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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM
THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
SHIP PRODUCTION COMMITTEE
PANEL SP-1

**ABATEMENT OF MARINE COATINGS
CONTAINING HEAVY METALS**

NSRP PROJECT NO. N1-89-2
SUBTASK 5

PREPARED BY

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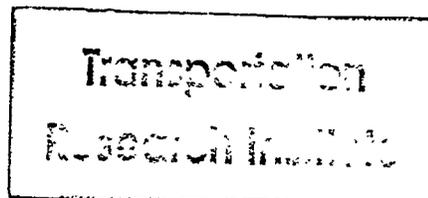
IN CONJUNCTION WITH

NATIONAL STEEL AND SHIPBUILDING COMPANY
PACIFIC SHIP REPAIR & FABRICATION, INC.
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FOR

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EXECUTIVE SUMMARY

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In early 1993, the Navy conducted testing at Norfolk Naval Shipyard to determine if personnel working with marine coatings containing lead, cadmium or chromium or other heavy metals were exposed to concentrations above the Occupational Safety Health Administration (OSHA) established permissible exposure limit (PEL). Based on these tests the Navy concluded that minute amounts of the heavy metals could result in exposures above the PEL. Additionally, the Navy concluded it could not predict exposure based on the concentration of the metal in the coating.

In September 1993, four San Diego Master Ship Repair contractors commenced research, testing, and analysis to develop a Technical Document that outlines cost-effective procedures to reduce exposure to lead, cadmium, chromium and other heavy metals while remaining compliant with OSHA and EPA Regulations.

This project provides a comprehensive technical document the inexperienced and experienced contractor may use in the abatement of heavy metal containing marine coatings.

Funding for this project was provided as a cooperative effort by the National Shipbuilding Research Program (NSRP) and by Continental Maritime of San Diego, Inc., National Steel and Shipbuilding Company, Pacific Ship Repair and Fabrication, Inc., and Southwest Marine, Inc. NSRP and these shipyards saw the need for shipyards to be proactive in the area of heavy metal coating systems abatement as current regulations were not "user friendly" in shipboard applications.

This technical document was prepared by the San Diego Ship Repair Association Environmental Committee Quality Action Team with Armando De Quesada, acting as Team Leader. David Silveri of United States Testing Company, Inc. provided technical input and Tom Bright of Alpha ITEC acted as Team Facilitator. We thank the following shipyards and their representatives for writing and reviewing the document:

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1.0 INTRODUCTION

In March of 1979, the Federal Occupational Safety and Health Administration (OSHA) Lead Standard (29 CFR.1910.1025) for general industry became effective. Since that time ship repairers have been complying with the Standard using a combination of experience, ships' preservation records, and testing to determine where coating containing lead had been applied and identifying abatement technologies to be used to reduce or eliminate worker and environmental exposures.

In July of 1993, OSHA, by technical amendment, incorporated into 29 CFR Part 1915, a comprehensive subpart Z which includes the toxic substance standards and certain related standards applicable to shipyards, including 1915.1025 (the lead standard) and a new standard for Cadmium (29 CFR 1910.1027).

In 1993, the Naval Environmental Health Center (NEHC) performed a study on U.S. Navy coating systems containing lead and chromate. The purpose of the study was to address three issues:

- A best estimate of hazards from lead and chromate exposure during paint removal operations.
- Necessary modifications to the Navy Occupational Safety and Health Program.
- Necessary modifications to the interim shipboard paint removal policy. The NEHC conclusion: ". . . there exists a good likelihood for workers to be exposed to lead during any mechanical paint removal operation. Collectively, a risk exists for lead, chromium or chromate exposure during such tasks."

This and other exposure information prompted the NAVSEA Standard Specification for Ship Repair and Alteration Committee (SSRAC) to draft and promulgate Standard Item 009-03 (Toxic and Hazardous Substances; Control) effective in FY94 REV. A, Standard Items. Additionally, 009-32 (Cleaning and Painting Requirements; Accomplish) was revised to include paragraph 3.1.2, "Consider shipboard coatings to contain heavy metal based material (e.g., lead, cadmium, or chromium), unless it can be established by laboratory analysis or other reliable methods that the coatings are free of those heavy metals."

The inclusion of 009-03 and the revision to 009-32 effectively put ship repairers on notice that disturbance of any Navy coating system may expose workers to heavy metals, unless proven otherwise.

Preliminary Revisions to FY-95 Standard Items indicate that 009-03 will be canceled because of the inclusion of OSHA subpart Z into 1915 (Maritime OSHA) into 009-32 references. Additional revisions to 009-32 include (1) notification to the SUPERVISOR and to the designated representative of the ship's Commanding Officer prior to the start of work, (2) posted notice on the vessel, and (3) laboratory analysis of personnel monitoring.

Although protection of employees from exposure during repair activities is of primary concern, compliance with regulatory standards and contractual requirements must be thoroughly understood and implemented.

A statistical analysis of heavy metals (lead, cadmium, and chromium) contained in coating systems aboard naval vessels has been evaluated with the variable parameters of abatement method, surface area to be abated, mechanical ventilation used, and other engineering, environmental, and administrative controls.

In addition to identifying shipboard coatings abatement technologies compliant with OSHA, this document will identify some of the most cost effective methods for paint removal and regulatory compliance.

2.0 DEFINITION OF TERMS

AL: Action Level. This is the level at which precautions must be taken (when dealing with airborne concentrations of heavy metals) in order to ensure that the PEL is not exceeded.

Lead	30 $\mu\text{g}/\text{m}^3$
Cadmium	2.5 $\mu\text{g}/\text{m}^3$

Until such time regulatory Action Levels for Chromium are established, and for the purposes of this study/project, one-half (1/2) of the PEL shall be considered the AL.

Chromium	500 $\mu\text{g}/\text{m}^3$
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Area Sample: Air sample(s) taken to determine ambient air concentrations of lead, Chromium, and/or Cadmium in the immediate work area.

Engineering Controls: Measures implemented at the work site to contain, control, and/or otherwise reduce worker exposure to, and environmental releases of Heavy Metals.

Hazardous Waste: Means a waste, or combination of wastes, that because of its physical, chemical, or infectious characteristics, can pose a present or potential danger to human health or the environment if improperly treated, handled, stored, disposed of, or otherwise managed.

Heavy Metals: For the purposes of this Study/Project, shall mean *Lead, Chromium, and/or Cadmium* as utilized in Marine Coatings.

HEPA: A High Efficiency Particulate Air filter, used as an integral part of a respirator, vacuum equipment, or other devices, that can effectively remove, trap at least 99.97% of all particles 0.3 microns in diameter or larger.

Lead-containing Paint: For the purposes of this Study/Project, shall mean paint-chip samples, identified by the Naval Environmental Health Center (NEHC), that contain lead at concentrations of 600 parts per million (ppm) or greater.

Linear Correlation: The relationship between two or more variables that determines whether a change in the value of one variable will cause a corresponding change in the value of the other variable.

Low-Lead Paint: For the purposes of this Study/Project, shall mean paint-chip samples, identified by NEHC, that contain lead at concentrations of 100 ppm or less.

PEL: Permissible Exposure Limit. This is the maximum level of airborne particle concentration at which an individual may be exposed over an 8-hour time period:

Lead	50 $\mu\text{g}/\text{m}^3$
Cadmium	5.0 $\mu\text{g}/\text{m}^3$
Chromium	1000 $\mu\text{g}/\text{m}^3$

Personal Sample: Air samples collected from within the breathing zone of a worker, but outside the respirator. The samples are collected with a personal sampling pump, pulling 1 to 4 liters/minute of air.

Micrograms per cubic meter ($\mu\text{g}/\text{m}^3$): Unit of measurement describing particle concentration in ambient air (PEL and AL).

Micrograms per square feet ($\mu\text{g}/\text{ft}^2$): Unit of measurement employed to describe particle concentration on affected surface area(s). See Wipe Sample.

Parts per million (ppm): Unit of measurement, typically for solids and liquids, describing the number or weight of one part, per weight or number, of the total amount of material or substance. For example, a lead concentration of 1 ppm expresses the ratio of one gram of lead dissolved in one million (1,000,000) grams of water.

Standard Deviation: A measure of the precision of analytical readings, defined as the root-mean-square deviation from the mean. The smaller the standard deviation, the more precise the analysis, and the less variation there is when an analysis is repeated.

