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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Productivity Study of Hydroblast Removal of Coatings

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

in cooperation with
Halter Marine, Inc.

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PRODUCTIVITY STUDY OF HYDROBLAST REMOVAL OF COATINGS

PROJECT 3-96-4

FINAL REPORT

Prepared for:
National Shipbuilding Research Program
Panel SP-3

December 1998

OCEAN CITY RESEARCH CORP.
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EXECUTIVE SUMMARY

The purpose of NSRP Project 3-96-4 was to evaluate the productivity of and areas of hydroblast (water-jetting) removal of coatings on representative areas of a ship, such as the hull, non-skid decking areas, tanks, complex geometry using open and closed loop systems. The objectives of this multi-task, 24-month project was to compile supporting information regarding productivity data. During this study various tasks were undertaken and completed; a brief description of each task follows.

During this project, a review of current literature on water-jetting, and surveys to shipyard industries was performed. The literature search was performed in publications dedicated to the painting industry. This was done to determine a baseline of what to expect in the shipyard industry. The next stage was to canvass public and private shipyards in the United States to determine if they were currently using water-jetting to remove coatings. Shipyards which stated that they perform water-jetting at their yard were sent a survey with an enclosed postage paid envelope to facilitate the prompt return of the survey. The surveys provided information on the types of equipment used, types of vessels and coating systems water-jetted, production rates, removal specifications, down-time, manning levels, and how they dealt with flash rusting.

Another aspect of this project was to identify ships suitable for the project study. As ships operational and repair schedules are constantly changing, this was an ongoing process throughout the study. Shipyards which stated that they did use water-jetting during our initial canvassing were regularly contacted for upcoming work in order to schedule on-site inspections. Water-jetting contractors were also contacted to advise us of their upcoming work so that we could schedule on-site visits.

One portion of the study involved the determination of test procedures and standards for the evaluation of water-jetting. These procedures include surface cleanliness, surface contamination, coating removal rates, visual appearance, flash rust, and waste collection. In order to standardize each on-site visit, standard data sheets were developed. These data sheets covered three separate phases of each visit.

1. General Information - Prior to Blasting
2. Production Information
3. Surface Condition (After Blast) Information

"General Information" data encompassed initial surface cleanliness, coating condition, and contamination levels (measured as chloride and conductivity) on the coated surfaces. The number of coats and the thickness of these individual coats are determined, and a full DFT survey of the area was performed. Location of the blast was noted, and ambient environmental conditions are monitored. Extent of specified coating removal (i.e. selective stripping to a tightly adhered coating or spot blast corroded areas to bare metal and sweep) was also recorded.

"Production Information" entails information about the water-jetting equipment, (make and model of pumps and lances, operating flow rates, operating pressures and the number of orifices per gun nozzle) production rates, and manning levels required. Ambient air conditions/quality, waste handling and collection, and whether the system was open or closed were also documented in this section. ("Open cycle" systems refer to machinery that does not collect and treat the process wastewater. The water was usually treated locally or remotely and disposed of or released to a sanitary sewer. A "closed loop" system collects and treats the process wastewater and reuses it for the water-jetting process, and usually involves some type of automated, or semi automated equipment.)

The "Surface Condition Information" data evaluated the hydroblasted surface with respect to a number of conditions and factors, such as removal efficiency of contaminants. If partial removal of a coating system was specified, tensile adhesion tests were performed on the intact coating to determine the remaining coating integrity after having been water-jetted. If complete coating removal was specified or occurred in areas, extent of flash rusting was noted and evaluated. The overall effectiveness of the blast was also noted in this section. Ambient conditions and location of the blast, as well as the coating system to be applied over the hydroblasted area are recorded in this section.

In addition, Phase II involved the actual on-site removal tests to be performed on representative areas of the ship using different surface preparation standards. During this project eight separate visits were made to shipyards implementing water-jetting for coatings removal. One study was performed on an off-shore pumping station undergoing maintenance painting work where water-jetting was implemented for coating removal.

During these nine visits, productivity of water-jet coating removal was observed on various ship's structures. These areas include underwater hull, freeboard, non-skid decking, and internal tanks. During these on-site observations data was collected with respect to coating system and individual coating thickness in conjunction with productivity data (ft^2/hour/gun). The surface preparation specified (standard) has a direct impact on the observed productivity rates. Therefore productivity data was categorized into three separate surface preparation specifications (standards):

1. Selective stripping
2. Sweep and spot blast to bare metal
3. Coating removal to bare metal.

In organizing surface preparation specifications into these three categories, removal rates within the same category may be realistically compared between various on-site observations.

CONCLUSIONS:

Surface Profile

The high speed spinning action of the high and ultra-high pressure jetting water impacting on coatings can create a measurable surface profile in the existing coating. The resulting profile aids in subsequent coating adhesion. Throughout the study, we measured resultant "coating profile" and discovered that the water-jetting process, when using a spinning nozzle, can produce profiles in paint ranging from 1.7 to 4.4 mils, as measured using ASTM D-4417, Method C.

Coating Adhesion

Where possible, tensile adhesion of the coating system, both prior to and after water-jetting, was determined to assess any detrimental effects that water-jetting may have on remaining coating. The notion that during a "spot and sweep" blasting operation, the high and ultra-high pressure water impacting on aged coatings would in some way compromise existing adhesion, was tested. Interestingly, similar tensile adhesion values (as measured by ASTM D-4940) to initial adhesion resulted after sweep water-jetting. Generally, if the coating's adhesion was questionable, the high, or ultra-high pressure water would remove the weak coating. If the remaining coating was still intact and well adhered the jetting would merely profile the coating and the remaining coating would stay well adhered.

Factors Affecting Production Rates

Numerous factors can affect production rates in a water-jetting operation. The single most important factor is a combination of existing coating type and condition, coupled with the experience and organization of the crew. We noticed that experienced crews can work up to twice as productive as inexperienced crews, performing identical work. Similarly, removal of well-adhered high-build deck coating will not proceed with the speed of a thirteen-year old, degraded epoxy in a tank. The working configuration also plays an important role in affecting productivity. Jetting the cramped flat under-bottom of a ship is at least twice as slow as removing the same coating system on the flat vertical side of an underwater hull. Similarly, maneuvering inside a heavily stiffened internal tank can certainly slow down an operation.

Flash Rusting

Flash rusting is a factor which must be dealt with on practically all jobs encountered. When a coating is removed to bare metal, the resultant moisture in the air, coupled with any other contaminants that may settle on the surface, will create some degree of flash rusting. Depending on a number of factors, this "rust bloom" may grow in intensity with time. In such cases, if the coating specification requires it, the bloom will have to be removed with a secondary blast, followed immediately (after the surface dries) by coating. Inside tanks, the rusting problem can be significantly reduced by properly sized and placed ventilation, and by the use of dehumidification. A related problem exists with the use of common desiccant dehumidification, where the dry air is of significantly higher temperature of ambient, thereby adding to the heat stress of the workers. The use of refrigerant dehumidification should be explored in such situations.

With the closed loop machinery, the blast residue and water is vacuumed away immediately. Adding to this is an evaporative effect caused by the increased temperature of the substrate due to the kinetic energy of the pressurized water impacting the substrate. Flash rusting is not an issue in such situations. In such scenarios, we have witnessed the substrate remaining rust-free for several days, provided no rain or other contaminants foul the blasted surface.

Some coating systems will not tolerate rust blooming, whereas many are designed for be applied over flash rusting. In all ballast tank scenarios, the entire surface was "sealed" with a penetrating sealer type coating (either a moisture-cured urethane or an epoxy-ester) followed by two coats of barrier coating. Well written specifications with clear guidance on acceptable limits of flash rusting, and, how to correct such occurrences if they occur, are key for water-jetting jobs to progress smoothly. Education by all inspection parties, in interpreting flash rusting is also imperative.

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The assistance of the following individuals for the scheduling of on-site visits was key to the execution of this project: Mr. Guy Lever, Cavi-Tech, Inc.; Mr. Richard Dupuy, UHP Projects, Inc.; Mr. Roger Melton, United Coatings, Inc.; Mr. Darren Lutovsky, Puget Sound Naval Shipyard; Mr. Peter Santos and Guillermo Gallegos, Southwest Marine, Inc.; Mr. Milt Lindgren, Lindgren Associates, Inc.; and Mr. Robert Crain, Alabama Shipyard, Inc. The assistance of these persons was greatly appreciated.

The help and assistance of many individuals was received during this project which contributed to its successful completion. Individuals who assisted in the completion of industry surveys were: Mr. John Coll, Alabama Shipyard, Inc.; Mr. Steve Cogswell, Atlantic Drydock, Inc.; Bill Naunton, Baltimore Marine Industries (formerly BethShip, Inc.); Mr. Jack Smith, Deytens Shipyards, Inc.; Mr. Tom Beacham, Norfolk Shipbuilding and Drydock, Inc.; Mr. Will Camble, Southwest Marine, Inc.; Mr. Ken Leroy, Todd Pacific Shipyards, Inc.; Mr. Joel Korzun, Norfolk Naval Shipyard; Mr. Richard Rodrigues, Pearl Harbor Naval Shipyard; Mr. Darren Lutovsky, Puget Sound Naval Shipyard; and Mr. Roger Melton, United Coatings, Inc.

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1.0 INTRODUCTION

This technical report details work completed for the National Shipbuilding Research Program, Panel SP-3 (Surface Preparation and Coatings). The project, designated #3-96-4, is titled "Productivity Study of Hydroblast Removal of Coatings". Ocean City Research Corporation (OCRC), a wholly owned subsidiary of Corrpro Companies, Inc., performed this study under contract to Halter Marine, Inc. (P.O. 2210 of May 28, 1998). Halter Marine is managing the project under Navy contract N00167-97-2-0010.

The intent of the study is to provide the shipbuilding and ship repair industry, commercial ship owners, and the U.S. Navy with an assessment of the productivity of closed and open-cycle hydroblasting technology when used for the removal of coatings in representative areas of a ship, such as the outer hull, inside tanks, non-skid weather decks, and surfaces with complex geometry. The productivity data gathered in this study can be used by ship owners and planners in assessing the cost-effectiveness of incorporating hydroblasting as a means of coating removal in various areas of shipbuilding and ship repair. Completion of this effort will provide the end user with a technically sound basis for incorporating a potentially cost effective method of coating removal in place of expensive abrasive grit blasting.

2.0 TECHNICAL NOTE

For the purposes of this report, the term “hydroblasting” in the abstract is used to connote the removal of coatings by using high pressure or ultra-high pressure water. The current SSPC-SP 12/NACE 5 standard on water-jetting (prepared by NACE/SSPC Joint Task Group D on Surface Preparation by High Pressure Water-Jetting) uses the term “water-jetting” to connote coating removal by water at pressures above 10,000 psi. To remain consistent with the NSRP SP-3 Project title, the terms “hydroblasting” and “water-jetting” will be used interchangeably throughout this report.

The SSPC-SP 12/NACE 5 standard describes High Pressure Water-Jetting as “cleaning performed at pressures from 70 to 170 MPa (10,000 to 25,000 psi)” and Ultra High Pressure Water-Jetting as “cleaning performed at pressures above 170 MPa (25,000 psi).”

3.0 PROJECT ABSTRACT

NATIONAL SHIPBUILDING RESEARCH PROGRAM
SNAME SHIP PRODUCTION COMMITTEE
SP-3 SURFACE PREPARATION AND COATINGS

3-96-4

Title: PRODUCTIVITY STUDY OF HYDROBLAST REMOVAL OF COATINGS

Objective: Demonstrate and document the use of closed and open cycle hydroblasting for the removal of various coatings in representative areas of a ship, such as hull, non-skid areas, tanks, and surfaces with complex geometry.

Background: Traditional coating removal by abrasive blasting is rapidly being restricted by environmental constraints. Hydroblasting has come to the forefront, offering many advantages over abrasive blasting.

Technical Approach

Phase I

- Task 1. Review shipyard and related industry use of hydroblasting.
- Task 2. Identify a ship(s) suitable for the project study.
- Task 3. Determine test procedures and standards for surface cleanliness, surface contamination, coating removal rates, visual appearance, air quality, flash rust, and waste collection.
- Task 4. Document type and thickness of coating to be removed.

Phase II

- Task 1. Conduct coating removal tests on representative areas of the ship using different surface preparation standards.

Phase III

- Task 1. Report writing.

Estimated Time: 2 years

Benefits:

1. Provide documented performance data on hydroblasting.

Deliverables:

1. Progress reports at all panel meetings.
2. Interim technical reports.
3. Implementation recommendations and plan.
4. Final report.

4.0 WORK PERFORMED

4.1 PHASE I SUMMARY

4.1.1 Review Of Shipyard And Related Industry Use Of Hydroblasting (Task 1)

During Task I, twenty-four shipyards were contacted via written survey (see Appendix A), eighteen private and six public. Of these twenty-four, half (twelve) stated that they were currently using hydroblasting (ultra-high pressure water jetting) to remove coatings from ships. All twelve of these shipyards were sent a survey in pre-paid mailers to complete and return to Ocean City Research.

Survey questions focused on the following issues:

- Types of equipment used and manufacturer of equipment
- Types of ships and structures prepared using hydroblasting
- Performance and Q.A. specifications followed
- Typical production rates achieved
- System reliability and manpower needs
- Types and thickness of coating systems removed and applied
- Performance history of applied coatings
- Experience with flash-rusting and use of corrosion inhibitors, if any.

Eleven survey responses (of the twelve shipyards that perform hydroblasting) were received. After review of these surveys only one seemed to be unfavorable to hydroblasting. Answers/responses to the questions of the survey varied but a general consensus could be made. For a table summarizing each shipyard's response, see Appendix B.

The shipyards either performed their own in-house hydroblasting, or sub-contracted work to contractors whom specialize in hydroblasting for coating removal. Shipyards that performed their own work, tend to own their hydroblasting equipment, rather than rent it. The manufactures reflected in the survey were Flow International, Woma, Geoquip and Jet Edge, although several other manufacturers of equipment do exist. Most of these systems are operated as open-cycle, however some of the equipment was set up so that the effluent from the process was directed to drydock sumps and/or holding tanks, analyzed, and sent to the sewer.

A broad range of ships and structures were reported as having been hydroblasted. The majority of ships in the commercial industry are tankers, cruise, cargo and fishing vessels. Typical government ships are Navy combatants, aircraft carriers, submarines, MSC, MARAD and Coast Guard vessels. Typical structures in or on ships that are hydroblasted were reported as decks, outer hulls, internal ballast tanks, storage tanks, fuel tanks, valves and pumps.

There was no common standard that every shipyard followed for hydroblasting, however most of the shipyards were familiar with SSPC-SP 12/ NACE 5 "Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-high-Pressure Water Jetting Prior to Recoating", and International Paint Co.'s Hydroblasting Standards. (The SSPC-SP 12/NACE 5 is a surface preparation standard that describes four visual conditions of coating removal, and three conditions of non-visible surface contamination. The International Standards visually describe varying degrees of flash rusting on different grades of steel that has been water jetted.)

According to the shipyards surveyed, hydroblasting is used for complete coating removal, as well as to remove loose coatings and corrosion products ("touch-up and repaint" situations). There is a wide range of the types of coatings removed. Some typical responses were epoxies (10-20 mils), alkyds (15-20 mils), underwater hull systems w/anti-fouling (20-30 mils). Productivity of coating removal varied depending on type, condition and extent of removal of coating. Generally complete coating removal ranged from 50 to 100 ft^2/hour/man and partial removal ranged from 100 to 250 ft^2/hour/man. Rates for closed-cycle machinery were reported to be 270-340 ft^2/hr during actual blasting time, however rates were not as high when maintenance down-time (reported as 23% of production time) and equipment problems and maneuverability are factored in.

As production rates varied from one shipyard to another so did the down-time/reliability rates of the hydroblast equipment. Some shipyards indicated a loss of productivity due to large down-times, but generally most yards experienced about 1 to 1.5 hours down-time per shift. Some shipyards were able to have even lower down-times possibly due to routine maintenance checks between shifts. Production rates for open-cycle blasting were reported generally lower than the typical benchmark of 200 ft^2/hr/nozzle for open abrasive blasting. Respondents to the survey also felt that down-times of the hydroblasting equipment might be higher than abrasive blasting, however the majority of the of the responses indicated the two balanced themselves when time for clean up and disposal of abrasive was taken into account.

A typical blasting crew of 1 pump operator with 2 blasters seemed consistent with most shipyard responses. Along with blasting crew, the types of coatings applied over the hydroblasted surfaces were consistent. They consisted of surface tolerant epoxies and under-water hull anti-foulants, offered by some of the more well known marine coating supplies, such as Devoe Marine, Sigma, Ameron, International, and Hemple.

One common problem that most all shipyards have encountered was flash-rusting, since none of the shipyards reported using rust inhibitors in their blast water. To solve this problem they re-blast the surface at a lower pressure prior to coating. Other problems associated with hydroblasting noted in the surveys other than production rates and down-times were:

- water containment/run-off and treatment
- edge feathering, sweeping
- no new surface profile on steel
- small window of time between blasting and coating.

Despite these problems the survey respondents felt that water-jetting is becoming accepted in the ship repair industry, however they do not think that the technology will totally replace abrasive blasting. Rather, they tend to think of it as one more tool that will aid in coating removal. A listing of the shipyards that were originally contacted for this survey is presented in Table 1. If the contacted shipyard indicated that they did not incorporate hydroblasting for coatings removal, they were not sent a survey.

Table 1:

SHIPYARDS CONTACTED NSRP 3-96-4 PRODUCTIVITY OF HYDROBLASTING STUDY (Phase I)			
SHIPYARD CONTACTED	HYDROBLASTING PERFORMED?(yes/no)	DATE SURVEY SENT	DATE RETURN SURVEY RECEIVED
Alabama Shipyard	yes	November 1, 1996	November 15, 1996
Atlantic Drydock Corp.	yes	November 1, 1996	November 18, 1996
Avondale Industries	no		
Bath Iron Works Corp.	no		
BethShip	yes	November 1, 1996	November 7, 1996
Detyens Shipyards	yes	November 1, 1996	December 5, 1996
Earl Industries Inc.	yes	November 1, 1996	November 12, 1996
Electric Boat Division	no		
Ingalls Shipbuilding	no		
McDermott Shipyards	no		
Metro Machine	no		
NASSCO	no		
NORSHIPCO	yes	November 1, 1996	November 11, 1996
Southwest Marine - San Diego	yes	November 1, 1996	None Received
Southwest Marine - Terminal Island	yes	November 1, 1996	November 8, 1996
Tampa Shipbuilding	no		
Texas Drydock	no		
Todd Pacific Shipyards	yes	November 1, 1996	November 11, 1996
Portsmouth NSY	no		
Norfolk NSY	yes	November 1, 1996	November 7, 1996
Puget Sound NSY	yes	November 1, 1996	February 24, 1997
Pearl Harbor NSY	yes	November 19, 1996	December 16, 1996
Trident Refit-Bangor	no		
Trident Refit-Kings Bay	no		

Review of Literature **-**

Review of related trade publications, such as *Journal of Ship Production, Journal of Protective Coatings and Linings,* and *Materials Performance* revealed that there is a steadily increasing interest in water-jetting for the shipbuilding and ship repair industry over the past few years. Water-jetting equipment is also used in the pipeline industry for coating removal[1], as well as in hydrodemolition of concrete in the building and general construction trades.[2]

Other informative articles discuss case histories of successful lead based paint removal efforts where water-jetting was selected over other more established technologies.[3,4] Associated with lead based coating removal is the concern for waste stream containment. A recent article discussed the use of configuring an otherwise open-cycle water-jetting operation into a contained, closed cycle system for environmentally sensitive operations.[5] Other articles [6,7] discussed the merits of a U.S. Navy-developed fully contained robotic ultra-high pressure coating removal system.

Two articles[8,9] discussed the recent technological advancements of water-jetting, which have contributed to more efficient removal rates and less maintenance downtime. Another article[10] discussed how ultrahighpressure water-jetting is becoming more accepted due to environmental benefits, improved industrial hygiene and surface preparation.

A technical guide[11] distributed by Hammelmann discussed the operating parameters necessary to achieve the various water-jetting standards. This guide discussed how to achieve surface conditions defined per the SSPC-SP 12/NACE 5 joint standard and STG Guide No. 2222, as well as visual standards produced by various paint manufactures.

The use of visual standards to evaluate hydroblasted surfaces[12] and coating performance over surfaces prepared by varying wet blasting methods (including ultra-high pressure water-jetting) are included in the literature.[13] Several other articles have been written concerning the use of water, in combination with other abrasive media (such as baking soda and mineral abrasives) as an alternate to grit blasting in the shipbuilding industry. These technologies, also promising alternatives, do not fit within the scope of NSRP 3-96-4, and are not included in this study.

4.1.2 Identification Of Candidate Ships Suitable For This Study (Task 2)

From Phase I, Task 1 surveys, a group of hydroblasting contractors and shipyards were identified as willing participants in this study. Until the completion of this project, the task of identifying suitable ships for this study was an on-going process. Ocean City Research engineers made nine trips to eight different locations with ongoing hydroblasting work. USS DULUTH (Austin Class, LPD 6) was visited on two occasions, once for freeboard and underwater hull hydroblasting, the second visit for ballast tank blasting. The Double Eagle Hull 684 was observed for selective stripping of the anti-fouling. USS La MOURE COUNTY (LST 1194) was observed during the removal of the freeboard coating system. The flight deck non-skid removal on USS CARL VINSON (CVN 70) with a Navy-developed closed-looped system was next observed. The removal of freeboard and underwater hull paint was observed on the Sea River Wilmington, a tanker from Exxon's fleet, using a proprietary closed-loop system from the German manufacturer, Hammelman. USS CLEVELAND (LPD 7) was visited while in drydock and undergoing ballast tank work. Other visits included Alabama Shipyard to observe the spot and sweep removal of shop primer on a chemical tanker during new construction and to an off shore oil pumping station to observe the blasting of the platform's exterior shell and internal tanks.

1., 2. A.W. Momber, "Decoating, Cutting, and Recycling Pipeline Elements with Waterjetting", JPCL, May 96, pp 20-26.
3. A.K. Marshall, "Lead Removal with Waterjetting", JPCL, Feb 1996, 47-51.
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11. "Achieving Surface Preparation Standards by Waterjetting", JPCL, Feb 1998, 37-43.
12. D. Gilbert, "New Hydroblasting and Slurryblasting Standards Issued", JPCL, Jan 1995, 64-69.
13. I.R. van der Kaaden, "Wet Blasting Studied to Replace Dry Blasting in Netherlands Shipyards", JPCL, May 1994, 79-86.

4.1.3 Determination Of Test Procedures And Standards For Evaluation Parameters (Task 3)

During production runs of the various hydroblasting equipment, various parameters were evaluated. These evaluations will constitute the major effort of the program. The parameters, and methods of evaluation are described below. Standardized data collection forms were made to record such data while performing field evaluations. Three standard data forms were made; a "General Information" form (to be completed prior to blasting), a "Production Information" form (completed during blasting), and a "Surface Condition Information" form (to be completed after blasting). Blank sample forms are included in Appendix C.

Test Procedures and Standards for Surface Contamination - Prior to each "production run" an evaluation, initial surface contamination, was determined and documented whenever possible. In most cases initial values were determined. However, sometimes accessibility to the area prior to blasting was not possible, or the existing condition of the surface (dirt or anti-fouling coating) did not permit proper adhesion of the sample cells to allow for sampling. Two types of surface cleanliness measurements were performed; chloride ion concentration and surface conductivity. Surface chloride contamination was measured via the "Chloride Analysis According to Bresle" method. The second surface sampling was performed using the same Bresle method with deionized water as extraction fluid and analyzed for conductivity. Both measurements were taken again after the hydroblasting had taken place, in order to determine surface contaminant removal efficiency. Chloride measurements do not take into account effects of other possible contaminants present such as sulfates and oxides of nitrogen, therefore the additional conductivity measurement provides a more complete measurement. Chloride measurements are very important since they have been identified to be a major contributor to premature coatings defects caused by ionic contamination. Results are tabulated (reported as $\mu g/cm^2$) and compared to the SSPC-SP 12/NACE 5 joint standard on water-jetting and classified as to surface contamination level ("SC-1", "SC-2", or "SC-3".) If the steel contains pitted and un-pitted sections, measurements were taken over both types of surfaces, to evaluate effectiveness of contamination removal inside pits.

Test Procedures and Standards for Surface Cleanliness - A set of initial 35 mm photographs (general view and macro) were taken prior to hydroblasting. At the time of this study, International Paint Co. published the only available visual cleanliness standards for bare hydroblasted steel. The SSPC-SP 12/NACE 5 joint standard contains verbiage on four water-jetting conditions of cleanliness. The surfaces were evaluated visually by both the International Paint and the SSPC/NACE standards and tabulated. A final set of photographs were generally taken after surface preparation. (At the time of publication of this report, SSPC-VIS 4 (I) NACE N$^{o.}$ 7 was just released. This publication mirrors the International visual standards.)

Test procedures for Coating Removal Rates - For all surface configurations (outer hull, tanks, non-skid decks, etc.) removal rates were measured in terms of ft^2/hour/blaster. Where applicable, an entire shift of work was monitored, with data being gathered for actual time blasting as well as equipment down time, worker breaks, and equipment movement. Coating removal rates are therefore be reported as production rates factoring in down time and the percent of actual nozzle on time.

Test Procedures for Visual Appearance - See above section on evaluation of surface cleanliness.

Test Procedures for Air Quality - During all observed hydroblasting, we had a thermo-hydrograph recorder on-hand. This device is compact and provides a real-time ink-pen chart recording of ambient temperature and ambient relative humidity. These parameters, in conjunction with substrate temperature, provide necessary information when evaluating and interpreting flash rusting occurrences, especially inside tanks, where humidity levels approach 100% during blasting.

Evaluation of Flash Rust - All open-cycle devices were expected to cause varying levels of surface flash rusting, due to the increased time that water is in contact with the steel surface, as compared to closed-loop devices. The closed-loop devices tend to vacuum up the water quick enough so that flash rusting is a rare occurrence. The flash rusting was evaluated twice; initially after coating removal, and directly prior to subsequent paint application. This remains consistent with procedures outlined in the International Paint Co.'s Hydroblast Standards. The degrees of flash rusting are photographed, and evaluated per International's standards.

Waste Collection - Most ultra-high pressure hydroblasting devices operate with water rates up to 10.0 gallons/minute. The closed-loop machinery either purifies the water (separating out the paint debris) and recycles the process water back into the blasting stream, or purifies the water so that it can be safely discharged into the sewer system. In either instance, the only waste to be collected is the actual paint debris from the hull. Open-cycle machinery, on the other hand, typically has a waste stream consisting of process water and paint debris which may or may not be hazardous (as defined by 40 CFR 261.24). Pending analysis, the waste must be transported to a treatment and disposal facility. (90 day on-site accumulation is also an option, pending appropriate EPA approvals.) Waste collection and treatment methods were documented and reported for each hydroblasting instance observed.

The above mentioned procedures and standards for evaluating surfaces before and after hydroblasting were broken down into three categories:

General Information - Prior to Blasting
Production Information - During Blasting
Surface Condition Information - After Blasting.

(Information for each category collected in the field was recorded on separate data sheets. These data sheets are included in Appendix D.)

4.1.4 Type And Thickness Of Coating To Be Removed (Task 4)

Coating type and thickness has a great impact on water-jetting equipment productivity and effectiveness. For that reason, each selected area had a dry film thickness (DFT) survey performed prior to coating removal to assess thickness of the paint system. Several thickness measurements were made using a "Positector 6000 FN2" electronic thickness gage. This gage is capable of determining statistical values (such as maximum reading, minimum reading, average, and standard deviation). Random Tooke Gage measurements were taken to determine number of coats and relative thickness of each coat. SSPC PA 2 was employed where possible and practical such as on the outer hull and inside tanks. Results of the overall coating system thickness can be located in Appendix D for each visit. The following table summarizes the thickness of each coat for a given system with the appropriate vessel and removal specification.

Table 2:

Type and Thickness of Coating to be Removed		
Location	**Coating System (Topcoat-→ Primer)**	**Removal Specification**
USS DULUTH, Freeboard	Gray alkyd (12 mils) / Gray epoxy, 151 (10 mils) / Green epoxy, 150 (6 mils)	Remove gray alkyd to gray epoxy 151
USS DULUTH, Underwater Hull	Red ablative (mostly gone) / Black ablative (mostly gone) / Red 121 (2-3 mils) / Buff epoxy (8 mils) / Red epoxy (6 mils)	Removal of all anti-fouling system down to buff epoxy
Double Eagle Hull, Underwater Hull	Red ablative (10 mils) / Black ablative (6 mils) / Red ablative (6 mils) / Gray epoxy (5 mils) / Red epoxy (5 mils)	Removal of all anti-fouling system to sound gray epoxy
USS LaMoure County, Freeboard	Six coats of silicon alkyd (3-4 mils per coat) / Gray epoxy, 151 (6-8 mils) / Green epoxy, 150 (6-8 mils) / Inorganic zinc primer	Removal of all organic coating systems to inorganic zinc
Trinmar, Exterior Shell	Orange topcoat (5 mils) / Gray (5 mils) / Black (2 mils) / Metallic primer (2 mils)	Removal of orange, gray and black down to intact primer
USS DULUTH, Ballast Tank	Blue MIL-P-23236 epoxy (4 mils) / White MIL-P-23236 epoxy (4 mils)	Spot blast corroded areas to bare metal, sweep blast all other surfaces
USS Cleveland, Ballast Tank	White, 152 epoxy (4 mils) / Gray, 151 epoxy (3 mils) / Green, 150 epoxy (3 mils)	Spot blast corroded areas to bare metal, sweep blast all other surfaces
Dannebrog Hull 47, Underwater Hull	One coat of pre-construction primer (0.67 to 1.8 mils)	Remove all damaged coating to bare metal, sweep blast all other surfaces
Trinmar , Tanks 16 & 19	Gray epoxy (10 mils) / Pre-construction primer (2 mils)	Spot blast corroded areas to bare metal, sweep blast all other surfaces
USS Carl Vinson, Flight Deck	Non-Skid matrix / Primer	Remove nonskid system down to bare metal.
Sea River Wilmington, Freeboard	Black modified chlorinated rubber (6 mils) / White epoxy (7 mils) / Red epoxy (4 mils)	Remove entire system down to bare metal
Sea River Wilmington, Underwater Hull	Red ablative (8 mils) / Black ablative (5 mils) / White epoxy (8mils) / Red epoxy (3 mils)	Remove entire system down to bare metal

4.2 PHASE II: Conduct Coating Removal Tests On Representative Areas Of The Ship Using Different Surface Preparation Standards.

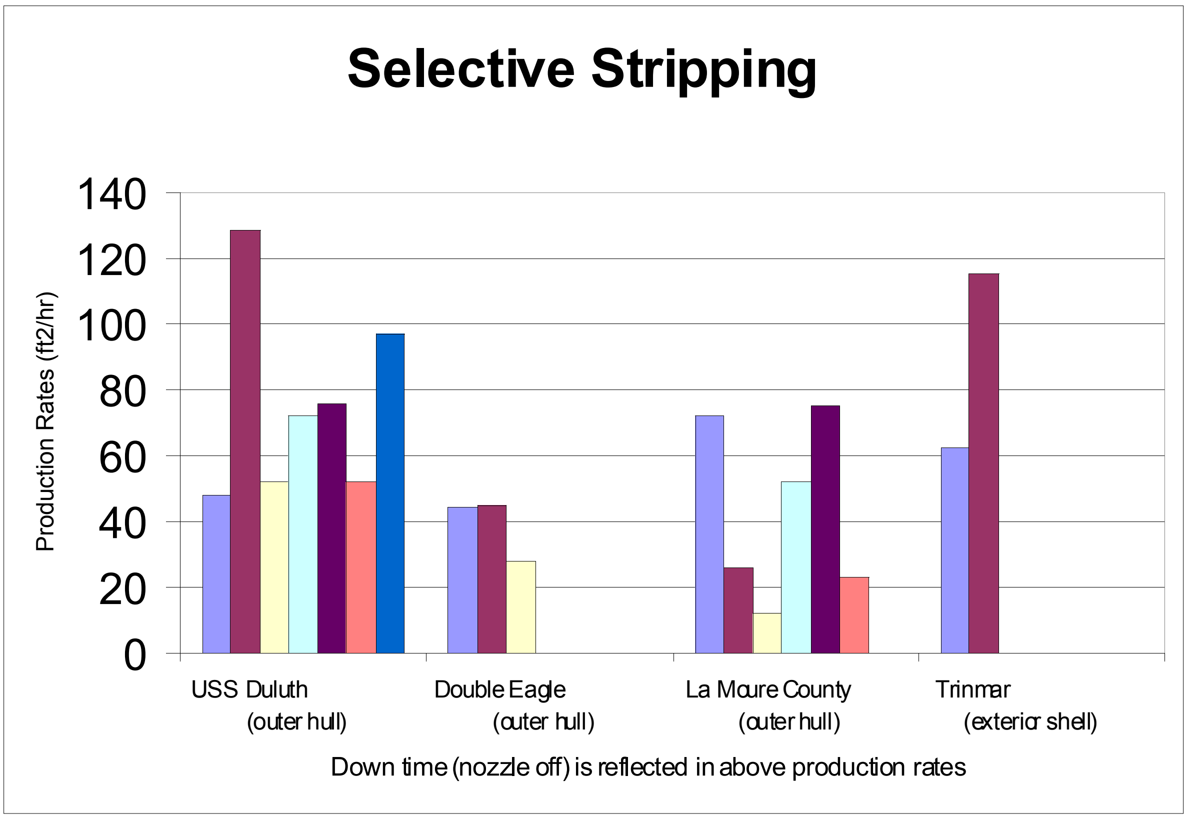
This phase summarizes key production data elements gathered on eight separate visits to ships undergoing repair pier-side, in dry dock, in new construction and one operating offshore pumping station. Data on various hydroblasting scenarios were gathered. Scenarios differed from type and thickness of coating, to equipment type, to type of removal specified. On-site visits ranged from one to three days, in order to obtain the most data during actual hydroblasting per trip. Production runs (where ft^2/hr data is computed) ranged from one hour to eight hours, depending on the dynamics of the situation. *Down time (nozzle off) is reflected in the production data presented, in order to portray more useful numbers to the reader. For example, if a certain crew can remove coatings at a rate of 300 ft^2/hour, for only thirty minutes at a time before their equipment needs thirty minutes of maintenance, then their true production rate are expressed as 150 ft^2/hr*

Detailed summaries for each individual visit are also included at the end of this section. These summaries include information on production rates, surface contamination, equipment statistics, surface preparation specifications, existing system coats and thickness, manning levels, new coating systems, flash rusting, effectiveness of blast, and waste handling**.**

4.2.1 Production Rates for "Selective Stripping"

Graph 1 represents production rates for structures that received a partial coating system removal down to a specified "tightly" adhered coating. All coating removal was performed using open cycle, hand-held lances.

Graph 1:



The first grouping of data (Graph 1), labeled "USS Duluth" contains seven production runs. The first six are for freeboard coating removal of ~ 12 mils of gray silicone alkyd down to an intact anti-corrosive epoxy (Navy F-151). The last production run in this group represents the removal of a 3-coat anti-fouling layer down to the topcoat of anti-corrosive epoxy on the underwater hull. Production rates ranged from 48 ft^2/hour/gun to 128 ft^2/hour/gun with an average of 85 ft^2/hour/gun.

