol - Model 500	Tysol Products Div., Chemical Research Associates	0 - 500	2	Electric	Internal	Rinses	Less than $300	See 501 below
Tysol - Model 501	Tysol Products Div., Chemical Research Associates	0 - 500	3	Electric	Internal	Rinses	Less than $300	Same as #500 above except 3 GPM vs. 2 GPM
Wyandotte Topper #1	Wyandotte Chemical Company	200	0.7-1.7	Air	External			Same as Graco Hydro Cleen 200
Wyandotte Topper Electric	Wyandotte Chemical Company	400	2	Electric	External			Same as Graco Cleen Bee Electric Hydro Cleen

Table B-2. Intermediate Pressure (500 psi to 1,000 psi) Spray Cleaning Equipment

Trade Name	Manufacturer	Operating Press (psi)	Volume GPM	Power Source	Mixing	Other Characteristic	Cost Range	Remarks
Alemite Powerwash 5:1	Alemite Company	500	1.7	Air	External		Less than $200	
Alemite Powerwash 7:1	Alemite Company	700	2.0	Air	External		$300-500	
AquaBlast - 420-5W	John Bean Div., Food Mach'y Corp.	600	20		External			
AquaBlast - 435-11W	John Bean Div., Food Mach'y Corp.	600	35		External			
AquaBlast - 420-7W	John Bean Div., Food Mach'y Corp.	900	12		External			
Aquamatic	Siebring Manufacturing Company	0 - 600	2	Electric	Internal	Rinses	Less than $200	Also listed under B-1 "Low Pressure"
Graco 10:1 Bulldog Hydro-Clean (1,000)	Gray Company, Incorporated (Graco)	1,000	3 - 10	Air	External		$1000-2000	
Graco 5:1 Bulldog Hydro-Clean (500)	Gray Company, Incorporated (Graco)	500	2.2 - 11.7	Air	External		$1000-2000	
Graco 1000 Hydro-Clean President	Gray Company, Incorporated (Graco)	1,000	1.4 - 3.1	Air	External		$500-700	
Graco 500 Hydro-Clean Monarch	Gray Company, Incorporated (Graco)	500	1.0 - 2.4	Air	External		$300-500	
Handyman	John E. Mitchell Company	500-600		Electric	Internal	Rinses	$300-500	
Hydro	Hydro Silica Company	1,000	22	Gasoline Eng. or Electric	External		Over $2000	
Jet Kleen 1000	Goodall Manufacturing Company	1,000	1.9	Electric	Internal	Rinses	$300-500	
Kleen King KA500-550	Britt Tech Corporation	500-550	3	Electric	Internal	Rinses	$500-700	3 GPM - 1½ hp - self-contained unit
Kleen King KA300-350	Britt Tech Corporation	500-550	1.8	Electric	External	Rinses	$300-500	1.8 GPM - 1 hp - same as 500-550 except capacity
Kleen King KA200	Britt Tech Corporation	500-550	1.8	Electric	Internal	Rinses	$300-500	55 gal. Drum mounting
Electro Magic Model 600	Electro-Magic Company	600	2.1	Elect. or Gas Eng.	External		$500-700	
Electro Magic Model 610	Electro-Magic Company	600	2.1	Electric	External		$300-500	Same as Model 600 but for 55 gal. drum mount
Kleen Brick	J-P Company Incorporated	600	2	Electric	Internal	Rinses	$300-500	

Table B-2. Intermediate Pressure (500 psi to 1,000 psi) Spray Cleaning Equipment (cont'd)

Trade Name	Manufacturer	Operating Press (psi)	Volume GPM	Power Source	Mixing	Other Characteristic	Cost Range	Remarks
Modern Hop Cleaner Model 4000	Slifer Manufacturing Company	1,000	3-4	Hydraulic	Internal	Rinses Heats	over $2000	
Modern Hop Cleaner Model 1000	Slifer Manufacturing Company	1,000	3-4	Hydraulic	Internal	Rinses Heats	$1000 to 2000	
Speed Kleen	National Industries Inc.	500	2	Electric	Internal	Rinses	$500-700	
Wyandotte Topper #2-5	Wyandotte Chemical Co.	500		Air	External		$300-500	Same as Graco Monark 500
Wyandotte Topper #3-10	Wyandotte Chemical Co.	1,000		Air	External		$300-500	Same as Graco President 1000
Wyandotte Topper #6-5	Wyandotte Chemical Co.	500	2.2-6.1	Air	External		$700-1000	Same as Graco Bulldog 500 (5:1)
Wyandotte Topper #5-10	Wyandotte Chemical Co.	1,000	3-7.5	Air	External		$700-1000	Same as Graco Bulldog 1000 (10:1)
Zee Model 400	Zee Manufacturing Co.	500	2.5	Electric	Internal	Rinses	$300-500	