Substrate: A surface upon which a coating, such as paint, varnish, etc., has been, or can be applied.

TWA: Time Weighted Average. The formula used to determine exposure(s) over the 8-hour maximum. Exposures above 8-hours shall be calculated according to the following formula: Maximum Exposure = 400 divided by the number of hours worked in the day.

Wipe Sample: A sample taken via an absorbent cloth-like material of area(s) to determine the concentration of Heavy Metals in residual dust on those affected surfaces.

3.0 TRAINING

3.1 Employee Information and Training

- 3.1.1 All employees who are exposed to heavy metals above the action level or who may suffer adverse health effects due to lead exposure shall attend an initial information and training program. This awareness training shall be repeated annually.
- 3.1.2 The program must inform the employee of the contents of 29 CFR 1915.1025, 1915.1027, and the following information:
 - 3.1.2.1 The specific nature of the operation which could result in exposure above the action level.
 - 3.1.2.2 The purpose, proper selection, fitting, use, and limitations of respirators.
 - 3.1.2.3 The purpose and a description of the medical surveillance program, and medical removal program including information concerning the danger of lead to their bodies (with particular attention to the adverse reproductive affects on both males and females and hazards to the fetus and additional precautions for employees who are pregnant).
 - 3.1.2.4 Engineering controls and work practices associated with the employee's job assignment.
 - 3.1.2.5 Instructions to employees that chelating agents should not be routinely used to remove lead from their bodies and should not be used at all except under the direction of a licensed physician.
 - 3.1.2.6 A copy of the 29 CFR 1915.1025 and 1915.1027 shall be readily available to all employees including those exposed below the action level.

3.2 Sample Collection and Handling

- 3.2.1 Any employee responsible for collection and handling of bulk samples, personal and/or environmental air samples, or dust wipe samples shall attend sample collection and handling training.
- 3.2.2 Sample collection and handling training will include the following information regarding sampling for Lead, Cadmium, and/or Chromium:
 - 3.2.2.1 Objective
 - 3.2.2.2 Responsibilities
 - 3.2.2.3 Implementation of Sampling Plan
 - a. Formulating Sampling Size
 - b. Determining Sample Collection Location and Frequency
 - 3.2.2.4 Lead, Chromium, and Cadmium Containing Coatings (Refer to Section 5.1 Sampling and Analysis Plan for Collection of Samples and Analysis for Lead, Chromium, and Cadmium)

- a. **Sample Collection Tools, Containers, Chain-of-Custody Forms**
 - b. **Collection of Samples**
 - c. **Preparation of Samples for Shipment**
 - d. **Recordkeeping**
- 3.2.2.5 Personal and Environmental Air Sampling (Refer to Section 5.2 Sampling and Analysis Plan for Identification and Analysis of Airborne Lead, Chromium, and Cadmium)**
- a. **Equipment Calibration**
 - b. **Sample Collection**
 - c. **Preparation of Samples for Shipment**
 - d. **Recordkeeping**
- 3.2.2.6 Dust Wipe Sampling (Refer to Section 5.3 Wipe Sample Collection Sampling and Analysis Plan)**
- a. **Sample Collection Implements**
 - b. **Sample Collection**
 - c. **Preparation of Samples for Shipment**
 - d. **Recordkeeping**
- 3.2.2.7 Health and Safety**
- a. **Personal Protective Equipment**
 - b. **Contamination Prevention (Area & Sample)**

4.0 HEALTH & SAFETY

4.1 Permissible Exposure Limit (PEL)

4.1.1 The Occupational Health & Safety Standard applicable to Shipyard employment/employees, 29 CFR, Part 1915, Subpart Z, sets a permissible exposure limit(s) (PEL) averaged over an 8-hour work day: Time Weighted Average (TWA). $TWA = \text{Exposure Concentration} \times \text{number of Hours Exposed} / 8 \text{ Hours}$. This is the highest level of a particular contaminant in ambient air that a worker may be permissibly exposed to during an 8-hour work day.

4.1.2 Prior to exposure to the PEL, the Action Level (AL) will be triggered. This is the level of airborne Heavy Metal(s) concentration at which precautions to reduce or preclude employee exposure(s) to the PEL must be implemented.

4.1.3 <u>Element</u>	<u>AL</u>	<u>PEL</u>
<i>Lead</i>	30 $\mu\text{g}/\text{m}^3$	50 $\mu\text{g}/\text{m}^3$
<i>Chromium</i>	500 $\mu\text{g}/\text{m}^3$	1000 $\mu\text{g}/\text{m}^3$
<i>Cadmium</i>	2.5 $\mu\text{g}/\text{m}^3$	5 $\mu\text{g}/\text{m}^3$

4.1.4 Workers may be permissibly exposed to short exposures above the PEL so long as the 8-hour-average exposure does not exceed the PEL. In recognition of the employment activity and that daily exposures may sometimes exceed 8-hours as a result of overtime or other alterations in the workplace, the standard contains a formula which reduces the permissible exposure when workers are exposed for more than 8-hours. $\text{Maximum exposure} = 400 \text{ divided by the number of hours worked that day}$. For example, if workers are exposed to Lead for 10 hours a day, the maximum permitted exposure, or PEL, would be 40 $\mu\text{g}/\text{m}^3$.

4.2 Exposure Monitoring

4.2.1 Each employer must determine whether any employee, without regard to respirators, may be exposed to airborne concentrations of heavy metals (i.e. lead, cadmium, or chromium) at or above the action level for:

<u>METAL</u>	<u>ACTION LEVEL</u>
Lead:	30 $\mu\text{g}/\text{m}^3$
Cadmium:	2.5 $\mu\text{g}/\text{m}^3$
Chromium:	500 $\mu\text{g}/\text{m}^3$

4.2.2 Employers must do this by measuring the employees' breathing zone to reflect their daily 8-hour TWA exposure to airborne concentrations of heavy metals*. Where several employees have identical job classifications, tasks, work areas and work shifts and length, duration and level of exposures are similar, employers may monitor exposure levels by sampling a representative number of these employees instead of all employees. Representative samples, however, shall include employees expected to have the highest exposures.

* Sample TWA Calculation:

PEL = 400 divided by the number of hours worked that day.

If the PEL is 50 $\mu\text{g}/\text{m}^3$ for an 8-hour workday, it is reduced to 40 $\mu\text{g}/\text{m}^3$ in the case of a 10-hour workday.

TWA Concentration:

$$TWA = \frac{(C_1 T_1) + (C_2 T_2) + (C_3 T_3)}{8}$$

where TWA = 8-hr TWA

C_1 = concentration at T_1 (time)

C_2 = concentration at T_2 (time)

Mixture Calculation – for a mixture of air contaminants where the component substances (heavy metals) have similar toxicological properties, compliance activities must consider the equivalent exposure to the mixture using:

$$Em = \frac{C_1}{PEL_1} + \frac{C_2}{PEL_2} + \frac{C_3}{PEL_3}$$

where EM = equivalent exposure for the mixture

C = concentration of contaminant

PEL = Permissible Exposure Limit for that contaminant

When EM exceeds unity, the exposure is considered in excess of the standard.

4.2.3 Other provisions of exposure monitoring require employers to do the following:

- 4.2.3.1 Monitor employees to determine initial exposures. Measurements of airborne concentrations of heavy metals made in the proceeding 12 months may be used if monitoring conditions closely resemble prevailing ones and the analytical methods have an accuracy (to confidence level of 95%) of not less than plus or minus 20% for airborne concentrations of heavy metals at the action level, permissible exposure limit (PEL), or (if applicable) the separate engineering control air limit (SECAL).
- 4.2.3.2 In addition to initial monitoring results, any information, observations, calculations or employee complaints of symptoms which would indicate employee exposure to heavy metals must be considered as part of any initial exposure determination.
- 4.2.3.3 Where determination conducted under the above provisions indicates the possibility of any employee exposure to airborne concentrations of heavy metals at or above the action level, monitoring shall be conducted which is representative of the exposure for each employee in the work place.
- 4.2.3.4 Where determination conducted under the above provisions indicates that no employee is exposed to airborne concentrations of heavy metals at or above the AL, the employer shall make a written record of such determination. The record shall include the basis of initial determination and shall include the date of determination, location within the worksite, and the name and social security number of each employee monitored.