The second group, "Double Eagle" contained three production runs. The coating removal specified was to remove all three coats of anti-fouling (17 mils total) down to sound gray anti-corrosive epoxy on the underwater hull. This observation was performed during new construction; the anti-fouling had started to delaminate from the anti-corrosive layer prior to immersion. Production rates ranged from 28 ft^2/hour/gun to 45 ft^2/hour/gun with an average of 39 ft^2/hour/gun.

The third group of data represents production rates observed on USS La Moure County. The removal specified was to remove all alkyd (approx. 6 layers @ 3-4 mils each) and epoxy coatings (2 coats @ 6-8 mils each) down to the inorganic zinc primer on the freeboard areas. Production rates ranged from 12 ft^2/hour/gun to 75 ft^2/hour/gun with an average of 43 ft^2/hour/gun.

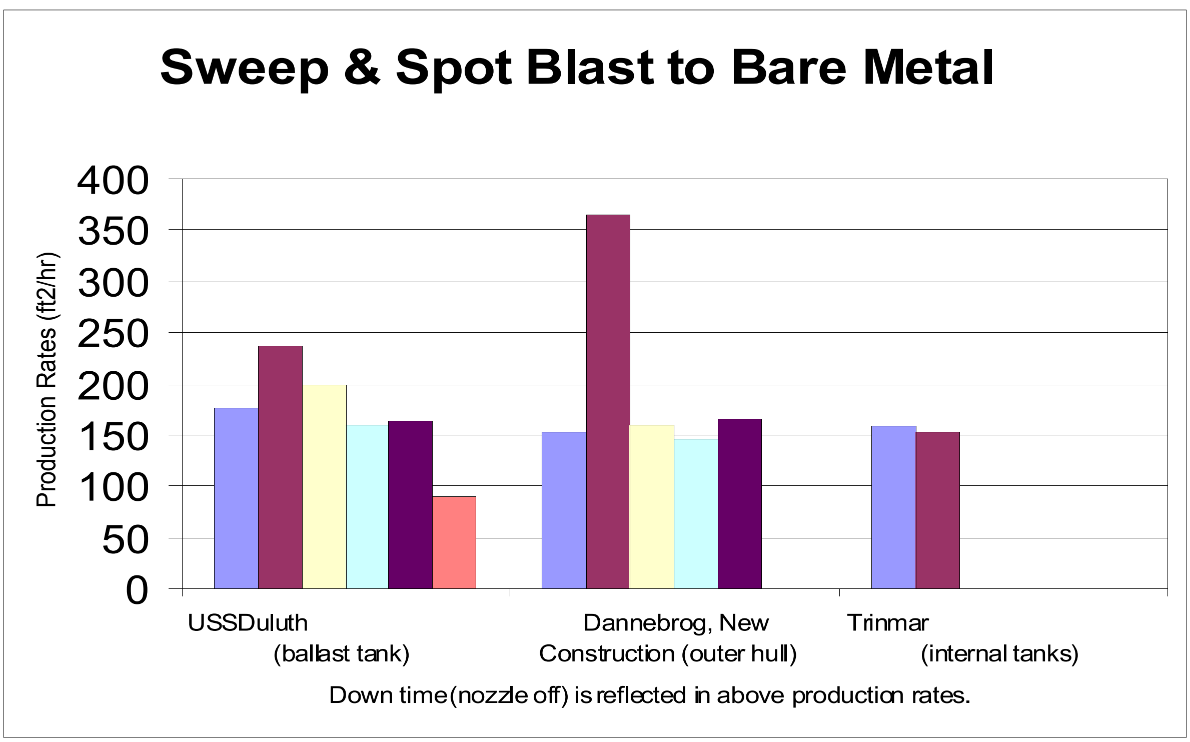
The final group of data on Graph 1 were the production rates observed from the exterior shell of the Trinmar offshore pumping station. The removal specified for the exterior shell was to selectively strip the painted surface down to intact primer, and remove all corrosion products down bare metal. The coating system for the exterior shell consisted of four coats: primer (~2 mils), black intermediate (~2 mils), gray (~5 mils) and orange top-coat (~5 mils). For this outer shell area about 12 mils of coating were selectively stripped. The production rates for the exterior shell ranged from 63 to 115 ft^2/hour/gun (average 89 ft^2/hour/gun).

Note that the production rates for selective stripping are somewhat similar for the removal of the freeboard system on the Duluth and the La Moure County as well as the exterior shell of the Trinmar pumping station. The lower observed productivity levels on the Double Eagle hull were chiefly due to worker orientation. In all other outer hull trials, workers were standing up, usually working from a high-lift, and blasting perpendicular to a vertical hull. On the Double Eagle, the blasters were removing coating on the cramped underbelly. They were sitting down, holding the guns vertically or at an angle toward the horizontal surface overhead. The low docking blocks created a cramped situation for the workers, resulting in lower productivity.

4.2.2 Production Rates for "Sweep and Spot Blast To Bare Metal"

Graph 2 represents production rates for removal involving a sweep and spot blast to bare metal. The sweep blast was intended to stress the coating system leaving only tightly adherent paint remaining. Corroded areas were spot blasted to bare metal. All coating removal was performed using open cycle, hand-held lances. Production data for the USS Cleveland is not included in the "Sweep and Spot Blast" graphs due to the low production (ft^2/hr) rates observed because of new blaster training during our on-site visit. Including this data would have skewed the results and realistic numbers for this type of preparation would not have been presented. However, production rates observed from USS Cleveland were reported in the on-site visit summary (section 4.7.7).

Graph 2:



The first group of data (Graph 2), "USS Duluth (ballast tank)" were production rates from the hydroblasting of ballast tank 8-84-4-W. The specification for the blasting of this tank was to spot blast to bare metal all corroded areas and sweep blast all other areas in order to remove staining, and provide a clean, profiled surface for subsequent coating adhesion. This ballast tank had a two-coat MIL-P-23236 epoxy system, averaging 9.8 mils DFT. Production rates ranged from 90 ft^2/hour/gun to 236 ft^2/hour/gun with an average of 171 ft^2/hour/gun.

The second group of data represents the production rates observed for the removal of damaged shop primer on the outer hull of the Dannebrog Hull 47 chemical tanker during new construction at Alabama Shipyard. The specified blast was to sweep blast the entire painted surfaces and remove any damaged areas down to bare metal (i.e. charred areas from internal welding, areas damaged by scraping, handling and erection joints). The shop primer ranged from 0.5 to 2.0 mils DFT. Production rates ranged from 146 to 365 ft^2/hour/gun with and overall average of 198 ft^2/hour/gun.

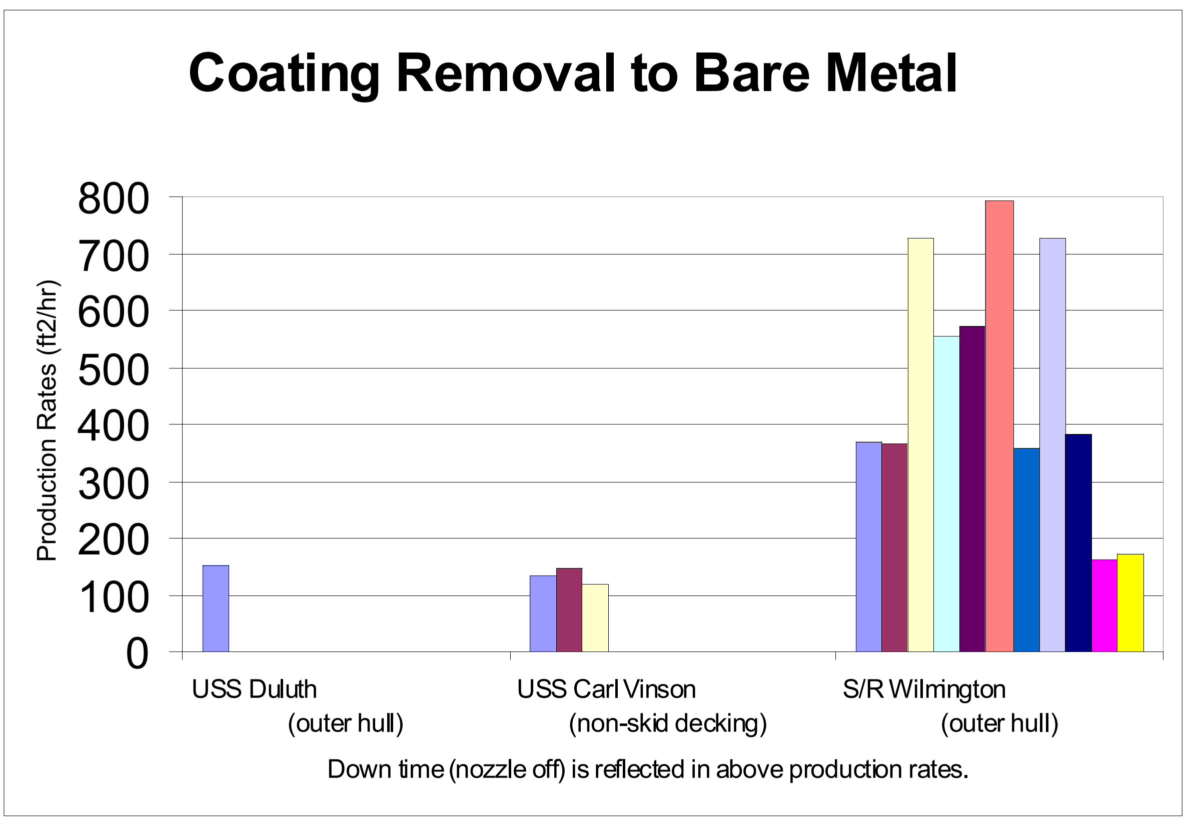
The final group of data on Graph 2 were the production rates observed from the internal tanks of the Trinmar offshore platform. The coating system for the tanks consisted of only two coats: epoxy primer (~1 mil), epoxy topcoat (~10 mils). The average production rate for the spot and sweep blast inside of the tanks was 157 ft^2/hour/gun.

Note the higher (compared to selective stripping, Graph 1) production rates when a specification called for a "spot and sweep," as in the case of the Duluth (ballast tank)**,** Dannebrog and the Trinmar (internal tank) data. Also note that the majority of production rates for these (three) spot and sweep observations achieved values around the 150 ft^2/hour/gun mark, fairly consistent for three separate scenarios.

4.2.3 Production Rates for Coating Removal To "Bare Metal"

Graph 3 represents production rates for areas on the ship where total coating system removal down to bare metal was either specified, or required due to prior corrosion and coating failure.

Graph 3:



The first group of data (Graph 3), "USS Duluth (outer hull)" contains only one production run where coating was removed to bare metal. The anchor chain damaged an area of the underwater hull and all coatings in the area were specified to be removed. This system included three coats of anti-fouling (~3 mils remaining), and two coats of anti-corrosive epoxy (~ 14 mils DFT). The production rate for this area was 152 ft^2/hour/gun.

The next data grouping, "USS Carl Vinson" contains three production runs all of flight deck non-skid removal, using the Navy's Pratt & Whitney fully closed-loop system. The specification called for an SSPC SP-10 near white metal blast. The decking material consisted of a 3-4 mil epoxy primer under a thick (up to 150 mils) non-skid matrix of epoxy and aluminum oxide grit. Production rates ranged from 121 ft^2/hour to 146 ft^2/hour with an average of 134 ft^2/hour.

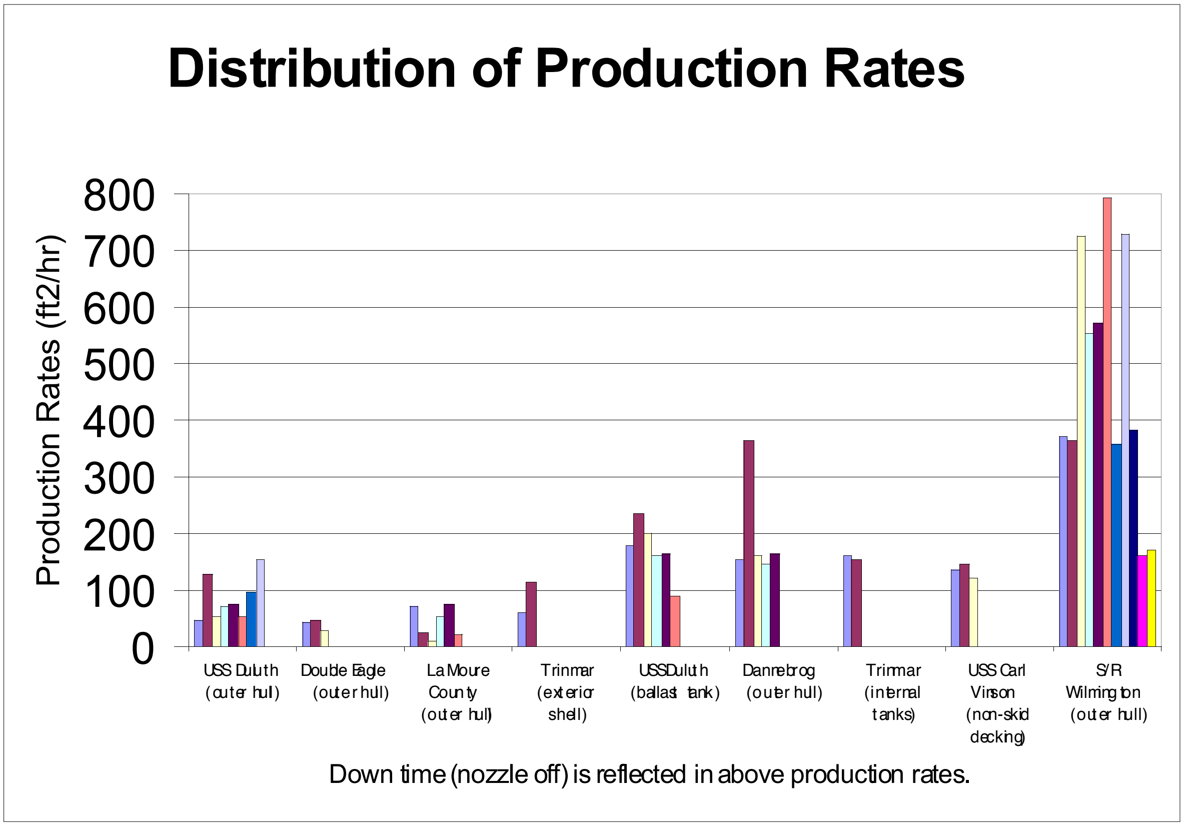
The final group, "Sea River Wilmington" contains eleven production runs for coating removal using the Hammelmann Dockmaster, a self contained open cycle machine, which treats the water on-site, however discards the treated water to the river, as opposed to reusing/recycling the water. The entire freeboard coating system [one coat modified chlorinated rubber (~5 mils) and two coats of anti-corrosive epoxy (~11 mils total)] was to be removed completely to bare metal. About the first twelve feet of the underwater hull area directly under the freeboard area was also removed down to bare metal. This system consisted of two coats of ablative anti-fouling (totaling ~14 mils), and two coats of anti-corrosive epoxy (totaling ~11mils). In both the freeboard and underwater hull areas 100% removal of the red anti-corrosive epoxy was not achieved, however. From 5% to 20% traces of a red primer residue still remained after blasting. Production rates ranged from 162 ft^2/hour to 792 ft^2/hour with an average of 471 ft^2/hour.

A fourth set of data for coating removal down to bare metal would have been included (in Graph 3), however production work was completed just prior to our scheduled visit. We were able to obtain data from the contractor (UHP Projects) regarding coating removal rates. A summary of additional information gathered from the contractor is presented in section 4.7.10 of this report. UHP Projects used Flow International's "HydroCat" to remove all coatings from the freeboard areas of the USS Ashland (LSD 48). These Hydrocats are operator remote controlled units that can attach themselves to vertical surfaces such as ship hulls using vacuum suction. This vacuum suction also removes wastewater and paint debris away from the blasted surface. Their observed production rate was 280 ft^2/hour/machine for the complete removal of approximately 30 mils of the freeboard system (epoxy/epoxy/urethane system).

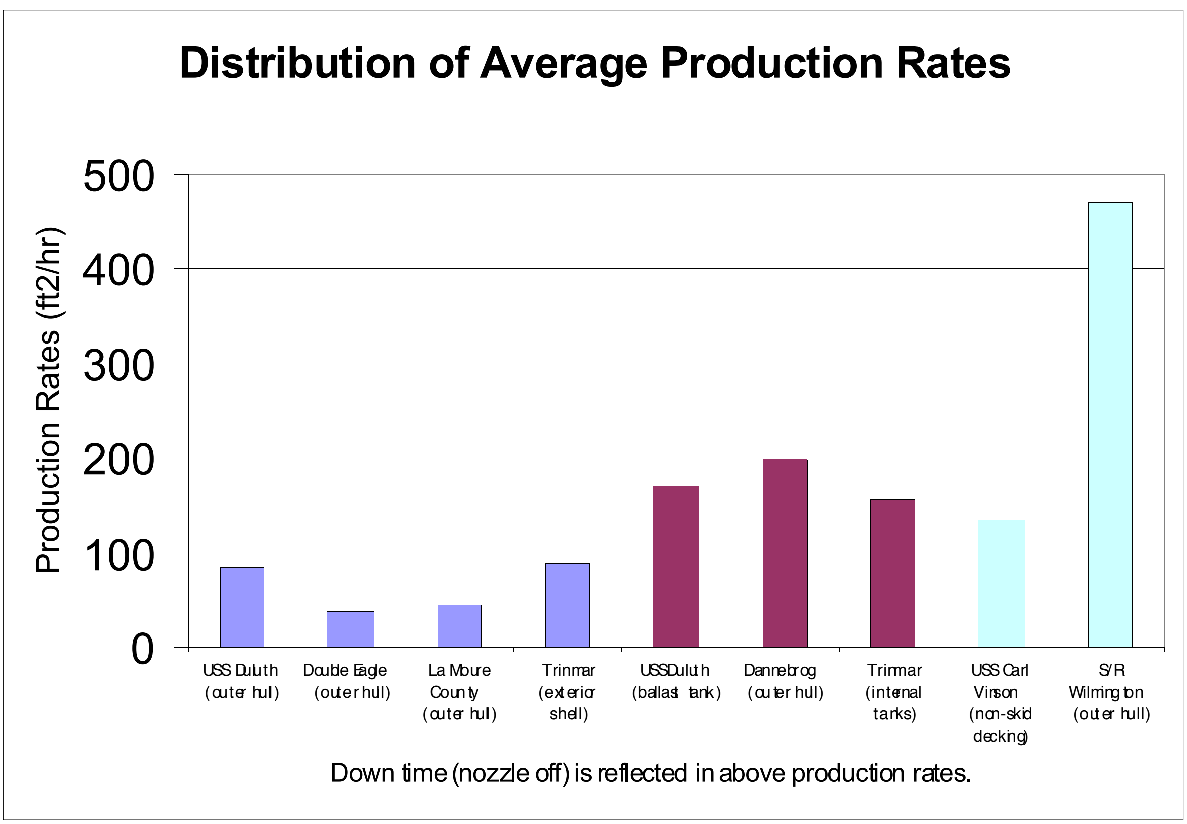
4.2.4 Distribution Of Production Rates

Graph 4, located on the following page, shows the production rates of all hydroblasting observations. Graph 5 is similar to Graph 4, but it represents the overall average production rates observed at each vessel. As seen from both Graphs 4 and 5, the production rates from the Sea River Wilmington exceed all the other production rates. A correlation between the USS Carl Vinson and the Sea River Wilmington would not be meaningful since the two represented the removal of two totally different coating systems. However, both systems represented a semi-automated method of coating removal, waste handling, and treatment which demonstrates the grouping of all technologies associated with shipyard water-jetting. All other methods observed utilized hand held lances and "open-cycle" jetting, which is a simpler, less involved way of removing coatings.

Graph 4:



Graph 5:



4.3 CONTAMINATION REMOVAL USING ULTRA-HIGH PRESSURE WATER-JETTING

One of the more recognized advantages of pressurized water as a means of surface preparation is its ability to remove contamination on either a coated or bare substrate to levels well below those that are believed detrimental to coating performance. A portion of this study involves the documentation of surface contaminants (as measured as chlorides and conductivity) on a surface prior to and after coating removal via water-jetting in order to confirm contamination removal. In some cases, surface contamination was measured both before and after blasting, however surface initial readings were not obtained in all cases for various reasons (e.g. hull accessibility, or inability of retrieval cell to adhere to anti-fouling paint).

> NOTE: In all cases, final surface contamination and chloride levels were measured within a few hours after water-jetting, and do not necessarily represent the surface condition just prior to coating. It is important to ensure the levels are low directly prior to painting, as well. The period from when a surface is initially jetted to the time it is coated can be several days, during which time increased quantities of contaminants can settle on the cleaned surface. Most contractors incorporate a "secondary cleaning" to remove residual contaminants, and flash rusting, to restore the surface to acceptable specifications.

4.3.1 Chloride Contamination

Chloride contamination has been identified as a major contributor to premature coatings defects caused by ionic contamination. Therefore, surface chloride levels are measured prior to and after water jetting. Chloride levels were measured by the Bresle Blister Patch Method (a.k.a. "Chloride Analysis According to Bresle"). In low areas of detectability (under 20 $\mu g/cm^2$) the results are reported in ranges, such as "0-2 $\mu g/cm^2$, 2-4 $\mu g/ cm^2$, 4-6 $\mu g/ cm^2$" ... and so on. For the purposes of graphing the results, "0-2 $\mu g/ cm^2$" was depicted as "1 $\mu g/ cm^2$", "2-4 $\mu g/ cm^2$"was depicted as "3 $\mu g/ cm^2$"... and so on.

Graphs 6 and 7 (located on the following pages) depict all chloride data captured to-date. Graph 6 includes all visits in which potable water was used for blasting. In Graph 6, initial chloride contamination levels were quite low (under 10$\mu g/cm^2$). All final readings were under 3$\mu g/cm^2$, with the majority of readings under 1$\mu g/cm^2$. Although initial readings were low in most cases due the surfaces having been pressure washed prior to our visits. Thus resulting in very little difference in "initial" and "final" readings. The DULUTH tank readings show that water-jetting does reduce surface chlorides to below acceptable levels. (The U.S. Navy has identified 3$\mu g/cm^2$ as the upper limit for acceptability for coating an immersed surface and 5 $\mu g/cm^2$ as the upper limit for coating an above-waterline surface. Realizing this, one can see that water-jetting is very effective in removing contaminants and producing a clean surface for coating.)

Graph 7 contains the chloride data from the Trinmar visit where filtered seawater was used for blasting, the surfaces were next washed down with ~10,000 psi potable water. The initial chloride levels on the pumping station platform were high (up to 40 $\mu g/cm^2$), but these levels were significantly (78% to 97%) reduced after the secondary (fresh water) blast. As a test, chloride measurements were taken after the filtered seawater blast and prior to the fresh water rinse on the exterior shell only. For the exterior shell as noted in Graph 7, levels were quite high (70 $\mu g/cm^2$) confirming the necessity of the secondary fresh water blast.

The effectiveness of contamination removal for the Trinmar pumping station platform should only be compared with itself. Comparisons of other before and after surface contamination numbers would not be meaningful since filtered seawater was used for the blasting during our visit to Trinmar. All other hydroblasting observations used a potable water source for blasting.

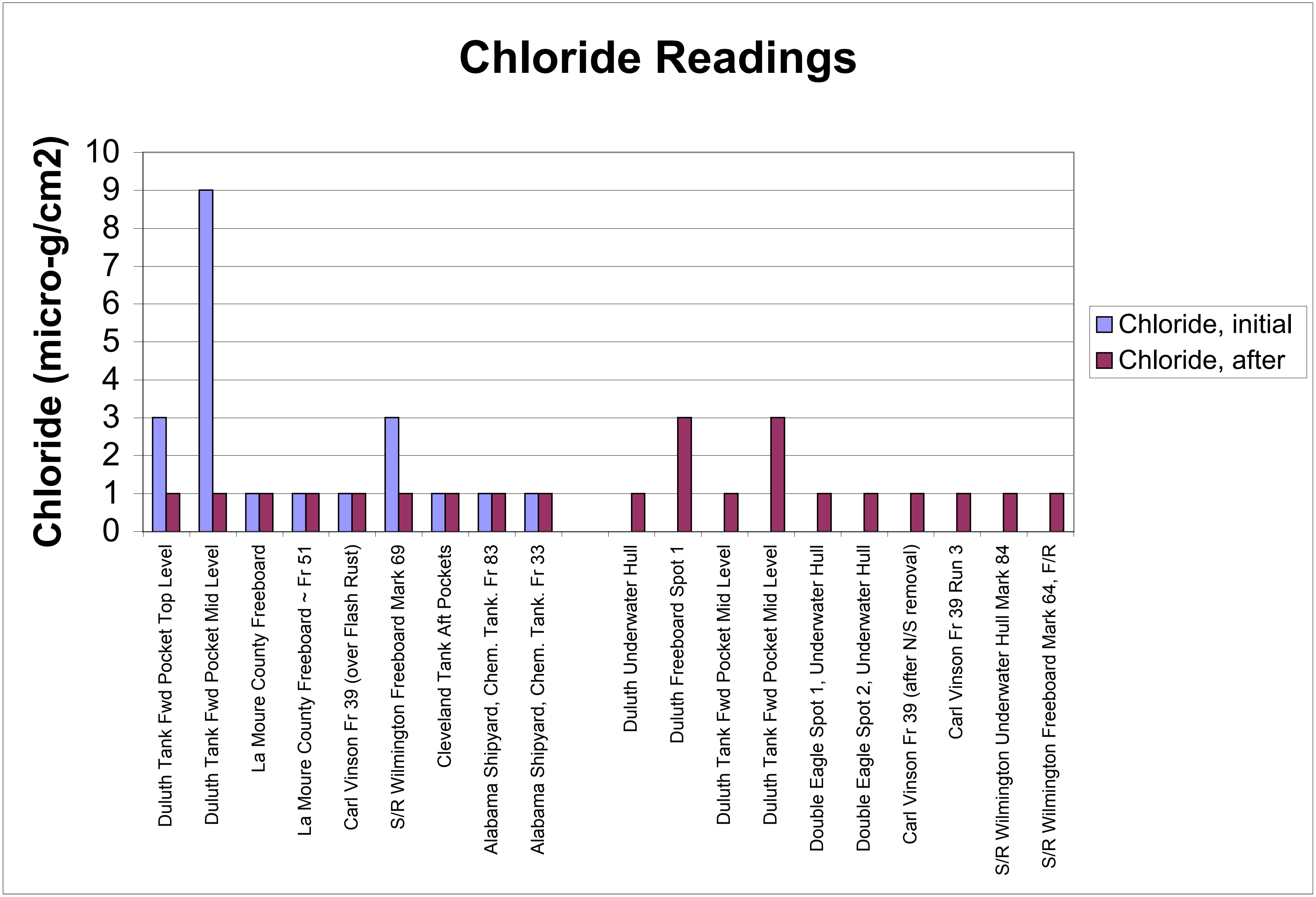
4.3.2 Surface Conductivity

If contaminants other than (or in addition to) chloride are present, conductivity measurements may provide information if such substances can be detrimental to coating longevity. Conductivity samples were captured using 3 ml distilled, deionized water (typically 0-1 $\mu S/cm$) injected into a sample cell (blister patch). Results were normalized for a 5 ml solution conductivity. Graphs 8 and 9 depict the conductivity data gathered to-date. Graph 8 includes all visits in which potable water was used for blasting. Graph 9 contains the data gathered on the Trinmar visit which was blasted with filtered seawater, followed by a secondary fresh water blast (~10,000 psi).

In most cases, conductivity levels dropped significantly after water-jetting. On Graph 8, fifteen of twenty-three final conductivity readings were under 20 μS/cm, and twenty-two of twenty-three were under 40 μS/cm. Typical city tap water conductivity ranges 80-130 μS/cm. Although no standard currently exists for acceptance criteria for conductivity, these readings further confirm water-jetting's ability to provide a suitably clean surface for coating.

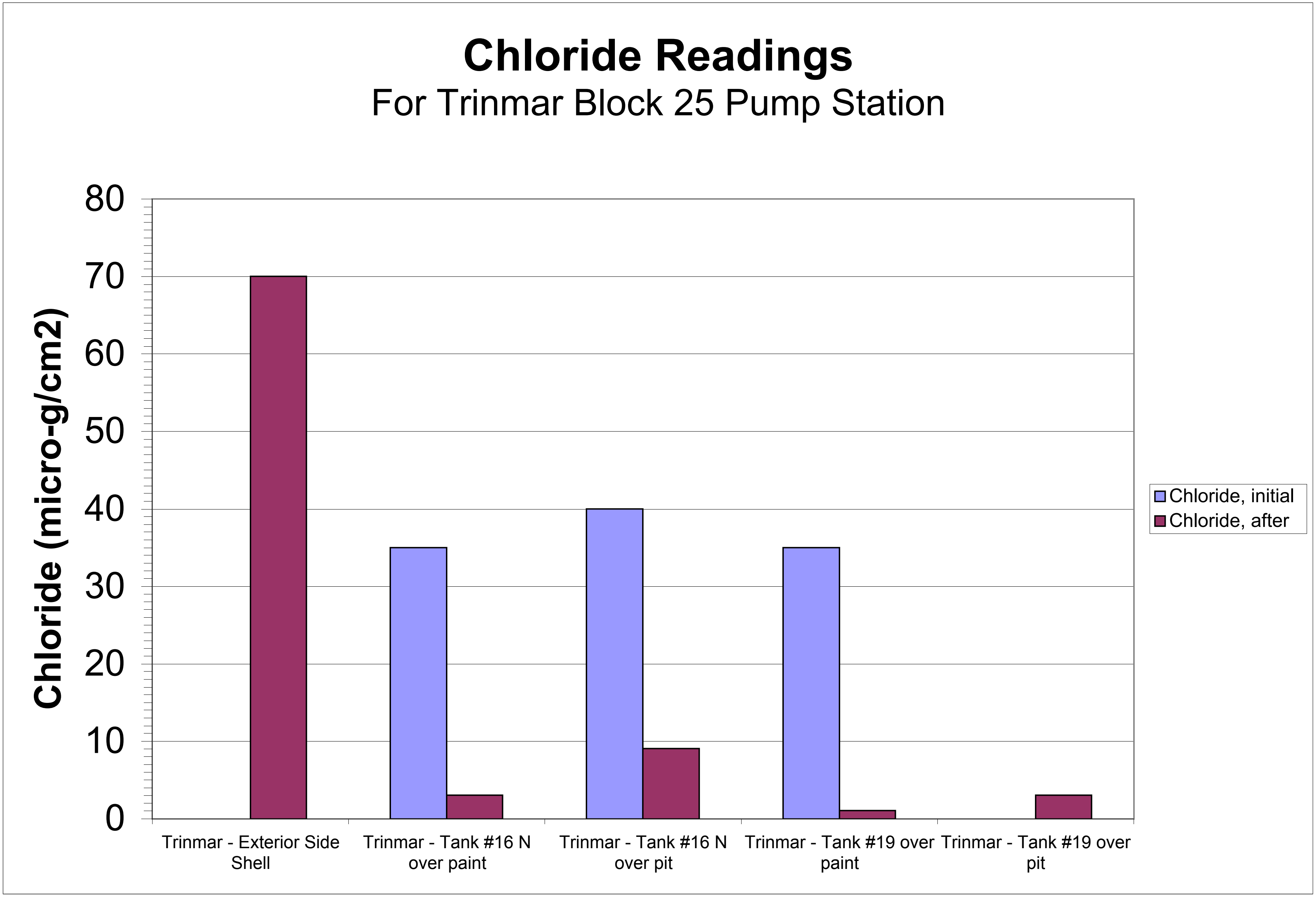
The data on Graph 9 shows that jetting with seawater with the secondary fresh water blast did significantly (77% to 92%) reduce the surface conductivity. However, the residual surface conductivity was still high compared with the final values achieved with potable water, water-jetting. As a test, conductivity measurements were taken after the filtered seawater blast and prior to the fresh water rinse on the exterior shell only. For the exterior shell as noted in Graph 9, conductivity levels were quite high (960 μS/cm) confirming the necessity of the secondary fresh water blast.