Table B-3. High Pressure (over 1000 psi) Spray Cleaning Equipment

Trade Name	Manufacturer	Operating Press (psi)	Volume GPM	Power Source	Mixing	Other Characteristic	Cost Range	Remarks
Alemite Powerwash 11:1	Alemite Company	1100	2.4	Air	External		$300-500	
Aquablast 735-SW	John Bean Div., Food Mach'y Co.	3000	13		External			
Aquablast - 75	John Bean Div., Food Mach'y Co.	6000	12		External		over $2000	($7150 w/hose)
Water Blaster	American	8500	14	Gasoline Engine	External			
Hydro	Hydro Silica Corporation	5000		Gas Engine or Electric				
Partek "Water Blaster"	John Bean Div., Food Mach'y Co.	150-6000	12	Gasoline Engine	External			Older version of John Bean "Aquablast 75"

Appendix C

SPRAY CLEANING TECHNIQUES AND SAFETY PRACTICES

It was observed during the spray cleaning tests and the equipment demonstrations that certain techniques are required and certain chemical additives can be used to obtain the maximum cleaning effectiveness. It was also apparent that certain practices and equipment should be used for the safety of the operator and others who may be close to the area where cleaning was being done. Although this information may not be complete, it is included to make it available for subsequent inclusion in a more comprehensive compilation of operating techniques and safety practices.

Spray Cleaning Techniques

Warm Water. Warm (110°-150°F) water removed grease and oil about 30% faster than cold water but was of no advantage in removing dirt or mud. A thin oil film which was left by cold water when oil or grease was present, was removed by the warm water. Warm water also increased the effectiveness of chemical cleaners.

Chemical Cleaners (detergents). The use of cleaning compounds (detergents) in cold water also removed the film of oil which was left when only cold water was used. As noted above, warm water increased the effectiveness of the chemical cleaners so that a smaller amount was required.

Volume of Water. Where heavy dirt was to be removed, a larger volume of water was found to be more effective. For example: 3 gpm at 500 psig was as effective as 1.2 gpm at 1,000 psig; but 4 gpm at 800 psig obtained better results than either.

Nozzle. The nozzle or spray tip used in spray cleaning was found to be an important factor in cleaning effectiveness. A jet nozzle was effective in removing tightly adhering substances like cement and asphalt. Cleaning with a jet nozzle was slow, however, and produced streaks. A 40°-60° fan was found to be most effective in covering enough area to clean rapidly without spreading the cleaning solution excessively and without atomizing the solution. Eighty degree fan nozzles were found to be useful with high pressures (3,000 to 8,500 psig) and large volumes (8 to 14 gpm) for cleaning large areas.

Angle of Attack. The angle of attack was found to be important in spray cleaning as the most rapid cleaning was obtained when the spray was directed to get underneath the dirt to "slice" it off. Using the spray in a manner similar to the way a putty knife would be used in scraping off a surface was most efficient.

Strokes. It was found that long, smooth strokes which were slightly overlapping were more effective than short waving motions. For machines which produced pulsations in the liquid delivery, timing the pulsations to occur at the ends of the strokes was advantageous.

Wands. Although some spray cleaning machines were equipped with spray wands about 10" long, it was found that the 24-36" wands furnished with most machines were easier to use and more effective in reaching inaccessible areas. With the short wands, the operator was too close to the work and was subjected to excessive wetting from spray back.

Hose Lines. Overhead hose lines were found to be a desirable feature, especially in any permanent spray cleaning facility. Dragging the hose through dirt and grease causes the object being cleaned and the operator to become dirty and greasy. Also, damage may result from equipment running over the hose lying on the ground.

Safety Practices

Avoiding Spray Impingement. High pressure sprays impinging on the human body will cause lacerations when the nozzle is within 12 inches of the skin. Complete clothing (coveralls) should be worn by the operators and all others should be excluded from the cleaning area. The control of the spray by the operator with the on-off trigger also reduces the possibility of injuries.

Avoiding Splash Back. Dirt and spray may splash back from surfaces being cleaned by high pressure sprays and at some times particles will fly back at high velocities. The operator should be protected by a full face shield and complete clothing (coveralls).