- 4.2.3.5 If monitoring reveals employee exposures to be at or above the AL, the employer shall monitor at a frequency and pattern needed to represent the levels of exposure of employees and where exposures are above the PEL to assure the adequacy of respiratory selection and the effectiveness of engineering and work practice controls. Exposure monitoring shall be performed at least every 6 months.
- 4.2.3.6 Where the initial or periodic monitoring shows employees exposures are below the action level and that result is confirmed by the results of another monitoring taken at least 7 days later, the employer may discontinue monitoring.
- 4.2.3.7 Conduct additional monitoring whenever there has been a change in raw materials and processes, equipment, personnel, work practices, or finished products that may result in additional exposures to airborne concentrations of heavy metals at or above the action level; that may result in workers previously exposed at or above the action level being exposed above the PEL; or whenever employers suspect that other changes may result in such further exposure.
- 4.2.3.8 Within 5* working days after the receipt of monitoring results, the employer shall notify each employee in writing of the results which represent that employee's exposure.
 - * The most restrictive regulation shall apply.
- 4.2.3.9 Whenever the results indicate that the representative employee exposure, without regard to respirators, exceeds the PEL, the employer shall include in the written notice a statement that the PEL was exceeded and a description of the corrective action taken or to be taken to reduce exposure to below the PEL.

4.3 Methods of Compliance

- 4.3.1 Where an employee is exposed to heavy metals above the PEL for more than 30 days per year, the Employer/Contractor shall implement engineering and workplace controls to reduce and maintain employee exposures below the PEL.
- 4.3.2 If these engineering and work practice controls do not reduce employee exposure to or below the PEL, the Employer shall supplement these controls with respirators in accordance with the most restrictive or stringent respiratory standard.
- 4.3.3 Each employer shall establish and implement a written compliance program to reduce exposures to or below the PEL. Written plans for these compliance programs shall include at least the following:
 - 4.3.3.1 A description of each operation in which heavy metals are, or may be, emitted: e.g., machinery used, materials processed, procedures, etc.
 - 4.3.3.2 A description of the specific means that will be employed to achieve compliance, including engineering controls and/or studies used to determine methods selected for controlling heavy metals.
 - 4.3.3.3 A report of the technology considered in achieving AL and PEL requirements.
 - 4.3.3.4 Air monitoring data which documents the source of heavy metal(s) emissions.
 - 4.3.3.5 A detailed schedule for implementation of the program, including documentation

such as copies of purchase orders, construction contracts, or other similar documents.

- 4.3.3.6 A work practice program which includes Protective Work Clothing, Housekeeping, and Hygiene Facilities and practices.
- 4.3.4 Written programs shall be kept on site and made available to the employee or to an authorized employee representative.
- 4.3.5 When mechanical ventilation is used to control exposure, measurements which demonstrate the effectiveness of the system, such as capture velocity, duct velocity, or static pressure shall be made at least every 3 months.
- 4.3.6 If air from exhaust ventilation is recirculated into the workplace, the employer shall assure that
 - (a) the system has a high efficiency particulate air filter (HEPA) with a reliable backup filter, and
 - (b) that controls to monitor the concentration of heavy metals in the return air and to bypass the recirculation system automatically if it fails, are installed, operating, and maintained.

4.4 Welding and Burning Operations

There are two routes of exposure to heavy metals: inhalation and ingestion. When coated surfaces are heated as a result of welding and burning, they give off fumes which are easier to inhale and ingest than coatings in the dust state.

When welding and burning are to be accomplished on surfaces in which coatings contain heavy metals, the coating system shall be removed four inches on each side adjacent to the weld or burn. Because heat will be transmitted through the metal, the coating shall be removed on both sides of the metal.

4.5 Respiratory Protection

4.5.1 Introduction

Employers are responsible for establishing an effective respirator program which conforms to the requirements of 29 CFR 1910.134. This section shall only address respiratory protection for environments suspected of containing heavy metals due to paint coating removal operations and other processes which may disturb existing coated surfaces.

4.5.2 Respiratory Protection

Where engineering and work practice controls do not reduce worker exposure to or below the PEL, the employer shall supplement these controls with respirators.

Respirators shall be used in the following circumstances:

- During the time period necessary to install or implement engineering or work practice controls;
- In work situations in which engineering and work practice controls are not sufficient to reduce exposures to or below the PEL; and
- Whenever an employee requests a respirator.

No employer shall require an employee to wear a negative pressure respirator longer than 4.4 hours per day.

4.5.3 Respirator Selection

The selection of a specific respirator must be made by individuals knowledgeable about the limitations associated with each class of respirator and familiar with the actual workplace environment. Persons will not be assigned to tasks requiring the use of respirators unless it has been determined that they are physically able to perform the work and use the equipment.

Table 4.5.3-1 correlates the class of particulate respirators with the anticipated or measured airborne concentrations of metals.

When performing paint removal operations using chemicals such as methylene chloride, positive pressure supplied air respirators or Self Contained Breathing Apparatus (SCBAs) are required.

4.5.3.1 The employer shall provide a powered, air purifying respirator in lieu of the respirator specified in Table 4.5.3-1 whenever:

The employee chooses to use this type of respirator; and this respirator will provide adequate protection to the employee.

The employer shall select respirators from among those approved for protection against particular hazards by the Mine Safety and Health Administration (MSHA) and the National Institute for Occupational Safety and Health Administration (NIOSH) under the provisions of 30 CFR Part 11.

4.5.4 For safe use of any respirator, it is essential that the user be properly instructed in its selection, use, and maintenance. Training shall provide the user an opportunity to handle the respirator, have it fitted properly, test its facepiece-to-face seal, wear it in normal air for a long familiarity period, and wear it in a test atmosphere.

Every respirator wearer shall receive instructions including demonstrations and practice in how the respirator should be worn, how to adjust it, and how to determine if it fits properly.

Table 4.5.3-1, Respiratory Protection

Airborne Concentration	Required Respirator Type ¹
Less than 10 x PEL (Lead)	Half mask, air-purifying respirator w/HEPA filter.
Less than 25 x PEL (Cadmium only)	Powered air-purifying respirator (PAPR) with a loose fitting hood or helmet w/HEPA filter, or a supplied air respirator with a loose fitting hood or helmet facepiece operated in the continuous flow mode.
Less than 50 x PEL (Lead)	Full facepiece air-purifying respirator w/HEPA filter.
Less than 50 x PEL (Cadmium only)	Full facepiece air-purifying respirator w/HEPA filter, or a powered air-purifying respirator (PAPR) with a tight fitting half mask w/HEPA filter, or a supplied air respirator with a tight fitting half mask operating in the continuous mode.
Less than 250 x PEL (Cadmium only)	Powered air-purifying respirator (PAPR) with a tight fitting full facepiece w/HEPA filter, or a supplied air respirator with a tight fitting full facepiece operated in the continuous mode.
Less than 1,000 x PEL (Lead)	Any powered air-purifying respirator (PAPR) w/HEPA filters, or half mask supplied air respirator operated in the continuous mode.
Less than 1,000 x PEL (Cadmium only)	Supplied air respirator with a half mask or full facepiece operated in the pressure demand or other positive pressure mode.
Less than 2,000 x PEL (Lead)	Supplied air respirator with full facepiece, helmet or suit, operated in the positive pressure mode.
> than 1,000 x PEL or unk. (Cadmium only)	Self-contained breathing apparatus with a full facepiece operated in the pressure demand or other positive pressure mode, or a supplied air respirator with a full facepiece operated in the pressured demand or other positive pressure mode and equipped with an auxiliary escape self-contained breathing apparatus operated in the pressure demand mode.
> than 100 mg/m ³ , unknown concentration, or fire fighting. (Lead)	Self-contained breathing apparatus with a full facepiece operated in the positive pressure mode.
Fire fighting (Cadmium only)	Self-contained breathing apparatus with a full facepiece operated in the pressure demand or other positive pressure mode.

Notes:

Respirators assigned for higher environmental concentrations may be used a lower exposure levels. Full facepiece is required if the particulate aerosols cause eye or skin irritation at the use levels.

¹ For exposure to chromium, use lead standard in conjunction with manufacturer's guidance.

4.5.5 Respiratory Usage

The employer shall assure that the respirator issued to the employee exhibits minimum facepiece leakage and that the respirator is fitted properly.