Graph 6:



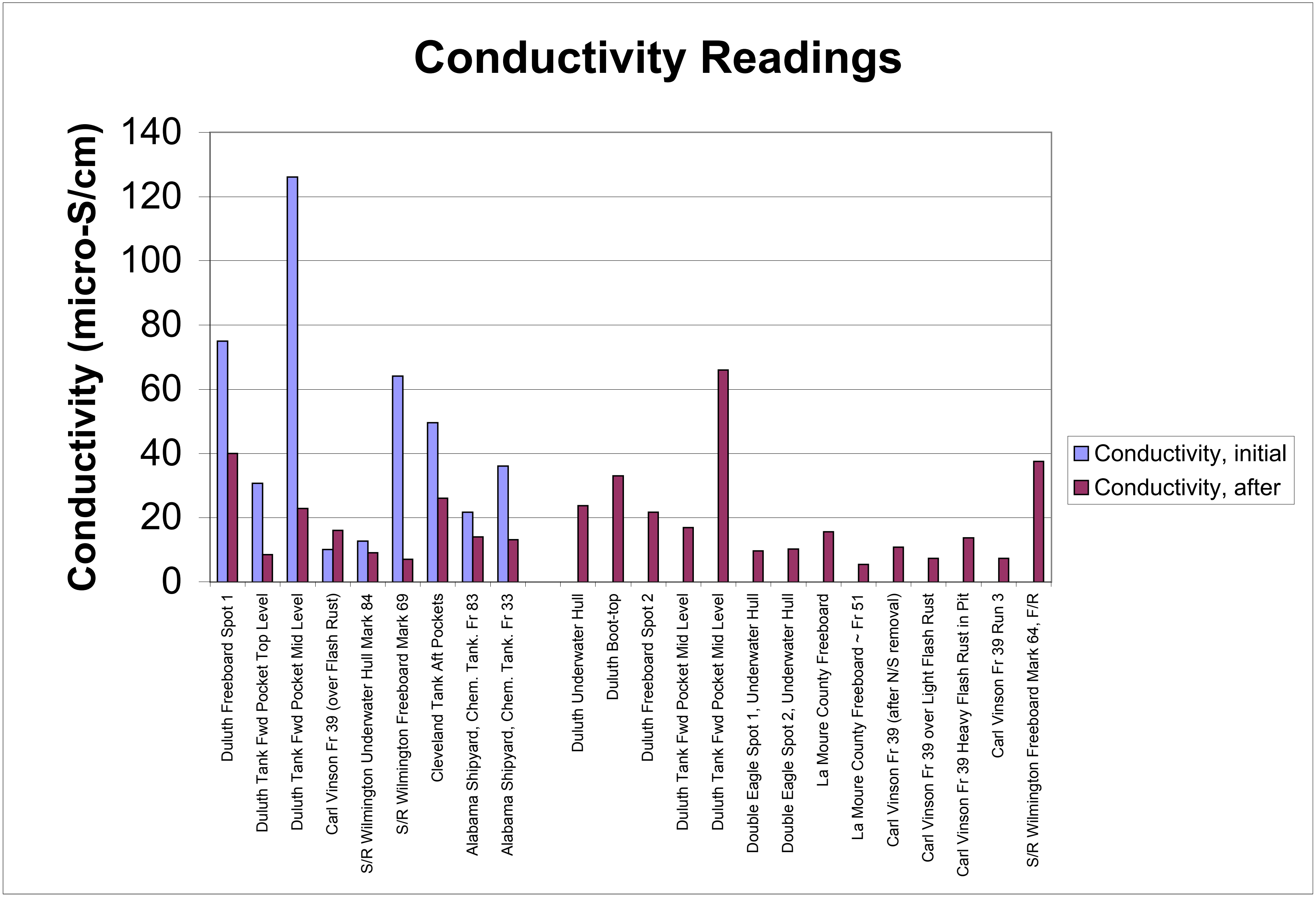
Chloride Readings
Chloride (micro-g/cm2)
0
1
2
3
4
5
6
7
8
9
10
Duluth Tank Fwd Pocket Top Level
Duluth Tank Fwd Pocket Mid Level
La Moure County Freeboard
La Moure County Freeboard ~ Fr 51
Carl Vinson Fr 39 (over Flash Rust)
S/R Wilmington Freeboard Mark 69
Cleveland Tank Aft Pockets
Alabama Shipyard, Chem. Tank. Fr 83
Alabama Shipyard, Chem. Tank. Fr 33
Duluth Underwater Hull
Duluth Freeboard Spot 1
Duluth Tank Fwd Pocket Mid Level
Duluth Tank Fwd Pocket Mid Level
Double Eagle Spot 1, Underwater Hull
Double Eagle Spot 2, Underwater Hull
Carl Vinson Fr 39 (after N/S removal)
Carl Vinson Fr 39 Run 3
S/R Wilmington Underwater Hull Mark 84
S/R Wilmington Freeboard Mark 64, F/R
Chloride, initial
Chloride, after

Graph 7:

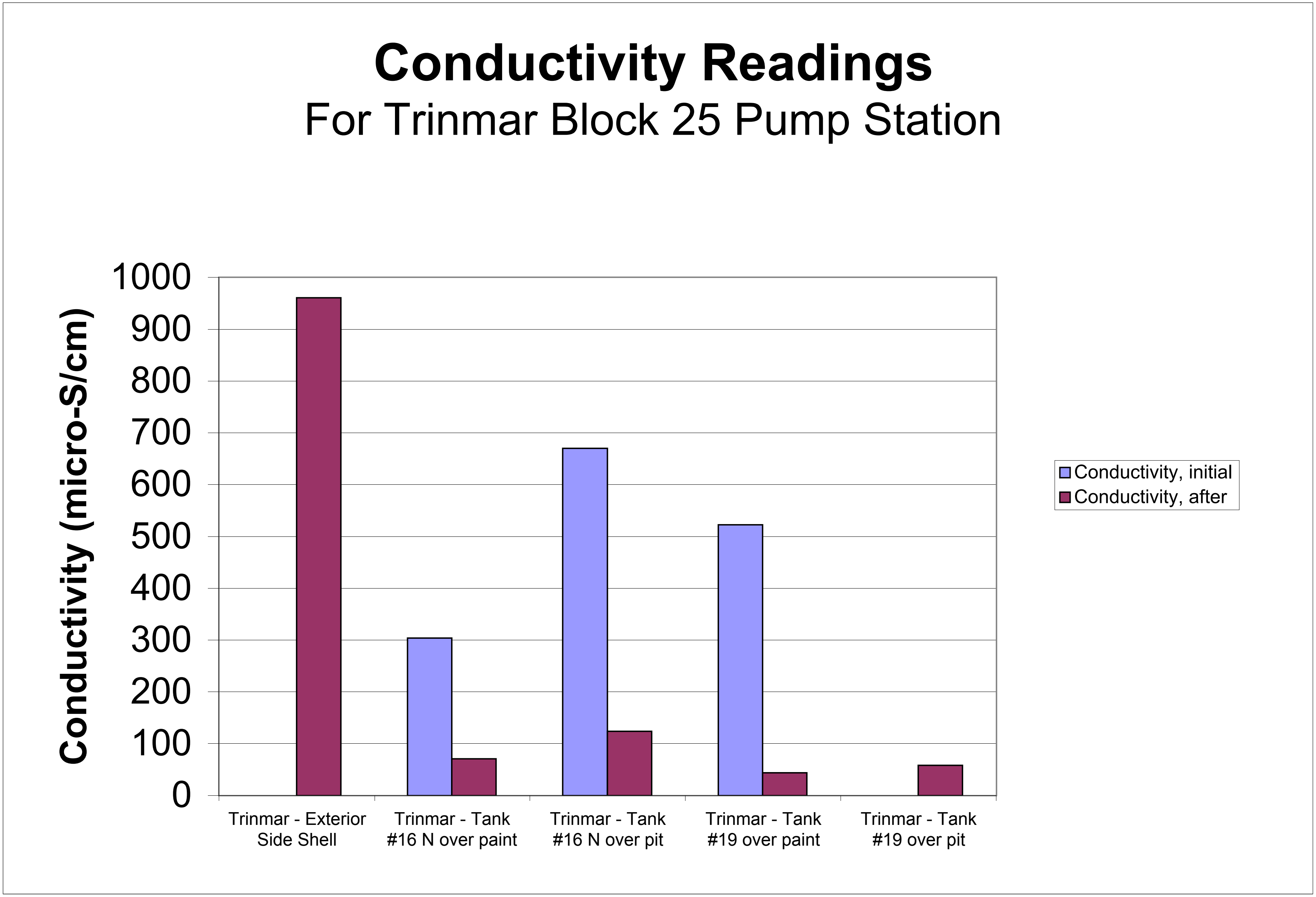


Chloride Readings
For Trinmar Block 25 Pump Station
Chloride (micro-g/cm2)
80
70
60
50
40
30
20
10
0
Trinmar - Exterior Side Shell
Trinmar - Tank #16 N over paint
Trinmar - Tank #16 N over pit
Trinmar - Tank #19 over paint
Trinmar - Tank #19 over pit
Chloride, initial
Chloride, after

Graph 8:


Conductivity Readings
Conductivity (micro-S/cm)
140
120
100
80
60
40
20
0
Duluth Freeboard Spot 1
Duluth Tank Fwd Pocket Top Level
Duluth Tank Fwd Pocket Mid Level
Carl Vinson Fr 39 (over Flash Rust)
S/R Wilmington Underwater Hull Mark 84
S/R Wilmington Freeboard Mark 69
Cleveland Tank Aft Pockets
Alabama Shipyard, Chem. Tank. Fr 83
Alabama Shipyard, Chem. Tank. Fr 33
Duluth Underwater Hull
Duluth Boot-top
Duluth Freeboard Spot 2
Duluth Tank Fwd Pocket Mid Level
Duluth Tank Fwd Pocket Mid Level
Double Eagle Spot 1, Underwater Hull
Double Eagle Spot 2, Underwater Hull
La Moure County Freeboard
La Moure County Freeboard ~ Fr 51
Carl Vinson Fr 39 (after N/S removal)
Carl Vinson Fr 39 over Light Flash Rust
Carl Vinson Fr 39 Heavy Flash Rust in Pit
Carl Vinson Fr 39 Run 3
S/R Wilmington Freeboard Mark 64, F/R
Conductivity, initial
Conductivity, after

Graph 9:


Conductivity Readings
For Trinmar Block 25 Pump Station
Conductivity (micro-S/cm)
1000
900
800
700
600
500
400
300
200
100
0
Trinmar - Exterior Side Shell
Trinmar - Tank #16 N over paint
Trinmar - Tank #16 N over pit
Trinmar - Tank #19 over paint
Trinmar - Tank #19 over pit
Conductivity, initial
Conductivity, after

4.4 TENSILE ADHESION OF REMAINING COATING SYSTEM

For coating removal specifications such as selective stripping and spot and sweep blasting where tightly adherent coatings are remaining, a question was raised as to the integrity of this coating after it had been stressed with 20,000 psi or greater pressures. Tensile adhesion testing was performed on applicable (i.e. selective stripping, and spot and sweep) accessible areas after water-jetting had taken place. Adhesion testing was performed according to ASTM D 4541 using an Elcometer 1000 adhesion tester with a fast curing acrylic adhesive to attach the adhesion dollies.

Initial (prior to blasting) adhesion data was gathered in order to make meaningful "before and after" comparisons to evaluate how water-jetting effects the remaining coating system. This information was gathered on four separate water-jetting observations. The results follow in table format for each separate visit as well as a description of the coating system and removal specification.

4.4.1 USS Duluth, Ballast Tank 8-84-2-W:

Coating System: MIL-P-23236: White epoxy primer (4mils), Blue epoxy topcoat (4 mils)
Removal Specified: Spot-blast corroded areas to bare metal and sweep blast all other surfaces to remove staining and feather edges.

Table 3:

USS DULUTH Ballast Tank - Coating Adhesion		
Initial Values		
Location (Fwd. pocket - top lvl.)	**Adhesion (psi)**	**Mode of Failure**
Outboard Atmospheric	825	10% cohesive, 90% adhesive to top-coat
Inboard Atmospheric	825	10% cohesive, 90% adhesive to top-coat
Outboard Web	700	50% adhesive to top-coat, 50% primer to steel
Inboard Immersion	800	70% adhesive to button, 30 % adhesive to top-coat
Inboard Immersion	700	50% primer to steel, 25% adhesive to top-coat, 25% adhesive to button
Final Values		
Outboard Atmospheric	1000+	50% cohesive in top-coat, 50% adhesive to button
Inboard Atmospheric	850	10% primer to steel, 50% adhesive to top-coat, 40%cohesive in adhesive
Outboard Web	500	100% primer to steel
Inboard Immersion	1000+	50% primer to steel, 50% adhesive to top-coat
Inboard Immersion	950	60% primer to steel, 40% cohesive in adhesive

All final (after blast) adhesion values had high adhesion values. In all but one case (Outboard Web) the adhesion values actually increased. Comparing the initial and final "Mode of Failures" for the four locations in the ballast tank where adhesion increased, the mode of failure with respect to the topcoat decreased. From this data it was determined that water-jetting did not negatively effect the coating adhesion of the remaining "tight" coating system. In effect, it increased the adhesion values (compared to before blast) by removing deteriorated portions of the exposed coating system allowing a secure surface for subsequent coating application.

4.4.2 Double Eagle (Hull № 648), Underwater Hull:

Coating System: Red epoxy (5 mils), Gray epoxy (5 mils), Red anti-fouling (7 mils), Black anti-fouling (7 mils), Red anti-fouling (9 mils).
Removal Specified: Remove all anti-fouling down to sound gray anti-corrosive.

Note: Initial adhesion data was not obtained since adhesion values over the anti-fouling would be extremely low and meaningless due to the soft nature of anti-fouling coatings.

Table 4:

Double Eagle - Coating Adhesion		
Location (underwater hull)	**Adhesion (psi)**	**Mode of Failure**
Button 1	650	50% adhesive to button, 50% intercoat gray to red
Button 2	650	50% adhesive to button, 50% intercoat gray to red
Button 3	725	50% adhesive to button, 50% intercoat gray to red
Button 4	1000+	50% adhesive to button, 50% cohesive in primer
Button 5	725	50% adhesive to button, 50% cohesive in primer

These high adhesion values indicate that the selective striping of the anti-fouling system by hydroblasting did not negatively impact the remaining anti-corrosive system's adhesion such problems would occur when topcoated.

4.4.3 USS Cleveland, Ballast Tank 8-216-0-W:

Coating System: Ballast Tank 8-216-0-W, MIL-P-24442 system: Green F150 primer (3 mils), Gray F151 (3 mils), White F152 (3 mils) topcoat.
Removal Specified: Spot-blast corroded areas to bare metal and sweep blast remaining surfaces.

Table 5:

USS CLEVELAND Ballast Tank - Coating Adhesion		
Initial Values Middle-upper level, port pocket		
Location	**Adhesion (psi)**	**Mode of Failure**
2nd bay from aft, center wall	725	100% adhesive to top-coat
aft wall	650	100% adhesive to top-coat
2nd bay from aft, port wall	650	100% adhesive to top-coat
Final Values Top level, port pocket		
2nd bay from aft, center wall	1000+	100% cohesive in top-coat
2nd bay from aft, center wall	1000+	100% cohesive in top-coat

The intact paint that remained after the blast showed extremely strong adhesion. It is apparent that hydroblasting did not negatively impact the coating when comparing initial and final values even though the adhesion tests were performed at different levels inside the tank. Both initial and final adhesion testing was performed over representative areas of the coating system such that before and after measurements from different locations would be meaningful.

4.4.4 Trinmar, Block 25 Pump Station, Internal Tanks:

Coating System: Pre-construction green primer (2 mils), gray epoxy (7-10 mils)
Removal Specified: Spot blast all corroded areas to bare metal, sweep blast painted surfaces to remove all loose paint.

Table 6:

Trinmar, Block 25 Pump Station - Coating Adhesion, Internal Tanks		
Initial Values		
Location	**Adhesion (psi)**	**Mode of Failure**
Tank 16, over top-coat	450	100% Cohesive in Primer
Tank 16, over top-coat	600	100% Cohesive in Primer
Tank 16, over top-coat	400	100% Cohesive in Primer
Tank 16, over top-coat	400	100% Cohesive in Primer
Final (after blast) Values		
Tank 16 (half top-coat/half primer)	400	100% Glue Failure
Tank 16, over primer	425	100% Glue Failure
Tank 16, over top-coat	650	50% Glue Failure, 50% Cohesive in Primer
Tank 16, over bare metal	600	100% Glue Failure
Tank 19 (half top-coat/half primer)	300	100% Glue Failure
Tank 19, over primer	200	100% Glue Failure
Tank 19, over top-coat	750	100% Glue Failure
Tank 19, over bare metal	375	100% Glue Failure

Final and initial adhesion values are not readily comparable since the mode of failure for the final values was due to the adhesion dolly adhesive. However, knowing the remaining coating's adhesion is greater than the (final) recorded failure, this would indicate that the remaining coating system adhesion was not affected

Overall, comparing final to initial adhesion data in Tables 3 through 6 indicates that the adhesion of remaining paint was not negatively affected.

4.5 SURFACE PROFILE OF REMAINING COATING

One known issue regarding water-jetting is that it does not appreciably impart a profile on steel [14]. If water-jetting is used to remove all coatings down to bare metal it merely exposes the original steel profile (assuming that it had been previously blasted). Water-jetting does, however, impart a profile on the intact paint which remains on surfaces that have been selectively stripped or sweep blasted. The profiles imparted on the remaining coating by these two surface preparation specifications can be measured using profile tape (ASTM D 4417, Method C).

Profiles of prepared surfaces on the Double Eagle Hull and Trinmar pump station were measured to quantify the surface roughness of the remaining paint as well as that of bare metal for comparison purposes. Profile tape measurements are listed below:

Table 7:

Profile Measurements	
Location on Double Eagle	**Profile (mils)**
Over anti-corrosive	1.7
Over anti-corrosive	1.3
Over anti-corrosive	1.7
Location on Trinmar	**Profile (mils)**
Tank 16, *over bare metal*	*4.0*
Tank 16, *over bare metal*	*4.4*
Tank 16, over primer	4.0
Tank 16, over primer	3.8
Tank 16, over top-coat	2.6
Tank 16, over top-coat	3.6
Tank 16, over top-coat	1.9
Tank 16, over top-coat	1.8
Tank 19, *over bare metal*	*3.4*
Tank 19, *over bare metal*	*4.2*
Tank 19, over primer	3.8
Tank 19, over top-coat	4.1
Tank 19, over top-coat	1.7

As seen, the profiles on the painted surfaces ranged from 1.3 to 4.1 mils. This is an excellent profile (on paint) to accept overcoats of anticorrosive coatings.

14. J. Howlett, R. Dupuy, "Ultrahigh-Pressure Water Jetting for Deposit Removal and Surface Preparation", Materials Performance, January 1993, p.38.

4.6 OTHER DATA REGARDING PRODUCTION

During productivity studies downtime was often noted and was always figured in for the total time required to finish a set area in order to get a true sense of water-jetting's productivity. For production runs where downtime was individually noted the percent working time (nozzle on) was calculated. The percent working time data is organized by the three surface preparation specifications: selective striping, spot and sweep, and bare metal. The method of removal (hand lance, machine) is also noted, as well as location on structure and observed removal rate.

Table 8:

Percent Working Time			
Selective Striping			
Location	**Removal Method**	**Production Rate (ft^2/hr/gun)**	**% Working Time**
USS Duluth, Freeboard	Hand Lance	48	72
USS Duluth, Freeboard	Hand Lance	72	77
USS Duluth, Freeboard	Hand Lance	52	80
USS Duluth, Underwater Hull	Hand Lance	97	85
Double Eagle, Underwater Hull	Hand Lance	44	87
Double Eagle, Underwater Hull	Hand Lance	45	70
Double Eagle, Underwater Hull	Hand Lance	28	97
USS LaMoure County, Freeboard	Hand Lance	46	87
Sweep & Spot Blast to Bare Metal			
USS Duluth, Ballast Tank	Hand Lance	200	68
USS Duluth, Ballast Tank	Hand Lance	163	57
Dannebrog, Underwater Hull	Hand Lance	153	45
Dannebrog, Underwater Hull	Hand Lance	365	71
Dannebrog, Underwater Hull	Hand Lance	146	87
Dannebrog, Underwater Hull	Hand Lance	165	72
USS Cleveland, Ballast Tank	Hand Lance	45	38
USS Cleveland, Ballast Tank	Hand Lance	84	49
USS Cleveland, Ballast Tank	Hand Lance	54	54
Coating Removal to Bare Metal		**(ft^2/hr/machine)**	
USS Carl Vinson, Flight Deck	Machine	146	79
USS Carl Vinson, Flight Deck	Machine	121	77
Sea River Wilmington, U/W Hull	Machine	366	32
Sea River Wilmington, U/W Hull	Machine	725	86
Sea River Wilmington, U/W Hull	Machine	888	97
Sea River Wilmington, U/W Hull	Machine	472	42
Sea River Wilmington, U/W Hull	Machine	792	89
Sea River Wilmington, U/W Hull	Machine	357	77
Sea River Wilmington, U/W Hull	Machine	162	79
Sea River Wilmington, U/W Hull	Machine	171	70

The percent working time (nozzle on) was consistently low for the "Sweep and Spot Blast to Bare Metal" on USS Duluth and USS Cleveland. Since these two observations involved tank blasting there are inherent issues which increase downtime such as poor visibility and complex geometries.

4.7 SUMMARY REPORTS OF ON-SITE WATER-JETTING OBSERVATIONS

4.7.1 *USS DULUTH (LPD-6) Visit 1:*

SHIP: USS DULUTH (LPD-6)
LOCATION: Southwest Marine, San Diego
DATE OF VISIT: February 11-13, 1997
CONTRACTOR: Cavi-Tech
EXISTING SYSTEM: Freeboard: Inorganic zinc, F-150 green epoxy primer (6 mils), F-151 gray epoxy primer (10 mils) and multiple TT-E-490 gray silicone alkyd topcoats (12 mils).
U/W Hull: Red epoxy (5 mils), Buff epoxy (8 mils), Red F-121 (3 mils), Black ablative A/F (mostly eroded), Red ablative A/F (mostly eroded).

REMOVAL SPECIFIED: Freeboard: Remove gray alkyd to intact gray epoxy layer.
U/W Hull: Remove both ablatives and the red 121 to intact buff epoxy; areas of corrosion blast to bare metal and feather in w/existing system.

GENERAL INFORMATION:
Cavi-Tech used six pumps, three positive displacement Flow Huskies when operating at 40,000 psi (flow rate of 6 gpm) and three reciprocating pumps by Jet Stream operating at a rate of 8 gpm with a maximum operating pressure of 20,000 psi. The 20,000 psi guns had a dual orifice nozzle which rotated by water pressure at 4800 rpm. The nozzles on the 40,000 psi guns had 5 jewels and rotated by compressed air at a rate of 3500 rpm.

PRODUCTION INFORMATION:
Cavi-Tech blasters operated in two-man teams; one man operated the high-lift and the other blasted with the 40,000 psi gun, alternating positions when necessary. Production rates varied from team-to-team. Two separate teams working at roughly the same freeboard location (starboard bow) were observed at having two very different removal rates. For example, one team working on the higher areas of the freeboard averaged a removal rate of 52 ft^2/hr/gun. The other team working on the lower sections of the freeboard averaged 128 ft^2/hr/gun. Both teams' pumps were operating at 35,000 psi. A third team using a 40K psi gun (operating at 30,000 psi) operated on a 30 foot long, two point suspension scaffold, and had consistent production runs throughout the day. This team was working mid-ship starboard on the freeboard area below the troop walk working down to the boot-top. Their average production rate was 67 ft^2/hr/gun.

Total removal to bare metal of a section of underwater hull system was observed at 152 ft^2/hr/gun, using the 40K psi gun operating at 34K psi. The location of this section was starboard bow and was the section of coating damaged by anchor chain scrapes. Coating removal of boot-top area specified on starboard bow was removal of anti-fouling to sound epoxy buff anti-corrosive. Removal rates observed for this section of boot-top was 97 ft^2/hr/gun, using the 40K psi gun operating at 35K psi. Individual production data is summarized in the table below:

USS DULUTH OBSERVED REMOVAL RATES (ft^2/hour/gun)							
Freeboard						**Underwater Hull**	
Partial Removal							**Bare Metal**
48	128	52	72	76	52	97	152

CONTAMINATION REMOVAL:
Contamination measurements were taken prior to and after blasting of the freeboard, starboard mid-ship section. Conductivity prior to and after hydro-blasting were 75μS/cm and 40μS/cm respectively. The chloride concentration after blasting was 2-4 μg/cm^2. A second conductivity measurement taken on the freeboard area after blasting was 21.6 μS/cm. These areas were pressure washed prior to painting to remove contamination spread by surrounding blasting.

Flash rusting was observed for this section of boot-top which had bare metal exposed while blasting. Based on International Paint Standards from an initial HB 2 _ it took 1 hour to flash to HB 2 _ L and total of two hours to flash to HB 2 _ M. Surface contamination measurements were taken after blasting. The conductivity of the boot-top and the underwater hull were 33 μS/cm and 40 μS/cm respectively. The chloride concentration of the underwater hull area after blasting was 0-2 μg/cm ft^2.

DULUTH LOCATION	Chlorides (μg/cm ft^2)		Conductivity (μS/cm)	
	Initial	Final	Initial	Final
Underwater Hull	not measured	1	not measured	23.7
Freeboard (spot 1)	not measured	3	75	40
Boot-top	not measured	not measured	not measured	33
Freeboard (spot 2)	not measured	not measured	not measured	21.6

WASTE HANDLING:
The floating dry dock at Southwest Marine was pitched approximately 1^o to the port and approximately 1^o to the starboard so that the water and paint waste was accumulated into a holding tank located at the forward end. Water was pumped from this tank through a series of two microseperator filters to remove paint debris. These filters were changed about four times a day. This filtered water was then transferred to a separate ballast tank within the dry dock where it was periodically analyzed and tested prior to disposal.

4.7.2 ***USS DULUTH (LPD-6) Visit 2:***

SHIP: USS DULUTH (LPD-6)
LOCATION: Southwest Marine, San Diego
DATE OF VISIT: March 18-20, 1997
CONTRACTOR: Cavi-Tech
EXISTING SYSTEM: Ballast Tank 8-84-4-W, MIL-P-23236 system: White epoxy primer (4mils), Blue epoxy topcoat (4 mils).

REMOVAL SPECIFIED: Spot-blast corroded areas to bare metal, sweep blast all other surfaces to clean and remove staining, feather edges.

GENERAL INFORMATION:
For ballast tank work Cavi-Tech used their proprietary 20,000 psi guns and pumps since these guns are shorter than the 40,000 psi lances and are better suited for tank work. These 20,000 psi reciprocating pumps by Jet Stream and Butterworth were operating in the range of 5-7 GPM per gun. The blasting guns made by NLB have dual orifice nozzle rotating at 4800 rpm by water pressure. On this job, one pump per gun was used. Blasters worked in teams of two blasters per gun switching off every hour.

Ballast tank 8-84-4-W was our study tank. The approximate dimensions of the tank were 12.5' wide x 24' long x 18' high. These numbers do not reflect the actual overall surface area of the tank. Areas of flanges and stiffeners were accounted for in production rate calculation. Due to staging, the tank was divided into three equal levels, each approximately 6' high.

An initial assessment of extent of corrosion was determined at each level. The top level had 10% blistering with isolated corrosion; the middle level had up to 25% coating failure with associated sectional loss and the lower level had approximately 40% overall coating failure with corrosion and associated sectional loss. The topcoat in the immersion zone was heavily stained with rust. Initial surface contamination levels are summarized under the "contamination removal" section.

Due to the coating removal specification (remove spot corrosion and "sweep" existing coating) this was an excellent opportunity to determine the impact water-jetting may have on the adhesion of the remaining coating. Adhesion tests were performed using an Elcometer 1000 and the results of these adhesion pulls are summarized in a following chart.

PRODUCTION INFORMATION:
During blasting, ambient conditions were taken inside the tank. Typical conditions were 88 ^{o}F with 100% humidity. Production rates varied for different blasters during their one-hour shifts. Production rates ranged from 90 ft ft^2/hour/gun to 236 ft^2/hour/gun for the bottom level. Their rates including down time for maneuvering, rest and inspection of work was 200 ft^2/hour/gun for the middle pocket and 163 ft^2/hour/gun for the forward pocket.

USS DULUTH Production Rates (ft^2/hour/gun)					
Ballast Tank 8-84-4-W, "Spot and Sweep"					
177	236	200	160	163	90

CONTAMINATION REMOVAL:
An inspection was performed to determine overall blast effectiveness. The corroded areas were blasted as specified, but tightly adherent paint in some sections still had staining on the top-coat. (This was due to the blaster moving the gun too quickly across the surface.) Flash rusting occurred immediately due to the high humidity in the tank. No comparison to flash rusting standards were done since the tank had not gone through its final wash/rinse. Final surface contamination readings were taken over areas corresponding to locations from the initial surface contamination readings. These values are summarized in the following table.

DULUTH Location	Chlorides ($\mu g/cm^2$)		Conductivity ($\mu S/cm$)	
	Initial	Final	Initial	Final
Fwd pocket top level	3	1	30.6	8.4
Fwd pocket mid level	9	1	126	22.8
Fwd pocket mid level 1	not measured	1	not measured	16.8
Fwd pocket mid level 2	not measured	3	not measured	66

Note, the decrease in the measured contamination when comparing the initial to final readings. These final values are expected to decrease even more after the final rinse/wash of the tank.

COATING ADHESION:
Final adhesion tests were conducted to see if the intact paint was affected by the ultra-high water blasting. A comparison of coating adhesion prior to and after water-jetting is summarized in the following table.

USS DULUTH Ballast Tank - Coating Adhesion		
Initial Values		
Location (Fwd. pocket - top lvl.)	**Adhesion (psi)**	**Mode of Failure**
Outboard Atmospheric	825	10% cohesive, 90% adhesive to top-coat
Inboard Atmospheric	825	10% cohesive, 90% adhesive to top-coat
Outboard Web	700	50% adhesive to top-coat, 50% primer to steel
Inboard Immersion	800	70% adhesive to button, 30 % adhesive to top-coat
Inboard Immersion	700	50% primer to steel, 25% adhesive to top-coat, 25% adhesive to button
Final Values		
Outboard Atmospheric	1000+	50% cohesive in top-coat, 50% adhesive to button
Inboard Atmospheric	850	10% primer to steel, 50% adhesive to top-coat, 40%cohesive in adhesive
Outboard Web	500	100% primer to steel
Inboard Immersion	1000+	50% primer to steel, 50% adhesive to top-coat
Inboard Immersion	950	60% primer to steel, 40% cohesive in adhesive

Due to these high adhesion values it is safe to say that the spot and sweep water-jetting did not adversely affect the remaining coating's integrity, in fact, adhesion increased in 4 of 5 locations.

WASTE HANDLING:
After final washing, the majority of paint chips and corrosion products were bucketed out from the bottom of the tank. The remainder was removed by rising debris through the outer hull sand holes. Water and paint waste was accumulated into a dry dock holding tank, from which the water was pumped through a series of two microseperator filters to remove paint debris. These filters were changed about four times a day. This filtered water was then transferred to a separate ballast tank within the dry dock where it was periodically analyzed and tested prior to disposal.

OTHER COMMENTS:
After observing the ballast tank water jetting, heat stress on the worker certainly plays an important role in production. The contractor stated that the temperature of the water as it comes out of the blast nozzle is about 150^{o}F. Even with ventilation, the tank quickly became 100% relative humidity and ~ 90^{o}F. Due to the heavy mist and steam from the blasting guns visibility is only a few feet, soon after start of blasting. Worker dehydration is also an issue, due to the fact that protective (non-breathing) rain suits are worn while blasting. At these conditions the blasters can only work for about one hour before they need an hour break from heat fatigue. A review of the production data shows that actual production time is limited to about 58% of total time in the tank equipped with a gun. This contrasts to approximately 98% efficiency for outer hull (less constricted, no heat stress).

Due to limited access of blasting nozzle to certain geometries about 1% to 3% overall surface area must be hand power tool cleaned prior to painting.

Flash rusting did occur in the tank, however was most likely a result of the blasters requesting the DH machine be removed during blasting. (The DH unit provided by Southwest Marine was a desiccant type machine and blows hot dehumidified air, which certainly adds to the heat stress of blasters inside the tank.) Existing ambient air ventilation inside the tank was insufficient in keeping misting down and cooling the area. A possible solution to the flash rusting problem and the heat stress problem affecting the blasters could be alleviated if refrigerant DH were used. (Refrigerant DH blows cool dry air into the tank, vs. hot dry air of the more common desiccant units.)

The day following blasting, ambient conditions were measured inside the tank. The temperature was 70^{o}F with 72% RH and dew point of 61^{o}F. The wood planking used in staging the tank retained much moisture, and probably contributed to the high relative humidity, thereby increasing propensity for flash rusting.

The coating system to be applied is Devoe Pre-Prime 167 stripe coat followed by a full coat of the Pre-Prime 167. Two full coats of Devoe Bar-Rust 235 with a stripe coat of 235 between full coats will then be applied.

4.7.3 *Double Eagle (Hull N° 648):*

SHIP: Double Eagle Hull 648
LOCATION: Newport News Shipbuilding and Drydock Company
DATE OF VISIT: March 27, 1997
CONTRACTOR: Ultra High Pressure Projects, Inc.
EXISTING SYSTEM: Underwater Hull; Red epoxy (5 mils), Gray epoxy (5 mils), Red anti-fouling (7 mils), Black anti-fouling (7 mils), Red anti-fouling (9 mils).

REMOVAL SPECIFIED: Remove all anti-fouling down to sound gray anti-corrosive.

GENERAL INFORMATION:
UHP used three Flow Huskies from Flow International for this outer hull work. These pumps were operating in the 23-25,000 psi range with a flow rate of 6 gpm to selectively strip the A/F from the sound A/C. Two guns were being operated on each pump, thus each gun had a flow of 3 gpm. The guns had rotating nozzles, spun by compressed air, and each nozzle contained 5 jewels.

Because of poor adhesion of anti-fouling to anti-corrosive UHP was contracted to remove the anti-fouling system down to well-adhered anti-corrosive system. This anti-fouling system was from new construction and the hull had yet to have been placed in water.

PRODUCTION INFORMATION:
Production rates were observed for the aft underbelly and forward starboard immersion areas. Production rates for removal of anti-fouling on the underbelly were observed at a rate of 44 ft^2/hour/gun. Removal rates observed for the forward starboard underwater hull area ranged from 45 ft^2/hour/gun to 28 ft^2/hour/gun. A reason for low production rates maybe because of the lack of clearance for these 4 foot long lances/guns. Blasters had to hold the guns at angles about 30^o to 40^o to the surface of the ship instead of the optimum 90^o.

Double Eagle Hull, Production Rates (ft^2/hour/gun)		
44	45	28

Overall, the hydroblast was effective in removing the anti-fouling and leaving the anti-corrosive intact. The profile, which the nozzles left on the intact coating, ranged from 1.3 to 1.7 mils, as measured by ASTM D4417.

CONTAMINATION REMOVAL:
Chloride and conductivity readings revealed that the intact paint contained 0-2 μg/cm^2 of chloride and 9.6 μS/cm and 10.2 μS/cm conductivity.

Double Eagle Location	Chlorides (μg/ cm^2)		Conductivity (μS/cm)	
	Initial	Final	Initial	Final
U/W Hull location 1	not measured	1	not measured	9.6
U/W Hull location 2	not measured	1	not measured	10.2

COATING ADHESION:
Adhesion pull tests performed were performed on the remaining epoxy system to see if the hydroblasting effected the coating's integrity. The results of these pulls performed with an Elcometer 1000 are tabulated below.

Double Eagle - Coating Adhesion		
Location (underwater hull)	**Adhesion (psi)**	**Mode of Failure**
Button 1	650	50% adhesive to button, 50% intercoat gray to red
Button 2	650	50% adhesive to button, 50% intercoat gray to red
Button 3	725	50% adhesive to button, 50% intercoat gray to red
Button 4	1000+	50% adhesive to button, 50% cohesive in primer
Button 5	725	50% adhesive to button, 50% cohesive in primer

These adhesion values indicate that the selective striping of the anti-fouling system by hydroblasting did not negatively impact the remaining anti-corrosive system's adhesion.

WASTE HANDLING:
The water from this open system arrangement was collected and strained through mesh to remove heavy debris. The water was then diverted to a holding tank from the dry dock floor drains.

OTHER COMMENTS:
Workers were observed blasting while sitting in custom-made four-wheeled wagon carts. This was an ingenious idea for productivity and maneuverability when working in low clearance areas like the underbelly.

4.7.4 ***USS La Moure County (LST 1194):***

SHIP: USS La Moure County (LST 1194)
LOCATION: Colonna's Shipyard, Norfolk, VA
DATE OF VISIT: May 5, 1997
CONTRACTOR: Earl Industries
EXISTING SYSTEM: Freeboard: Six coats of silicon alkyd (3-4 mils per coat), Gray Navy F-151 (6-8 mils), Green Navy F-150 (6-8 mils) and inorganic zinc primer.

REMOVAL SPECIFIED: Remove all alkyd and epoxy coatings down inorganic zinc primer.

GENERAL INFORMATION:
Earl Industries had two Flow International Husky pumps. These Flow Huskies were operating at 38,000 psi (40,000 psi Max.) with a flow rate of 3.0 gpm. Two types of guns were being used; a "Wasp"" 5 jewel lance, and a "Hammerhead" 8 jewel lance.

Tooke Gauge readings taken on the freeboard area (aft, frame 290 and forward, frame 51 starboard sides) revealed an eight coat system over inorganic zinc. The first coat was F-150 epoxy (6-8 mils) the second was F-151 epoxy at (6-8 mils) the remaining coats were silicone-alkyd, MIL-E-24635 (3-4 mils each coat). The first two coats of epoxy and silicone-alkyd were original, the last four coats of silicone-alkyd were applied at a later date. Overall coating thickness in these areas ranged from 36.2-42.0 mils. Earl Industries removed the entire organic system leaving most of the inorganic zinc intact.