Avoiding Toxic Chemicals. No toxic chemical cleaning compounds should be used with spray cleaning units because of the aerosols resulting from the high pressure sprays impinging on the surfaces. Also, great care should be taken and proper protective clothing worn if strong chemical compounds are used.

Appendix D

QUESTIONNAIRE ON CLEANING PRACTICES

CLEANING COST QUESTIONNAIRE INSTRUCTIONS

The Naval Civil Engineering Laboratory is studying new cleaning methods for incorporation into the Navy's cleaning program. The purpose of this questionnaire is to allow the Laboratory to compare the cost of the presently used cleaning methods with the new cleaning methods being studied. It is understood that the data requested will not be available in documented form; rather the intent is to obtain the best estimates of qualified personnel. Your assistance with this study is greatly appreciated.

The following is an example of how the questionnaire should be filled out:

Column (1) Lists the general type of items we are interested in.

Column (2) Is to be filled out with a specific item you have knowledge of and its size, model or area.

Column (3) Is to be filled out with the purpose of cleaning; if the reason is one of those listed, the associated number may be used.

Column (4) Is to be filled out with the method used to do the cleaning; here again if it is one of the methods listed, the number may be used.

Column (5) Is to be filled out with the time in man-hours required to do the cleaning job listed.

Item of Interest (1)	Specific Item Type, Model or Area (2)	Type of Cleaning 1. Pre-overhaul 2. Pre-paint 3. De-preservation 4. Pre-preservation 5. Maintenance 6. Other (3)	Method Used 1. Steam 2. Sandblast 3. Hand Clean 4. Chemical Dip 5. Vapor Degrease 6. Spray 7. Other (4)	Time Required Man-hours Per Item (5)
Dozer	D-8 with 18 yd scraper	5. Pre-Lubrication	1.	2 hr 10 min
Wall	Exterior wooden wall (20'x100')	2. Present paint peeling	7. Power Sander	16 hrs

CLEANING COST QUESTIONNAIRE

Item of Interest (1)	Specific Item Type, Model or Area (2)	Type of Cleaning 1. Pre-overhaul 2. Pre-paint 3. De-preservation 4. Pre-preservation 5. Maintenance 6. Other (3)	Method Used 1. Steam 2. Sandblast 3. Hand Clean 4. Chemical Dip 5. Vapor Degrease 6. Spray 7. Other (4)	Time Required Man-hours Per Item (5)
Transportation Equipment:				
Car				
Truck				
Trailer				
Bus				

Note: Use the back of this sheet for any additional information, comments or specific cleaning problems.

Sheet No.

CLEANING COST QUESTIONNAIRE

Item of Interest (1)	Specific Item Type, Model or Area (2)	Type of Cleaning 1. Pre-overhaul 2. Pre-paint 3. De-preservation 4. Pre-preservation 5. Maintenance 6. Other (3)	Method Used 1. Steam 2. Sandblast 3. Hand Clean 4. Chemical Dip 5. Vapor Degrease 6. Spray 7. Other (4)	Time Required Man-hours Per Item (5)
Construction Equipment:				
Dozer				
Grader				
Paving Equipment (Asphalt or concrete)				
Crane, power shovel				
Ditcher, backhoe				
Forklift				
Other				

Note: Use the back of this sheet for any additional information, comments or specific cleaning problems.

Sheet No.

CLEANING COST QUESTIONNAIRE

Item of Interest (1)	Specific Item Type, Model or Area (2)	Type of Cleaning 1. Pre-overhaul 2. Pre-paint 3. De-preservation 4. Pre-preservation 5. Maintenance 6. Other (3)	Method Used 1. Steam 2. Sandblast 3. Hand Clean 4. Chemical Dip 5. Vapor Degrease 6. Spray 7. Other (4)	Time Required Man-hours Per Item (5)
Buildings & Grounds				
Wall,door,				
Window				
Fence				
Venetion blind				
Sign (traffic, building)				
Loading dock, ramp				
Conveyor (roller, track)				
Water & fuel tanks				
Other				

Note: Use the back of this sheet for any additional information, comments or specific cleaning problems.

Sheet No.