4.5.5.1 Employers shall perform either quantitative or qualitative face fit tests at the time of initial fitting and at least every six months thereafter for each employee wearing negative pressure respirators. If an employee exhibits difficulty in breathing during the fitting test or during use, the employer shall make available to the employee an examination to determine whether the employee can wear a respirator while performing the required duty.

4.5.6 Care and Maintenance

A program for care and maintenance of respirators shall include the following basic services:

- Inspection for defects (including a leak check)
- Cleaning and disinfecting
- Repair
- Storage

All respirators shall be inspected routinely before and after each use.

4.6 Protective Clothing and Equipment

4.6.1 Personnel engaged in heavy metal operations, or in situations where the concentrations of airborne heavy metal particulates is likely to exceed the PEL or where the possibility of skin or eye irritation exists, shall remove clothing work to and from work and wear protective clothing provided by their employer. Protective clothing includes:

4.6.1.1 Full body, one piece coveralls supplied and laundered by the employer or a contractor shall be used. One piece disposable coveralls constructed of TYVEK® material (or equivalent) may also be used.

4.6.1.2 Durable gloves and head covering shall be used. Hoods (head covering) shall extend beyond the collar of the coverall, completely protecting the neck area.

4.6.1.3 Slip resistant shoe covers or lightweight rubber boots shall be provided. Disposable shoe covers may also be used.

4.6.1.4 Face shields, vented goggles, or other appropriate protective equipment shall be provided and used whenever the possibility of eye exposure exists.

4.6.2 The proper use of protective clothing requires that all openings be closed and that garments fit snugly about the neck, wrists, and ankles. Accordingly, the wrist and ankle junctions, as well as the collar opening on coveralls, shall be taped, as necessary, to prevent contamination of skin and underclothing without restricting physical movement.

4.6.2.1 Clean protective clothing shall be provided at least weekly and shall be provided daily when the 8 hour TWA airborne concentration exceed 200 $\mu\text{g}/\text{m}^3$.

4.6.2.2 Change rooms shall be provided as close as practical to the heavy metal work area(s) for employees who work where the airborne exposure is above the PEL (without regard to the use of respirators). Change rooms shall be maintained under

positive pressure with respect to adjacent heavy metal work areas. Protective clothing removal procedures shall be posted in the change room and include vacuuming of clothing (before removal and while wearing a respirator, if one was required for the task) using a HEPA filter equipped vacuum approved by the cognizant industrial hygienist. Removal of heavy metal particles from clothing by blowing or shaking is prohibited.

4.6.2.3 Employees exposed to airborne heavy metal concentrations above the PEL (without regard to respirator use) shall shower at the end of the work shift. Shower facilities shall be located between the clean and dirty change rooms for employees to shower at the end of their work shift. Change rooms shall have two separate clothing lockers for each employee to prevent contamination of street clothes and to ensure that employees do not leave wearing any clothing or equipment worn during their work shift. Supervisors shall ensure that employees shower at the end of their work shift.

4.6.2.4 Laundering of heavy metal contaminated clothing shall be done to prevent release of heavy metal dust in excess of the AL. Contracts governing laundering of heavy metal contaminated clothing shall specifically require that contractors comply with precautions specified in 29 CFR 1915.1025. Heavy metal contaminated clothing shall be transported in sealed containers which are labeled as follows:

CAUTION: CLOTHING CONTAMINATED WITH HEAVY METAL. DO NOT REMOVE DUST BY BLOWING OR SHAKING. DISPOSE OF HEAVY METAL CONTAMINATED WASH WATER IN ACCORDANCE WITH APPLICABLE LOCAL, STATE, OR FEDERAL REGULATIONS.

And, in the case of Cadmium:

**DANGER
CONTAINS CADMIUM
CANCER HAZARD
AVOID CREATING DUST
CAN CAUSE LUNG AND KIDNEY DISEASE**

4.7 Housekeeping

4.7.1 All surfaces shall be maintained as free as practicable of accumulations of dust containing heavy metals.

4.7.2 Cleaning Floors

4.7.2.1 Floors and other surfaces where dust containing heavy metals accumulate shall not be cleaned by the use of compressed air.

4.7.2.2 When vacuuming or other equally effective methods are not feasible, wet methods, including wet sweeping, wet shoveling, or wet brushing, shall be used. Dry methods may be used only when vacuuming and wet methods are not practicable.

4.7.3 Vacuuming

4.7.3.1 When vacuuming methods are utilized, only a vacuum with a HEPA filter shall be used and the residue collected shall not be allowed to re-enter the workplace.

4.8 Hygiene Facilities and Practices

4.8.1 In areas where employees are exposed to heavy metals above the Permissible Exposure Limit (PEL) without regard to the use of respirators, the employer shall assure that food or beverage is not present or consumed, tobacco products are not used, and cosmetics are not applied, except in designated change rooms.

4.8.2 Change Rooms

4.8.2.1 Shall be provided by the employer for employees who work in areas where their airborne exposure to heavy metals is above the PEL, without regard to the use of respirators.

4.8.2.2 The employer shall assure that change rooms have separate storage facilities for protective work clothing and equipment, and storage for street clothes which prevents cross-contamination.

4.8.3 Showers

4.8.3.1 The employer shall provide shower facilities in accordance with 1910.141(d)(3) of this part. Which states the following:

- (a) Washing facilities shall be maintained in sanitary condition.
- (b) One shower shall be provided for each ten employees of each sex, or numerical fraction thereof, who are required to shower during the same shift.
- (c) Body soap or other appropriate cleansing agents convenient to the showers shall be provided.
- (d) Showers shall be provided with hot and cold water feeding a common discharge line.
- (e) Employees who use showers shall be provided with individual clean towels.

4.8.3.2 Any employee who's airborne heavy metal exposure is above the respective PEL, without regard to the use of respirators, must shower at the end of the work shift.

4.8.4 Lunchrooms

4.8.4.1 The employer shall provide lunchroom facilities¹ (within work areas) for employees who work in areas where their airborne exposure to heavy metals is above the PEL, without regard to the use of respirators if the employees are to eat, drink, or smoke within these areas.

4.8.4.2 The lunchroom facilities shall have a temperature controlled, positive pressure, filtered air supply, and are readily accessible to employees.

4.8.4.3 The employer shall assure that employees who work in areas where their airborne exposure to heavy metals is above the PEL without regard to the use of respirators, wash their hands and face prior to eating, drinking, smoking or applying cosmetics.

4.8.4.4 The employer shall assure that employees do not enter the lunchroom facilities with protective clothing or equipment, unless surface lead has been removed by HEPA

¹Clarification of when lunchroom facilities shall be provided for shipboard work in consultation with Federal OSHA via telephone.

vacuuming, downdraft booth, or other approved cleaning method.

4.8.5 Lavatories

4.8.5.1 The employer shall provide an adequate number of lavatory facilities which comply with 1910.141(d)(1) and (2) of this part. Which states the following:

- (a) Washing facilities shall be maintained in sanitary condition.
- (b) Lavatories shall be made available in all places of employment. The requirements of this subdivision do not apply to mobile crews or to normally unattended work locations if employees working at these locations have transportation readily available to nearby washing facilities which meet the other requirements of this paragraph.

4.9 Medical Surveillance

4.9.1 A medical surveillance program must be established for all employees who are exposed at or above the action level, unless based on air monitoring the employee is not exposed to airborne concentrations of the heavy metals at or above the action level on 30 or more days per year.

4.9.2 Several procedures must be complied with to satisfy the medical surveillance requirements of OSHA. These include:

4.9.2.1 Medical examinations and biological monitoring tests;

4.9.2.2 Appropriate corrective actions required by monitoring results;

4.9.2.3 Ensure the medical procedures meet OSHA recommendations, and that employees are allowed to use multiple physician reviews and alternative medical determination procedures, if needed; and

4.9.2.3.1 Giving to and obtaining from physicians the necessary information and data to evaluate an employee's health status.

4.9.3 At a minimum, medical surveillance provisions require an initial limited pre-placement examination, a periodic full medical examination within one year after the initial examination and biennially after that, and annual biological monitoring. The following provides the biological monitoring for lead and cadmium (OSHA has not identified biological monitoring requirements for chromium):

Lead

Blood lead level – 50 μ g/dl blood

Cadmium

Blood cadmium level – 5 μ g/L

Cadmium in urine – 3 μ g Cd/gram creatinine

4.9.4 Medical examinations and biological monitoring results will result in the reassessment of factors such as work practices, personal hygiene, smoking history and status, respiratory protection, hygiene facilities, personal protective equipment, engineering controls, and correcting any deficiencies responsible for excess exposures.