PRODUCTION INFORMATION:
Two "Wasp" lances were used on the freeboard (starboard, aft) areas. Blasting teams were operating with two men per man-lift. Production rates with this gun varied by location on the freeboard areas. Various production rates were: 72 ft^2/hr/gun, 26 ft^2/hr/gun and 12 ft^2/hr/gun. Two "Hammerhead" lances were used on the forward, freeboard (starboard) areas. Blasters operating these guns were operating with some difficulties. Observed productions rates for this area were: 52 ft^2/hr/gun, 75 ft^2/hr/gun and 23 ft^2/hr/gun. Varying production rates were possibly due to experienced versus novice blasters.

La Moure County, Production Rates (ft^2/hour/gun)					
72	26	12	52	75	23

CONTAMINATION REMOVAL:
The areas without any inorganic zinc flash rusted in 2-3 minutes after blasting. Areas with intact organic zinc flash rusted in about 30 minutes. Chloride and conductivity readings prior to and after blast were obtained and the results are summarized below.

La Moure County Location	Chlorides (μg/ cm^2)		Conductivity (μS/cm)	
	Initial	Final	Initial	Final
Freeboard	1	1	not measured	15.6
Freeboard Frame 51	1	1	not measured	5.4

WASTE HANDLING:

Blast debris from this open system was collected by allowing the floating dry dock to list to the aft. A three inch plate was welded to the end of the dry dock and bails of hay were stacked in front of this plate to allow blast water to exit the dry dock while containing the paint chips in the dry dock. After water evaporation, dried material was removed by shovel.

OTHER COMMENTS:

Overall the blast was effective in removing all epoxy and silicone-alkyd, any remaining inorganic zinc was difficult to notice until flash rusting of the bare steel had taken place.

The paint specified to be applied to the hydroblasted surface is International's 303 Series Epoxy System.

4.7.5 *USS Carl Vinson (CVN 70):*

SHIP: USS CARL VINSON (CVN 70)
LOCATION: Puget Sound Naval Shipyard
DATE OF VISIT: July 9-12, 1997
CONTRACTOR: Puget Sound Naval Shipyard Paint Shop, Code 71
EXISTING SYSTEM: Flight Deck, 3-4 mil epoxy primer under a thick (up to 150 mils) non-skid matrix of epoxy and aluminum oxide grit.

REMOVAL SPECIFIED: 100% removal of existing system to near white metal (SP-10)

GENERAL INFORMATION:
This machine was developed for the Naval Surface Warfare Center by Pratt & Whitney Waterjet Systems, Inc., and has been in used for production removal of coatings since 1995. The machine is a closed loop system (where the blasting water is treated and reused) and is housed on the end of a 60-foot high-lift boom. The six inch wide rectangular, 22 jewel orifice (synthetic sapphire) is rotated at 600 RPM by air pressure. A vacuum shrouds this nozzle so that all water and paint debris are remove instantly as this nozzle moves along its path. There are two pumps that are currently being used for this unit, HydroPac and NLB. The shipyard is currently in a transition of using the NLB pump as the primary pump and keeping the original HydroPac as backup. Both of these pumps have a potential output pressure of 40,000 psi and flow rate of 10 GPM. The HydroPac is a hydraulically activated dual intensifier and the NLB pump is a positive displacement pump.

The hydroblast unit is operated on the ground by one operator (1 spotter is needed for U/W hull areas) and one water reclamation operator. The hydroblast operator controls the unit at the ground control console. At this console, the rate of nozzle translation speed can be adjusted from 1 to 3 inches/second. The removal pattern is typically pre-programmed. This unit removes an area of 4.5 ft x 6.5 ft per patch, or it can be guided manually at the console to remove smaller areas. The water and paint debris are removed by the vacuum shroud which surrounds the nozzle area. This slurry is treated on-site by the water reclamation trailer [Automated Robotic Maintenance System (ARMS)] where the solids are filtered out and the water is tested for conductivity before cycling through the system again. The solids are packed into 55-gallon drums and are handled as industrial waste. It is the water reclamation operator’s responsibility to insure the purity of the water during the recycling process.

PRODUCTION INFORMATION:
During this four-day visit, various removal rates were observed on the flight deck near Frame 39 port of Catapult 2. Removal rates for the non-skid ranged from 120 ft^2/hour (nozzle rate 2.0 in/sec) to 146 ft^2/hour (nozzle rate, 1.75 to 2.0 in/sec), removal rates for moderate to heavy flash rusting only was about 190 ft^2/hour (nozzle rate, 2.5 in/sec). The result of the machine's operation was a near white metal surface, with the exception of areas of staining. Some areas, (old pits), were darker than others, which created concern for local Navy inspectors, since their previous experience was limited to a shot blasted surface specification that stated 5% staining per square inch. A slight golden hue was noticed in some areas of jetted bare metal but the surface never flash rusted unless rained upon.

USS CARL VINSON Observed Production rates (ft^2/hour)				
Non-Skid Removal			**Flash Rusting Removal**	
135	146	121	191	189

CONTAMINATION REMOVAL:
Sample retrieval for initial chloride and conductivity measurements over non-skid was not possible due to the porous texture of the non-skid. We did however, take data over surfaces that flash rusted after rainfall. The data indicate this machine does produce an ultra clean surface, after coating removal (see Table below).

CARL VINSON Location	**Chlorides (μg/cm^2)**		**Conductivity (μS/cm)**	
	Initial	Final	Initial	Final
Flash Rust Removal	1	1	10	16
After N/S Removal	not measured	1	not measured	10.8
Over Light Flash Rust	not measured	not measured	not measured	7.2
Over Heavy Flash Rust	not measured	not measured	not measured	13.6
After N/S Removal	not measured	1	not measured	7.2

OTHER COMMENTS:
The major draw back to this machine was equipment reliability. There were several times when the machine was not running (sometimes for over 4 hours) due to either hydraulic leaks, or pump failure. Other factors affecting production were due to sequencing and planning of work during unfavorable weather conditions. Available enclosures were not placed over freshly blasted surfaces (resulting in rain/contaminant deposits leading to flash rusting). This caused re-work to remove the flash rusting prior to coating. Maneuverability from patch-to-patch was also slow in areas of complex configuration. (If the manipulator frame were able to rotate/pivot at the boom so that it could easily square-up areas, instead of totally repositioning the man-lift this would save a lot of time.)

To date, this is the only machine evaluated that is capable of 100% effluent recovery. This technology is promising, in that the complete recovery leads to increased cleanliness on the substrate to be re-coated.

The flight deck was being re-coated with Devoe's non-skid system. Dev-grip 137 epoxy primer, and Dev-grip 138 roll-on non-skid.

4.7.6 *Sea River Wilmington:*

SHIP: SEA RIVER WILMINGTON
LOCATION: NORSHIPCO, Norfolk, VA
DATE OF VISIT: July 21-23, 1997
CONTRACTOR: Hammelmann Corporation, Dayton, OH
EXISTING SYSTEM: Freeboard: Red epoxy primer (~4 mils), White epoxy (~7 mils), Black modified chlorinated rubber topcoat (~6 mils).
Underwater Hull: Red epoxy primer (~3 mils), White epoxy (~8mils), Black ablative anti-fouling (~5 mils), Red ablative anti-fouling (~8 mils)

REMOVAL SPECIFIED: Freeboard: 100% bare metal
Underwater Hull: Spot blast corroded/failed areas and touch-up.

GENERAL INFORMATION:
The machine used in coating removal (the "Dockmaster") was on loan from the German firm Hammelmann, and is a self-contained open-cycle hydroblasting unit, that resembles a man-lift. The pumps and diesel engines are housed at the base of a mobile unit and the blasting nozzle head is attached to a boom that has an 88.5 ft (27 m) reach. The vacuum lines for water and paint recovery are attached to the blasting head and empty into a collection bin that is also located at the base of the unit. The only external attachment to the Dockmaster unit is the fresh water feed line. This feed line is on a spool that will feed out or roll up the water line automatically as needed when the unit moves. The entire unit is hydraulically driven (wheel steering, rotation, boom and blasting head rotation.) The unit is operated by joystick remote control (radio control) that is worn on the operator's chest.

The Dockmaster has two HDP 234 (Hochdruckpumpe) pumps, one for each nozzle. These HDP 234 pumps have a 308 horsepower (230 kW) output, with five reciprocating pistons per pump. Each pump is capable of 36,260 psi (2500 bar) output pressure at the pump with an estimated pressure at the nozzle of 34,809 psi (2400 bar) due to line pressure losses. Each pump has a flow rate of 13.2 gpm (50 L/m) at 2500 bar, which leads to a combined/overall flow rate of 26.4 gpm (100L/m). The blasting head of the Dockmaster contains two nozzles and a vacuum line. The nozzles are each 300 mm in diameter and are mounted off center of each other achieving a total coverage of 23 5/8" (600 mm). These nozzles are hydraulically spun at 2500 rpm. Each nozzle contains four stainless steel jewels, which have a service life of 150 to 200 hours.

The Dockmaster is operated by one person, who can maneuver himself easily to inspect alignment of the unit to the side of the ship. From the ground, using the radio control, the operator can adjust the speed at which the entire unit moves along side of the vessel. He can also adjust the reach of the boom, the angle of contact of the blasting head has to the surface, as well as the amount of overlap per individual pass.

PRODUCTION INFORMATION:
Throughout the three-day visit, various production rates were observed. These all varied due to operator experience since some of NORSHIPCO's workers were learning how to operate this unit. Also the curvature of the side of the vessel played a factor in the production since this required more maneuvering.

On July 21, the production rate varied during different runs from 366 ft^2/hr to 725 ft^2/hr. The areas blasted were a mix of freeboard and underwater hull sections from the stem to mark 84. These numbers are taking into account downtime. Downtime resulted from refueling and repriming the fuel system of the Dockmaster, and changing/emptying the paint collection bin. During this production, the operators were double blasting the surface (i.e. for each pass they overlapped the previous pass by 50%). The overall production rate over a nine hour shift for this unit was 493 ft^2/hr. The night shift averaged 572 ft^2/hr over a 7 hour shift.

The overall effectiveness of the blast left about 20% of the original red primer on the steel while the specification called for 100% removal. However, the local coating representative stated that this was acceptable. Areas of staining existed where old areas of corrosion had occurred. After about 25 minutes a light bloom of flash rusting could be seen and after 40 minutes moderate to heavy areas of flash rusting could be seen.

On July 22, the production rate varied from 357 ft^2/hr to 792 ft^2/hr. Again, these areas were a mix of freeboard and underwater hull areas. Downtime resulted from refueling, changing and emptying the paint bin and inspecting and changing the jewels. The operators were still operating at a 50% overlap per pass. The night-shift was only able to blast from about 18:00 to 20:00 due to a pump breakdown. During this time the operator was able to achieve a production rate 728 ft^2/hr for two hours. The remainder of the shift was used to repair the pump.

The overall effectiveness of coating removal was not 100%, about 20-25% of the red primer still remained on the surface. Areas of dark stains were noticed where original areas of corrosion had occurred. About 1 hour after initial blast a light flash rust bloom was noticed. About 5-10% of the blasted surface was effected by light flash rusting prior to the rain. On 7/23 heavy flash rusting had occurred over 90-95% of the areas blasted on 7/22 due to night rains. (This heavy flash rusting could be easily rubbed off with a cloth.)

On July 23, production rates were lower, ranging from 162 ft^2/hr to 383 ft^2/hr. All production was done on freeboard areas. The surfaces were not straight like those blasted on previous days, rather, they were curved, from Mark 58 to the stern. During this day's production all primer was specified to be removed. Only ~5% of the red primer remained. Operators were still running the Dockmaster so that the nozzles overlapped the previous pass by 50%. Another factor, which accounted for some downtime was the inspection and replacement of jewels. Over a 9 hour period, about 20% of the blasted steel had moderately to heavily flash rusted.

The following table summarizes the production rates observed throughout the visit.

SEA RIVER WILMINGTON Observed Production Rates (ft^2/hr)											
Day Shift 7/21				Night	Day Shift 7/22			Night	Day Shift 7/23		
U/W Hull and Freeboard mix					U/W Hull and Freeboard mix				Freeboard Only		
370	366	725	555	572	472	792	357	728	383	162	171

CONTAMINATION REMOVAL:
Contamination measurements before and after blasting were taken for the first two days. Results of surface contamination measurements are summarized in the following table. It is also important to note that NORSHIPCO had pressure washed the outer hull areas of this vessel prior to any water-jetting work taking place. As seen in the table, water-jetting had lowered the amount of surface contamination compared to the initial values.

Sea River Wilmington Location	Chlorides (μg/ ft^2)		Conductivity (μS/cm)	
	Initial	Final	Initial	Final
U/W Hull, Mark 84	not measured	1	12.6	9
Freeboard, Mark 69	3	1	64	7
Freeboard, Mark 64 (Over Flash Rust from rain)	not measured	1	not measured	37.5

WASTE HANDLING:
Although there is a vacuum shroud encompassing the blast nozzles, the resultant water and paint debris was not completely contained. In fact, there was a constant cascade of mist and wastewater escaping the shroud. The captured effluent was collected by a vacuum system located on the blasting head. From here it was vacuumed into a bin located on the rear of the

Dockmaster, where a 200 micron filter separates out large particles. Water leaving this collection bin, as well as effluent escaping the vacuum system was collected in the dry dock troughs and pumped to a holding tank.

The shipyard contracted a separate company to treat the wastewater directly on-site. The holding tank wastewater was pumped to a chemical addition tank (~100 gal). Here, iron was added to aid in solids settling and lime was added to adjust pH. After the chemical addition, a pressurized tank was used to saturate the water with air. The aerated water is injected with a polymer solution during in-line transfer to a 1100 gallon solids separation tank. The tank was equipped with internal baffles that separate the solids flock from the water. The solids (paint and chemicals) are removed to a waste bin and the water was transferred to a monitoring tank, pumped through a carbon filter chamber, and the effluent from this chamber was discharged overboard.

OTHER COMMENTS:

Wastewater treatment unit, Jalbert Environmental Inc, (757) 468-2747 1-800-475-3603.
Conductivity of fresh feed water = 178 μS/cm
Conductivity of water discharged overboard = 5.4 mS/cm

The coating system applied was by Hemple. On the freeboard areas, two coats (red and black) of a surface tolerant epoxy 6-8 mils WFT each (Hempadur, black 45159 19990; cure 9545*). The top-coat specified was one coat of Exxon Gray, modified acrylic, 4 mils WFT (Hempadur, gray 4563U 11480; cure 95190). The coating specification for the bare underwater hull areas requires two coats of the same surface anti-corrosive epoxy as the freeboard areas, at the same thicknesses, followed by two coats (10 mils WFT/coat) of ablative anti-fouling (black / red). The underbelly of the vessel is to receive one coat of anti-fouling (10 mils WFT).

One of the delaying factors to production with the Dockmaster unit is that it needs to be refueled at least every four hours. This results in downtime, since the machine can not be moving during refueling.

As with all shrouded devices, the blasting head cannot remove coatings up close near protuberances such as overboard drains.

Maneuvering / steering the Dockmaster so that it ran parallel to curved areas on the ship proved difficult for inexperienced operators, resulting in significant differences in production rates around curved surfaces.

The vacuum did not retrieve all the blasting water and paint residue. Consequently, this excess water added to the flash rusting problem.

4.7.7 *USS CLEVELAND (LPD 7):*

SHIP: USS CLEVELAND (LPD 7)
LOCATION: Southwest Marine, San Diego
DATE OF VISIT: August 25-27, 1997
CONTRACTOR: Action Cleaning
EXISTING SYSTEM: Ballast Tank 8-216-0-W, MIL-P-24442 system: Green F150 primer (3 mils), Gray F151 (3 mils), White F152 (3 mils) topcoat.

REMOVAL SPECIFIED: Spot-blast corroded areas to bare metal and sweep blast remaining surfaces.

GENERAL INFORMATION:
For blasting this tank Action cleaning used one NLB Ultra Clean 36 which has a flowrate of 20gpm when operating at maximum output pressure of 36,000 psi. Action cleaning however was operating this pump at 35,000 psi for the tank cleaning. Action cleaning used two guns inside the tank. Both guns were operating off the one NLB pump. The guns were long style lances, the nozzles had 2 jewels and were spun by compressed air. During our production run the two blasters stayed in the tank for their entire shift, exiting the tank only to break midway through shift.

We were able do an initial assessment prior to hydroblasting. Because of the size of this tank it was staged in four levels; top, middle-upper, middle, and lower levels each about five feet high.

An initial assessment of the extent of corrosion was determined, blistering and corrosion occurred at most stiffeners, flat areas were corroded at welds with spot breakdown. The severity of coating failure / corrosion decreased from bottom to top of the tank. Initial surface contamination measurements were taken and are summarized under the "contamination removal" section.

Due to the removal specification this visit was an excellent opportunity to determine if hydroblasting has any effect on coating adhesion. Initial adhesion tests were performed using an Elcometer 1000 and these initial results are tabulated along with after blast adhesion test in a following chart.

PRODUCTION INFORMATION:
During blasting ambient conditions were taken in the tank. Typical conditions were 78^{o}F with 96% relative humidity. Production rates were fairly consistent throughout the day. Two different blasters were observed in the upper level, port pocket of tank 8-216-0-W, one during the first shift and the other blaster during the second shift. The first blaster was observed for two production runs during his entire shift, one 3-hour run before lunch and one hour and twenty minute run after lunch. The second blaster was observed for over two hours during the second shift until he stopped for break. The following production rates include all downtime, which occurred as a result of; waiting for mist to clear, maneuvering and rest. The blasters used forced ventilation in very close proximity to the area being blasted. Along with halogen lamps this dramatically improved visibility compared to previously observed tank work.

USS CLEVELAND Production Rates (ft^2/hour/gun)		
1st Shift, Run 1	**1st Shift, Run 2**	**2nd Shift, Run 3**
45	84	54

Because of the large amount of downtime associated with tank work, the following table is provided to show how much production time was consumed due to maneuvering and poor visibility.

USS CLEVELAND Working Time Percentage (Nozzle On)		
1st Shift, Run 1	**1st Shift, Run 2**	**2nd Shift, Run 3**
38%	49%	54%

CONTAMINATION REMOVAL:
Prior to our arrival tank 8-216-0-W had been scrubbed with Dev-Prep 88 and "Scotch Brite" pads, then pressure washed with 10,000 psi water. This had removed any staining that had existed over intact paint. An after blast inspection was performed to determine overall blast effectiveness. The corroded areas were blasted as specified. Areas of blisters were removed leaving behind islands of bare metal surrounded by intact paint. During our observation some areas of the tank had lightly flash-rusted, while other areas had been dried by the forced ventilation. Final surface contamination readings were taken over areas that had been blasted. Initial data was that over corroded surfaces.

CLEVELAND Location	**Chlorides (μg/ cm^2)**		**Conductivity (μS/cm)**	
	Initial	Final	Initial	Final
Mid-upper lvl, 2nd pocket from aft, center wall	1	not measured	35.6	not measured
Mid-upper lvl, aft wall	1	not measured	63.5	not measured
Upper lvl, 2nd pocket from aft, center wall	not measured	1	not measured	23
Upper lvl, 2nd pocket from aft, over head	not measured	1	not measured	29

Even though the initial and final data were not taken at the exact location, they do represent realistic levels representative of before and after conditions. Therefore the average initial conductivity value is 49.55 μS/cm and the average final value is 26 μS/cm which represents a 47.5 % decrease in the conductivity levels after hydroblasting.

COATING ADHESION:
Final adhesion tests were conducted over intact paint that was located near areas of corrosion that had received impact from the hydroblasting. These final values can be compared to the initial values taken prior to hydroblasting in the following chart.

USS CLEVELAND Ballast Tank - Coating Adhesion		
Initial Values Middle-upper level, port pocket		
Location	**Adhesion (psi)**	**Mode of Failure**
2nd bay from aft, center wall	725	100% adhesive to top-coat
aft wall	650	100% adhesive to top-coat
2nd bay from aft, port wall	650	100% adhesive to top-coat
Final Values Top level, port pocket		
2nd bay from aft, center wall	1000+	100% cohesive in top-coat
2nd bay from aft, center wall	1000+	100% cohesive in top-coat

The intact paint that remained after the blast showed extremely strong adhesion. It is apparent that hydroblasting did not negatively impact the coating when comparing initial and final values even though the adhesion tests were performed at different levels inside the tank.

WASTE HANDLING:

After final washing all blasting debris are washed from the tank. Water and paint waste is accumulated into a dry dock holding tank, from which the water was pumped through a series of two microseperator filters to remove paint debris. These filters were changed about four times a day. This filtered water was then transferred to a separate ballast tank within the dry dock where it was periodically analyzed and tested prior to disposal.

OTHER COMMENTS:

Blasters used ventilation, this improved visibility and also helped force dry the blasted surface minimizing flash rusting.

Conductivity of blast water out of gun and out of water source prior to entering pump:
0.72 mS/cm (720 μS/cm).

4.7.8 *Dannebrog Hull 47:*

SHIP: Dannebrog Hull 47
LOCATION: Alabama Shipyard
DATE OF VISIT: January 27, 1998
CONTRACTOR: Alabama Shipyard
EXISTING SYSTEM: Pre-construction primer (~1 mil)

REMOVAL SPECIFIED: Sweep blast entire structure, all damaged areas were removed to bare metal.

GENERAL INFORMATION:
Alabama Shipyard used Flow International Husky pumps. These Flow Huskies operated at 40,000 psi with a flowrate of 5.5 gpm. Hand-held, five jewel, rotating nozzles were used to removed the primer that had been damaged during activities of new construction (i.e. welding).

PRODUCTION INFORMATION:
Teams consisting of two blasters and one pump operator worked at blasting the outer hull. Working from a man lift or the ground, one blaster would blast while the other handled the lines, switching duties when the blaster became fatigued. Observed production rates ranged from 146 ft^2/hr/gun to 365 ft^2/hr/gun. The following chart summarizes the production rates observed for five separate production runs. Four of the five have very similar production rates. The other (365 ft^2/hr/gun) is very high reflecting a change in orientation for that particular production run area. This production run was oriented on the vertical outer hull whereas others were for the flat underbelly.

Dannebrog Hull 47, Production Rates (ft^2/hour/gun)				
153	365	161	146	165

CONTAMINATION REMOVAL:
Keeping in mind that this ship had never been placed in water, it was not surprising to see no difference in chloride levels for before and after blasting. However, differences in conductivity were noticeably lower after blasting had taken place. This was due to the removal of surface contamination from the industrial shipbuilding environment that had deposited onto the hull's surface. The following table summarizes the chloride and conductivity measurements before and after blasting.

Dannebrog Hull Location	Chlorides (μg/ ft^2)		Conductivity (μS/cm)	
	Initial	Final	Initial	Final
Frame 83	1	1	21.7	14
Frame 33	1	1	36	13

4.7.9 *Trinmar, Block 25 Pump Station:*

SHIP: Trinmar Block Station 25 Off Shore Pumping Station
LOCATION: West Soledad Field, off the coast of Venezuela
DATE OF VISIT: March 4-5, 1998
CONTRACTOR: Cavi-Tech
EXISTING SYSTEM: Exterior Shell: metallic filled primer (2 mils), black (2 mils), gray (5 mils), orange top-coat (5 mils)
Internal Tanks: pre-construction green primer (2 mils), gray epoxy (7-10 mils)

REMOVAL SPECIFIED: Exterior Shell: Strip all paint down to intact primer
Internal Tanks: Spot blast all corroded areas to bare metal, sweep blast painted surfaces to stress and remove all loose paint.

GENERAL INFORMATION:
Job Scope:
Observations were made inside two of forty-two internal tanks that the contractor was tasked to de-scale, water-jet and recoat. Other work performed by the contractor-included re-preservation of platform legs, underside, exterior shell, and deck preparation.

Cavi-Tech used three Butterworth positive displacement pumps for all blasting work. These Butterworth pumps operated between 18,000 and 20,000 psi. When operated at 20,000 psi the pumps consumed 8 gpm/gun. The hand-held lances were modified NLB guns. These 20,000 psi guns had a dual orifice nozzle which is rotated by water pressure.

PRODUCTION INFORMATION:
Exterior Shell:
Production rates for this selective stripping down to primer ranged from 63 ft^2/hr/gun to 115 ft^2/hr/gun. Blasters worked in two man teams with one gun. One man would blast while the other would maneuver hoses, alternating when the blaster became fatigued. This method maximized crews' productivity throughout each day.

Interior Tanks:
Both interior tanks (#16N and #19) contained heavy scale while the coating was blistered and undercut. Prior to blasting, the loose scale was removed (typically by scraper and sledgehammer). Internal tanks were in very advanced stages of disrepair with severe section loss and several areas of corrosion perforating through structural members an to the outside environment. During a six-hour observation the production rate inside of tank 16N was 159 ft^2/hr/gun. The production rate inside of tank 19 was 154 ft^2/hr/gun, after a five-hour observation. As was the case for the exterior shell blasting, two man teams worked together using one gun between them, alternating when the blaster became fatigued. Production data is presented in the table on the following page.

TRINMAR OBSERVED PRODUCTION RATES (ft^2/hour/gun)			
Exterior Shell		Interior Tanks	
63	115	159	154

CONTAMINATION REMOVAL:
Effectiveness of contamination removal for the pumping station platform can only be compared with itself. Comparisons of other before and after contamination removal would not be meaningful since filtered seawater followed by a fresh water rinse was used for the blasting at the Trinmar platform during the duration of our visit. All other hydroblasting observations used a potable water source for blasting.

Platform Location	Chlorides (μg/ ft^{2}cm^2)		Conductivity (μS/cm)	
	Initial	**Final**	**Initial**	Final
Exterior Side Shell	*	70***	*	960***
Tank 16 - over paint	35	3	303	70
Tank 16 - over pitted steel	40	9	670	123
Tank 19 - over paint	35	1	522	43
Tank 19 - over pitted steel	**	3	**	58

*Could not measure initial values due to poor adhesion of Bresle patch on dirty/oily surface.
** Did not measure initial values.
*** Measured prior to secondary fresh water (~10,000 psi) blast.

While the surface contamination values are high compared to what can be obtained using potable water, the decrease in surface contamination using the filtered seawater is still significant.

COATING ADHESION:
To determine the water-jetting's effect upon the remaining coating adhesion, adhesion was measured prior to and after surface preparation in selected areas by the ASTM 4541 method. Results are as follows:

Trinmar, Block 25 Pump Station - Coating Adhesion, Internal Tanks		
Initial Values		
Location	**Adhesion (psi)**	**Mode of Failure**
Tank 16, over top-coat	450	100% Cohesive in Primer
Tank 16, over top-coat	600	100% Cohesive in Primer
Tank 16, over top-coat	400	100% Cohesive in Primer
Tank 16, over top-coat	400	100% Cohesive in Primer
Final (after blast) Values		
Tank 16 (half top-coat/half primer)	400	100% Glue Failure
Tank 16, over primer	425	100% Glue Failure
Tank 16, over top-coat	650	50% Glue Failure, 50% Cohesive in Primer
Tank 16, over bare metal	600	100% Glue Failure
Tank 19 (half top-coat/half primer)	300	100% Glue Failure
Tank 19, over primer	200	100% Glue Failure
Tank 19, over top-coat	750	100% Glue Failure
Tank 19, over bare metal	375	100% Glue Failure

PROFILE MEASUREMENTS:
Profiles of prepared surfaces (with remaining paint) were measured to quantify the surface roughness of the remaining paint. Profile tape measurements (method C, ASTM-D-4417) are listed below:

Profile Measurements	
Location	**Profile (mils)**
Tank 16, over bare metal	4.0
Tank 16, over bare metal	4.4
Tank 16, over primer	4.0
Tank 16, over primer	3.8
Tank 16, over top-coat	2.6
Tank 16, over top-coat	3.6
Tank 16, over top-coat	1.9
Tank 16, over top-coat	1.8
Tank 19, over bare metal	3.4
Tank 19, over bare metal	4.2
Tank 19, over primer	3.8
Tank 19, over top-coat	4.1
Tank 19, over top-coat	1.7

As seen, the profiles on the painted surfaces range from 1.7 to 4.1 mils. This is an excellent profile (on paint) to accept overcoats of anticorrosive coatings.

WASTE HANDLING:
Oily scale was placed in a holding tank. All other debris was discharged into the sea.

OTHER INFORMATION:
Seawater is collected by a submersible pump into a 500 gallon holding tank stored on the top deck of the platform. From this holding tank the water is filtered through a series of (decreasing) filters down to a 3 micron particulate filter. The filters in this series are changed three times a day. The feed water to each pump is sent through a _" line and is again filtered with another three micron filter prior to entering the pump.

4.7.10 ***USS ASHLAND (LSD 48):***

SHIP: USS Ashland
LOCATION: Newport News Shipbuilding, Inc.
DATE OF VISIT: N/A
CONTRACTOR: UHP Projects
EXISTING SYSTEM: Freeboard: Two coats of anti-corrosive epoxy, one coat of urethane top-coat. Total dry film thickness of the system ~ 30mils.

REMOVAL SPECIFIED: Remove all coatings down to bare metal (International HB2M visual standard for flash rust).

Notice:
An Ocean City Research representative was not on-site during this water-jetting work on USS Ashland. The data presented in this summary is based on information received from UHP Projects.

GENERAL INFORMATION:

UHP Projects used a Flow International HydroCat in conjunction with a Flow Husky pump. The HydroCat, a hardwired remote controlled machine, can attach itself to vertical surfaces using vacuum suction. This same vacuum suction removes all paint debris and water away from the freshly blasted surface. The HydroCat is also secured in place with automatic recoil and release safety cables, which automatically tension in case of vacuum failure. The HydroCat contains one nozzle head, which will clean one twelve-inch wide section per pass. This nozzle contains eight, 0.014" orifices. The Hydrocat was operated as an open loop; system since the water collected by the vacuum was not reused. The vacuum of the HydroCat unit did effectively remove all paint and wastewater from the blasted surface. The HydroCat could operate a maximum pressure of 40,000 psi. When the pump was operated a 40,000 psi the flowrate of water was 6.5 gallons per minute.

PRODUCTION INFORMATION:

According to UHP Projects, the observed production rate for the freeboard coating removal down to bare metal on USS Ashland was 280 ft^2/hr/machine.

According to Flow International the HydroCat's production rate on the flight deck nonskid of the USS Nimitz was 360 ft^2/hr/machine and up to 480 ft^2/hr/machine on the apron areas of the non-skid decking.

CONTAMINATION REMOVAL:

UHP Projects performed their own surface chloride analysis (Bresle Patch method) to evaluate the cleanliness of the water-jetted surface. Most of the measurements were in the 0-2 $\mu g/cm^2$ range. A few heavily pitted areas were in the range of 2-4 $\mu g/cm^2$ however, no readings exceeded this 2-4 $\mu g/cm^2$ range. All readings were in an acceptable range for immersion coating service.

OTHER INFORMATION:

After coating application (type of coating) UHP Projects performed coating tensile adhesion tests. Results ranged from 900 psi to 2000 psi, with the average being 1200 psi. All coatings were applied over a HB2M maximum (International Paint Flash Rust Standard) flash rusted surface.

5.0 BENEFITS OF WATER-JETTING

- The use of water-jetting in the marine environment has many benefits. The most important benefit of water-jetting is the ultra clean surface that remains. Water-jetting washes the surface of soluble salts and other material that may have a negative impact on coating adhesion or may lead to osmotic blistering of coatings upon immersion. As seen in Graphs 6 thru 9, water-jetting significantly decreased both chloride salt contamination and surface conductivity. During 100% coating removal or spot blasting corroded areas, water-jetting effectively washes away contamination from the existing steel profile. It does not trap contamination by peening over original peeks, which may occur during abrasive blasting.

- Water-jetting can also be an effective tool in selectively stripping layer(s) from a coating system. Also the adhesion of the remaining coating is not negatively effected, if the underlying coating layer(s) are in good shape. As seen in Tables 3-6, the adhesion values of the coating often increased after water-jetting when compared to initial values. This is due to the fact that when done properly, water-jetting stresses and removes coating deficiencies, leaving behind a tightly adherent coating system.

- In addition to cleaning the surface of the remaining coating system water-jetting will also impart a profile on the remaining coating system. As seen in Table 7 these profiles provide an excellent surface for subsequent coating applications.

- Another benefit of water-jetting is the minimum containment necessary since dust plumes do not occur. When water-jetting is used, containment or masking of motors or other sensitive equipment is not necessary since water-jetting will not damage these pieces due to the absence of airborne dust.

- Other trade work can continue in adjacent areas to water-jetting work, where as this typically is not the case with abrasive blasting. In abrasive blasting, airborne dust which precludes workers and open machinery to function properly.

6.0 REMAINING ISSUES CONCERNING WATER-JETTING

One of the main issues concerning water-jetting in the shipbuilding industry is the occurrence of flash rusting. It is hard to break away from the traditional surface preparation standards of abrasive blasting and evaluate water-jetting in its own category since the remaining bare metal surfaces of the two (abrasive blast and water-jetting) have different appearances. Abrasive blasted surfaces appear bright and shiny (SP-10), where as open-cycle water-jetted surfaces may appear dull or flat (WJ-2) and usually develop flash rust. Currently, many marine coating suppliers have issued visual standard to evaluate the degree of flash rust on a surface to determine if it is acceptable for coating application. It is important to note that these visual standards for flash rusting should not be correlated to the surface preparation standards set forth by the water-jetting joint standard SSPC SP-12/ NACE 5. As surface tolerant coating technologies continue to develop and the long term effects of painting over flash rust for immersion service becomes better-known the issue of flash rusting may diminish.

Because of the complexities of the water-jetting equipment, down-time due to equipment repair is not as high for certain systems as was the case a decade ago. If a pump requires maintenance another pump must be available on-site to take its place, as would be the case for a compressor if one where to breakdown during abrasive blasting operations. With the advancement of water-jetting pump technology from hydraulic intensifier pumps to positive displacement pumps, not only were higher out-put pressures achieved but so were more durable pumps suited for the harsh shipyard environment.

Down time due to worker fatigue is also an issue. The force required to maintain the proper distance of the lance nozzle to the blasting surface is tiring. During our shipyard visits in which hand held lances were being used for blasting, blasters often worked in teams of two men per gun alternating jobs as blaster and helper when the current blaster became fatigued. Blasting in tanks or confined spaces physically stressed workers. In addition to the difficulties of maneuvering in these tight spaces (which would pose problems for any method of surface preparation), water-jetting blasters are faced with poor visibility conditions because of the misting/vapor that is created at these high pressures as well as the high temperature the water attains while being forced out at ultra-high pressures. Granted abrasive blasting also creates poor visibility conditions due to the creation of dust. The poor visibility is improved by the use of suction or positive ventilation. One common problem created by desiccant dehumidification is that the heat and humidity achieved in a confined space severely fatigues workers such that they can only work for one hour before needing a break.

7.0 LESSONS LEARNED

During the Duluth ballast tank water-jetting work dehumidified (convection) air was forced into the tank in an effort to help visibility and reduce the severity of flash rusting. However, the heated dehumidified air added to the heat stress of workers inside the tank. Refrigerant based dehumidified forced air may have been a better choice. In addition to providing ventilation, it would help decrease the temperature inside the tank, making it more comfortable for workers.