CLEANING COST QUESTIONNAIRE

Item of Interest (1)	Specific Item Type, Model or Area (2)	Type of Cleaning 1. Pre-overhaul 2. Pre-paint 3. De-preservation 4. Pre-preservation 5. Maintenance 6. Other (3)	Method Used 1. Steam 2. Sandblast 3. Hand Clean 4. Chemical Dip 5. Vapor Degrease 6. Spray 7. Other (4)	Time Required Man-hours Per Item (5)
Miscellaneous:				
Garbage cans				
Dempsey dumpster				
Chemical tanks & vats				
Ventilation filter (kitchen, etc.)				
Lawn & garden equipment				
Other				

Note: Use the back of this sheet for any additional information, comments or specific cleaning problems.

Appendix E

TRANSPORTATION AND CONSTRUCTION EQUIPMENT CLEANING INFORMATION

Table E-1. Transportation and Construction Equipment Cleaning Survey

Maintenance Cleaning

Item	No. of Replies	Methods	Time Range Man-hours	Ave. Time	Method for Minimum Time	Remarks
SEDANS						
Sta. Wagons Pick-ups	9	Steam, Hand Clean Spray	0.25-1.0	0.7	Hand Clean	
TRUCKS						
1-5 tons	7	Steam, Steam & Spray	0.6-2.0	1.2	Steam	
5-10 tons	6	Steam, Hand Steam & Spray	0.7-2.0	1.2	Hand Clean	
TRAILERS						
10-20 tons	7	Steam, Hand	0.5-3.0	1.8	Steam	
BUSES						
16-30 pass.	3	Steam, Steam & Spray	1.0-3.0	---	Steam & Spray	Insufficient number on which to base an average
30-50 pass.	8	Steam, Hand, Spray & Hand	0.5-4.0	1.8	Steam	
Engines, various	15	Steam, Steam & Hand Vapor Degrease Spray	0.5-2.5	1.1	Vapor Degrease Spray	
Bulldozers	11	Steam, Steam, Hand & Spray	1.0-6.0	3.4	Steam Steam, Hand & Spray	
Graders	10	Steam Steam & Spray Steam, Hand & Spray	0.7-4.0	2.6	Steam	
Asphalt Pavers	5	Steam Steam & Chem. Add. Vapor Degreasing	1.0-5.0	2.1	Steam Steam & Chem. Add.	

Table E-1. Transportation and Construction Equipment Cleaning Survey (cont'd)

Maintenance Cleaning

Item	No. of Replies	Methods	Time Range Man-Hours	Ave. Time	Method Used for Minimum Time	Remarks
Truck Cranes	8	Steam, Steam & Spray, Steam, Hand & Spray	1.0-8.0	4.7	Steam Steam, Hand & Spray	
Locomotive cranes	3	Steam, Steam & Spray	4.0-10.0	---	Steam, Steam & Hand	Insufficient number on which to base an average
Portal cranes	3	Steam, Steam & Hand	4.0-16.0	---	Steam & Hand	Insufficient number on which to base an average
Ditchers, back-hoe	12	Steam, Spray, Steam, Hand & Spray, Steam & Chem. Add.	0.5-4.0	1.9	Steam & Chem. Add. Spray	
Fork lifts	9	Steam, Steam & Spray Steam, Hand & Spray	0.3-2.0	1.2	Steam Steam, Hand & Spray	

Table E-2. Transportation and Construction Equipment Cleaning Survey

Pre-Overhaul Cleaning

Item	No. of Replies	Methods	Time Range Man-Hours	Ave. Time	Method Used for Minimum Time	Remarks
SEDANS						
Sta. Wagons Pick-ups	6	Steam, Steam & Spray Steam & Hand	1.0-2.0	1.3	Steam, Steam & Spray	
TRUCKS						
1-5 tons	5	Steam, Steam & Spray	1.0-2.0	1.3	Steam, Steam & Spray	
BUSES						
16-30 pass	3	Steam, Steam & Spray	1.0-3.0	---	Steam, Steam & Spray	Insufficient number on which to base an average
30-50 pass	6	Steam, Steam & Spray	1.0-3.0	1.5	Steam, Steam & Spray	One report of 16 m-h omitted from average
Bulldozers	11	Steam, Steam & Spray Steam, Hand & Spray	1.0-6.0	3.6	Steam, Steam, Hand & Spray	One report of 36 m-h omitted from average
Graders	8	Steam, Steam & Spray Steam, Hand & Spray	1.0-4.0	2.8	Steam, Hand & Spray	
Truck Cranes	9	Steam, Steam & Spray, Steam & Chem. Dip, Steam, Hand & Spray	2.0-10.0	5.8	Steam & Spray	One report of 24 m-h omitted from average
Locomotive Cranes	3	Steam, Steam & Hand Steam, Chem., & "Other"	8.0-40.0	---	Steam & Hand	Insufficient number on which to base an average
Portal Cranes	3	Steam, Steam & Hand Steam, Chem. & "Other"	8.0-60.0	---	Steam & Hand	Insufficient number on which to base an average