4.9.5 All medical examinations and procedures required by this rule shall be done under the

supervision of a licensed physician (medical doctor) who has read and is familiar with the health information provided in the OSHA rules. Examinations and procedures must be provided without cost to, and at a time and place that is reasonable for the employee.

- 4.9.6 Employees should be notified of their right to seek a second medical opinion after completion of the initial medical examination or consultation. The employer and employee may agree upon the use of any alternate form of physician determination, instead of more than one medical opinion (multiple physician review), as long as the alternative is expeditious and equally protective.
- 4.9.7 The licensed physician must provide a written, signed, medical opinion (about the employee's exposure to heavy metals), which includes the following:
 - 4.9.7.1 The physician's diagnosis and any opinion on the status of the employee's medical condition that would place the employee at increased risk from further exposure to the heavy metals;
 - 4.9.7.2 The results of any employee tests that reveal heavy metal exposure; and
 - 4.9.7.3 A statement by the physician that he or she has clearly and carefully explained the important medical facts to the employee.

4.10 Medical Removal Program

- 4.10.1 Employees must be temporarily removed from jobs with exposure to heavy metals at or above the AL anytime that a physician decides in a written opinion that the employee should be removed from the heavy metal exposure or where the employee's biological monitoring results are so high as to require mandatory medical removal. The physician may decide the need for medical removal based on:
 - 4.10.1.1 Biological monitoring results,
 - 4.10.1.2 Evidence of illness,
 - 4.10.1.3 Inability to wear a respirator,
 - 4.10.1.4 Signs or symptoms of heavy metal related dysfunction or disease, or
 - 4.10.1.5 Any other reason deemed medically sufficient.
- 4.10.2 Employees must also be provided with the following:
 - 4.10.2.1 A copy of the physician's written medical opinion within two weeks after receipt;
 - 4.10.2.2 A copy of the employee's biological monitoring results within two weeks after receipt; and,
 - 4.10.2.3 Information given to the physician under the provisions of the OSHA rules, within thirty days of an employee request.
- 4.10.3 The employer must also establish and maintain an accurate medical surveillance record for each employee to whom medical surveillance is provided.
- 4.10.4 The medical surveillance record must include the following information:

4.10.4.1 The name, social security number, and description of the duties of each employee;

4.10.4.2 A copy of the physician's written opinion;

4.10.4.2.1 A copy of the employee's medical history, the results of any physical examination and all test results that must be provided by the OSHA rules, including biological tests, X-rays, and pulmonary function tests; and any results that have been obtained to further evaluate any condition that might be related to heavy metal exposure.

4.10.4.2.2 A copy of the information provided to the physician as required under this rule.

4.10.5 According to the provisions of 29 CFR 1910.20, the employer must retain the medical surveillance records for the duration of the employee's employment plus 30 years.

4.10.6 The employer must make available either to the employee, or to anyone having the written consent of the employee, within fifteen days after a request, all required medical records. After an employee's death or incapacitation such records also must be given within fifteen days of a request to the employee's family. Similarly, the employer is responsible for the proper transfer of these records when he or she ceases to do business.

4.11 Signs

4.11.1 The employer may use signs required by other statutes, regulations or ordinances in addition to, or in combination with, signs required by this paragraph.

4.11.2 The employer shall assure that no statement appears on or near any sign required by this paragraph which contradicts or detracts from the meaning of the required sign.

4.11.3 In each work area where the Permissible Exposure Limit (PEL) is exceeded, the employer shall post the following warning sign(s).

WARNING
LEAD WORK AREA
POISON
NO SMOKING OR EATING

DANGER
CADMIUM
CANCER HAZARD
CAN CAUSE LUNG & KIDNEY DISEASE
AUTHORIZED PERSONNEL ONLY
RESPIRATORS REQUIRED IN THIS AREA

4.11.4 The employer is required to assure all signs are illuminated and cleaned as necessary so that the legend is readily visible.

4.12 Recordkeeping

4.12.1 The employer shall establish and maintain an accurate record of all monitoring performed in Section 4.2, Exposure Monitoring.

4.12.2 The employer shall maintain these monitoring records for at least 40 years or for the duration of employment plus 20 years, whichever is longer. This record shall include:

4.12.2.1 A description of the sampling and analytical methods used and evidence of their accuracy.

4.12.2.2 The date(s), number, duration, location, and results of each of the samples taken, including a description of the sampling procedure used to determine representative employee exposure where applicable.

4.12.2.3 The type of respiratory protection device worn, if any.

4.12.2.4 Name, social security number, and job classification of the employee monitored and of all other employees whose exposure the measurement is intended to represent.

4.12.2.5 The environmental variables that could affect the measurement of employee exposure.

4.12.3 The employer shall establish and maintain an accurate record for each employee subject to medical surveillance required by Section 4.8, Hygiene Facilities and Practice.

4.12.4 The employer shall maintain or assure that the physician maintains those medical records for at least 40 years, or for the duration of employment plus 20 years, whichever is longer. This record shall include:

4.12.4.1 The name, social security number, and description of the duties of the employee.

4.12.4.2 A copy of the physician's written opinions.

4.12.4.3 Results of any airborne exposure monitoring done for that employee and the representative exposure levels supplied to the physician.

4.12.4.4 Any employee medical complaints relating to exposure to airborne concentration of heavy metals.

- 4.12.5 The employer shall keep or assure that the examining physician keeps the following records:
- 4.12.5.1 A copy of the medical examination results including medical and work history required under Section 4.8, Hygiene Facilities and Practices.
 - 4.12.5.2 A description of the laboratory procedures and a copy of any standards or guidelines used to interpret the test results or references to that information.
 - 4.12.5.3 A copy of results of biological monitoring.
 - 4.12.5.4 The employer shall maintain or assure that the physician maintains those medical records for at least 40 years, or the duration of employment plus 20 years, whichever is longer.
- 4.12.6 The employer shall establish and maintain an accurate record for each employee removed from current exposure to lead. Each record shall include:
- 4.12.6.1 The name and social security number of the employees.
 - 4.12.6.2 The date on each occasion that the employee was removed from current exposure to lead, as well as the corresponding date on which the employee was returned to his or her former job status.
 - 4.12.6.3 A brief description of how each removal is being accomplished.
 - 4.12.6.4 A statement with respect to each removal indicating whether or not the reason for the removal was an elevated blood lead level.
 - 4.12.6.5 The employer shall maintain each medical removal record for at least the duration of an employee's employment.
- 4.12.7 The employer shall make available upon request all required records. Environmental monitoring, medical removal, and medical records shall be provided upon request to employees, designated representatives, etc., in accordance with 29 CFR 1915.1120(a)-(e), and (2)i.
- 4.12.8 The employer shall comply with all requirements involving transfer of records in accordance with 29 CFR 1915.1120(h).

5.0 SAMPLING PROTOCOL

5.1 Sampling and Analysis Plan for Collection of Samples and Analysis for Lead, Chromium, and Cadmium

5.1.1 Planning and Design

- 5.1.1.1 Shipboard coating systems may contain Lead, Chromium, and/or Cadmium. The primary objective of the Sample and Analysis Plan is to identify the presence of these metals in shipboard coatings that may be disturbed during ship repair work operations.
- 5.1.1.2 A representative sample of coatings on surfaces to be disturbed during ship repair work operations must be analyzed for the presence of heavy metals. Analysis will be performed using Atomic Absorption Spectrometry (AAS) or Inductively Coupled Plasma Spectrometry (ICP).
- 5.1.1.3 Sample locations and number of samples will be determined based on visual observation of coating characteristics by trained personnel (as described in the NSRP Lead Abatement Project Sample Collection and Handling Training Outline) as follows:
 - 5.1.1.4 Size of surface being disturbed by work operations;
 - 5.1.1.5 Homogeneity (coating texture, color, and identical appearance in all respects);
 - 5.1.1.6 Unique components (beam, pipes, ducts, conduits, machinery, equipment, etc.);
 - 5.1.1.7 Coatings on one or both sides of surface to be disturbed by work operations;
 - 5.1.1.8 Refer to Reference (A) for pertinent information required to be reported for Sample Collection and Laboratory Analysis.