8.0 COMMENTS

In recent years, water-jetting has been used more and more by ship builders and ship repairers as a means of preparing surfaces for repainting. As learned from this study, a wide variety of situations are ideal for water jetting, such as:

- touch-up and maintenance of underwater-hull coating systems
- touch-up of internal tank systems
- full removal of decking materials
- full removal of coating systems
- selective (partial) removal of coating layers (such as anti-fouling, or freeboard coatings), leaving full intact coating layers
- preparation of pre-construction primer for re-coating (in new-construction)

As learned in the study, some localities even prohibit the use of open air abrasive blasting in their shipyard activities, leaving water-jetting as the sole productive medium for coating removal.

The study also revealed that different means of coating removal (open cycle/closed cycle), different objectives of coating removal (selective stripping/full removal/spot and sweep), and different types of coating being removed all play a determining role in the observed production rate. Just as important, are the experience of the operator, and the configuration of the blaster (interior tank vs. flat hull), in determining production rate. All of the above factors are integral in determining production rates of any large-scale general coating removal process, such as abrasive grit blasting.

Differences in overall job productivity (as opposed to ft^2/hour) between water-jetting and other methods arise when considering other factors, such as equipment size and maneuverability, the waste stream created, and impact on other trades. In this study, a welcome advantage of shipyard water-jetting versus traditional means was that water-jetting does allow the work of other trades to proceed directly adjacent to water-jetting, a situation un-common during abrasive blasting.

It is the opinion of the authors that for large-scale, quick turn-around coating removal on a ship underwater hull or free-board, the automated, or semi-automated robotic type machinery that contains all blasting water and effluent, represent the most promise for impacting the ship-repair industry. These machines can efficiently remove coatings down to the original substrate without the fear of flash rusting, and provide excellent surfaces for immediate re-coating. Such devices represent the wave of the future for high production shipyard coating removal.

Factors Affecting Production Rates

Numerous factors can affect production rates in a water-jetting operation. The single most important factor is a combination of existing coating type and condition, coupled with the experience and organization of the crew. We noticed that experienced crews can work up to twice as productive as inexperienced crews, performing identical work. Similarly, removal of well-adhered high-build deck coating will not proceed with the speed of a thirteen-year old, degraded epoxy in a tank. The working configuration also plays an important role in affecting productivity. Jetting the cramped flat under-bottom of a ship is at least twice as slow as removing the same coating system on the flat vertical side of an underwater hull. Similarly, maneuvering inside a heavily stiffened internal tank can certainly slow down an operation.

Flash Rusting

Flash rusting is a factor which must be dealt with on practically all jobs encountered. When a coating is removed to bare metal, the resultant moisture in the air, coupled with any other contaminants that may settle on the surface, will create some degree of flash rusting. Depending on a number of factors, this "rust bloom" may grow in intensity with time. In such cases, if the coating specification requires it, the bloom will have to be removed with a secondary blast, followed immediately (after the surface dries) by coating. Inside tanks, the rusting problem can be significantly reduced by properly sized and placed ventilation, and by the use of dehumidification. A related problem exists with the use of common desiccant dehumidification, where the dry air is of significantly higher temperature of ambient, thereby adding to the heat stress of the workers. The use of refrigerant dehumidification should be explored in such situations.

With the closed loop machinery, the blast residue and water is vacuumed away immediately. Adding to this is an evaporative effect caused by the increased temperature of the substrate due to the kinetic energy of the pressurized water impacting the substrate. Flash rusting is not an issue in such situations. In such scenarios, we have witnessed the substrate remaining rust-free for several days, provided no rain or other contaminants foul the blasted surface.

Some coating systems will not tolerate rust blooming, whereas many are designed for be applied over flash rusting. In all ballast tank scenarios, the entire surface was “sealed” with a penetrating sealer type coating (either a moisture-cured urethane or an epoxy-ester) followed by two coats of barrier coating. Well written specifications with clear guidance on acceptable limits of flash rusting , and, how to correct such occurrences if they occur, are key for water-jetting jobs to progress smoothly. Education by all inspection parties, in interpreting flash rusting is also imperative.

9.0 INDUSTRIAL IMPLEMENTATION PLAN

A shipyard implementation plan for incorporating water-jetting into routine surface preparation operations should include, at a minimum, the following points:

- Become familiarized with the technologies.
  - Obtain references on water-jetting in the surface preparation industry.
  - Participate in SSPC/NACE /SNAME meetings, symposiums on water-jetting.

- Observe water-jetting operations in other shipyards.

- Invite water-jetting contractors and equipment manufactures to demonstrate their technology in their shipyard on an actual ship hull, deck, or tank.

- Supervisors / Foreman should attend formal training in the use, operation and maintenance of water-jetting equipment.

- Planners investigate lease / pre-lease options.

- Perform pilot demonstrations and evaluate lessons learned, positive/negative impacts of water-jetting versus other means of surface preparations.

- If positive, implement water-jetting as part of doing business.

10. 0 CONCLUSIONS

The purpose of this study was to evaluate the productivity of water-jetting. Based on this study coating removal rates were categorized into three scenarios; selective stripping, sweep and spot blast corroded areas to bare metal, and complete removal to bare metal. Average rates from individual visits were compiled are as follows:

- The average observed production rates for selective stripping of outer hull coatings with open-cycle, hand held lances ranged from 39 ft^2/hr/gun - 89 ft^2/hr/gun.
- The average observed production rates for sweep and spot blast inside of tanks with hand-held lances ranged from 157 ft^2/hr/gun - 171 ft^2/hr/gun.
- The average observed production rate for a sweep and spot blast of outer hull coatings with hand-held lances was 198 ft^2/hr/gun.
- The average observed production rate for the complete removal of severely damaged outer hull coatings using open-cycle hand-held lances was 152 ft^2/hr/gun.
- The average observed production rate for the complete removal of non-skid flight deck down to bare metal using a closed loop machine was 134 ft^2/hr/gun.
- The average observed production rate for the complete removal of outer hull coatings down to bare metal using an open-cycle self-contained machine was 471 ft^2/hr/gun.

One of the other major purposes of this study was to determine the effectiveness of surface contamination removal. From this study it was determined that water-jetting was highly effective in removing soluble chloride contamination as well as other highly conductive surface contaminates. Multiple before and after blast chloride contamination and surface conductivity measurements were performed and compared. In every instance (see Graphs 6 & 7) chloride contamination decreased or was maintained at the lowest detectable limit of 0-2 $\mu g/cm^2$ (1 $\mu g/cm^2$ for graphing purposes).

Chloride contamination data obtained from the Trinmar, pumping station (Graph 7) illustrates the effectiveness that water-jetting has on reducing chloride contamination. These measurements show that chloride levels were reduced by 78% to 97%.

Surface conductivity generally decreases from prior to water-jetting to after water-jetting readings (see Graphs 8 & 9). The one reading (Carl Vinson Frame 39 over flash rust) that had an increase in conductivity after blasting was only slightly higher than the initial value. For this one instance the initial reading (10 μS/cm) was performed over flash-rust and the final over bare metal (16 μS/cm) at the exact sample location. The reason for the slight increase may have been due to the contamination of the needle and syringe used to extract the fluid from the surface sample cell. It is important to note that both of these conductivity readings were low.

The surface conductivity data from the Trinmar observation (Graph 9) also effectively illustrates the reduction in before and after readings. These measurements show that surface conductivity measurements were reduced by 77% to 92%.

In most cases, coating adhesion values increased after water-jetting was performed. This can be attributed to the fact that water-jetting removes deteriorated portions of the exposed coating system allowing a secure surface for subsequent coating adhesion.

Water-jetting creates a profile on remaining paint systems that were selectively stripped and sweep blasted. Results of surface profiles over coatings are listed in Table 7. These profiles ranged from 1.7 to 4.1 mils which is adequate for overcoat applications.

Based on the data obtained during this study water-jetting is an effective tool in the marine surface preparation industry. Due to advancing technology for water-jetting equipment and paint systems the effectiveness of water-jetting will improve with respect to productivity and the acceptance of the surface it creates.

11.0 APPENDICES

11.1 APPENDIX A

Industrial Survey

NATIONAL SHIPBUILDING RESEARCH PROGRAM

PROJECT 3-96-4

PRODUCTIVITY STUDY OF HYDROBLAST REMOVAL OF COATINGS

OCEAN CITY RESEARCH CORP.

TASK 1: SHIPYARD SURVEY

1. Does your shipyard use hydroblasting to remove coatings?

   a. If yes, do you subcontract this work to a hydroblast contractor?
      do hydroblasting with in-house personnel?
      both?

2. Does your shipyard
   own hydroblasting equipment?
   rent hydroblasting equipment?
   both?

3. If you own hydroblasting equipment who is the manufacturer and what model?

   If you rent hydroblasting equipment what manufacturer and model do you prefer to use?

4. What types of hydroblasting equipment do you use? (check whichever apply)

   Closed cycle (where water is collected, treated and reused)
   Closed cycle (where water is collected, treated and released to sewer)
   Open cycle (hand held lances, etc.)

5. What type of ships are cleaned through hydroblasting at your facility?

   Commercial (check whichever apply)

Tankers	Cargo
Fishing	Cruise
Other __________________	

   Government (check whichever apply)

Coast Guard Vessels	Navy Aircraft Carriers
Navy Combatants	Navy Submarines
Other________________________	

   Structures (check whichever apply)

Internal Ballast tanks	Storage tanks
Fuel tanks	Outer Hulls
Decks (non-skid, other)	Antennas, Radomes
Other Equipment, please list:	

6. Does your shipyard, or contractor, blast to any type of hydroblasting performance specification and / or standard? If so, briefly explain.

7. Is the majority of your blasting (check whichever apply)

   complete coating removal to bare metal?
   removal of loose paint, rust?
   general cleaning?

8. Please state, to the best of your knowledge the typical production rate of coating removal obtained when operating. (ft^2/hour/man)
   Please specify if complete removal of all coatings, or partial coating removal.

9. How reliable is the equipment you use? (i.e. average hours / shift down-time due to maintenance)

10. What is the typical size of a hydroblasting crew? (i.e. 1 pump operator, 2 blasters, etc.)

11. What type of coatings systems are typically removed and what are their general thicknesses?

12. What type of coatings systems are re-applied after hydroblasting?

13. Do you use "surface tolerant" coatings? If so, what types?

14. To the best of your knowledge, how have the applied coatings performed over the hydroblasted surfaces?

15. Have you experienced or had problems with flash-rusting subsequent to blasting? If so how do you deal with flash-rusting? (re-blast flash-rust, use photographic standards, etc.)

16. Do you use any rust inhibitors in your blasting water? If so, what brand(s)?

17. If you do use inhibitors, to the best of your knowledge, how do the inhibitors perform? (i.e. do coatings adhere well to them?)

18. Do you see any drawbacks to hydroblasting for coating removal?

19. Do you feel the use of hydroblasting equipment is gaining acceptance in the ship repair industry?

20. Can you envision hydroblasting as a total replacement for grit blasting in ship re-coating operations? Why / why not?

21. Will your shipyard be doing any hydroblasting in the next 18 months? If yes, may we visit your shipyard and witness, so as not to interfere with production schedules, the coating removal with hydroblasting machinery as part of our study? (Please list a point of contact and phone number if okay.)

General comments:

Please use this space to provide any general comments you have on hydroblasting.

Ocean City Research Corporation thanks you for your help in completing this survey. Please place the survey into the enclosed pre-addressed, pre-paid express package and forward back to us for inclusion in our study.

Thank you,

Darren Melhuish
Staff Engineer

11.2 APPENDIX B

Survey Results

RESULTS OF INDUSTRY SURVEY

queston #	Alabama Shipyard, Inc. John Coll	Atlantic Drydock, Inc. Steve Cogswell	BethShip, Inc. Bill Naunton	Deytens Shipyards, Inc. Jack Smith	Norfolk Shipbuilding Drydock Tom Beacham
1	yes in-house / subcontract	yes in-house	yes subcontract	yes in-house / subcontract	yes in-house / subcontract
2	own / rent	own / rent		own	rent
3 own man. model rent man. rent model	 Geoquip Flow International	 Flow International Husky Woma		WOMA 2170 Pumps John Deere Engines	 N/A No Preference
4	Closed (sewer) / open	open	closed (sewer)	Open	open
5 comm. govern. structure	 Tankers, Cargo, Cruise, Research Decks, Outer Hulls	 Tankers, Cargo Cruise Decks, Outer Hulls	 Tankers, Cargo, Cruise Navy Combatants Internal Ballast Tanks Decks, Outer Hulls	 Tankers, Fishing, Cargo, Cruise, Cable Layers Coast Guard Vessels, MARAD Combatants, Aircraft Carriers, Submarines, U.S. Army, M.S.C. Internal Ballast Tanks, Decks, Outer Hulls	 Tankers, Cargo, Fishing, Cruise, US Naval Vessels Coast Guard Vessels, Navy Combatants Navy Non-Combatants Internal Ballast Tanks, Fuel Tanks, Decks Storage Tanks, Fuel Tanks, Outer Hulls
6	International Stds	Paint Manuf. Specs.	no	International Paint Co. Hydroblasting Stds. 2/HS/10/94 Reference: SSPC-SP-12	SSPC-VIS 1-89, ISO 8501-1:21988, Hydroblasting stds.-CHB2, CHB2 1/2
7	loose paint / rust	complete to bare metal, loose paint / rust, cleaning	complete to bare metal, loose paint / rust	Complete to bare metal, loose rust, general cleaning	general cleaning
8	Guns, Complete ~ 20 ft2/hr Guns, Partial ~ 40 ft2/hr Robotic, Complete ~ 200 ft2/hr Robotic, Partial ~ 600 ft2/hr	Gun, Complete, 16 to 20 mils ~ 60 to 70 ft2/hr	Complete ~ 50-80 ft2/hr Partial ~ 100-250 ft2/hr	10-12 mil epoxies ~ 65 ft2/hr/gun	Complete ~ 75-100 ft2/hr
9	3 hr down/ 10 hr day	running 3 guns: 1.5 hrs/shift	Jet Edge & Flow: 15-20 % down	1 - 1.5 hrs / 10 hour shifr maintenace check between shifts	low press(2000-3500psi) minimum down high (5000-40000) down 1.5hr/shift
10	1 operator 2 men / gun	1 operator 3 blasters	4 to 6 pumps 1 to operators & 1 blaster/ pump	2 operaters for up to 8 pumps 2 jetters per gun	2 pump operators 2 blasters 1 supervisor
11	all types 10 - 40 mils	underwater hull 20 -30 mils freeboard & topside 15-20 mils	epoxy, chlorinated rubber, vinyl, antifouling, alkyd thickness vary	epoxies, Vinyl A-F, Silicone Alkyd underwater 16 - 20 mils freeboard 10-12 mils	epoxies: 10 mils antifouling: 15 - 20 mils
12	surface tolerant epoxies	surface tolerant primers reinstall systems as required	typically surface tolerant epoxy	Surface tolerant two part epoxies	surface tolerant epoxies antifouling
13	International, Hemple, Sigma, Devoe/Ameron, CMP	Ameron #385 & #400 Devoe #235 & 230 International FPL 274	epoxy	Devoe 235 & 230 Barrust International FP & FA Series Hempel 45I5 Series Ameron 385 Series	International FP series Devoe 235 BR series Hempel 4514 / 4515 series Ameron 385 / 400 series
14	good	good	very good	very effective	good
15	3000# wash down	reblast, brush off w/ broom	re-sweep @ 3 - 5,000 psi	Resweep	reblast any flash rust areas
16	no	no	no	no	no
17	N/A	N/A	N/A	N/A	N/A
18	production rate, wastewater treatment equipment expence & reliability	production rate, down time water run off training	cost	effectively blast shapes and angles	low production rates window of time between blasting and coating too short
19	Yes	Yes	Yes, slowly	Yes	Yes, in certain areas
20	external hull prep. because of environmental concerns	not completely, it is another tool to get the job done, grit blasting will always have a place in SY	yes, environmental & health concerns w/ grit blasting $/ft2 must get in line w/ grit blast	yes, as long as the vessel has been previoulsy grit blasted	No. Production rates low. Certain ship structural configurations will not allow direct blast pressure.
21	John Coll 334-473-3082	Steve Cogswell 904-251-1714	Bill Naunton 410-388-4607	Jack Smith 803-308-8043 or 803-849-8009, Ext. 254	not at this time
comments	improvement by automatic or semi-automatic systems	another tool to get the job done.		Less set-up time, little protective covering, no weather restrictions, healthier work site, concurrent work	good for cleaning, far from being a replacement to grit blasting.

RESULTS OF INDUSTRIAL SURVEY CONTINUED

queston #	Southwest Marine Inc. Will Camble	Todd Pacific Shipyards Ken Leroy	Norfolk Naval Shipyard Joel Korzun	Pearl Harbor Naval Shipyard Richard Rodrigues	Puget Sound Naval Shipyard Darren Lutovsky	United Coatings, Inc. Roger Melton
1	yes subcontract	yes in-house / subcontract	yes in-house	yes in-house	yes inhouse	yes in-house
2		own	own	rent	own/rent	own / rent
3 own man. model rent man. rent model		Flow Systems Kent Wash S-200	Jet Edge (1) / Ad-Mac (3) 36 K 250 D/	MIT-M Model CW4004-3MVO 4000 psi (4 gallon/min)	Closed-cycle Pratt & Whitney open : Flow Husky & NLB Triplex Pumps	Flow International Husky S-200 (4) / 150 H.P. electric (1) Flow International Husky S-200
4	closed (sewer)	open, see note	open	open	closed Pratt & Whitney reuse, open rentals	open
5 comm.	Fishing, Tug Boats Barges, Commercial	Tankers, Fishing				Tankers, Cargo, Cruise
govern.			Navy Combatants, Submarines Navy Aircraft Carriers	Navy Combatants Navy Submarines	Navy Combatants Navy Aircraft Carriers Navy Submarines	Coast Guard Vessels, Navy Combatants Navy Aircraft Carriers, Military Sealift MARAD
structure	Outer Hulls	Internal Ballast Tanks, Outer Hulls, Decks	Fuel tanks, Valves, Pumps, Bilges, Machinery rooms, various mechanical components		outer hulls	Internal Ballast Tanks, Storage Tanks, Outer Hulls, Decks, Piping, Foundations
6	Customer satisfaction	International Paint Visual Standards	International Paint Co. Standard as required by NAVSEA03M	NSTM Chapter 631 (Job Order Spec.)	NAVSEA interim guidance for Surf. Prep of Underwater Hulls International Paint Co. standard CHB 2 1/2 L	Joint surface prep. std., SSPC-SP 12/NACE 5
7		complete to bare metal	complete to bare metal, loose paint / rust, cleaning	loose paint / rust	complete to bare metal	complete to bare metal
8		Company Confidental	Complete ~ 50 ft2/hr	removal of AF coatings 200 ft2/hour/man	closed cycle 270-340 ft2/hour open - cycle 85 ft2/nozzle/hour (Husky)	
9		10% down time	ask hydroblast comp. about this	very reliable works for 8 hour shift	maintance time is 23% of production time open 2 shifts down time over 3 months	2hrs down/ 22 hours operation
10		1 pump operator 2 to 4 blasters	shipboard: 2 blasters, 1 pump oper. in shop: 2 blasters per crew	1 Pump Operator, 1 Blaster	closed: 1 maintance person, 2 highlift operator open: 1 pump operator, 1-2 blasters/pump	1 pump operator 2 blasters 1 foreman
11	antifouling: 6 - 10 mils	epoxy, antifouling 22 mils	all types of navy coatings epoxy: 3-10 mils (1 to 3 coats)	Anti-Fouling Coatings 4 mil thicknesses	typical Navy exterior hull coatings 25-35 mils	epoxies, enamel 1 to 45 mils
12	antifouling	surface tolerant epoxies	see NSTM ch 631, preservation of ships in service	Anti-Fouling paint system	typical Navy exterior hull coatings are re-applied after hydroblasting	surface tolerant epoxy
13	International Pro-Line Ameron	International Hempel Devoe	NO	Devran 235 for spot priming	use coatings approved for use on exterior hulls of Naval vessels	epoxies: Devoe Bar-Rust 235, IPCO K4 series, Ameron 400 series, Hempel 4514 series
14	ok	good	no reported failures	excellent	no problems yet	do not know of any discrepencies or failures
15	reblast		citric acid	No	if excessive surface is reblasted	not to the extent that it impared the application or adhesion of the paint
16	no	no	not authorized	No	No	no, coating manufactures have not been conserned with light flash rust.
17	N/A	N/A	N/A	N/A	N/A	N/A
18	water runoff / containme	edge feathering sweeping	no new surface profile	No	closed: cannot blast near protrusions open : relatively slow, flash rusting, physically tiring, envirnomental risk, water collection	production rate will not remove a properly applied inorganic zinc coating
19	for some applications	slowly	Yes	Yes	Yes	Yes
20	No. Too slow, no surface profile, water containme	Yes. more time to complete work, better nozzels to get behind shapes.	no. Does not provide a new surface profile	No. Heavily rusted areas need grit blasting tanks can't be done due to water collection and length of the hydoblasting gun	No. where containment is not a problem grit blasting will be more cost effective	may not, hydro to bare metal is longer than grit. Time constrants to owner and drydock costs due to slower production rates.
21	only at customer reques	none scheduled	Nadine Philpotts, shop 71 hydroblast supervisor 757-396-5912	Paint Chemist 808-474-4437	Darren Lutovsky 360-476-1069	Lee D. Murphy / Roger A. Melton 757-398-0785
comments	I don't like it			Good for Hulls, tanks are difficult because of water collection and size of guns		

11.3 APPENDIX C

Inspection Sheets

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: ______________________

SHIP (TYPE&NAME): ______________________

DATE: ______________

TIME OF ARRIVAL: ______________

AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: [ ]

OTHER: ______________________

AMBIENT CONDITIONS:

WET BULB: [ ] DRY BULB: [ ] RH %: [ ] D.P.: [ ] SUB. TEMP: [ ]

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.) ______________________

____

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) ______________________

____

SURFACE CONTAMINATION:

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

TOOKE GAUGE READING:

LOCATION:						
DISCRIPT. OF COATS:						
THICKNESS OF CTS:						

TYPES/THICKNESSES OF COATING TO BE REMOVED: ______________________

____

SAMPLES COLLECTED: YES: [ ] NO: [ ]

DFT SURVEY:

LOCATION: ______________ LOCATION: ______________ LOCATION: ______________

FT^2 REPRESENTED: ______ FT^2 REPRESENTED: ______ FT^2 REPRESENTED: ______

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: ______________________________

SHIP (TYPE&NAME): ______________________________

DATE: ______________

TIME OF ARRIVAL: ______________

AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: [ ]

OTHER: ______________________________

AMBIENT CONDITIONS:

WET BULB: [ ] DRY BULB: [ ] RH %: [ ] D.P.: [ ] SUB. TEMP: [ ]

MACHINE:

PUMP MANUFACTURER/MODEL/OTHER INFO: ______________________________

OPERATING FLOWRATE (GPM): ______________

OPERATING PRESSURE (PSI): ______________

NOZZLE TYPE: ______________

TYPE OF SURFACE PREP. SPECIFIED: ______________________________

START TIME:				
FINISH TIME:				
DOWN TIME:				
AREA BLASTED:				

PRODUCTION RATE / AREA REMOVED: ______________________________

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP): ______________________________

OPEN / CLOSED SYSTEM: ______________________________

WASTE HANDLING / ACCUMULATION: ______________________________

AMBIENT AIR QUALITY: ______________________________

OTHER INFORMATION: ______________________________

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: ______________________________

SHIP (TYPE&NAME): ______________________________

DATE: ______________

TIME OF ARRIVAL: ______________

AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: [ ]

OTHER: ______________________________

AMBIENT CONDITIONS:

WET BULB: [ ] DRY BULB: [ ] RH %: [ ] D.P.: [ ] SUB. TEMP: [ ]

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

____

____

____

TIME TO FLASH RUST: ______________________________

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):

____

____

____

____

SURFACE CONTAMINATION:

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

REMAINING COATING ADHESION:

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: ______________________________

____

____

COATING APPLICATION TIME: ______________

OTHER COMMENTS: ______________________________

11.4 APPENDIX D

Data From Water-Jetting Visits

VISIT 1

USS DULUTH

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO

SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)

DATE: 2/11/97

TIME OF ARRIVAL: 12:00

AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:

OTHER:

AMBIENT CONDITIONS:

	WET BULB	DRY BULB	RH %	D.P.	SUB. TEMP
	52°F	59°F	47%	46°F	N/A
13:00	53.5°F	61°F	51%	47°F	N/A

MACHINE:

PUMP MANUFACTURER/MODEL/OTHER INFO: Positive displacement, Flow Husky (3) 6 GPM up to 40K psi Houston, TX (713)462-7000 (model 4220) Jet Stream 20K Reciprocating Pump 8GPM Twin Disc Incorporated "Deutz" Deutch air cooled 20K Reciprocating Pump

OPERATING FLOWRATE (GPM):

OPERATING PRESSURE (PSI):

NOZZLE TYPE: Proprietary 20K 4800 RPM 2 orifice water driven
5 Jewel (Flow) 40K 3500 RPM compressed air driven

TYPE OF SURFACE PREP. SPECIFIED: 009-32 spot to bare metal HB 2.5 L on Underwater Hull (full A/F removal) Freeboard-Full alkyd removed to intact epoxy; bare steel at corroded areas.

START TIME:	15:10			
FINISH TIME:	16:40 Nozzle on: 65 min.			
DOWN TIME:	~25 min			
AREA BLASTED:	72 ft^2			

PRODUCTION RATE / AREA REMOVED: Freeboard starboard bow 48 ft^2/hr/gun, working time = 72%

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
Two men per highlift. One operates the highlift while the other blasts, alternating when the blaster becomes tired.

OPEN / CLOSED SYSTEM:

WASTE HANDLING / ACCUMULATION:

AMBIENT AIR QUALITY:

OTHER INFORMATION: Must obtain SDAPCO 619-694-3307 Registration rule 12.1 "Portable emission unit" for diesel pumps.

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: SOUTHWEST MARINE, SAN DIEGO

SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)

DATE: 2/12/97

TIME OF ARRIVAL: 7:00

AREA OF BLAST: U/W HULL: FREBRD: X TANK: DECK:

OTHER: Starboard midship above bilge keel

AMBIENT CONDITIONS:

WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Haze gray alkyd intact

SURFACE CONTAMINATION:

LOCATION:	baseline	under troop walk				
CHLORIDE:						
CONDUCTIVITY:	0 µS/cm	121 µS/cm	128 µS/cm		(3 ml samples)	

TOOKE GAUGE READING:

LOCATION:	freeboard midship above bilge keel below troop walk	
DISCRIPT. OF COATS:	Green epoxy / Gray epoxy / Gray alkyd	
THICKNESS OF CTS:	6 / 10 / 12 mils	

TYPES/THICKNESSES OF COATING TO BE REMOVED: alkyd Gray

SAMPLES COLLECTED: YES: NO:

DFT SURVEY:

LOCATION: frebrd, strb, midship LOCATION: LOCATION:

FT^2 REPRESENTED: FT^2 REPRESENTED: FT^2 REPRESENTED:

average of 30 readings 27.6 mils

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: SOUTHWEST MARINE, SAN DIEGO

SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)

DATE: 2/12/97

TIME OF ARRIVAL: 7:00

AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:

OTHER: Starboard midship above bilge keel below boot-top

AMBIENT CONDITIONS:

WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.) Corroded, Fouled, blistered partially intact

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) fouling, pitting

SURFACE CONTAMINATION:

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

TOOKE GAUGE READING:

LOCATION:	starboard midship above bilge keel below troop walk				Red A/C Buff A/C Red 121
DISCRIPT. OF COATS:	red / buff / red 121	red / buff / red 121			Black Ablative mostly gone
THICKNESS OF CTS:	5 / 10 / ~3 mils	6 / 6 / ~2mils			Red Ablative mostly gone

TYPES/THICKNESSES OF COATING TO BE REMOVED: black ablative epoxy, red ablative epoxy, Red 121

SAMPLES COLLECTED: YES: NO: X

DFT SURVEY: Above bilge keel below boot-top

LOCATION: starboard, mid-ship	LOCATION starboard, mid-ship	LOCATION:
FT² REPRESENTED:	FT² REPRESENTED:	FT² REPRESENTED:
16.3 mil	22.3 mil	

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 2/12/97
TIME OF ARRIVAL: 7:00
AREA OF BLAST: U/W HULL: ___ FREBRD: X TANK: ___ DECK: ___
OTHER: Starboard bow above boot top

AMBIENT CONDITIONS:
WET BULB: ___ DRY BULB: ___ RH %: ___ D.P.: ___ SUB. TEMP: ___

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):

SURFACE CONTAMINATION:

LOCATION:							
CHLORIDE:							
CONDUCTIVITY:							

COATING SYSTEM APPLIED:

COATING APPLICATION TIME:

OTHER COMMENTS:

Freeboard starboard from work done 2/11/97
gray primer 151 left behind. 11.5 mils (with green 150 underneath)
green primer 150 left behind 7.5 mils
originally taking off alkyd 25.7 mils average of 16 readings, (with green 150 & gray 151 underneath)

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 2/12/97
TIME OF ARRIVAL:
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER: starboard FR 0-22, bow

AMBIENT CONDITIONS:

	WET BULB	DRY BULB	RH %	D.P.	SUB. TEMP
12:00	54°F	59°F	51%	50°F	N/A
13:00	54°F	59°F	51%	50°F	N/A

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Flow Husky

OPERATING FLOWRATE (GPM): 6 GPM
OPERATING PRESSURE (PSI): 34000 psi
NOZZLE TYPE: 5 Jewel (Flow) 40K 3500 RPM

TYPE OF SURFACE PREP. SPECIFIED: welds (100%) about 15 linear ft/min, corroded areas to bare metal intact areas leave alone. 100% to bare metal anchor chain scrape areas and keel block.

START TIME:	14:50			
FINISH TIME:	16:11			
DOWN TIME:	0			
AREA BLASTED:	205 ft^2			

PRODUCTION RATE / AREA REMOVED: 152 ft^2/hr/gun

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
Two men per highlift. One operates the highlift while the other blasts, alternating when the blaster becomes tired.

OPEN / CLOSED SYSTEM:

WASTE HANDLING / ACCUMULATION:

AMBIENT AIR QUALITY:

OTHER INFORMATION: prior to blast 5 mil red, 5 mil buff, 3 mil A/F
1/2 hour after blasting: 41 μS/cm & 38 μS/cm over bare steel (3 ml samples)
Cl^- = 0-2 μg/cm^2

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 2/12/97
TIME OF ARRIVAL:
AREA OF BLAST: U/W HULL: [ ] FREBRD: [X] TANK: [ ] DECK: [ ]
OTHER: starboard FR 0-22
AMBIENT CONDITIONS:
WET BULB: [ ] DRY BULB: [ ] RH %: [ ] D.P.: [ ] SUB. TEMP: [ ]

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Flow Husky

OPERATING FLOWRATE (GPM): 6 GPM
OPERATING PRESSURE (PSI): 35000 psi
NOZZLE TYPE: 5 Jewel (Flow)

TYPE OF SURFACE PREP. SPECIFIED: remove alkyd to sound epoxy (gray)
start at 3rd weld above upper boottop

START TIME:	9:06			9:06
FINISH TIME:	10:17			10:50
DOWN TIME:	0			
AREA BLASTED:	152 ft^2			80 - 100 ft^2

PRODUCTION RATE / AREA REMOVED: area one 128.45 ft^2/hr/gun
area two 52 ft^2/hr/gun

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
Two men per highlift. One operates the highlift while the other blasts, alternating when the blaster becomes tired.

OPEN / CLOSED SYSTEM:

WASTE HANDLING / ACCUMULATION:

AMBIENT AIR QUALITY: permits for diesel emissions for pumps

OTHER INFORMATION: blasting from 7:30 to 17:30, painters paint on night shift Devoe Bar Rust 235
after blasting average 14.3 mils green/gray inorganic zinc underneath 36 μS/cm & 36 μS/cm
(3 ml samples)

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 2/12/97
TIME OF ARRIVAL: 7:00
AREA OF BLAST: U/W HULL: X FREBRD: ___ TANK: ___ DECK: ___
OTHER: BOOT-TOP Starboard FR 0-22
AMBIENT CONDITIONS:
WET BULB: ___ DRY BULB: ___ RH %: ___ D.P.: ___ SUB. TEMP: ___

CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):

TIME TO FLASH RUST: Boot top bare metal 1 hour to HB2.5L from HB 2.5 and 2 hours from HB2.5 to HB 2.5M
BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):

SURFACE CONTAMINATION:

LOCATION:	Boottop			U/W Hull			
CHLORIDE:				0-2 $\mu g/cm^2$			
CONDUCTIVITY:	55 μS/cm	54μS/cm	(3 ml spl)	41 μS/cm	38 μS/cm	(3 ml samples)	

COATING SYSTEM APPLIED:

COATING APPLICATION TIME:

OTHER COMMENTS:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 2/12/97
TIME OF ARRIVAL: 7:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: [ ]
OTHER: BOOT-TOP starboard FR 0 - FR 22

AMBIENT CONDITIONS:
WET BULB: [ ] DRY BULB: [ ] RH %: [ ] D.P.: [ ] SUB. TEMP: [ ]

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Flow Husky

OPERATING FLOWRATE (GPM): 6 GPM
OPERATING PRESSURE (PSI): 35000 psi
NOZZLE TYPE: 5 Jewel (Flow)

TYPE OF SURFACE PREP. SPECIFIED: remove black A/F to sound Epoxy Buff
Boot top is 71/2 feet wide
Frame 22 - 0 = 44 = 330 ft^2

START TIME:		10:19		
FINISH TIME:		13:43 nozzle on:173 min.		
DOWN TIME:		31 min		
AREA BLASTED:		330 ft^2		

PRODUCTION RATE / AREA REMOVED: 97 ft^2/hr/gun, working time = 85%
Before 5 mil Red / 5 mil Buff / 3 mil A/F

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
one man in basket blasting no operator 1/2 the time the other half 1 operator.

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION:

AMBIENT AIR QUALITY:

OTHER INFORMATION: observed bare metal go from "HB 2.5 to HB 2.5 L with in one hour and to HB 2.5 Moderate to within 1 hour from that! Other blasting operators from above contaminate the surface.
After - conductivity = 55 μS/cm, 54 μS/cm, blasters left an average of 8.3 mils Buff/Red (3 ml sample)

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 2/12/97
TIME OF ARRIVAL: 7:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: X TANK: [ ] DECK: [ ]
OTHER: starboard midship above bilge keel below walk deck

AMBIENT CONDITIONS:
WET BULB: [ ] DRY BULB: [ ] RH %: [ ] D.P.: [ ] SUB. TEMP: [ ]

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Flow Husky

OPERATING FLOWRATE (GPM): 6 GPM
OPERATING PRESSURE (PSI): 30000 psi
NOZZLE TYPE: 5 Jewel (Flow)

TYPE OF SURFACE PREP. SPECIFIED: remove gray alkyd

	area 1	area 2	area 3	
START TIME:	8:30	13:00	14:55	
FINISH TIME:	11:00	14:43	16:25	
	Nozzle on: 115 min.		Nozzle on: 72 min.	
DOWN TIME:	35 min	0	18 min	
			2 guns	
AREA BLASTED:	180 ft^2	132 ft^2	156 ft^2	

PRODUCTION RATE / AREA REMOVED: area 1 : 72 ft^2/hr/gun, working time = 77%
area 2: 76 ft^2/hr/gun
area 3: 52 ft^2/hr/gun, working time = 80%
Removed about 60% to green 150 epoxy

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
For areas 1 & 2: one blaster and one high lift operator.
For area 3: two blasters and one suspension lift operator.