Table E-2. Transportation and Construction Equipment Cleaning Survey

Pre-Overhaul Cleaning (cont'd)

Item	No. of Replies	Methods	Time Range Man-Hours	Ave. Time	Method Used for Minimum Time	Remarks
Ditcher, Backhoe	6	Steam, Steam, Hand & Spray	10.0-10.0	3.1	Steam	
Fork lifts 6,000 lb	8	Steam, Steam & Spray Steam, Hand & Spray Steam & Chem. Add.	0.5-3.0	1.4	Steam, Hand & Spray	

Table E-3. Transportation and Construction Equipment Cleaning Survey

Pre-Paint Cleaning

Item	No. of Replies	Methods	Time Range Man-Hours	Ave. Time	Method Used for Minimum Time	Remarks
Sedans Sta. Wagons Pick-ups	5	Steam Steam & Spray Hand & Power Sanding	0.5-2.0	1.2	Steam Steam & Spray	
Trucks 1-5 tons	5	Steam Steam & Spray Spray	1.0-2.0	1.7	Steam & Spray	
Trucks 5-10 tons	3	Steam Steam & Spray	1.0-4.0	---	Steam & Spray	Insufficient number on which to base an average
Trucks 10-20 tons	3	Steam Steam & Spray Sand Blast	1.0-4.0	---	Steam Steam & Spray	Insufficient number on which to base an average
Buses 16-30 pass	3	Steam Steam & Spray	1.0-4.0	---	Steam & Spray	Insufficient number on which to base an average
Buses 30-50 pass	7	Steam Steam & Hand Steam & Spray	1.0-4.0	3.3	Steam & Spray	
Bulldozers	5	Steam Steam, Hand & Spray	2.0-6.0	4.2	Steam Steam, Hand & Spray	
Graders	6	Steam Steam, Hand & Spray Steam & Chem. Add.	1.0-8.0	5.0	Steam, Hand & Spray	
Cranes	4	Steam, Steam, Hand & Spray	3.0-10.0	8.0	Steam, Hand & Spray	

Table E-3. Transportation and Construction Equipment Cleaning Survey

Pre-Paint Cleaning (cont'd)

Item	No. of Replies	Methods	Time Range Man-Hours	Ave. Time	Method Used for Minimum Time	Remarks
Ditcher	4	Steam Steam, Hand & Spray	1.0-10.0	4.5	Steam, Hand & Spray	
Fork lifts	5	Steam Steam, Hand & Spray	1.0-3.0	2.0	Steam, Hand & Spray	

NOTE: Some replies included the time required for operations such as sanding and priming. These have been omitted from the tabulation as a valid comparison could not be made with the times reported for pre-paint cleaning only.

Appendix F

NCEL SPRAY CLEANING TESTS

Table F-1. Transportation Equipment Cleaning

Table F-1. MCEL Spray Cleaner Tests

Transportation Equipment Cleaning

Item Cleaned	Cleaning Equipment	Cleaning Compound or Detergent Used	Water Temp.	Water Press psi	Nozzle Used	Time Req'd	Remarks
Pick-up Truck	Speed-Kleen	Soap concentrate	not heated	500		0.42 hr	Final results were good. Note 1.
Sedan, 4-door	Jet Kleen	Jet-Kleen #1 1 oz per gal diluted with #6 setting	cold	950	15° Fan	0.20 hr	Final results were good. Detergent was difficult to mix.
Sedan, 4-door	Jet Kleen	Jet Kleen #1 1 oz per gal diluted	cold	1,000	50° Fan	0.27 hr	Final results satisfactory. Some delay was caused by suction hose sticking to bottom of container.
Sedan, 4-door	Graco-Hydra-Clean Bulldog	Calla 301 2% solution	cold	900	40° Fan	0.19 hr	Good results.
Sedan, 4-door	Kleen King	Decon. powder 30 oz/16 gal diluted 10:1 in machine	cold	500		0.22 hr	Cleaning was satisfactory, but soap did not completely stop during rinse cycle.
Station Wagon	Kleen King	Turco 30 oz/20 gal concentrated solution		500		0.25	Unsatisfactory operation; soap not effective and concentrated solution was used. Suction hose kept losing its prime.
Pick-up Truck (cab over)	Jet Kleen	Jet Kleen #1 1 oz/gal diluted by #6 setting	cold	950	15° Fan	0.17 hr	Good results.
Ambulance	Kleen King	Jet Kleen #1	hot	500		0.17 hr	Very good results, but condition of paint & wax was good at start.
Bus	Graco-Hydra Clean Bulldog	Calla 301 0.2% solution	cold	1,000		0.25	Fair results -- road tar not removed.
Engine, Automobile	Speed Kleen	Emulsion cleaner used first; then soap concentrate	hot	500		0.16	Good results.