5.1.2 References

NSRP Lead Abatement Project
Data Collection Form
Paint and Coatings Samples and Analysis
(See Attachment #1 for examples of forms and instruction for completion)

5.1.3 Field Sampling Equipment and Methods

- 5.1.3.1 Sampling may be accomplished by collection of coatings (paint chips) and laboratory analysis for each of the metals to be identified.
- 5.1.3.2 All persons collecting samples for laboratory analysis must complete training for Sample Collection and Handling, including the following topics:
 - a. Objective
 - b. Responsibilities
 - c. Implementation of Sampling Plan
 - d. Lead, Chromium, and Cadmium Containing Coatings
 - e. Personal and Environmental Air Sampling
 - f. Dust Wipe Sampling

g. Health and Safety

- 5.1.3.3** The following are standard practices for collecting coating (paint chip) samples for laboratory analysis.
- 5.1.3.4** Collection of paint chip samples is performed using clean, sharp chisels and/or razor knives. Paint films are carefully removed to ensure that only the paint film, and not the substrate, is sampled.
- 5.1.3.5** When sampling, the competent person will place a clean piece of poly sheeting beneath the component to be sampled, to catch debris which may be created in the sampling process. This will prevent contamination from the sample collection process.
- 5.1.3.6** The sample is placed in a clean sample container (sealable plastic baggie or centrifuge tube with screw cap) and marked with a specific, individual identification number. This number will relate to the area and component sampled.
- 5.1.3.7** Samples will be containerized at the end of each shift for delivery to the laboratory. All samples will be transported under a strict chain-of-custody to ensure quality assurance and accountability.

5.1.4 Laboratory Analysis and Measurements

- 5.1.4.1** Upon receipt of the collected samples by the laboratory, the transported package will be inspected to ensure all samples are listed and accounted for on the chain-of-custody form.
- 5.1.4.2** Sample containers will be inspected to ensure that no cross-contamination has occurred.
- 5.1.4.3** Samples will be prepared in accordance with the laboratory Standard Operating Procedure for analysis.
- 5.1.4.4** Paint chips will be weighed, ashed, digested and analyzed using Atomic Absorption Spectrometry.
- 5.1.4.5** Digestion Methods include USEPA Methods 3005A, 3050A.
- 5.1.4.6** Analysis by:
 - AAS (Atomic Absorption Spectrometry)
 - USEPA Methods for Lead 7420, Chromium 7190, Cadmium 7190
 - ICP (Inductively Coupled Plasma Spectrometry)
 - USEPA Method 6010 for Lead, Chromium, and Cadmium
- 5.1.4.7** Analysis reports will be issued stating concentrations in parts per million (ppm).

5.1.5 Data Processing and Analysis

Data collection forms have been developed for use by the shipyards (See Attachment #1 for examples of forms and instructions for completing forms.)

5.1.6 Quality Assurance

5.1.6.1 Effective laboratory and field Quality Assurance Programs must be in place for the shipyard and selected laboratory. Employees and management staff must be trained in the QA/QC Program for internal quality assurance for all operations.

5.1.6.2 Field personnel will be responsible for daily logs. The supervisor will collect and review all generated documentation at the end of each day's work. This data will be compiled and submitted to the proper person to ensure information is correctly gathered and samples are properly handled.

5.1.6.3 Laboratory Quality Assurance is maintained in accordance with a written QA/QC manual. Other quality assurance measures are implemented in accordance with the AIHA, NVLAP and State Standards.

5.2 Sampling and Analysis Plan for Identification and Analysis of Airborne Lead, Cadmium, and Chromium

5.2.1 Planning and Design

5.2.1.1 Shipboard coating systems may contain Lead, Chromium, and/or Cadmium. The primary objective of the Sample and Analysis Plan is to identify the presence of Airborne Lead, Chromium, and/or Cadmium in work areas and adjacent areas during ship repair work operations.

5.2.1.2 Measurements of airborne Lead, Cadmium, and Chromium must be performed to determine both worker and area exposures. Sample analysis will be performed using Atomic Absorption Spectrometry (AAS) Method 7105, 7030, 7048, 7024/7600, or Inductively Coupled Plasma Spectrometry (ICP) Method 7300.

5.2.1.3 Sample locations and number of samples will be determined based on the size of the work force, size of the work area and tasks being performed.

5.2.1.4 Air sample collection will be in accordance with OSHA 1915.1025 and 1915.1027.

5.2.1.5 Refer to Reference (C) for pertinent information required to be collected for Air Sample Analysis.

5.2.2 References

- a. Lead Standard OSHA 1915.1025
- b. Cadmium Standard OSHA 1915.1027
- c. Air Sample Analysis Form (Attachment #1)

5.2.3 Field Sampling Equipment and Methods

- 5.2.3.1, Air monitoring, sample collection, and laboratory analysis will be performed for personal exposure and area concentrations of airborne Lead, Cadmium, and Chromium.
- 5.2.3.2 Training in the proper methods of collecting air samples is required for field personnel.
- 5.2.3.3 Personal samples will be collected using personnel pumps as follows:
 - 5.2.3.3.1 Calibrate each personal sampling pump with a representative sample cassette in line.
 - 5.2.3.3.2 Samples are to be collected with personal sampling pumps at a flow rate of 2 liters per minute. The sample cassette is to be oriented in the worker's breathing zone.
 - 5.2.3.3.3 Sample cassettes should be 37mm, 0.8 um mixed cellulose-ester filters meeting OSHA specifications.
- 5.2.3.4 Area samples will be collected as stated above, except that the sample cassette will be placed in each work area and/or adjacent area as determined by the trained competent person to give a representative sample of airborne concentrations during work operations.

5.2.4 Laboratory Analysis and Measurements

- 5.2.4.1 Upon receipt of the collected samples by the laboratory, the transported package will be inspected to ensure all samples are listed and accounted for on the chain-of-custody form.
- 5.2.4.2 Sample cassettes will be inspected to ensure that cassettes are intact.
- 5.2.4.3 Samples will be prepared in accordance with the laboratory Standard Operating Procedures for analysis by:
 - AAS (Atomic Absorption Spectrometry)
Method 7105 for Lead, Method 7048 for Cadmium,
and Method 7024 and/or 7600 for Chromium
 - ICP (Inductively Coupled Plasma Spectrometry)
Method 7300 for Lead, Cadmium, and Chromium
- 5.2.4.4 Analysis reports will be issued stating concentrations $\mu\text{g}/\text{m}^3$ (micrograms per cubic meter).

5.2.4.5 OSHA PELs:

Lead	50. $\mu\text{g}/\text{m}^3$
Cadmium	5. $\mu\text{g}/\text{m}^3$
Chromium	1,000. $\mu\text{g}/\text{m}^3$

5.2.5 Data Processing and Analysis

Data collection forms have been developed for use by the shipyards (see Attachment #1 for Examples of Forms and Instructions for Completing Forms).

5.2.6 Quality Assurance

5.2.6.1 Effective laboratory and field Quality Assurance Programs must be in place for the shipyard and selected laboratory. Employees and management staff must be trained in the QA/QC Program for internal quality assurance for all operations.

5.2.6.2 Field personnel will be responsible for daily logs and field orders. The supervisor will collect and review all generated documentation at the end of each day's work. This data will be compiled and submitted to the proper person to ensure information is correctly gathered and samples are properly handled.

5.2.6.3 Laboratory Quality Assurance is maintained in accordance with a written QA/QC manual. Other quality assurance measures are implemented in accordance with the AIHA, NVLAP and State of California Laboratory standards.

5.3 Wipe Sample Collection Sampling and Analysis Plan

5.3.1 Planning and Design

5.3.1.1 Shipboard coating systems may contain Lead, Chromium, and Cadmium. The primary objective of this Sample and Analysis Plan is to identify the presence of residual dust containing these metals after shipboard coatings have been disturbed during ship repair work operations.

5.3.1.2 Prior to the collection of wipe samples, an aggressive visual inspection must be performed throughout the work area. All horizontal surfaces should be inspected to determine the presence of settled dust. If visual dust or debris is present, the surfaces should be cleaned using wet wiping and HEPA vacuuming techniques.

5.3.1.3 A wipe sample must be collected from surfaces within the designated work spaces and submitted for laboratory analysis for heavy metals. Analysis will be performed using Atomic Absorption Spectrometry (AAS) or Inductively Coupled Plasma Spectrometry (ICP).