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION:

AMBIENT AIR QUALITY:

OTHER INFORMATION: jetting water conductivity = 1.18 mS/cm
= 1.15 mS/cm

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 2/13/97
TIME OF ARRIVAL: 7:45
AREA OF BLAST: U/W HULL: ____ FREBRD: X TANK: ____ DECK: ____
OTHER: starboard front

AMBIENT CONDITIONS:
WET BULB: 50 °F DRY BULB: 61 °F RH %: 44% D.P.: 39 °F SUB. TEMP: 58 °F
ambient readings taken at 10:00.

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: ____
OPERATING FLOWRATE (GPM): ____
OPERATING PRESSURE (PSI): ____
NOZZLE TYPE: ____

TYPE OF SURFACE PREP. SPECIFIED: ____

START TIME:				
FINISH TIME:				
DOWN TIME:				
AREA BLASTED:				

PRODUCTION RATE / AREA REMOVED: ____

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP): ____

OPEN / CLOSED SYSTEM: ____

WASTE HANDLING / ACCUMULATION: ____

AMBIENT AIR QUALITY: ____

OTHER INFORMATION: ____

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 2/13/97
TIME OF ARRIVAL: 7:45 time of readings 12:14
AREA OF BLAST: U/W HULL: FREBRD: X TANK: DECK:
OTHER: Starboard midship above bilge keel; below troop walk
AMBIENT CONDITIONS:
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

Picture of Zinc & 150 and 151 remaining
alkyd removed

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):

SURFACE CONTAMINATION:

LOCATION:	starboard mid-ship above bilge keel; below troop walk						
CHLORIDE:	2-4μg/cm^2						
CONDUCTIVITY:	68 μS/cm	65 μS/cm	(3 ml sample)				

COATING SYSTEM APPLIED:

COATING APPLICATION TIME:

OTHER COMMENTS:

2 to 15 mils remaining (zinc 150 and 151)
average 9.8 mils
surface contamination readings taken 18 hours after surface prep completed.

VISIT 2

USS DULUH

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 3/18/97
TIME OF ARRIVAL: 1500
AREA OF BLAST: U/W HULL: ___ FREBRD: ___ TANK: X DECK: ___
OTHER: Frame 84, port balast tank 12.5' wide x 24' long x 18' high

AMBIENT CONDITIONS:
WET BULB: ___ DRY BULB: ___ RH %: ___ D.P.: ___ SUB. TEMP: ___

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.) Upper level - 10% blistered isolated corrosion middle level up to 25% failure w/ sectional loss. lower ~ 40% overall corrosion and sectional loss

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Layer/film of rust stain on top-coat

SURFACE CONTAMINATION: baseline DI water conductivity - 0 µS/cm

LOCATION:	FWD pocket toplevel			FWD pocket middle level	
CHLORIDE:	2-4 µg/cm^2			8-10 µg/cm^2	
CONDUCTIVITY:	51 µg/cm	(3 ml sample)		0.21 mS/cm (210 µS/cm) (3 ml samples)	
	on film and paint			over corrosion	

TOOKE GAUGE READING:

LOCATION:	Upper and all through out tank				
DISCRIPT. OF COATS:	2 coats epoxy white primer, skyblue topcoat				
THICKNESS OF CTS:	4 mil white/ 4 mil blue				

TYPES/THICKNESSES OF COATING TO BE REMOVED: 2 coat epoxy mil-p-23236 white/ lt. blue 8-10 mils DFT

SAMPLES COLLECTED: YES: ___ NO: X

DFT SURVEY:

LOCATION: upper level		LOCATION: mid level		LOCATION: lower level	
FT^2 REPRESENTED:		FT^2 REPRESENTED:		FT^2 REPRESENTED:	
7.2		5.8		10.2	
11.7		6.4		11.3	
7.1	8.7	6.0	6.1	11.7	11.1
9.2		7.4		10.2	
12.9		6.6		9.3	
9.4	10.5	6.9	7.0	10.7	10.1
11.7		11.0		8.0	
7.2		10.7		8.6	
11.2	10.0	11.9	11.2	7.9	8.2
11.3		5.6		20.3	
8.5		7.8		17.0	
9.5	9.8	5.8	6.4	20.1	19.1
6.7		11.4		9.3	
8.3		11.7		10.2	
8.7	7.9	10.5	11.2	11.2	10.2
	9.4		8.4		11.7
					std deviation 3.35

3/18/97

prior to blasting Adhesion of coating

	location: forward pocket, top level	psi	mode of failure
1	outboard atmospheric	825	10% cohesive, 90% A to T
2	inboard atmospheric	825	10% cohesive, 90% A to T
3	outboard web-dirty	700	50% A to T, 50% steel
4	inboard immersion	800	70% B to A, 30% A to T
5	inboard immersion	700	50% P to steel, 25% A to T, 25% A to button

A to T is adhesive to topcoat

#3,4,5 are in immersion zones

	repeat pulls 3/20/97	psi	
1	outboard atmospheric	1000+	50% cohesion blue, 50% adhesive
2	inboard atmospheric	850	10% Paint to steel, 50% adhesive to blue topcoat, 40% cohesive adhesive
3	outboard web-dirty	500	100 Primer to steel (paint still wet)
4	inboard immersion	1000+	50% Primer to steel, 50% adhesive to topcoat
5	inboard immersion	950	60% Primer to steel, 40% cohesive adhesive

PRODUCTION INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 3/19/97
TIME OF ARRIVAL: 700
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [X] DECK: [ ]
OTHER: Frame 84 port 8-84-4-W

AMBIENT CONDITIONS:
WET BULB: 88°F DRY BULB: 88°F RH %: 100% D.P.: 88°F SUB. TEMP: [ ]

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: 2 pumps; 1pump per gun; 2 men
Butterworth and Jet Stream 20K psi pumps

OPERATING FLOWRATE (GPM): 5-7 GPM per gun
OPERATING PRESSURE (PSI): 20,000 psi (NLB)
NOZZLE TYPE: 1 spin nozzle; two orifices

TYPE OF SURFACE PREP. SPECIFIED: spot blast corroded areas to bare metal, sweep blast all other areas

	middle level: aft pocket	bottom level: middle pock.	mid level: middle pock.	bottom level: fwd pocket
START TIME:	825	825	942	957
FINISH TIME:	927	930	1026	1046
DOWN TIME:	*	unknown	Nozzle on: 30 min. 14 min.	unknown
AREA BLASTED:	183 ft^2	256 ft^2	147 ft^2	130 ft^2

PRODUCTION RATE / AREA REMOVED: middle level aft pocket: 177 ft^2/hour/gun
bottom level middle pocket: 236 ft^2/hour/gun bottom level fwd pocket: 160 ft^2/hour/gun
middle level middle pocket: 200 ft^2/hour/gun, working time = 68%
Middle area 10 to 15% corrosion in flange angles. Bottom 50+% corrosion, 100% forward wall

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
One gun per pump. One blaster per gun, switching on/off with partner every hour.

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION: into drydock - catch in sump see last visit data sheets for more details

AMBIENT AIR QUALITY: 100% humidity while blasting in tank ~ 90°F

OTHER INFORMATION: entire top level was done, aft pocket bottom level done,
aft pocket mid level 2/3 done on second shift (3/18 - 3/19/97)
* 12 minutes out of 18 gun was on remainder of time was for looking at work and positioning around stiffeners and flanges.

PRODUCTION INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 3/19/97
TIME OF ARRIVAL: 700
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [X] DECK: [ ]
OTHER: Frame 84 port 8-84-4-W

AMBIENT CONDITIONS:
WET BULB: 88ºF DRY BULB: 88ºF RH %: 100% D.P.: 88ºF SUB. TEMP: [ ]

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: 2 pumps; 1pump per gun; 2 men
Butterworth and Jet Stream 20K psi pumps

OPERATING FLOWRATE (GPM): 5-7 GPM per gun
OPERATING PRESSURE (PSI): 20,000 psi (NLB)
NOZZLE TYPE: 1 spin nozzle; two orifices

TYPE OF SURFACE PREP. SPECIFIED: spot blast corroded areas to bare metal, sweep blast all other areas

	middle level: fwd pocket		bottom level forward pocket	
START TIME:	1055		1055	
FINISH TIME:	1156		1156	
DOWN TIME:	Nozzle on: 35 min. 26 minutes		unknown	
AREA BLASTED:	166 ft^2		92 ft^2	

PRODUCTION RATE / AREA REMOVED:
middle level, forward pocket: 163 ft^2/hour/ gun, working time = 57%
bottom level, forward pocket: 90 ft^2/hour/gun
middle level, forward pocket 30% corrosion. Bottom level, forward pocket 40% corrosion outboard 70% inboard

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
One gun per pump. One blaster per gun, switching on/off with partner every hour.

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION: into drydock - catch in sump see last visit data sheets for more details

AMBIENT AIR QUALITY: 100% humidity while blasting in tank ~ 90ºF

OTHER INFORMATION: Cavi-tech finished the initial blast of this tank by 1600 hours on 3/19/97, needs final washdown and removal of paint chips before coating can occur.

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 3/20/97
TIME OF ARRIVAL: 630
AREA OF BLAST: U/W HULL: FREBRD: TANK: X DECK:
OTHER: FRAME 84

AMBIENT CONDITIONS:
WET BULB: 64°F DRY BULB: 70°F RH %: 72% D.P.: 61°F SUB. TEMP:

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):
spot blast of corroded areas, sweepblast for remainder

SURFACE CONTAMINATION: base line DI water 0 μS/cm

LOCATION:	top level, forward pocket, forward wall					
CHLORIDE:	0-2 $\mu g/cm^2$		0-2 $\mu g/cm^2$			
CONDUCTIVITY:	14 μS/cm	(3 ml spl)	38 μS/cm	(3 ml samples)		
	intact paint		corroded area(blisters blasted off with intact paint remained)			

REMAINING COATING ADHESION:

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: Devoe preprime 167 stripe coat, full coat of preprime. 2 coats of Devoe Bar-rust 235 with stripe coat of 235 inbetween coats.

COATING APPLICATION TIME:

OTHER COMMENTS:

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: SOUTHWEST MARINE, SAN DIEGO
SHIP (TYPE&NAME): LDP-6, USS DULUTH (AUSTIN CLASS)
DATE: 3/20/97
TIME OF ARRIVAL: 630
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [X] DECK: [ ]
OTHER: FRAME 84 middle level forward pocket

AMBIENT CONDITIONS:
WET BULB: 64°F DRY BULB: 70°F RH %: 72% D.P.: 61°F SUB. TEMP:

CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
spot blast of corroded areas, sweepblast for remainder

SURFACE CONTAMINATION: base line DI water 0 µS/cm

LOCATION:	1		2	2		
CHLORIDE:	0-2 µg/cm²		2-4 µg/cm²			
CONDUCTIVITY:	28 µS/cm	(3ml smpl)	110 µS/cm	109 µS/cm	(3 ml sample)	
	intact paint		corroded area(blisters blasted off with intact paint remained)			

buttons set 835
buttons pulled 940

REMAINING COATING ADHESION: middle level forward pocket

LOCATION:	forward wall		inboard wall		vert. stiff.between pocket and outboard	
ADHESION (PSI):	970		600		1000+	
METHOD:						
MODE OF FAILURE:	100% adhesive to topcoat		100% primer to steel		100% primer to steel	

COATING SYSTEM APPLIED:

COATING APPLICATION TIME:

OTHER COMMENTS: location 1 Mid level - forward pocket forward wall in blasted paint area
location 2 mid level - forward pocket forward wall in 1/2 rust 1/2 paint blasted area.

200 psi for dolly over mixture of intact paint and rust

Adhesion tests were done 18 hours after blast, areas of paint still wet.

VISIT 3

DOUBLE EAGLE HULL

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY
GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Newport News Shipbuilding and Drydock Company.
SHIP (TYPE&NAME): Double Eagle Hull 684
DATE: 3/27/97
TIME OF ARRIVAL: 8:48
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER: up to heavy load line
AMBIENT CONDITIONS:
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)
A/F poor adhesion to A/C never been in water
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Not applicable, new construction

SURFACE CONTAMINATION:

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

TOOKE GAUGE READING:

LOCATION:	Port aft 1/3 3' inboard bilge keel, 50' aft draft marks					
DISCRIPT. OF COATS:	A/F (Red -Black-Red) A/C (Red-Grey)					
THICKNESS OF CTS:	10-6-8-5-6	8-7-4-5-4	9-7-7-4-5			

TYPES/THICKNESSES OF COATING TO BE REMOVED: All A/F (3 coats: Red-black-red) to sound A/C (2 coats: red-gray)

SAMPLES COLLECTED: YES: NO: X
DFT SURVEY:

LOCATION: port aft 1/3 by bilge keel		LOCATION: port side		LOCATION: under belly aft 1/3	
FT² REPRESENTED: 30ft²		FT² REPRESENTED:		FT² REPRESENTED:	
32.6		8.9		12.9	
32.9		10.2		11.5	
31.1	32.2	10.7	9.9	12.4	12.3
32.6		11.4		14.4	
37.5		11.9		14.0	
37.0	35.7	12.2	11.8	9.6	12.7
30.2		10.9		11.0	
28.7		11.8		11.1	
28.8	29.2	10.9	11.2	10.9	11.0
32.4		16.8		15.8	
31.2		14.9		15.0	
32.0	31.9	14.9	15.5	16.5	15.8
26.8		20.6		15.1	
29.9		14.4		15.6	
23.9	26.9	18.4	17.8	16.4	15.7
	31.2		**13.3**		**13.5**

with A/F

w/o A/F port side

w/o A/F under belly aft 1/3

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY
PRODUCTION INFORMATION

LOCATION: Newport News S.D.D. company
SHIP (TYPE&NAME): Double Eagle Project Hull 684
DATE: 3/27/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER: underbelly
AMBIENT CONDITIONS:
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Flow Husky

OPERATING FLOWRATE (GPM): 6 gpm/pump - 3 gpm/gun
OPERATING PRESSURE (PSI): 23-25,000 psi
NOZZLE TYPE: rotating 5 orifice ~ 3500rpm (spun by compressed air)

TYPE OF SURFACE PREP. SPECIFIED: take off 3 coats of A/F (red-black-red) to tight A/C (gray)

START TIME:	9:34			
FINISH TIME:	10:34 Nozzle on: 60 min			
DOWN TIME:	8 min 2 guns			
AREA BLASTED:	88 ft^2			

PRODUCTION RATE / AREA REMOVED: 44 ft^2/hour/gun, working time = 87%

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
2 blasters per pump at one time

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION: water is strained through mesh to get heavy debris and water is placed in holding tank

AMBIENT AIR QUALITY:

OTHER INFORMATION: Because of only 4' clearance, guns were held at approx. 30° to 40° angles to surface rather than 90° optimum. Men blasting on 4 wheeled wagon carts-great idea for productivity and maneuverability.
All men, hardhats safety goggles with side shields and face shield. Some blasters wore mist dust masks

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY
SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Newport News
SHIP (TYPE&NAME): Double Eagle Project hull 684
DATE: 3/37/97
TIME OF ARRIVAL: 10:00
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER:

AMBIENT CONDITIONS:
WET BULB: 48°F DRY BULB: 58°F RH %: 47% D.P.: 37°F SUB. TEMP: n/a

CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):
none

TIME TO FLASH RUST: N/A

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
0% A/F 100% A/C

SURFACE CONTAMINATION: aft 1/3 port 70' aft of tailing edge of bilge keel 7' outboard side blocks

LOCATION:	1	2				
CHLORIDE:	<2 μg/cm^2	<2 μg/cm^2				
CONDUCTIVITY:	16 μS/cm	17 μS/cm	(3 ml samples)			

REMAINING COATING ADHESION:

LOCATION:	1	2	3	4	5	
ADHESION (PSI):	650	650	725	1000+	725	
METHOD:	*	*	*	**	**	

COATING SYSTEM APPLIED:

COATING APPLICATION TIME:

OTHER COMMENTS: * Failure in adhesive 50% to button, 50% topcoat
** Failure cohesive in paint to primer, 50% adhesive to button

surface profile on existing paint: 1.7 mils, 1.3 mils, 1.7 mils by testex tape

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Newport News Shipbuilding and Drydock Company.
SHIP (TYPE&NAME): Double Eagle Hull 684
DATE: 3/27/97
TIME OF ARRIVAL: 8:45
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER:
AMBIENT CONDITIONS:
WET BULB: 46°F DRY BULB: 51°F RH %: 69% D.P.: 41°F SUB. TEMP: n/a
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)
clean and smooth
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) none, very clean red topcoat can be marked with fingernail (depression) with difficulty, some run down from topside washing

SURFACE CONTAMINATION:

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

TOOKE GAUGE READING:

LOCATION:						
DISCRIPT. OF COATS:						
THICKNESS OF CTS:						

TYPES/THICKNESSES OF COATING TO BE REMOVED: Ameron 3-coat Antifouling

SAMPLES COLLECTED: YES: NO: X
DFT SURVEY:

LOCATION: forward (fr 20) starboard		LOCATION forward (fr 20) starboard		LOCATION:	
FT^2 REPRESENTED:		FT^2 REPRESENTED:		FT^2 REPRESENTED:	
46.0		26.7			
48.8		28.7			
50.0	48.3	27.8	27.7		
45.2		28.4			
59.8		28.6			
55.9	53.6	27.0	28.0		
45.6		30.7			
44.4		28.9			
44.4	44.8	34.0	31.2		
47.2		35.6			
46.8		35.1			
46.8	46.9	34.8	35.2		
46.4		34.0			
48.0		31.5			
49.6	48.0	27.2	30.9		
	48.3		30.6		

prior to blast

after blast

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: Newport News S.D.D. company

SHIP (TYPE&NAME): Double Eagle Project Hull 684

DATE: 3/27/97

TIME OF ARRIVAL: 9:50

AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:

OTHER:

AMBIENT CONDITIONS:

WET BULB: 48°F DRY BULB: 51°F RH %: 78% D.P.: 45°F SUB. TEMP: n/a

MACHINE:

PUMP MANUFACTURER/MODEL/OTHER INFO:

OPERATING FLOWRATE (GPM):

OPERATING PRESSURE (PSI):

NOZZLE TYPE:

TYPE OF SURFACE PREP. SPECIFIED:

	*1	*2		
START TIME:	8:55	9:20		
FINISH TIME:	9:15	10:20		
	Nozzle on: 14 min.	Nozzle on 58 min.		
DOWN TIME:	6.0 min	2.0 min		
AREA BLASTED:	15 ft^2	28 ft^2		

PRODUCTION RATE / AREA REMOVED:

*1 45 ft^2/hour/ gun, working time = 70%

*2 28 ft^2/ hour/ gun, working time = 97%

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):

one man per gun

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION:

AMBIENT AIR QUALITY: clear moderate mist down stream about 50-75 feet. Slight turpentine smell from A/F system

OTHER INFORMATION:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Newport News
SHIP (TYPE&NAME): Double Eagle Project hull 684
DATE: 3/37/97
TIME OF ARRIVAL: 9:50
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER:

AMBIENT CONDITIONS:
WET BULB: 50°F DRY BULB: 60°F RH %: 49% D.P.: 40°F SUB. TEMP: n/a

CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):
none

TIME TO FLASH RUST: N/A

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
100% primer (gray) remains, some localized areas of antifouling less than $1 cm^2$
most less than $1.0 mm^2$

SURFACE CONTAMINATION:

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

REMAINING COATING ADHESION:

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: N/A removal of coating system at this time.
Existing system: 2 coat Amercoat 385 with three coat (red - black - red) Ameron self polishing antifouling.

COATING APPLICATION TIME:

OTHER COMMENTS: Smooth epoxy primer after AF removal has a slight gum-like appearance when blasted, possibly from heat of water blast. Some epoxy disbondment where heat from internal welding was performed.

VISIT 4

USS LAMOURE COUNTY

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Colonna's Shipyard / Earl Industries

SHIP (TYPE&NAME): La Moure County LST 1194

DATE: 5/5/97

TIME OF ARRIVAL: 9:50

AREA OF BLAST: U/W HULL: [ ] FREBRD: X TANK: [ ] DECK: [ ]

OTHER: Aft, starboard side

AMBIENT CONDITIONS:

WET BULB: 61°F DRY BULB: 70°F RH %: 59% D.P.: 55°F SUB. TEMP: [ ]

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Clean, some overspray

SURFACE CONTAMINATION:

LOCATION:						
CHLORIDE:	<2μg/cm²	<2μg/cm²				
CONDUCTIVITY:						

TOOKE GAUGE READING:

LOCATION:	Frb/Frm 290	Frb/Fr290	1st coat	2nd coat	3rd coat	4th coat	5th-8th coat
DISCRIPT. OF COATS:	4 minimum	8 max.	F-150	F-151	24635	24635	silicon alkyd MIL-E-24635
THICKNESS OF CTS:			6-8 mils	6-8 mils	3-4 mils	3-4 mils	3-4 mils each

TYPES/THICKNESSES OF COATING TO BE REMOVED: silicon alkyd, epoxies some apparent IOZ in a few areas.

At least 8 coats of paint on freeboard; 2 coat epoxy, 2 ct silicon alkyd as original. Plus 4 cts silicon alkyd applied at a later date. Some IOZ present on freeboard. No IOZ on boottop or UWH.

SAMPLES COLLECTED: YES: X NO: [ ]

DFT SURVEY:

LOCATION: Aft Freeboard		LOCATION Aft Freeboard		LOCATION:	
FT² REPRESENTED: 75 ft²		FT² REPRESENTED:		FT² REPRESENTED:	
36.2		34.3			
36.2		36.6			
36.9	36.4	37.3	36.1		
39.7		40.1			
37.6		40.9			
34.3	37.2	52.3	44.4		
33.5		40.1			
37.2		40.5			
32.4	34.4	42.5	41.0		
40.5		37.0			
39.3		38.6			
34.2	38.0	40.1	38.6		
40.1		49.2			
39.0		47.6			
38.3	39.1	53.5	50.1		
	37.0		42.0		

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY
PRODUCTION INFORMATION

LOCATION: Colonna's Shipyard / Earl Industries
SHIP (TYPE&NAME): La Moure County LST 1194
DATE: 5/15/97
TIME OF ARRIVAL: 8:30
AREA OF BLAST: U/W HULL: ___ FREBRD: X TANK: ___ DECK: ___
OTHER: Aft starboard side
AMBIENT CONDITIONS:
WET BULB: 58°F DRY BULB: 66°F RH %: 61% D.P.: 52°F SUB. TEMP: ___

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Flow International
200 hp 460V electric motor (2 pumps)

OPERATING FLOWRATE (GPM): 3.0 GPM
OPERATING PRESSURE (PSI): 38,000 psi (40,000 static)
NOZZLE TYPE: WASP (5 jewel per head) (2 lances)

TYPE OF SURFACE PREP. SPECIFIED: White metal freeboard stern area leaving IOZ intact but removing all organic systems.

	#1	#2	#3	
START TIME:	8:45	10:25	12:30	
FINISH TIME:	10:00	11:20	13:30	
DOWN TIME:	0	0	0	
AREA BLASTED:	2 guns 180 ft^2	2 guns 48 ft^2	2 guns 24 ft^2	

PRODUCTION RATE / AREA REMOVED:

Combined	Individual
Location #1 144 ft^2/hr	72 ft^2/hr/gun
Location #2 52.4 ft^2/hr	26 ft^2/hr/gun
Location #3 24 ft^2/hr	12 ft^2/hr/gun

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
2 men per man lift and per pump, blasting at the same time, (one experienced, one novice)

OPEN / CLOSED SYSTEM: Open system

WASTE HANDLING / ACCUMULATION: Floating dry dock tilted to the aft of the ship. Metal plate welded at this end to drydock. Hay bails placed in front of this plate to keep paint debris from entering sea water while allowing wash water to exit drydock.

AMBIENT AIR QUALITY: ___

OTHER INFORMATION: Freeboard F-151 Silicone Alkyd topcoat stern area (about 30ft forward starboard side)

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY
SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Colonna's Shipyard
SHIP (TYPE&NAME): La Moure County LST 1194
DATE: 5/15/97
TIME OF ARRIVAL: 9:43
AREA OF BLAST: U/W HULL: [ ] FREBRD: [X] TANK: [ ] DECK: [ ]
OTHER: Aft Starboard side 20 ft from stern

AMBIENT CONDITIONS:
WET BULB: 61ºF DRY BULB: 70ºF RH %: 59% D.P.: 55ºF SUB. TEMP: 70ºF

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):
About 40% light flash rust in area blasted previous day.

TIME TO FLASH RUST: 20-30 minutes for IOZ area. 2-3 minutes for non-IOZ areas

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
~0% organic coating remaining, some IOZ left in localized areas, difficult to see until after flash rusting has occurred.

SURFACE CONTAMINATION:

LOCATION:	Freeboard					
CHLORIDE:	<2μg/cm^2					
CONDUCTIVITY:	26 μS/cm	(3 ml sample)				

conductivity of water: 3μS/cm

REMAINING COATING ADHESION:

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: International 303 series epoxy to be applied by yard

COATING APPLICATION TIME:

OTHER COMMENTS:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Colonna's Shipyard
SHIP (TYPE&NAME): La Moure County LST 1194
DATE: 5/5/97
TIME OF ARRIVAL: 9:00
AREA OF BLAST: U/W HULL: ___ FREBRD: X TANK: ___ DECK: ___
OTHER: Forward frame 51 starboard
AMBIENT CONDITIONS: taken at 11:00
WET BULB: 63°F DRY BULB: 77°F RH %: 45% D.P.: 54°F SUB. TEMP: ___
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)
Chalked and faded, no blistering or peeling
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) clean, no oils, fouling or overspray

SURFACE CONTAMINATION:

LOCATION:	Frame 51					
CHLORIDE:	<2µg/cm^2					
CONDUCTIVITY:						

Note this all over IOZ on freeboard. No IOZ on boot top or UWH

TOOKE GAUGE READING	coat #1	coat #2	coat #3	coat #4	coat #5	coat #6	coat #7	coat #8
LOCATION:	Frame 51	Frame 51	Frame 51	51	51	51	51	51
DISCRIPT. OF COATS:	F-150	F-151	24635	24635	24635	24635	24635	24635
THICKNESS OF CTS:	6-8 mils	6-8 mils	3-4 mils	3-4 mils	3-4 mils	3-4 mils	3-4 mils	3-4 mils

TYPES/THICKNESSES OF COATING TO BE REMOVED:
At least 8 coats of paint on freeboard; 2 coat epoxy, 2 ct silicon alkyd as original. Plus 4 cts silicon alkyd applied at a later date.

SAMPLES COLLECTED: YES: ___ NO: ___

DFT SURVEY:

LOCATION: Frame 51 forward stbd		LOCATION Aft Freeboard		LOCATION:	
FT^2 REPRESENTED: 75 - 85 ft^2		FT^2 REPRESENTED:		FT^2 REPRESENTED:	
40.5					
39.7					
34.8	38.3				
33.3					
30.8					
31.8	32.0				
33.7					
35.3					
45.6	38.2				
37.2					
39.7					
39.3	38.7				
34.4					
33.5					
33.7	33.9				
	36.2				

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: Colonna's Shipyard
SHIP (TYPE&NAME): La Moure County LST 1194
DATE: 5/15/97
TIME OF ARRIVAL: 8:30
AREA OF BLAST: U/W HULL: [ ] FREBRD: [X] TANK: [ ] DECK: [ ]
OTHER: forward starboard side

AMBIENT CONDITIONS:
WET BULB: 59°F DRY BULB: 68°F RH %: 58% D.P.: 53°F SUB. TEMP: [ ]

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Flow International
200 hp 460V electric motor (2 pumps)

OPERATING FLOWRATE (GPM): 3.0 GPM
OPERATING PRESSURE (PSI): 38,000 psi (40,000 static)
NOZZLE TYPE: HAMMERHEAD 8 Jewel per head (2 lances)

TYPE OF SURFACE PREP. SPECIFIED: White metal (leaving IOZ essentially intact, but no organic systems)

	#1	#2	#3	
START TIME:	8:50	10:50	12:33	
FINISH TIME:	10:00	11:20	15:04	
DOWN TIME:	0	0	Nozzle on: 131 min. 20 min	
AREA BLASTED:	2 guns 120 ft^2	2 guns 75 ft^2	2 guns 100 ft^2	

PRODUCTION RATE / AREA REMOVED:

	Combined	Individual
Location #1	103 ft^2/hr	52 ft^2/hr/gun
Location #2	150 ft^2/hr	75 ft^2/hr/gun
Location #3	46 ft^2/hr	20 ft^2/hr/gun, working time = 87%

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
2 men per man lift blasting at the same time, (one experienced, one novice)

OPEN / CLOSED SYSTEM: Open system

WASTE HANDLING / ACCUMULATION: Drydock Floor

AMBIENT AIR QUALITY:

OTHER INFORMATION: Freeboard F-151 and Silicone Alkyd removed. These guns having problems

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Colonna's Shipyard
SHIP (TYPE&NAME): La Moure County LST 1194
DATE: 5/15/97
TIME OF ARRIVAL: 14:00 AM
AREA OF BLAST: U/W HULL: [ ] FREBRD: X TANK: [ ] DECK: [ ]
OTHER: forward, starboard side

AMBIENT CONDITIONS:
WET BULB: 66°F DRY BULB: 80°F RH %: 47% D.P.: 58°F SUB. TEMP: [ ]

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):
less than 20% due to IOZ primer

TIME TO FLASH RUST: rust occurred in about 30 minutes of IOZ area. 2-3 minutes for non-IOZ areas.

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):
~0% organic coating remaining, some IOZ left in localized areas, difficult to see until after flash rusting has occurred.

SURFACE CONTAMINATION:

LOCATION:	frame 51					
CHLORIDE:	<2μg/cm^2					
CONDUCTIVITY:	9 μS/cm	(3 ml sample)				

conductivity of water: 3μS/cm

REMAINING COATING ADHESION: no organic coating present

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: International 303 series epoxy to be applied by yard

COATING APPLICATION TIME:

OTHER COMMENTS: difficult to see IOZ until after substrate dries and small areas flash rust appear.

VISIT 5

USS CARL VINSON

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: Puget Sound Naval Shipyard

SHIP (TYPE&NAME): CVN 70 USS Carl Vinson

DATE: 7/9/97

TIME OF ARRIVAL: 14:00

AREA OF BLAST: U/W HULL: FREBRD: TANK: DECK: X

OTHER: Non-skid removal ~ frame 39 port of Cat 2.

AMBIENT CONDITIONS:

WET BULB:	DRY BULB:	RH %:	D.P.:	SUB. TEMP:
58	64	70	54	65

MACHINE:

PUMP MANUFACTURER/MODEL/OTHER INFO: HydroPac - Hydraulically Activated Dual Intensifier
NLB Pump - 10 GPM @ 40K positive displacement
(Guintiplex - 5 plungers / cylinder)

OPERATING FLOWRATE (GPM): 10 GPM at 40,000psi

OPERATING PRESSURE (PSI): at nozzle ~ 30 to 32,000 psi

NOZZLE TYPE: 6" wide rectangular; 22 jewel orifice, synthetic sapphire air activated 600 RPM

Translation speed range 1-3 inches/sec. Patch size: 4.5 ft x 6.5 ft (1/2" to 1" overlap/pass)

TYPE OF SURFACE PREP. SPECIFIED: Complete coating removal to bare steel

	HydroPac			
START TIME:	10:30			
FINISH TIME:	15:30			
DOWN TIME:				
AREA BLASTED:	675 ft^2 =26 patches			

PRODUCTION RATE / AREA REMOVED: 135 ft^2/hr

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
2 operators for non-skid: one blaster operator and one waste water reclamation operator.
(3 persons for under water hull areas, the third is a spotter)

OPEN / CLOSED SYSTEM: closed

WASTE HANDLING / ACCUMULATION: Solids are shipped as waste in drums, water is recycled.

AMBIENT AIR QUALITY:

OTHER INFORMATION: Production was low today due to weather and changing of orifices.

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: Puget Sound Naval Shipyard

SHIP (TYPE&NAME): CVN 70 USS Carl Vinson

DATE: 7/10/97

TIME OF ARRIVAL: 8:15

AREA OF BLAST: U/W HULL: FREBRD: TANK: DECK: X

OTHER: Non-skid removal ~ frame 39 port of Cat 2.

AMBIENT CONDITIONS:

WET BULB:	DRY BULB:	RH %:	D.P.:	SUB. TEMP:
60 at 12:05	66	71	56	61

MACHINE:

PUMP MANUFACTURER/MODEL/OTHER INFO: HydroPac - Hydraulically Activated Dual Intensifier NLB Pump - 10 GPM @ 40K positive displacement (Guintiplex - 5 plungers / cylinder)

OPERATING FLOWRATE (GPM): 10 GPM at 40,000psi

OPERATING PRESSURE (PSI): at nozzle ~ 30 to 32,000 psi

NOZZLE TYPE: 6" wide rectangular; 22 jewel orifice, synthetic sapphire air activated 600 RPM

Translation speed range 1-3 inches/sec. Patch size: 4.5 ft x 6.5 ft (1/2" to 1" overlap/pass)

TYPE OF SURFACE PREP. SPECIFIED: Complete coating removal to bare steel

	HydroPac			
START TIME:				
FINISH TIME:	7min 30sec			
DOWN TIME:	0			
AREA BLASTED:	1 patch 29.25 ft^2			

PRODUCTION RATE / AREA REMOVED: 234 ft^2/hr this rate is not realistic, only based on one patch for 7.5 min. Since it does not take into account maneuvering of machine, etc.

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):

One blasting unit operator

One waste water reclamation operator

OPEN / CLOSED SYSTEM: closed

WASTE HANDLING / ACCUMULATION: Solids are shipped as waste in drums, water is recycled.

AMBIENT AIR QUALITY:

OTHER INFORMATION:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

Run 1

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: ___ FREBRD: ___ TANK: ___ DECK: X
OTHER: ~ Frame 39 port of Cat 2
AMBIENT CONDITIONS: At 10:00
WET BULB: 58 DRY BULB: 65 RH %: 66 D.P.: 53 SUB. TEMP: 70
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.) These areas were blasted on 7/14/97 and flash rusted due to rain. Moderate - Heavy Flash rust - not tightly adherent.
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.)

SURFACE CONTAMINATION:

LOCATION:	Frame 39					
CHLORIDE:	0-2 $\mu g/cm^2$					
CONDUCTIVITY:	10 $\mu S/cm$	(5 ml sample)				

baseline water = 1$\mu S/cm$

TOOKE GAUGE READING: N/A

LOCATION:						
DISPIRIT. OF COATS:						
THICKNESS OF CTS:						

TYPES/THICKNESS OF COATING TO BE REMOVED: Moderate to heavy Flash Rusting

SAMPLES COLLECTED: YES: ___ NO: X
DFT SURVEY: N/A
LOCATION: ___ LOCATION: ___ LOCATION: ___
FT^2 REPRESENTED: ___ FT^2 REPRESENTED: ___ FT^2 REPRESENTED: ___

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

Run 1

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: [X]
OTHER: Moderate to heavy Flash rusting

AMBIENT CONDITIONS:
WET BULB: 58 (at 10:00) DRY BULB: 65 RH %: 66 D.P.: 53 SUB. TEMP: 70

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: HydroPac - Hydraulically Activated Dual Intensifier

OPERATING FLOWRATE (GPM): 10 GPM at 40,000psi
OPERATING PRESSURE (PSI): 36 - 40,000 at pump
NOZZLE TYPE: 6" wide rectangular; 22 jewel orifice, synthetic sapphire air activated 600 RPM
Translation speed range 1-3 inches/sec. Patch size: 4.5 ft x 6.5 ft (1/2" to 1" overlap/pass)

TYPE OF SURFACE PREP. SPECIFIED: Near white metal

	HydroPac			
START TIME:	8:56			
FINISH TIME:	9:45 (Nozzle on: 45 min.)			
DOWN TIME:	4 min			
AREA BLASTED:	156 ft^2 (6.5' x 24')			

PRODUCTION RATE / AREA REMOVED: 191 ft^2/hr, working time = 92%

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
One blasting unit operator
One waste water reclamation operator

OPEN / CLOSED SYSTEM: closed

WASTE HANDLING / ACCUMULATION: Solids are shipped as waste in drums, water is recycled.