NOTE 1: Speed Kleen demonstration on pick-up truck included: (1) sprayed soap on truck; (2) rubbed over with hand mitt to remove flecks of tar; (3) spray cleaned with soap solution; (4) rinsed; (5) waxed by spraying wax solution. Waxing operation took about 5 minutes extra.

Table F-1. NCEL Spray Cleaner Tests (cont'd)

Transportation Equipment Cleaning

Item Cleaned	Cleaning Equipment	Cleaning Compound or Detergent Used	Water Temp.	Water Press psi	Nozzle Used	Time Req'd	Remarks
Engine, Automobile	Jet Kleen	None	Cold	1,000	15°Fan	not recorded	An oily film was left on engine; otherwise satisfactory results.
Engine, Automobile	Jet Kleen	Jet Kleen #2 1 oz per gal	Cold	1,000	50°Fan	0.13 hr	Good results.
Engine, Truck-Tractor	Jet Kleen	None	Hot (140°F)	1,000	50°Fan	not recorded	Excellent results.
Engine, Truck-Tractor	Kleen King	Decon. Powder 1 oz per gal	Cold	500		0.42 hr	Concentrate solution sprayed on; then washed with diluted solution and rinsed. Good results.
Engine, Bus	Graco-Hydra Clean Bulldog	Calla-301 1 oz per gal	Cold	1,000		0.13 hr	Fair results.
Engine, Auto. dismantled	Jet Kleen	Calla-301	Hot	1,000	50°Fan	not recorded	Poor results -- baked on oil was not removed.
Engine, Auto. dismantled	Jet Kleen	HP Liquid Cleaner	Hot	1,000	50°Fan	not recorded	Excellent results.
Engine locomotive	Jet Kleen	Aircraft cleaning comp. 1% solution	Hot (150°F)	500	50°Fan	0.5 hr	Excellent results -- oil film removed.
Engine locomotive	Jet Kleen	None	Hot	1,000	50°Fan	1.0 hr	Good results -- light oil film remained. Engine was warm when cleaned.
Truck, dumpster	Jet Kleen	Decon. Powder, 1 oz per gal		1,000	50°Fan	0.33 hr	Poor results, grease on hydraulic rams not removed.
Truck, dumpster	Jet Kleen	Decon. Powder, 4 oz per gal		1,000	50°Fan	0.33 hr	Poor results, grease on hydraulic rams not removed.

Appendix G

CLEANING OF MISCELLANEOUS ITEMS

Table G-1 Survey of Cleaning Miscellaneous Items -- Maintenance Cleaning

Table G-1. Survey of Cleaning Miscellaneous Items

Maintenance Cleaning

Item	No. of Replies	Methods	Time Range Man-Hours	Ave. Time	Method Used for Minimum Time	Remarks
Venetian Blinds	14	Steam, Hand, Chemical Dip, Spray, "Washomatic"	0.08-0.50	0.26	Hand, Chemical Dip "Washomatic"	
Loading Docks & Ramps	4	Hand, Spray	2.9-5.5	3.8	Hand	All times adjusted to 4,000 sq. ft.
Conveyors (roller)	3	Hand, Vapor Degrease	1.0-2.0		Hand	Adjust to 40 ft. length
Garbage cans 16 to 55 gal.	13	Steam, Steam & Hand Steam & Chem. Spray & Chem.	0.02-0.45	0.17	Steam	No adjustments made for size
Garbage containers, (Dumpsters, dinosaurs)	9	Steam, Steam & Hand Steam & Spray Spray & Chem	0.13-1.0	0.57	Spray & Chem.	Reported times of 3 min. and 2-4 hrs. discounted pending further information
Ventilation Filters	6	Steam, Hand, Chem. Dip, Hot Water	0.03-0.25	0.12	Hot Water	
Lawn Mowers	9	Steam & Hand	0.10-1.00	0.33	Hand	