5.3.1.4 Sample locations and number of samples will be determined based on the size of the space and area where coatings were disturbed.

5.3.2 References

NSRP, Lead Abatement Project
Data Collection Form
Wipe Samples & Analysis
(See Attachment #1 for examples of forms and instructions for completion)

5.3.3 Field Sampling Equipment and Methods

5.3.3.1 Sampling may be accomplished by Wipe Sample collection and laboratory analysis for each of the metals to be identified.

5.3.3.2 All inspectors must receive training in the proper methods of collecting and transporting samples for laboratory analysis.

5.3.3.3 The following are standard practices for collecting wipe samples for laboratory analysis.

5.3.3.4 Wipe Sampling must be carried out in a carefully controlled manner in order to ensure the validity and reproducibility of the sampling results. The samples are taken with commercially available wipes moistened with a non-alcohol wetting agent. In order to precisely control the area wiped, a square piece of aluminum or plastic with an open center, or "template" is used where practicable. Careful precautions are also recommended to avoid contamination of samples and to keep track of sample locations. The full list of wipe sampling equipment and supplies is:

- a. Sealed package of non-alcohol disposable wipes
- b. Washable template (inner dimensions 1 ft. by 1 ft.)
- c. Steel measuring tape
- d. Pencil and marking pen
- e. Sealable 50 ml centrifuge tubes
- f. Disposable vinyl or latex gloves
- g. Self-adhesive labels
- h. Field sample log

5.3.3.5 For sampling flat uniform surfaces, the procedure is as follows:

- a. Position a clean 1 ft. by 1 ft. template on the surface to be sampled.
- b. Place the disposable wipe flat on the surface within the sample area as defined by the template. Using an open flat hand with the fingers together, wipe the defined surface in an overlapping "S" pattern, first side-to-side and then front-to-back so that the entire one square foot area is covered.
- c. Fold the wipe in half with the sample side folded in and repeat the wiping procedure within the defined surface area on one side of the folded wipe (at a 90 degree angle from the first pass).
- d. Fold the wipe again with the sample side folded in.
- e. Collect all visible dust from the sample area.
- f. Insert the folded wipe into a new sealable 50 ml centrifuge tube and seal.
- g. Clean the vinyl or latex gloves with a new wipe. Clean the template with a new wipe.
- h. Label the sample site location, date and time, and record the same information on the field sample log.

5.3.3.6 For wipe sampling of unusual surfaces, the length and width of sample areas must

be taken to sample a minimum one square foot. The exact area sampled must be measured and recorded. Otherwise, the sampling procedure is the same. For quality control purposes, a "field blank" sample should be collected for each sampling period or batch of samples. This is a disposable wipe which is handled exactly the same as a sample, except that no area is actually wiped. These samples are sent to the lab and analyzed "blind" (without the knowledge that they are blanks), as a check on field sampling and laboratory procedures. Of course, blanks should be recorded as such in the field sampling log.

5.3.4 Laboratory Analysis and Measurements

- 5.3.4.1** Upon receipt of the collected samples by the laboratory, the transported package will be inspected to ensure all samples are listed and accounted for on the chain-of-custody form.
- 5.3.4.2** Sample containers will be inspected to ensure that no cross-contamination has occurred.
- 5.3.4.3** Samples will be prepared in accordance with the laboratory Standard Operating Procedures for analysis.
- 5.3.4.4** Digestion Methods include USEPA Methods SW-846-3050, 3005A, 3050A.
- 5.3.4.5** Analysis by:
 - ICP (Inductively Coupled Plasma Spectrometry)
 - USEPA Methods 6010 for Lead, Chromium, and Cadmium
 - GFAA (Grafite Furnace Atomic Absorption Spectrometry)
 - USEPA Methods for Lead 7421, Chromium 7191, Cadmium 7131.
- 5.3.4.6** Analysis reports will be issued stating concentrations in micrograms per square foot or other appropriate measurements.

5.3.5 Data Processing and Analysis

Data collection forms have been developed for use by the shipyards (see Attachment #1 for examples of forms and instructions for completion).

5.3.6 Quality Assurance

- 5.3.6.1** Effective laboratory and field Quality Assurance Programs must be in place for the shipyard and selected laboratory. Employees and management staff must be trained in the QA/QC Program for internal quality assurance for all operations.
- 5.3.6.2** Field personnel will be responsible for daily logs and field orders. The supervisor will collect and review all generated documentation at the end of each day's work. This data will be compiled and submitted to the proper person to ensure information is correctly gathered and samples are properly handled.
- 5.3.6.3** Laboratory Quality Assurance is maintained in accordance with a written QA/QC manual. Other quality assurance measures are implemented in accordance with the AIHA, NVLAP, and State of California Laboratory standards.

6.0 ENGINEERING AND ENVIRONMENTAL CONTROLS

6.1 Personal Protective Equipment

Refer to Section 4.0, HEALTH AND SAFETY, for details regarding Personal Protective Equipment. Subsection 4.6 addresses Protective Clothing and Equipment.

6.2 Respiratory Protection

Where engineering and environmental controls do not reduce worker exposure to or below the PEL, the employer shall supplement these controls with respirators. See Section 4.0, HEALTH AND SAFETY, Subsection 4.5.

6.3 Containment Design and Construction

A successful abatement job requires containment all heavy metals within the work area so that the heavy metals are not released into adjacent areas and/or the outside environment. Containment systems not ventilated well enough may increase exposure to workers. Exposure may also occur during disassembly of the containment. Containment is necessary whenever a heavy metal coating system is disturbed. Even when encapsulation is the only abatement strategy to be used, there is still the need for containment measures.

6.3.1 Interior Containment

Interior containment procedures consist of the following:

- 6.3.1.1** The removal of all movable objects from the work area. It is recommended that any carpeting (including wall to wall) be removed and thrown away because it is difficult to clean heavy metal dusts from carpets. Workers should wear protective coveralls and respirators during the removal of carpet because the activity can produce large amounts of heavy metal dusts.
- 6.3.1.2** Use 6-mil plastic secured with duct tape to cover exposed areas. Floors and other horizontal surfaces should be covered.
- 6.3.1.3** Seal the work area from non-work areas. Openings to compartments and/or adjacent compartments not to be abated must be sealed off with 6-mil plastic and tape. Special attention should be paid to the isolation of ventilation systems during dust generating activities. This isolation can be accomplished by making sure ventilation systems are secured and tagged out.
- 6.3.1.4** Create effective barriers at entrances between work and non-work areas by using two layer of 6-mil plastic sheeting. On one side of the hatch frame secure the first sheet to the top of the opening and down along one side of the opening. Next, on the other side of the hatch frame secure the second sheet to the top of the opening and down along the opposite side to which the first sheet was secured.
- 6.3.1.5** Cover all non-movable objects with 6-mil plastic and seal with duct tape. Non-movable objects include such things as cabinets, furniture and sinks.

- 6.3.1.6 Covering all floors with 2 layers of 6-mil plastic (after the first layer of plastic has been secured to the floor, a second layer is added to ensure proper containment of floor surfaces). Additional layers of 6-mil plastic should be considered in some locations such as high-traffic areas or where there is concern that the plastic might be damaged. This enables easy removal and clean-up of debris at different points in time during the abatement process, while protecting the floor containment system. While the additional layers of plastic can be removed during the abatement process, the first layer of plastic should not be removed from the floor surfaces during abatement to avoid more costly clean-up efforts.

6.3.2 Exterior Containment

- 6.3.2.1 Proper exterior containment is necessary because:

- 6.3.2.1.1 Exterior abatements have the potential to produce large amounts of liquid and/or dry waste.

- 6.3.2.1.2 Heavy metal dusts can contaminate local waters.

- 6.3.2.2 The containment of liquid waste requires planning and sometimes creative solutions. In general, the containment of liquid waste is achieved by the following steps:

- 6.3.2.2.1 Place 6-mil plastic as close to the equipment/bulkhead foundation as possible and secure.

- 6.3.2.2.2 Extend the plastic a sufficient distance in order to contain runoff. Raise the outside edge of the plastic (e.g. with two by fours) to trap liquid waste.

- 6.3.2.2.3 Seal all seams with duct tape.

- 6.3.2.2.4 Have proper containers available to hold liquid waste for later transfer and disposal (see Section 7.11.4).

- 6.3.2.2.5 Liquid waste can be pumped or vacuumed for transfer into proper containers for disposal facility.