AMBIENT AIR QUALITY: Diesel from pump, high lift

OTHER INFORMATION: ARMS - Automated Robotic Maintenance System (water reclamation unit)

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

Run 1

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: X
OTHER: ~ Frame 39, port of Cat 2

AMBIENT CONDITIONS:
WET BULB: 58/65 DRY BULB: 65/80 RH %: 66/44 D.P.: 53/56 SUB. TEMP: 70/105
10:00/11:00

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):
0% remaining

SURFACE CONTAMINATION:

LOCATION:	frame 39						Baseline
CHLORIDE:	0-2 $\mu g/cm^2$						water
CONDUCTIVITY:	16 $\mu S/cm$	(5ml sample)					=0 $\mu S/cm$

REMAINING COATING ADHESION:

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: Devoe Devgrip 137 epoxy primer
Devoe Devgrip 138 roll-on non-skid

COATING APPLICATION TIME:

OTHER COMMENTS: Very slight golden hue starting with in 45 minutes
Casters on shroud of blast nozzle seized up. Due to this the resultant profile was destroyed as the casters scratched flat the previously peened profile . This probably effects ~ 5% of the total area.

profile of bare steel: 4.2 mils and 3.8 mils

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

Run 2

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: ___ FREBRD: ___ TANK: ___ DECK: X
OTHER: ~ Frame 39 port of Cat 2
AMBIENT CONDITIONS:
WET BULB: ___ DRY BULB: ___ RH %: ___ D.P.: ___ SUB. TEMP: ___
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)
Mix of non-skid and flash rusting
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Moderate to heavy flash rusting

SURFACE CONTAMINATION:

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

TOOKE GAUGE READING: N/A

LOCATION:						
DISPIRIT. OF COATS:						
THICKNESS OF CTS:						

TYPES/THICKNESS OF COATING TO BE REMOVED: Moderate to heavy Flash Rusting

SAMPLES COLLECTED: YES: ___ NO: X
DFT SURVEY: N/A
LOCATION: ___ LOCATION: ___ LOCATION: ___
FT^2 REPRESENTED: ___ FT^2 REPRESENTED: ___ FT^2 REPRESENTED: ___

PRODUCTION INFORMATION

Run 2

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: [X]
OTHER: ~ Frame 39 port of Cat 2

AMBIENT CONDITIONS:
WET BULB: 63 at 11:33 DRY BULB: 78 RH %: 43 D.P.: 55 SUB. TEMP: 110

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: NLB

OPERATING FLOWRATE (GPM): 10 GPM at 40,000psi
OPERATING PRESSURE (PSI): 37,000 at pump
NOZZLE TYPE: 6" wide rectangular; 22 jewel orifice, synthetic sapphire air activated 600 RPM
Transition speed range 2.5 inches/sec.

TYPE OF SURFACE PREP. SPECIFIED: Near white metal
Removing Flash Rust and areas primed with Devoe.

START TIME:	10:13			
FINISH TIME:	12:18 Nozzle on: 85 min.			
DOWN TIME:	40 min			
AREA BLASTED:	394.25 ft^2			

PRODUCTION RATE / AREA REMOVED: 189.24 ft^2/hr, working time = 68%
Area blasted overlapped 1/2 of the previous run (run 1) in the 6.5 ft dimension
13 patches + 14 ft^2 for squaring off edges.

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
One blasting unit operator
One waste water reclamation operator

OPEN / CLOSED SYSTEM: closed

WASTE HANDLING / ACCUMULATION: Solids are shipped as waste in drums, water is recycled.

AMBIENT AIR QUALITY: Diesel from pump, high lift

OTHER INFORMATION: To move from one spot to the next and start blasting takes ~ 1min. 30 seconds.

SURFACE CONDITION (AFTER BLASTING) INFORMATION

Run 2

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: X
OTHER: ~ Frame 39, port of Cat 2

AMBIENT CONDITIONS:

WET BULB:	DRY BULB:	RH %:	D.P.:	SUB. TEMP:
63	74	54%	56	110

at 12:00

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):

0% remaining

SURFACE CONTAMINATION:

LOCATION:	Run 2						Baseline
CHLORIDE:	0-2 μg/cm^2						water
CONDUCTIVITY:	18 μS/cm	(3ml spl)	or 10.8 μS/cm (@ 5 ml sample)				= 0 μS/cm

REMAINING COATING ADHESION: N/A

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: Devoe Devgrip 137 epoxy primer
Devoe Devgrip 138 roll-on non-skid

COATING APPLICATION TIME:

OTHER COMMENTS:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: X
OTHER: ~ Frame 39 port of Cat 2 area of flash rusting with dark stained pits
AMBIENT CONDITIONS: At 13:09
WET BULB: 62 DRY BULB: 82 RH %: 30 D.P.: 48 SUB. TEMP: 118
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)
N/A
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.)
Flash Rusted area: Pitted areas show darker amounts of flash rusting
SURFACE CONTAMINATION:

LOCATION:	Frame 39					
CHLORIDE:						
CONDUCTIVITY:	clean metal (3 ml) = 12 μS/cm		Pitted stain (2ml) = 34 μS/cm			

Baseline of water = 0μS/cm

adjusted to 5 ml: 7.2 μS/cm (@ 5 ml sample) 13.6 μS/cm (@ 5 ml sample)

TOOKE GAUGE READING: N/A

LOCATION:						
DISPIRIT. OF COATS:						
THICKNESS OF CTS:						

TYPES/THICKNESS OF COATING TO BE REMOVED:

SAMPLES COLLECTED: YES: [ ] NO: [ ]
DFT SURVEY: N/A

LOCATION: LOCATION: LOCATION:
FT^2 REPRESENTED: FT^2 REPRESENTED: FT^2 REPRESENTED:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

Run 3

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: ___ FREBRD: ___ TANK: ___ DECK: X
OTHER: ~ Frame 39 port of Cat 2
AMBIENT CONDITIONS: At 12:00
WET BULB: 63 DRY BULB: 74 RH %: 54 D.P.: 56 SUB. TEMP: 110
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Clean Non-skid

SURFACE CONTAMINATION: N/A

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

TOOKE GAUGE READING: N/A

LOCATION:						
DISPIRIT. OF COATS:						
THICKNESS OF CTS:						

TYPES/THICKNESS OF COATING TO BE REMOVED: all non-skid to bare metal

SAMPLES COLLECTED: YES: ___ NO: X
DFT SURVEY: N/A
LOCATION: ___ LOCATION: ___ LOCATION: ___
FT^2 REPRESENTED: ___ FT^2 REPRESENTED: ___ FT^2 REPRESENTED: ___

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

Run 3

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: [X]
OTHER: ~ Frame 39 port of Cat 2

AMBIENT CONDITIONS:
WET BULB: 63/62 DRY BULB: 74/82 RH %: 54/30 D.P.: 56/48 SUB. TEMP: 110/118
at 12:00 / 13:09

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: NLB

OPERATING FLOWRATE (GPM): 10 GPM at 40,000psi
OPERATING PRESSURE (PSI): 37,000 at pump
NOZZLE TYPE: 6" wide rectangular; 22 jewel orifice, synthetic sapphire air activated 600 RPM
Transition speed range 2.0 to 1.75 inches/sec.

TYPE OF SURFACE PREP. SPECIFIED: Near white metal
Remove all non-skid

	A	B	A + B	
START TIME:	12:27	14:15		
FINISH TIME:	14:10	15:25	173 min Nozzle on: 136 min.	
DOWN TIME:	28 min	4 min	37 min	
AREA BLASTED:			421.72 ft^2	
	nozzle rate = 2.0 in/sec	nozzle rate = 1.75 in/sec		

PRODUCTION RATE / AREA REMOVED: 146.3 ft^2/hr, working time = 79 %

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
One blasting unit operator
One waste water reclamation operator

OPEN / CLOSED SYSTEM: closed

WASTE HANDLING / ACCUMULATION: Solids are shipped as waste in drums, water is recycled.

AMBIENT AIR QUALITY: Diesel from pump, high lift

OTHER INFORMATION: section A had 11 patches
section B had 9 patches

SURFACE CONDITION (AFTER BLASTING) INFORMATION

Run 3

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: X
OTHER: ~ Frame 39, port of Cat 2
AMBIENT CONDITIONS:
WET BULB: 60 DRY BULB: 74 RH %: 43% D.P.: 50 SUB. TEMP: 110
at 14:00
CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
0% remaining

SURFACE CONTAMINATION:

LOCATION:	Run 3						Baseline
CHLORIDE:	0-2 $\mu g/cm^2$						water
CONDUCTIVITY:	12 μS/cm	(3ml spl)	or 7.2 μS/cm (@ 5 ml sample)				= 0 μS/cm

REMAINING COATING ADHESION: N/A

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: Devoe Devgrip 137 epoxy primer
Devoe Devgrip 138 roll-on non-skid

COATING APPLICATION TIME:

OTHER COMMENTS: one patch at a transition rate of 1.75 in/sec takes 6 min 15 sections (nozzle time)

GENERAL INFORMATION (PRIOR TO BLASTING)

Run A

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/12/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: [X]
OTHER: ~ Frame 39 port of Cat 2
AMBIENT CONDITIONS:
WET BULB: [ ] DRY BULB: [ ] RH %: [ ] D.P.: [ ] SUB. TEMP: [ ]
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Clean Non-skid

SURFACE CONTAMINATION: N/A

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

TOOKE GAUGE READING: N/A

LOCATION:						
DISPIRIT. OF COATS:						
THICKNESS OF CTS:						

TYPES/THICKNESS OF COATING TO BE REMOVED: all non-skid to bare metal

SAMPLES COLLECTED: YES: [X] NO: [ ]
DFT SURVEY: N/A
LOCATION: LOCATION: LOCATION:
FT^2 REPRESENTED: FT^2 REPRESENTED: FT^2 REPRESENTED:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

Run A

LOCATION: Puget Sound Naval Shipyard

SHIP (TYPE&NAME): CVN 70 USS Carl Vinson

DATE: 7/12/97

TIME OF ARRIVAL: 8:00

AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [ ] DECK: [X]

OTHER: ~ Frame 39 port of Cat 2

AMBIENT CONDITIONS:

WET BULB: 62/64 DRY BULB: 73/77 RH %: 53/49 D.P.: 55/56 SUB. TEMP: 70/80

at 8:50 / 10:40

MACHINE:

PUMP MANUFACTURER/MODEL/OTHER INFO: NLB

OPERATING FLOWRATE (GPM): 10 GPM at 40,000psi

OPERATING PRESSURE (PSI): 36,000 at pump (33,800 at nozzle)

NOZZLE TYPE: 6" wide rectangular; 22 jewel orifice, synthetic sapphire air activated 600 RPM

Transition speed range 2.0 inches/sec.

TYPE OF SURFACE PREP. SPECIFIED: Near white metal

Remove all non-skid

		Nozzle hours		
START TIME:	8:34	770.9		
FINISH TIME:	10:00	772		
DOWN TIME:	Nozzle on: 66 min. 20 min			
AREA BLASTED:	161.05 ft^2			

PRODUCTION RATE / AREA REMOVED: 120.8 ft^2/hr, working time = 77%

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):

One blasting unit operator

One waste water reclamation operator

OPEN / CLOSED SYSTEM: closed

WASTE HANDLING / ACCUMULATION: Solids are shipped as waste in drums, water is recycled.

AMBIENT AIR QUALITY: Diesel from pump, high lift

OTHER INFORMATION:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

Run A

LOCATION: Puget Sound Naval Shipyard
SHIP (TYPE&NAME): CVN 70 USS Carl Vinson
DATE: 7/11/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: FREBRD: TANK: DECK: X
OTHER: ~ Frame 39, port of Cat 2
AMBIENT CONDITIONS:
WET BULB: 60 DRY BULB: 74 RH %: 43% D.P.: 50 SUB. TEMP: 110
at 14:00
CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):
none, only staining

TIME TO FLASH RUST: no flash rusting was seen on exposed bare metal blasted on 7/11, no rain last night. Near white metal with original stains still exist
BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
0% remaining

SURFACE CONTAMINATION:

LOCATION:	Pitted with stains			near white metal			Baseline water = 0 μS/cm
CHLORIDE:	4-6 μg/cm^2			0-2 μg/cm^2			
CONDUCTIVITY:	43 μS/cm	(5ml sample)		10 μS/cm	(5 ml sample)		

REMAINING COATING ADHESION: N/A

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: Devoe Devgrip 137 epoxy primer
Devoe Devgrip 138 roll-on non-skid

COATING APPLICATION TIME:

OTHER COMMENTS: Areas of old pit corrosion are stained deep gray. When viewed at an angle these stains have a white hallow around them, when viewed from direct above the pits appear only gray. Photos were taken to document this.

Profiles were taken over areas abraded by steel casters

VISIT 6

SEA RIVER
WILMINGTON

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: NORSHIPCO

SHIP (TYPE&NAME): Tanker, Sea River Wilmington

DATE: 7/21/97

TIME OF ARRIVAL: 8:30

AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:

OTHER: Portside, Forward Frame 93-84

AMBIENT CONDITIONS: @9:43

WET BULB: 76 DRY BULB: 81 RH %: 80 D.P.: 74 SUB. TEMP: 80

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)

Areas of coating abrasion down to bare metal near water line.

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.)

Clean

SURFACE CONTAMINATION:

LOCATION:	Frame 84 U/W hull					DI water baseline=0μS/cm
CHLORIDE:	Not applicable over antifouling, extraction fluid dissolved A/F					
CONDUCTIVITY:	63 μS/cm	67 μS/cm				
	(5 ml sample)					

TOOKE GAUGE READING:

LOCATION:	Frame 84 U/W hull				
DISCRIPT. OF COATS:	Red / white/ Black/ Red				
THICKNESS OF CTS:	3 / 8 / 5 / 8				

TYPES/THICKNESSES OF COATING TO BE REMOVED: Freeboard (20ft) and U/W Hull (12ft) 100% bare metal

Lower U/W Hull, and belly spot removal and repair. U/W Hull 2 coats AC, 2 coats of ablative A/F

Freeboard: 2 coats of epoxy(red/white), 1 coat of modified chlorinated rubber(black)

SAMPLES COLLECTED: YES: NO: X

DFT SURVEY:

LOCATION: ~ Frame 84		LOCATION:		LOCATION:	
FT^2 REPRESENTED:	$100ft^2$	FT^2 REPRESENTED:		FT^2 REPRESENTED:	
25.4					
23.5					
34.1	27.7				
30.2					
26.8					
37.5	31.5				
26.5					
28.3					
23.9	26.2				
32.1					
36.2					
39.8	36.0				
	30.4				

n=20

x=28.57

σ =5.88

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: NORSHIPCO

SHIP (TYPE&NAME): Tanker, Sea River Wilmington

DATE: 7/21/97

TIME OF ARRIVAL: 8:30

AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:

OTHER: Portside, forward Frame 93-84

AMBIENT CONDITIONS: @ 9:43

	WET BULB:	DRY BULB:	RH %:	D.P.:	SUB. TEMP:
@ 9:43	76°F	81°F	80%	74°F	80°F
@ 15:26	79°F	86°F	73%	76°F	82°F

MACHINE: Hammelmann DOCKMASTER

PUMP MANUFACTURER/MODEL/OTHER INFO: HDP 234 (Hochdruckpumpe) (230kilowatts or 308.43 hp)
5 reciprocating pistons per pump, DOCKMASTER contains two of these HDP 234s
Boom reach 27meters(88.5 ft). The machine is operated by remote control

OPERATING FLOWRATE (GPM): 100 L/min (26.417 gal/min) {50 liters/min per pump}

OPERATING PRESSURE (PSI): 2500 bar (36,260 psi) at pump, ~2400 bar (34,809 psi) at nozzle

NOZZLE TYPE: two circular (off center from each other) nozzles 600mm (23 5/8") total coverage,
4 S.S. jewels per nozzle which have a life of 150 to 200 hrs., each nozzle is hydraulically spun at 2500 rpm

TYPE OF SURFACE PREP. SPECIFIED: 100% removal of freeboard coatings and ~ 12 ft of upper underwater hull area.
Underwater Hull and underbelly is to be spot repaired.

	U/W Hull		U/W Hull		U/W Hull		U/W Hull	
START TIME:			9:58	stop for fuel and reprime	11:34	stop to empty/change paint bin	12:24	switched to NORSHIPCO operator from Hammelmann
FINISH TIME:	30 min		11:33		12:23		14:00	
			nozzle on: 30 min		nozzle on: 42 min		nozzle on: 1hr 33 min	
DOWN TIME:	0		1hr 5min		7 min		3 min	
AREA BLASTED:	185 ft^2	curved	396 ft^2	curved	592 ft^2	straight	888 ft^2	straight
PRODUCTION RATE / AREA REMOVED:	370 ft^2/hr		366 ft^2/hr	working time 32%	725 ft^2/hr	working time 86%	555 ft^2/hr	working time 97%

operators are running the unit such that each spot is blasted twice, the operator is running the nozzles such that they overlap ~ 300mm of the previous pass

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
one operator running the DOCKMASTER
two operators running the water treatment unit at the end of the drydock

OPEN / CLOSED SYSTEM: open with vacuum recovery, most of the paint and some water is recovered to the DOCKMASTER's paint bin, a lot of water/steam is lost to the sides and bottom of the nozzle housing.

WASTE HANDLING / ACCUMULATION: See attached paper

AMBIENT AIR QUALITY: The exhaust from the diesel engines is not noticeable.

OTHER INFORMATION: DOCKMASTER operator controls the machine by remote control pack on his chest.
Herman Hammelmann stated that thicker paint is easier to remove than thinner coatings.

PRODUCTION INFORMATION

LOCATION: NORSHIPCO
SHIP (TYPE&NAME): Tanker, Sea River Wilmington
DATE: 7/21/97
TIME OF ARRIVAL: 8:30
AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:
OTHER: Portside, forward - 84
AMBIENT CONDITIONS: @16:38

WET BULB:	DRY BULB:	RH %:	D.P.:	SUB. TEMP:
79°F	86°F	73%	76°F	85°F

MACHINE: Hammelmann DOCKMASTER
PUMP MANUFACTURER/MODEL/OTHER INFO: HDP 234 (Hochdruckpumpe) (230kilowatts or 308.43 hp)
5 reciprocating pistons per pump, DOCKMASTER contains two of these HDP 234s
Boom reach 27meters(88.5 ft). The machine is operated by remote control
OPERATING FLOWRATE (GPM): 100 L/min (26.417 gal/min) {50 liters/min per pump}
OPERATING PRESSURE (PSI): 2500 bar (36,260 psi) at pump, ~2400 bar (34,809 psi) at nozzle
NOZZLE TYPE: two circular (off center from each other) nozzles 600mm (23 5/8") total coverage,
4 S.S. jewels per nozzle which have a life of 150 to 200 hrs., each nozzle is hydraulically spun at 2500 rpm
TYPE OF SURFACE PREP. SPECIFIED: 100% removal of freeboard coatings and ~ 12 ft of upper underwater hull area.
Underwater Hull and underbelly is to be spot repaired.

	7/21 day shift		7/21 night shift	
START TIME:	7:00		19:30	
FINISH TIME:	16:00	stop for fuel	2:30	
	overall 9 hour shift		overall 7 hour shift	
DOWN TIME:	N/A			
	mix of freeboard and underwater hull		2/3 freeboard and 1/3 u/w hull: Fr 84-68	
AREA BLASTED:	4440 ft^2		5144 ft^2	straight area
	493.3 ft^2/hr average for the day		735 ft^2/hr avg. night shift, 572 ft^2/hr including 2 hours rework on 7/22 day shift	

PRODUCTION RATE / AREA REMOVED: overall for a 9 hour day & overall for 7 hour night shift

operators are running the unit such that each spot is blasted twice, the operator is running the nozzles such that they overlap ~ 300mm of the previous pass

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
one operator running the DOCKMASTER
two operators running the water treatment unit at the end of the drydock

OPEN / CLOSED SYSTEM: open with vacuum recovery, most of the paint and some water is recovered to the DOCKMASTER's paint bin, a lot of water/steam is lost to the sides and bottom of the nozzle housing.
WASTE HANDLING / ACCUMULATION: See attached paper

AMBIENT AIR QUALITY: The exhaust from the diesel engines is not noticeable.

OTHER INFORMATION: DOCKMASTER operator controls the machine by remote control pack on his chest.

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: NORSHIPCO

SHIP (TYPE&NAME): EXXON TANKER Sea River Wilmington

DATE: 7/21/97

TIME OF ARRIVAL: 8:30

AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:

OTHER: Portside, forward to frame 84

AMBIENT CONDITIONS:

WET BULB: 68°F DRY BULB: 77°F RH %: 63% D.P.: 63°F SUB. TEMP: 83°F

@12:26

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

Areas of old corrosion stains existed after blasting

light to moderate flash rusting began after 25 minutes.

moderate to heavy flash rusting was noticed after 40 minutes

TIME TO FLASH RUST: 25 minutes

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):

20% of the original red epoxy primer was left remaining on the surface, Hemple representative said that this was acceptable.

SURFACE CONTAMINATION:

LOCATION:	~Frame 84					
CHLORIDE:	0-2 $\mu g/cm^2$					
CONDUCTIVITY:	9 μS/cm	9 μS/cm	(5 ml sample)			

REMAINING COATING ADHESION: N/A since after sanding the surface bare metal is exposed and adhesive would be in contact with metal

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: Freeboard: 2 coats of Hemple surface tolerant AC epoxy primer (red/black) 6-8 wft

4563U 11480 gray Hempadur, cure: 95190 topcoat with Exxon Gray modified acrylic(alkyd) 4 wft

45159 19990 Black Hempadur, cure: 9545* U/W Hull: areas of bare metal 2 coats of Hemple surface tolerant AC epoxy primer two coats of A/F on flat sides, 1 coat A/F only on belly and undamaged areas 10 wft

COATING APPLICATION TIME: night shift, weather permitting

OTHER COMMENTS: Hemple Rep will evaluate flash rusting for tightly adherent. If F/R is to loose a wipe down or blow down will be required

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: NORSHIPCO
SHIP (TYPE&NAME): Tanker, Sea River Wilmington
DATE: 7/22/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:
OTHER: Portside
AMBIENT CONDITIONS: @9:00
WET BULB: 76 DRY BULB: 79 RH %: 87 D.P.: 75 SUB. TEMP: 77
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.) Freeboard coating has areas of blisters and areas of pinpoint rusting as a result. Areas of coating abrasion down to bare metal near water line.
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Clean, NORSHIPCO pressure washed all freeboard and U/W hull areas.
SURFACE CONTAMINATION:

LOCATION:	Freeboard, Port Frame 69					baseline DI water=0μS/cm
CHLORIDE:	2-4 $\mu g/cm^2$					
CONDUCTIVITY:	63 μS/cm	65 μS/cm				

(5 ml sample)

TOOKE GAUGE READING:

LOCATION:	Freeboard, Port Frame 69				
DISCRIPT. OF COATS:	Red / White/ Black				
THICKNESS OF CTS:	4 / 7 / 5				

TYPES/THICKNESSES OF COATING TO BE REMOVED: Freeboard (20ft) and U/W Hull (12ft) 100% bare metal Lower U/W Hull, and belly spot removal and repair. U/W Hull 2 coats AC, 2 coats of ablative A/F
Freeboard: 2 coats of epoxy(red/white), 1 coat of modified chlorinated rubber(black)
SAMPLES COLLECTED: YES: NO: X
DFT SURVEY:

LOCATION: ~ Frame 69		LOCATION:		LOCATION:	
FT^2 REPRESENTED: ~80ft^2		FT^2 REPRESENTED:		FT^2 REPRESENTED:	
17.2					
16.4					
16.3	16.6				
15.2					
18.0					
16.7	16.6				
15.3					
15.7					
15.0	15.3				
16.2					
17.3					
18.2	17.2				
	16.5				

PRODUCTION INFORMATION

LOCATION: NORSHIPCO
SHIP (TYPE&NAME): Tanker, Sea River Wilmington
DATE: 7/21/97
TIME OF ARRIVAL: 8:30
AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:
OTHER: Portside
AMBIENT CONDITIONS: @ 11:19

	WET BULB	DRY BULB	RH %	D.P.	SUB. TEMP
@ 11:19	78°F	85°F	70%	78°F	82°F
@ 14:00	81°F	92°F	62%	77°F	90°F

MACHINE: Hammelmann DOCKMASTER
PUMP MANUFACTURER/MODEL/OTHER INFO: HDP 234 (Hochdruckpumpe) (230kilowatts or 308.43 hp)
5 reciprocating pistons per pump, DOCKMASTER contains two of these HDP 234s
Boom reach 27meters(88.5 ft). The machine is operated by remote control
OPERATING FLOWRATE (GPM): 100 L/min (26.417 gal/min) {50 liters/min per pump}
OPERATING PRESSURE (PSI): 2500 bar (36,260 psi) at pump, ~2400 bar (34,809 psi) at nozzle
NOZZLE TYPE: two circular (off center from each other) nozzles 600mm (23 5/8") total coverage,
4 S.S. jewels per nozzle which have a life of 150 to 200 hrs., each nozzle is hydraulically spun at 2500 rpm
TYPE OF SURFACE PREP. SPECIFIED: 100% removal of freeboard coatings and ~ 12 ft of upper underwater hull area.
Underwater Hull and underbelly is to be spot repaired.

	redone from night shift	Frbd.&U/W hull Fr.69-65	Freeboard Fr. 65-58	
START TIME:	8:16 stop to refuel and change jewels	11:02	13:33 stop for refuel and empty paint bin	
FINISH TIME:	10:18	13:08	17:38	
	nozzle on: 51 min	nozzle on:1hr 52 min	nozzle on: 3 hrs 8 min	
DOWN TIME:	71 min	14 min	57 min	
AREA BLASTED:	960 ft^2 straight	1664 ft^2 straight	1456 ft^2 straight	
	472 ft^2/hr work time 42%	792 ft^2/hr work time 89%	357 ft^2/hr work time 77%	

PRODUCTION RATE / AREA REMOVED:
operators are running the unit such that each spot is blasted twice, the operator is running the nozzles such that they overlap ~ 300mm of the previous pass
MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
one operator running the DOCKMASTER
two operators running the water treatment unit at the end of the drydock

OPEN / CLOSED SYSTEM: open with vacuum recovery, most of the paint and some water is recovered to the DOCKMASTER's paint bin, a lot of water/steam is lost to the sides and bottom of the nozzle housing.
WASTE HANDLING / ACCUMULATION: See attached paper

AMBIENT AIR QUALITY: The exhaust from the diesel engines is not noticeable.

OTHER INFORMATION: DOCKMASTER operator controls the machine by remote control pack on his chest.

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: NORSHIPCO
SHIP (TYPE&NAME): EXXON TANKER Sea River Wilmington
DATE: 7/22/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:
OTHER: Portside, frame 69-65

AMBIENT CONDITIONS:
WET BULB: 73°F DRY BULB: 78°F RH %: 79% D.P.: 71°F SUB. TEMP: 84°F
@17:45

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):
1hr after blast stains from earlier corrosion and a light F/R bloom has started on areas 1st blasted at 11:52
5% - 10% Area flash rusted prior to rain

TIME TO FLASH RUST: 1 hour

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
20- 25% original red primer is remaining
representative said that this was acceptable.

SURFACE CONTAMINATION:

LOCATION:	freeboard port frame ~69					
CHLORIDE:	0-2 $\mu g/cm^2$					
CONDUCTIVITY:	7 μS/cm	7 μS/cm				

(5ml sample)

DI baseline =0μS/cm

REMAINING COATING ADHESION: N/A since after sanding the surface bare metal is exposed and adhesive would be in contact with metal

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: Freeboard: 2 coats of Hemple surface tolerant AC epoxy primer (red/black) 6-8 wft
topcoat with Exxon Gray modified acrylic(alkyd) 4 wft
U/W Hull: areas of bare metal 2 coats of Hemple surface tolerant AC epoxy primer
two coats of A/F on flat sides, 1 coat A/F only on belly and undamaged areas 10 wft

4563U 11480 gray Hempadur, cure: 95190
45159 19990 Black Hempadur, cure: 9545*

COATING APPLICATION TIME: night shift, weather permitting

OTHER COMMENTS: Hemple Rep will evaluate flash rusting for tightly adherent. If F/R is to loose a wipe down or blow down will be required

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: NORSHIPCO

SHIP (TYPE&NAME): EXXON TANKER Sea River Wilmington

DATE: 7/23/97

TIME OF ARRIVAL: 8:00

AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:

OTHER: Portside, frame 69-65

AMBIENT CONDITIONS:

WET BULB: 73°F DRY BULB: 78°F RH %: 79% D.P.: 71°F SUB. TEMP: 84°F

@17:45

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

Heavy Flash rusting has affected 90% to 95% of the areas blasted on 7/22 due to rains on the night of 7/22.

This F/R was easily removed when rubbed with a white cloth.

TIME TO FLASH RUST: overnight due to rains

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):

20- 25% original red primer is remaining

representative said that this was acceptable.

SURFACE CONTAMINATION:

LOCATION:	freeboard port frame ~64 OVER FLASHRUSTING					
CHLORIDE:	0-2 μg/cm^2					
CONDUCTIVITY:	36 μS/cm	36 μS/cm				

(5ml sample)

DI baseline =0μS/cm

REMAINING COATING ADHESION: N/A since after sanding the surface bare metal is exposed and adhesive would be in contact with metal

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: Freeboard: 2 coats of Hemple surface tolerant AC epoxy primer (red/black) 6-8 wft

topcoat with Exxon Gray modified acrylic(alkyd) 4 wft

U/W Hull: areas of bare metal 2 coats of Hemple surface tolerant AC epoxy primer two coats of A/F on flat sides, 1 coat A/F only on belly and undamaged areas 10 wft

4563U 11480 gray Hempadur, cure: 95190

45159 19990 Black Hempadur, cure: 9545*

COATING APPLICATION TIME: No painting was done on 7/22 on areas blasted on 7/22.

OTHER COMMENTS: The blasting head/platform can not maneuver over overboard drains and other protuberances,

PRODUCTION INFORMATION

LOCATION: NORSHIPCO
SHIP (TYPE&NAME): Tanker, Sea River Wilmington
DATE: 7/22/97 night shift
TIME OF ARRIVAL: 8:30
AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:
OTHER: Portside freeboard and u/w hull Frame 65-58
AMBIENT CONDITIONS: @ 11:19

	WET BULB	DRY BULB	RH %	D.P.	SUB. TEMP
@ 11:19	78°F	85°F	70%	78°F	82°F
@ 14:00	81°F	92°F	62%	77°F	90°F

MACHINE: Hammelmann DOCKMASTER
PUMP MANUFACTURER/MODEL/OTHER INFO: HDP 234 (Hochdruckpumpe) (230kilowatts or 308.43 hp)
5 reciprocating pistons per pump, DOCKMASTER contains two of these HDP 234s
Boom reach 27meters(88.5 ft). The machine is operated by remote control
OPERATING FLOWRATE (GPM): 100 L/min (26.417 gal/min) {50 liters/min per pump}
OPERATING PRESSURE (PSI): 2500 bar (36,260 psi) at pump, ~2400 bar (34,809 psi) at nozzle
NOZZLE TYPE: two circular (off center from each other) nozzles 600mm (23 5/8") total coverage,
4 S.S. jewels per nozzle which have a life of 150 to 200 hrs., each nozzle is hydraulically spun at 2500 rpm
TYPE OF SURFACE PREP. SPECIFIED: 100% removal of freeboard coatings and ~ 12 ft of upper underwater hull area.
Underwater Hull and underbelly is to be spot repaired.

	Night shift			
START TIME:	18:00			
FINISH TIME:	20:00 pump breakdown			
DOWN TIME:				
AREA BLASTED:	1456 ft^2			

728 ft^2/hr or 182 ft2/ hr over the entire night shift (8hours) while they repaired the pump.
PRODUCTION RATE / AREA REMOVED:

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
one operator running the DOCKMASTER
two operators running the water treatment unit at the end of the drydock

OPEN / CLOSED SYSTEM: open with vacuum recovery, most of the paint and some water is recovered to the DOCKMASTER's paint bin, a lot of water/steam is lost to the sides and bottom of the nozzle housing.
WASTE HANDLING / ACCUMULATION: See attached paper

AMBIENT AIR QUALITY: The exhaust from the diesel engines is not noticeable.

OTHER INFORMATION: One of the pumps on the DOCKMASTER broke down early in the night shift, little production was accomplished since it took the remainder of the shift to repair the pump.

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: NORSHIPCO
SHIP (TYPE&NAME): Exxon crude and refined oil Tanker, Sea River Wilmington
DATE: 7/23/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:
OTHER: Portside, freeboard and underwater hull Frame ~ 58 to aft
AMBIENT CONDITIONS: @9:20
WET BULB: 73°F DRY BULB: 76°F RH %: 87% D.P.: 72°F SUB. TEMP: 75°F
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.) freeboard areas have blisters and areas of pin point rusting. Areas of coating abrasion down to bare metal near water line.
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.)
Clean
SURFACE CONTAMINATION:

LOCATION:	Frame 58 freeboard port					DI water baseline=0μS/cm
CHLORIDE:	0-2 $\mu g/cm^2$					
CONDUCTIVITY:	11 μS/cm	13 μS/cm				

(5 ml sample)

TOOKE GAUGE READING:

LOCATION:	Frame 58 freeboard port				
DISCRIPT. OF COATS:	Red / white/ Black				
THICKNESS OF CTS:	4 / 7 / 6				

TYPES/THICKNESSES OF COATING TO BE REMOVED: Freeboard (20ft) and U/W Hull (12ft) 100% bare metal Lower U/W Hull, and belly spot removal and repair. U/W Hull 2 coats AC, 2 coats of ablative A/F
Freeboard: 2 coats of epoxy(red/white), 1 coat of modified chlorinated rubber(black)
SAMPLES COLLECTED: YES: NO: X
DFT SURVEY:

LOCATION: ~ Frame 84 | LOCATION: | LOCATION:
FT^2 REPRESENTED: $100ft^2$ | FT^2 REPRESENTED: | FT^2 REPRESENTED:

Readings	Average	Readings	Average	Readings	Average
19.2					
12.6					
15.3	15.7				
18.3					
18.1					
17.6	18.0				
20.3					
16.5					
16.6	17.8				
15.8					
20.2					
17.8	17.9				
	17.4				

PRODUCTION INFORMATION

LOCATION: NORSHIPCO

SHIP (TYPE&NAME): Tanker, Sea River Wilmington

DATE: 7/21/97

TIME OF ARRIVAL: 8:30

AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:

OTHER: Portside, Frame 58-aft

AMBIENT CONDITIONS: @ 9:20

	WET BULB	DRY BULB	RH %	D.P.	SUB. TEMP
@ 9:20	73°F	76°F	87%	72°F	75°F
@ 15:00	77°F	84°F	73%	76°F	80°F

MACHINE: Hammelmann DOCKMASTER

PUMP MANUFACTURER/MODEL/OTHER INFO: HDP 234 (Hochdruckpumpe) (230kilowatts or 308.43 hp)
5 reciprocating pistons per pump, DOCKMASTER contains two of these HDP 234s
Boom reach 27meters(88.5 ft). The machine is operated by remote control

OPERATING FLOWRATE (GPM): 100 L/min (26.417 gal/min) {50 liters/min per pump}

OPERATING PRESSURE (PSI): 2500 bar (36,260 psi) at pump, ~2400 bar (34,809 psi) at nozzle

NOZZLE TYPE: two circular (off center from each other) nozzles 600mm (23 5/8") total coverage,
4 S.S. jewels per nozzle which have a life of 150 to 200 hrs., each nozzle is hydraulically spun at 2500 rpm

TYPE OF SURFACE PREP. SPECIFIED: 100% removal of freeboard coatings and ~ 12 ft of upper underwater hull area.
Underwater Hull and underbelly is to be spot repaired.

	Freeboard	Freeboard	Freeboard	
START TIME:	6:30	8:12 stop for fuel and check jewels	10:40	
FINISH TIME:	8:10	10:39	15:13	
		nozzle on: 1 hr 56 min	nozzle on: 3 hrs 10 min	
DOWN TIME:		31 min	1 hr 23 min	
AREA BLASTED:	$639 ft^2$ curved	$399 ft^2$ curved	$780 ft^2$ curved	
PRODUCTION RATE / AREA REMOVED:	$383 ft^2/hr$	$162 ft^2/hr$ working time 79%	$171 ft^2/hr$ working time 70%	

All primer is being removed.
operators are running the unit such that each spot is blasted twice, the operator is running the nozzles such that they overlap ~ 300mm of the previous pass

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
one operator running the DOCKMASTER
two operators running the water treatment unit at the end of the drydock

OPEN / CLOSED SYSTEM: open with vacuum recovery, most of the paint and some water is recovered to the DOCKMASTER's paint bin, a lot of water/steam is lost to the sides and bottom of the nozzle housing.

WASTE HANDLING / ACCUMULATION: See attached paper

AMBIENT AIR QUALITY: The exhaust from the diesel engines is not noticeable.

OTHER INFORMATION: DOCKMASTER operator controls the machine by remote control pack on his chest.

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: NORSHIPCO
SHIP (TYPE&NAME): EXXON TANKER Sea River Wilmington
DATE: 7/23/97
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: X FREBRD: X TANK: DECK:
OTHER: Portside, frame 69-65
AMBIENT CONDITIONS:
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):
Over 9hour period ~20% of area (isolated) has moderate to heavy flashrusting.

TIME TO FLASH RUST: 2 hours to start bloom

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
0-5% original red primer is remaining

SURFACE CONTAMINATION:

LOCATION:	freeboard port frame ~64 OVER FLASHRUSTING					
CHLORIDE:	0-2 $\mu g/cm^2$					
CONDUCTIVITY:	36 µS/cm	36 µS/cm				

DI baseline =0µS/cm

(5ml sample)

REMAINING COATING ADHESION: N/A since after sanding the surface bare metal is exposed and adhesive would be in contact with metal

LOCATION:						
ADHESION (PSI):						
METHOD:						

COATING SYSTEM APPLIED: Freeboard: 2 coats of Hemple surface tolerant AC epoxy primer (red/black) 6-8 wft
topcoat with Exxon Gray modified acrylic(alkyd) 4 wft
4563U 11480 gray Hempadur, cure: 95190
45159 19990 Black Hempadur, cure: 9545*
U/W Hull: areas of bare metal 2 coats of Hemple surface tolerant AC epoxy primer
two coats of A/F on flat sides, 1 coat A/F only on belly and undamaged areas 10 wft

COATING APPLICATION TIME: No painting was done on 7/22 on areas blasted on 7/22.

OTHER COMMENTS:
Feed blast water, conductivity 178 µS/cm
Conductivity of effluent from treatment unit flowing into river = 5.4mS/cm

VISIT 7

USS CLEVELAND

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Southwest Marine

SHIP (TYPE&NAME): USS Cleveland (LDP 7)

DATE: 8/25/97

TIME OF ARRIVAL: 13:00

AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [X] DECK: [ ]

OTHER: Tank 8-216-0-W (Port side)

AMBIENT CONDITIONS:

WET BULB: 73 DRY BULB: 76 RH %: 87% D.P.: 72 SUB. TEMP: 73

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.) Blistering, corrosion at most structural stiffeners. Flat areas corroded at welds w/ spot breakdown

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Clean. 10,000 psi wash performed prior to our readings.

SURFACE CONTAMINATION: Middle-upper level port side over corrosion

LOCATION:	inside center wall			aft wall		
CHLORIDE:	0-2 μg/cm^2			0-2 μg/cm^2		
CONDUCTIVITY:	45, 44 μS/cm (4 ml sample)			66, 61 μS/cm (5 ml sample)		

35.6 μS/cm (@ 5 ml)

Baseline of DI water = 2 μS/cm

TOOKE GAUGE READING:

LOCATION:	Middle upper level port side				
DISCRIPT. OF COATS:	MIL-P-24441	Green (150) / Gray (151) / White (152)			
THICKNESS OF CTS:	3 / 3 / 4	3 / 3 / 2			

TYPES/THICKNESSES OF COATING TO BE REMOVED:

SAMPLES COLLECTED: YES: [ ] NO: [X]

DFT SURVEY:

LOCATION: LOCATION: LOCATION:

FT^2 REPRESENTED: FT^2 REPRESENTED: FT^2 REPRESENTED:

n=21

σ =1.43

average= 7.99

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Southwest Marine
SHIP (TYPE&NAME): USS Cleveland (LDP 7)
DATE: 8/25/97
TIME OF ARRIVAL: 13:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [X] DECK: [ ]
OTHER: Tank 8-216-0-W (Starboard side)

AMBIENT CONDITIONS:
WET BULB: 73 DRY BULB: 76 RH %: 87% D.P.: 72 SUB. TEMP: 73

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.) Corrosion around edges of lightening holes, stiffeners, some welds < 1% spot corrosion.

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) Clean washed with Dev-prep 88 with 10,000 psi pressure wash prior to our readings

SURFACE CONTAMINATION: Middle-upper level starboard side over pin point corrosion

LOCATION:	inside center wall					
CHLORIDE:	0-2 μg/cm²					
CONDUCTIVITY:	14, 12 μS/cm (5 ml sample)					

Baseline of DI water = 2 μS/cm

TOOKE GAUGE READING:

LOCATION:	Middle upper level starboard side aft wall					
DISCRIPT. OF COATS:	MIL-P-24441	Green (150) / Gray (151) / White (152)				
THICKNESS OF CTS:	3 / 3 / 4	3 / 3 / 4				

TYPES/THICKNESSES OF COATING TO BE REMOVED:

SAMPLES COLLECTED: YES: [ ] NO: [X]

DFT SURVEY:

LOCATION:	LOCATION:	LOCATION:
FT² REPRESENTED:	FT² REPRESENTED:	FT² REPRESENTED:

n=25
σ =2.16

average=	9.22		

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: Southwest Marine

SHIP (TYPE&NAME): USS Cleveland

DATE: 8/26/97

TIME OF ARRIVAL: 7:30

AREA OF BLAST: U/W HULL: ____ FREBRD: ____ TANK: X DECK: ____

OTHER: Tank 8-216-0-W

AMBIENT CONDITIONS:

WET BULB: ____ DRY BULB: ____ RH %: ____ D.P.: ____ SUB. TEMP: ____

MACHINE:

PUMP MANUFACTURER/MODEL/OTHER INFO: Three NLB Ultra Clean 36
one Jet Edge

OPERATING FLOWRATE (GPM): NLB 10 gpm, Jet Edge 20 gpm

OPERATING PRESSURE (PSI): 35,000 psi

NOZZLE TYPE: 2 jewel air spun

TYPE OF SURFACE PREP. SPECIFIED: Spot touch up in tank - remove to bare metal all corroded areas

START TIME:				
FINISH TIME:				
DOWN TIME:				
AREA BLASTED:				

PRODUCTION RATE / AREA REMOVED:

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION: Drydock is pitched, sump, pump, filter bay
1st Filters is 25 micron to 10 micron filter pumped to wing wall 94,000 gallon tank.
When tank is full test for sewer water acceptability, Show to SWM pump to sewer.
1 man is dedicated to this operation

AMBIENT AIR QUALITY:

OTHER INFORMATION: 8/26 at night Action cleaning started blasting the upper levels of tank 216.

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: Southwest Marine
SHIP (TYPE&NAME): USS Cleveland
DATE: 8/27/97
TIME OF ARRIVAL: 6:50
AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [X] DECK: [ ]
OTHER: Tank 8-216-0-W
AMBIENT CONDITIONS:

WET BULB:	DRY BULB:	RH %:	D.P.:	SUB. TEMP:
77	78	96%	77	76

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Using only one NLB Ultra Clean 36

OPERATING FLOWRATE (GPM): NLB 10 gpm
OPERATING PRESSURE (PSI): 35,000 psi
NOZZLE TYPE: 2 jewel air spun

TYPE OF SURFACE PREP. SPECIFIED: Spot touch up in tank - remove to bare metal all corroded areas

	1st shift	1st shift	2nd shift	
START TIME:	8:20	13:33	16:30	
FINISH TIME:	11:26	14:50	18:40	
	nozzle on 1 hr 10 min	nozzle on 38 min	nozzle on 1 hr 10 min	
DOWN TIME:	116 min	39 min	60 min	
20 min of downtime for broken light				
AREA BLASTED:	142 ft^2	108 ft^2	117 ft^2	

PRODUCTION RATE / AREA REMOVED: Top level port side second bay from aft
45 ft^2/hr/gun, working time = 38%
84 ft^2/hr/gun, working time = 49%
54 ft^2/hr/gun, working time = 54%
MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
1 blaster per gun, 2 blaster per tank (one port side, one starboard side)

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION: Drydock is pitched, sump, pump, filter bay
1st Filters is 25 micron to 10 micron filter pumped to wing wall 94,000 gallon tank.
When tank is full test for sewer water acceptability, Show to SWM pump to sewer.
1 man is dedicated to this operation
AMBIENT AIR QUALITY: Humid

OTHER INFORMATION:
Blasters had ventilation, blowers which kept visibility up and steam down to a minimum.
Conductivity of blast water out of gun = 0.72 mS/cm
Conductivity of blast water out of water source prior to pump = 0.72 mS/cm

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Southwest Marine

SHIP (TYPE&NAME): USS Cleveland (LDP 7)

DATE: 8/27/97

TIME OF ARRIVAL: 6:50

AREA OF BLAST: U/W HULL: [ ] FREBRD: [ ] TANK: [X] DECK: [ ]

OTHER: Tank 8-216-0-W

AMBIENT CONDITIONS:

WET BULB: 78 DRY BULB: 81 RH %: 88% D.P.: 77 SUB. TEMP: 77

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

Light Flash rusting did occur in some areas

TIME TO FLASH RUST: about 1 hour for the areas that did flash rust

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):

Removal of corroded areas and "stand off" sweep of intact paint.
Blisters were removed but surrounding areas "islands of paint" were left i.e., areas of blisters were not taken down to 100% bare metal.

SURFACE CONTAMINATION: upper level 2nd bay from aft over metal (no F/R)

LOCATION:	center wall			overhead		
CHLORIDE:	0-2 $\mu g/cm^2$			0-2 $\mu g/cm^2$		
CONDUCTIVITY:	23, 23 μS/cm (5 ml sample)			29 μS/cm (5 ml sample)		

baseline of DI water = 0 μS/cm

REMAINING COATING ADHESION:

LOCATION:	upper level 2nd bay from aft, center wall					
ADHESION (PSI):	1000+ psi			1000+ psi		
METHOD:	100% Cohesive in top-coat			100% Cohesive in top-coat		

COATING SYSTEM APPLIED: Devoe preprime 167, 2 coats of Devoe 235 Bar-Rust with stripe coats of 235 prior to full coats.

COATING APPLICATION TIME:

OTHER COMMENTS: Not much F/R because blasters are using forced ventilation to move mist away and this also helps dry the surface faster.

Coating Adhesion Prior to Blasting: Port Side

Location	Adhesion	Mode of Failure
Mid-upper level inside wall	725 psi	adhesive to top-coat
Mid-upper level aft wall	650 psi	adhesive to top-coat
Mid-upper level outside (port) wall	650 psi	adhesive to top-coat

VISIT 8

DANNEBROG HULL

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY
GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Alabama Shipyard
SHIP (TYPE&NAME): In New Construction, Chemical Tanker 400ft, 6 cargo tanks, 6 W/T, FP, AD
DATE: 1/27/98
TIME OF ARRIVAL: 9:00
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER:
AMBIENT CONDITIONS: Cloudy, Fog, Windy
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.) OK

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.)

SURFACE CONTAMINATION:

LOCATION:	Port FR# 83 Underbelly					
CHLORIDE:	0-2 μg/cm^2					
CONDUCTIVITY:	22, 22, 21 μS/cm		5 mls sample			

Adhesion Before:
650, 500, 500 psi
Adhesion After:
600, 550, 600

TOOKE GAUGE READING:

LOCATION:						
DISCRIPT. OF COATS:	1					
THICKNESS OF CTS:						

TYPES/THICKNESSES OF COATING TO BE REMOVED:
Sweep PCP (W/B epoxy?)

SAMPLES COLLECTED: YES: NO: X
DFT SURVEY:

LOCATION: Flat Underbelly LOCATION: LOCATION:
FT^2 REPRESENTED: 500 FT^2 REPRESENTED: FT^2 REPRESENTED:

Readings	Average	Readings	Average	Readings	Average
0.7, 0.6, 0.7	0.7				
1.0, 1.2, 0.8	1.0				
0.8, 0.8, 0.7	0.8				
0.5, 0.7, 1.4	0.9				

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY
PRODUCTION INFORMATION

LOCATION: Alabama Shipyard
SHIP (TYPE&NAME): 477' Chemical Tanker - Dannebrog Hull 47
DATE: 1/27/98
TIME OF ARRIVAL: 9:00
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER: Flat Underbelly
AMBIENT CONDITIONS: Cloudy, misty
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Flow International

OPERATING FLOWRATE (GPM): 5.5 GPM
OPERATING PRESSURE (PSI): 40 - 41,000 psi
NOZZLE TYPE: 5 Jewel spinning nozzle, #10 tip

TYPE OF SURFACE PREP. SPECIFIED: Sweep the PCP - Corroded areas remove to bare metal

	1	2		
START TIME:	9:16	10:11		
FINISH TIME:	9:56	11:28		
DOWN TIME:	22 min	22 min		
AREA BLASTED:	102 ft^2	468 ft^2		

PRODUCTION RATE / AREA REMOVED:
1) 153 ft^2/hour/gun, working time = 45%
2) 364.7 ft^2/hour/gun, working time = 71%

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
2 Blasters, 1 pump operator

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION:

AMBIENT AIR QUALITY:

OTHER INFORMATION: 14 minutes maintenance on gun, extra man positions lights (move lines)
During production run #2, man swept a 144 ft^2 patch in 10 minutes.

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY
SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Alabama Shipyard
SHIP (TYPE&NAME): Chemical Tanker - Dannebrog Hull 47
DATE: 1/27/98
TIME OF ARRIVAL: 9:00
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER: Flat Underbelly Mid-Ship / Port side
AMBIENT CONDITIONS:
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):
Light flash rusting - Difficult to determine due to wet conditions. Very slow evaporation on underside of hull.

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
In damaged areas, no paint is remaining.
In "ok" paint areas 90% of paint is remaining.

SURFACE CONTAMINATION:

LOCATION:						
CHLORIDE:	0-2 $\mu g/cm^2$					
CONDUCTIVITY:	14 $\mu S/cm$					

REMAINING COATING ADHESION:

LOCATION:	Mid-Ship	Mid-Ship	Mid-Ship			
ADHESION (PSI):	600	550	600			
METHOD:	ASTM 4940	ASTM 4940	ASTM 4940			

COATING SYSTEM APPLIED: Hemple

COATING APPLICATION TIME: N/A

OTHER COMMENTS:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Alabama Shipyard
SHIP (TYPE&NAME): 477' Chemical Tanker - Dannebrog Hull 47
DATE: 1/27/98
TIME OF ARRIVAL: 12:00
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER: AFT by ICCP Port
AMBIENT CONDITIONS: Partly Sunny, Windy, Cold
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)
PCP poor condition. Damaged from new construction, burn marks, grinds, general corrosion
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.) New Construction

SURFACE CONTAMINATION:

LOCATION:	Fr 23	Fr 23					Adhesion Prior
CHLORIDE:	0-2 μg/cm²	0-2 μg/cm²					500, 550, 600 psi
CONDUCTIVITY:	16, 16, 18 μS/cm	36 μS/cm					

TOOKE GAUGE READING:

LOCATION:						
DISCRIPT. OF COATS:	1 PCP					
THICKNESS OF CTS:						

TYPES/THICKNESSES OF COATING TO BE REMOVED: All to bare metal, 2 K Hempel 1589 Epoxy PCP

SAMPLES COLLECTED: YES: NO: X
DFT SURVEY:

LOCATION: Aft Port (Frame 23) | LOCATION: | LOCATION:
FT^2 REPRESENTED: 500 | FT^2 REPRESENTED: | FT^2 REPRESENTED:

Readings	Average	Readings	Average	Readings	Average
1.8, 2.0, 1.6	1.8				
1.4, 2.0, 1.2	1.5				
1.5, 2.0, 1.0	1.5				
1.6, 1.8, 1.6	1.7				

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: Alabama Shipyard
SHIP (TYPE&NAME): 477' Chemical Tanker
DATE: 1/27/98
TIME OF ARRIVAL: 12:00
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER: Keel. Aft by ICCP anode Port

AMBIENT CONDITIONS:
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Flow Husky

OPERATING FLOWRATE (GPM): 5.5 GPM
OPERATING PRESSURE (PSI): 40 - 41,000 psi
NOZZLE TYPE: 5 jewel nozzle, #10 tip

TYPE OF SURFACE PREP. SPECIFIED: All to bare metal. This PCP was very damaged and corroded leaving obviously good areas intact.

	3	4	5	
START TIME:	12:00	12:50	13:39	
FINISH TIME:	12:35	13:24	15:17	
DOWN TIME:	0	4.5 min	27 min	
AREA BLASTED:	94 ft^2	72 ft^2	270 ft^2	

PRODUCTION RATE / AREA REMOVED: 3) 161 ft^2/hour/gun, damaged PCP to bare metal, leaving ~10% stains of former paint.
4) 146.4 ft^2/hr/gun, working time = 87%: leaving behind 10% stains of former paint
5) 165.3 ft^2/hr/gun, working time = 72%: leaving behind 50% bare metal, 50% staining

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):

OPEN / CLOSED SYSTEM: open

WASTE HANDLING / ACCUMULATION: none

AMBIENT AIR QUALITY: Not Taken

OTHER INFORMATION: Conductivity of jetting water - 111, 112, 108 μS/cm. This explains the quick flash rust formation, usually about 10 minutes from the blasting to bare metal.

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Alabama Shipyard
SHIP (TYPE&NAME): 477' Chemical Tanker - Dannebrog Hull 47 - New Construction
DATE: 1/27/98
TIME OF ARRIVAL: 12:00
AREA OF BLAST: U/W HULL: X FREBRD: TANK: DECK:
OTHER: Underbelly

AMBIENT CONDITIONS:
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):
Quickly flashed to medium F/R within 15 minutes of blasting. When dry, a residue was easily wiped off on a rag; necessitating a secondary rinse at a lower pressure.

TIME TO FLASH RUST: 5 minutes to light F/R, 15 minutes to medium F/R

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
Between 10 -30 % depending on the area

SURFACE CONTAMINATION:

LOCATION:	FR 33					
CHLORIDE:	0-2 $\mu g/cm^2$					
CONDUCTIVITY:	13 $\mu S/cm$					

REMAINING COATING ADHESION:

LOCATION:	FR 30	FR 30	FR 30			
ADHESION (PSI):	600	650	610			
METHOD:	ASTM 4940	ASTM 4940	ASTM 4940			

COATING SYSTEM APPLIED: Hempel

COATING APPLICATION TIME:

OTHER COMMENTS: Aft Conductivity: 18, 16, 16 $\mu S/cm$

VISIT 9

TRINMAR PUMPING

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Trinmar

SHIP (TYPE&NAME): Block 25 Pump Station - Exterior Side Shell

DATE: 3/4/98

TIME OF ARRIVAL: 8:00

AREA OF BLAST: U/W HULL: FREBRD: X TANK: DECK:

OTHER: Outer Hull - Side Shell Exterior

AMBIENT CONDITIONS:

WET BULB: 79ºF DRY BULB: 87ºF RH %: 71% D.P.: 76ºF SUB. TEMP: 114ºF

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)

Dirty with tar residue, spot corrosion

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.)

Oily/Dirt

SURFACE CONTAMINATION: Could not measure. Bresle Patch would not stick to dirty surface.

LOCATION:						
CHLORIDE:						
CONDUCTIVITY:						

TOOKE GAUGE READING:

LOCATION:	Upper Level					
DISCRIPT. OF COATS:	4 coat system					
THICKNESS OF CTS:	2 / 2 / 5 / 5 mils					

TYPES/THICKNESSES OF COATING TO BE REMOVED: 2 mil metallic filled, 2 mil black, 5 mil Gray, 5 mil orange topcoat

SAMPLES COLLECTED: YES: NO: X

DFT SURVEY:

LOCATION: Upper level (left) LOCATION: LOCATION:

FT^2 REPRESENTED: FT^2 REPRESENTED: FT^2 REPRESENTED:

Readings	Average	Readings	Average	Readings	Average
11.9					
7.3					
8.4	9.2				
11.0					
9.7					
14.5	11.7				
11.2					
11.1					
13.8	12.0				
8.1					
8.6					
9.5	8.7				
8.5					
6.9					
8.2	7.9				
	9.9				

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY
PRODUCTION INFORMATION

LOCATION: Trinmar
SHIP (TYPE&NAME): Block 25 Pump Station - Exterior Side Shell
DATE: 3/4/98
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: [ ] FREBRD: [X] TANK: [ ] DECK: [ ]
OTHER: Outer Hull - Side Shell
AMBIENT CONDITIONS:
WET BULB: [ ] DRY BULB: [ ] RH %: [ ] D.P.: [ ] SUB. TEMP: [ ]

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO:
Butterworth, positive displacement (24 mm plungers)

OPERATING FLOWRATE (GPM): 8 gpm/gun
OPERATING PRESSURE (PSI): 18,000-20,000 psi @ 8 gpm
NOZZLE TYPE: NLB water spun nozzle (modified, proprietary) two orifice

TYPE OF SURFACE PREP. SPECIFIED: Stress the paint. Go down to intact primer / tar mix.
Actual: Went down to intact green primer and spot corrosion

START TIME:	8:37	8:30		
FINISH TIME:	12:30	14:30		
DOWN TIME:				
AREA BLASTED:	250 ft^2 A	693 ft^2 B		

PRODUCTION RATE / AREA REMOVED: Crew A: 62.5 ft^2/hour/gun
Crew B: 115 ft^2/hour/gun

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
2 Blasters

OPEN / CLOSED SYSTEM:

WASTE HANDLING / ACCUMULATION:
Into the Sea

AMBIENT AIR QUALITY:

OTHER INFORMATION:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Trinmar

SHIP (TYPE&NAME): Block 25 Pump Station - Exterior Side Shell

DATE: 3/5/98

TIME OF ARRIVAL: 8:00

AREA OF BLAST: U/W HULL: ___ FREBRD: X TANK: ___ DECK: ___

OTHER: Outer Hull - Side Shell

AMBIENT CONDITIONS:

WET BULB: ___ DRY BULB: ___ RH %: ___ D.P.: ___ SUB. TEMP: ___

CONDITION OF SURFACE:

FLASH RUSTING (PER INTERNATIONAL STANDARDS):

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:

OVERALL CONDITION (% REMAINING):

SURFACE CONTAMINATION:

LOCATION:	Exterior side shell					
CHLORIDE:	70µg/cm^2					
CONDUCTIVITY:	960 µS/cm					

conductivity is normalized to 5 ml sample

REMAINING COATING ADHESION:

LOCATION:	Exterior side shell					
ADHESION (PSI):	200	300				
METHOD:	ASTM 4541	ASTM 4541				

COATING SYSTEM APPLIED:

COATING APPLICATION TIME:

OTHER COMMENTS:

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Trinmar
SHIP (TYPE&NAME): Block 25 Pump Station - Tank 16 N
DATE: 3/4/98
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: FREBRD: TANK: X DECK:
OTHER: Tank #16 N

AMBIENT CONDITIONS:
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:

CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)
Blistered, Undercut, Surface Rust, Lower two feet - Heavy scale

SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.)
Heavily pitted: 3/8" wide, 30 mils deep to 1" wide to 160-170 mils deep

SURFACE CONTAMINATION:

LOCATION:	tank 16, pit	tank 16, paint				
CHLORIDE:	30-50 $\mu g/cm^2$	30-40 $\mu g/cm^2$				
CONDUCTIVITY:	670 $\mu S/cm$	303 $\mu S/cm$				

conductivity was normalized to a 5ml sample volume

TOOKE GAUGE READING:

LOCATION:	tank 16					
DISCRIPT. OF COATS:	1 Gray					
THICKNESS OF CTS:	10 mils					

TYPES/THICKNESSES OF COATING TO BE REMOVED:
Assume epoxy, 10 mils DFT from Tooke gauge reading (Grey) + 2 mils P.C. primer

SAMPLES COLLECTED: YES: X NO:

DFT SURVEY:

LOCATION: / FT² REPRESENTED:		LOCATION: / FT² REPRESENTED:		LOCATION: / FT² REPRESENTED:	
8.6		12.2			
9.6		9.7			
9.4	9.2	12.1	11.3		
13.9		12.8			
18.3		9.1			
5.5	12.6	7.9	9.9		
8.8		6.8			
9.5		5.9			
8.3	8.9	8.0	6.9		
9.6		7.8			
18.3		7.4			
8.3	12.1	7.0	7.4		
11.6					
14.8					
12.3	12.9				
	11.1		**8.9**		

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: Trinmar
SHIP (TYPE&NAME): Block 25 Pump Station - Tank 16 N
DATE: 3/4/98
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: ___ FREBRD: ___ TANK: #16 DECK: ___
OTHER: ___
AMBIENT CONDITIONS:
WET BULB: ___ DRY BULB: ___ RH %: ___ D.P.: ___ SUB. TEMP: ___

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO: Butterworth, positive displacement (24 mm plungers)

OPERATING FLOWRATE (GPM): 8 gpm/gun
OPERATING PRESSURE (PSI): 18,000-20,000 psi @ 8 gpm
NOZZLE TYPE: NLB water spun nozzle (modified, proprietary) two orifice

TYPE OF SURFACE PREP. SPECIFIED: "CT 2" w/ CM 2 and FGS 2
Remove all loose corrosion and non-adherent paint, stress existing paint, if tightly adherent leave alone.

START TIME:	10:20			
FINISH TIME:	16:00			
DOWN TIME:				
AREA BLASTED:	902 ft^2			

PRODUCTION RATE / AREA REMOVED: 159 ft2/hour

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):
2 blasters/station (3 blast stations)
1 blast foreman
1 mechanic, 1 site supervisor

OPEN / CLOSED SYSTEM: open, with seawater

WASTE HANDLING / ACCUMULATION: Heavy scale was previously removed by shovel. If it was oily, it was placed in a slop tank. All other debris was discharged into the sea.

AMBIENT AIR QUALITY: ___

OTHER INFORMATION: Safety on pumps kicks in at 24,000 psi at fluid end.
NLB Gun (31-0978)
Sea water is collected by submersible pump into a 500 gallon holding tank. From the holding tank the water is filtered through a series of filters down to a 3 micron particulate filter. The filters in this series are changed 3 times a day. The feed water to each pump (3) is again filtered with a 3 micron filter.

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Trinmar
SHIP (TYPE&NAME): Block 25 Pump Station - Tank 16 N
DATE: 3/5/98
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: FREBRD: TANK: #16 DECK:
OTHER:

AMBIENT CONDITIONS:
WET BULB: 81°F DRY BULB: 88°F RH %: 74% D.P.: 79°F SUB. TEMP: 103°F

CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):
Heavy flash rust in blasted areas. Heavily pitted areas are dark brown.

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
Top level 70% coating remaining
Bottom level 50% coating remaining
Deck 0% coating remaining

SURFACE CONTAMINATION:

LOCATION:	Top paint	Top pitted				
CHLORIDE:	2-4 $\mu g/cm^2$	8-10 $\mu g/cm^2$				
CONDUCTIVITY:	70 µS/cm	123 µS/cm				

conductivity was normalized to a 5 ml sample

REMAINING COATING ADHESION:

		After Blast Pulls			
LOCATION:	Before Blast	50/50	Primer	Topcoat	Blast
ADHESION (PSI):	450, 600, 400, 400	400	425	650	600
METHOD:	Cohesive in Primer	Glue failure	Glue failure	50% glue failure/ 50% paint	

COATING SYSTEM APPLIED:

COATING APPLICATION TIME:

OTHER COMMENTS: After Blast DFT's: 6.3, 4.9, 6.0, 8.7, 10.0, 6.9, 8.8, 6.0, 5.9, 5.4, 6.3, 8.5, 7.5, 8.1, 9.4, 4.4, 4.9, 5.4 mils. Average= 6.9 mils

Profiles on paint after blast: Bare metal: 4.0, 4.4 mils
Primer: 4.0, 3.8 mils
Top Coat: 2.6, 3.6, 1.9, 1.8 mils

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

GENERAL INFORMATION (PRIOR TO BLASTING)

LOCATION: Trinmar
SHIP (TYPE&NAME): Block 25 Pump Station - Tank 19
DATE: 3/4/98
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: FREBRD: TANK: #19 DECK:
OTHER:
AMBIENT CONDITIONS:
WET BULB: DRY BULB: RH %: D.P.: SUB. TEMP:
CONDITION OF COATING: (CORRODED, BLISTERING, FOULING etc.)
Blistered, Under Cut, Pitted
SURFACE CLEANLINESS: (OILY, SLUDGE, FOULING etc.)

SURFACE CONTAMINATION:

LOCATION:	Top level					
CHLORIDE:	30-40 μg/cm^2					
CONDUCTIVITY:	564, 480 μS/cm					

Conductivity was normalized to a 5 ml sample

TOOKE GAUGE READING:

LOCATION:	Top					
DISCRIPT. OF COATS:	1, Grey					
THICKNESS OF CTS:	10 mils					

TYPES/THICKNESSES OF COATING TO BE REMOVED: 1 Ct PCP (<1 mil Green) & 10 mils Grey

SAMPLES COLLECTED: YES: X NO:

DFT SURVEY:

LOCATION: Bottom Level		LOCATION: Middle Level		LOCATION:	
FT^2 REPRESENTED:		FT^2 REPRESENTED:		FT^2 REPRESENTED:	
6.9		7.0			
8.2		10.5			
9.5	8.2	7.8	8.4		
5.7		6.9			
5.7		9.8			
6.2	5.9	8.2	8.3		
7.1		5.2			
7.4		5.4			
9.2	7.9	5.0	5.2		
7.6		6.8			
7.8		8.3			
7.6	7.7	7.0	7.4		
	7.4		7.3		

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

PRODUCTION INFORMATION

LOCATION: Trinmar
SHIP (TYPE&NAME): Block 25 Pump Station - Tank 19
DATE: 3/4/98
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: ____ FREBRD: ____ TANK: #19 DECK: ____
OTHER: ____

AMBIENT CONDITIONS:
WET BULB: 97°F DRY BULB: 98°F RH %: 96% D.P.: 97°F SUB. TEMP: 98.5°F

MACHINE:
PUMP MANUFACTURER/MODEL/OTHER INFO:
Butterworth, positive displacement (24 mm plungers)

OPERATING FLOWRATE (GPM): 8 gpm/gun
OPERATING PRESSURE (PSI): 18,000-20,000 psi @ 8 gpm
NOZZLE TYPE: NLB water spun nozzle (modified, proprietary) two orifice

TYPE OF SURFACE PREP. SPECIFIED:

START TIME:	10:00			
FINISH TIME:	15:00			
DOWN TIME:				
AREA BLASTED:	770 ft^2			

PRODUCTION RATE / AREA REMOVED: 154 ft^2/hour/gun
2 Men per gun, switching when tired.

MANNING LEVELS: (BLASTERS & OPERATORS / PUMP):

OPEN / CLOSED SYSTEM:

WASTE HANDLING / ACCUMULATION:

AMBIENT AIR QUALITY:

OTHER INFORMATION: High Temperature - Outer surface faces sun, is heated all day.

NSRP SP-3 PRODUCTIVITY OF HYDROBLASTING STUDY

SURFACE CONDITION (AFTER BLASTING) INFORMATION

LOCATION: Trinmar
SHIP (TYPE&NAME): Block 25 Pump Station - Tank 19
DATE: 3/5/98
TIME OF ARRIVAL: 8:00
AREA OF BLAST: U/W HULL: FREBRD: TANK: #19 DECK:
OTHER:

AMBIENT CONDITIONS:
WET BULB: 82ºF DRY BULB: 89ºF RH %: 74% D.P.: 80ºF SUB. TEMP: 82ºF

CONDITION OF SURFACE:
FLASH RUSTING (PER INTERNATIONAL STANDARDS):

TIME TO FLASH RUST:

BLASTING EFFECTIVENESS:
OVERALL CONDITION (% REMAINING):
0% remaining on deck, 80% remaining elsewhere

SURFACE CONTAMINATION:

LOCATION:	Up lvl pitted	Up.lvl non-pitted				
CHLORIDE:	2-4 $\mu g/cm^2$	0-2 $\mu g/cm^2$				
CONDUCTIVITY:	58 $\mu S/cm$	43 $\mu S/cm$				

conductivity normalized to 5 ml sample

REMAINING COATING ADHESION:

LOCATION:	50/50	Topcoat	Primer	Blast		
ADHESION (PSI):	300	750	200	375		
METHOD:	glue failure		glue failure	glue failure		

COATING SYSTEM APPLIED: Wasser - Mid zinc @ 4 mils WFT (Stripe lips, holes, edges)
MC Tar @ 6-8 mils WFT (Stripe lips, holes, edges)

COATING APPLICATION TIME:

OTHER COMMENTS: Spray paint, Hand stripe

After Blast DFT's: 7.6, 8.0, 5.3, 4.9, 3.8, 3.2, 8.8, 8.9, 8.4, 8.1, 10.5, 11.0
Average: 7.4 mils

Surface profile after blast:
Bare metal: 3.4, 4.2 mils
Primer: 3.8 mils
Top Coat; 4.2, 1.7 mils

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