- 6.3.2.3 The containment of dry waste from exterior abatement is accomplished by the following steps:

- 6.2.3.2.1 Place 6-mil plastic as close to the equipment or bulkhead foundation as possible and secure.

- 6.2.3.2.2 Extend the plastic out from the foundation a distance of twenty feet (where feasible) and secure the plastic. The plastic should extend five additional feet for each deck being abated.

- 6.2.3.2.3 Remove as much of the surface plastic as practical at the end of each work day. Weather can create problems in exterior containment. For example, high winds could cause the plastic to become damaged or unsecured, allowing release of heavy metal dusts. Damaged or unsecured 6-mil plastic should be removed at the end of each day. If the plastic is left in place, barricades must be erected to keep

personnel away from the area.

- 6.2.3.2.4 Erect vertical shrouds (wind breaks) if constant wind speed exceeds 15 MPH (e.g., erect scaffolding and attach 6-mil plastic to the hull). High winds could be a major problem. Abatement should not take place when there are high winds. Work must be performed in a manner both safe to the worker and protective of the environment. If abatement must occur regardless of weather conditions, then other provisions must be made to secure vertical shrouds. Under such conditions, the scaffolding must be positively anchored to the structure. An alternative is to build a containment structure independent of the scaffolding.

6.4 Ventilation Systems

- 6.4.1 Portable ventilation systems utilizing temporary ducting may be used as a means for removing airborne concentrations of heavy metals in immediate work areas. Shipboard ventilation systems shall not be used. Negative pressure should be established within the immediate work space.
- 6.4.2 The use of negative pressure prevents the escape of contaminants into other spaces. Using such a system requires the following:
 - 6.4.2.1 Ventilation equipment with HEPA filter of sufficient CFM capacity to produce negative pressure in immediate work area;
 - 6.4.2.2 Ducting or other means of conveying the air from the work area;
 - 6.4.2.3 Monitoring of the discharged air to ensure filtration efficiency.
- 6.4.3 The entire system, including the HEPA filter, shall be monitored/inspected to ensure proper operation.

6.5 High-Efficiency Particulate Air (HEPA) Filtration Systems

- 6.5.1 HEPA filtration systems included with vacuum equipment (HEPA-VAC), negative pressure filtration equipment (refer to Section 6.4 above), and respiratory protection equipment (refer to Section 4.5 of this document) are rated to trap at least 99.97% of all particles 0.3 microns in diameter or larger.
- 6.5.2 HEPA equipped vacuums and air filtration devices differ from conventional vacuums and air filtration devices in that they trap small, micron-sized particles. Conventional vacuums will simply exhaust small dust particles back into the environment.
- 6.5.3 During surface preparation activities (removal of coatings containing heavy metals) power tools may be equipped with a shroud assembly connected to a HEPA-VAC to collect airborne dust and debris.
- 6.5.4 Properly used HEPA equipped power tools reduce employee exposure to airborne dust containing heavy metals during shipboard coatings removal operations (refer to Section 7.4.3.1 of this document).
- 6.5.5 HEPA filtered negative pressure air filtration equipment reduces environmental exposure to airborne dust containing heavy metals during shipboard coatings removal operations.

6.6 Project Monitoring

Project monitoring should include the following:

- 6.6.1 Project monitoring shall be performed by a trained, competent person. Training shall include items outlined in the following sections of this document.

Section 3.0	Training
Section 4.0	Health and Safety
Section 5.0	Sampling Protocol
Section 6.0	Engineering and Environmental Controls
Section 7.0	Marine Coating Removal Methods and Equipment
Section 8.0	Post Abatement Cleanliness

- 6.6.2 Project monitoring shall consist of visual inspection of work space to determine adequacy of implemented engineering controls, collection of personal and area air samples (work space and adjacent spaces), sample documentation and shipping, and dissemination of laboratory analysis results.

- 6.6.3 Project monitor shall ensure that sample collection equipment (i.e., air pumps) is fully charged and properly calibrated prior to sampling period. Post sample collection calibration is also required.

- 6.6.4 Air samples shall be collected using 0.8mm, 37mm, mixed cellulose ester sample cassettes. Personal air samples shall be collected within the breathing zone from at least 25% of the work force performing like tasks in accordance with OSHA 1915.025. Area air samples shall be collected within the work space to determine the airborne concentrations of heavy metals within the space. Area air samples shall be collected from spaces adjacent to the work space to determine if heavy metals are migrating from the work space.

- 6.6.5 Sampling data shall be documented on sample chain-of-custody forms (see Section 5.0, Sampling Protocol). These completed forms shall accompany all samples sent to the laboratory for analysis.

- 6.6.6 Laboratory sample results shall be posted and entered in project documentation.

7.0 MARINE COATING REMOVAL METHODS AND EQUIPMENT

7.1 Small Quantity (Spot) Removal

Work on board Navy and commercial ships does not always result in complete removal of coating systems. There is much work accomplished which results in a small quantity (spot) removal of paint. Some examples would be:

- a. A stud run for a new wire run. This effort may result in the removal of four square inch areas of paint for each stud.
- b. Foundation to be welded to a frame of the ship.
- c. Pipe penetration through a bulkhead, etc.

Each time coatings are disturbed during these work efforts, there may be an exposure. The ideal situation is to remove the paint before its being disturbed. However, each contractor has the option to monitor workers while the coating is being disturbed and determines the level of exposure. If the exposure is below the action level, no additional monitoring or effort is required. Verification of monitoring results must be conducted on an annual basis. If the exposure is between the action level and the permissible exposure limit, then monitoring must be accomplished every six months. No special precautions must be established.

If the decision is made to remove the coating, the engineering controls and procedures can be modified because of the small quantity of removals. (See Subsections 7.2, 7.3, and 7.4)

7.2 Chemical Stripping

- 7.2.1 With proper precautions, certain chemicals may be used for stripping marine coatings containing heavy metals.
- 7.2.2 The selection, use and handling of any chemical must be in accordance with manufacturer's instructions.
- 7.2.3 The Material Safety Data Sheet for any chemical should be reviewed to evaluate any hazard potential and to determine the required respiratory protection.
- 7.2.4 These precautions may include, but would not be limited to, proper ventilation, protective clothing, proper eye protection and required respiratory protection.
- 7.2.5 The use of highly toxic, highly flammable, or extremely hazardous chemicals should be limited.

NOTE: When using chemicals such as Methylene chloride, NIOSH recommends at a minimum, the use of supplied-air respirators with a full facepiece mask.

7.3 Hand Tool Abatement

- 7.3.1 Hand tools, for the purposes of this study, shall consist of non-powered tools which are hand held and are used for chipping, scraping, or other means of removing marine coatings which contain heavy metals.
- 7.3.2 Hand tools are commonly used for the removal of small quantities of marine coatings. Some examples of production tasks requiring small quantity (spot) removals include stud runs, pipe and cable hangers, and light fixture mounts.

Some loosening of nuts and bolts, which disturb marine coatings is also an example of potential exposure through the use of hand tools.

Spot removal using hand tools also include the process of sample collection for paint chip analysis.

- 7.3.3 Personal protective equipment required when using hand tools will vary depending upon the actual conditions in the field. Considerations for selection of PPE may include type of tool used, type and condition of substrate, and location of removal relative to breathing zone.

The use of hand tools in the removal of marine coatings generally do not create airborne concentrations which exceed the AL or PEL. As such, the use of respiratory protection is generally not required for most coating removal work, but again is a function of actual workplace conditions. Hand sanding and other operations producing fine dust must be given special consideration due to the ease of inhalation from these fine dust particles. The two primary considerations in the determination of PPE are the concentration of heavy metals in the coating and anticipated exposure during the removal process. If the concentration of metals in the coating are low and the anticipated exposure is low, these tools may be used without all of the exposure requirements delineated in Section 4.0, Health and Safety. This determination must be made by an individual experienced in respiratory protection and the exposure of heavy metal containing coatings.

7.4 Power Tool Abatement

- 7.4.1 For the purposes of this study, power tools shall consist of tools which operate or are assisted in operation by electricity, pneumatics, or other energy sources for the purposes of removing marine coatings.

- 7.4.2 Power tools are generally used for the removal of marine coatings over small and medium surface areas. Some examples of production tasks requiring removal include, inserts, installation and removal of doors and hatches, and installation and removal of equipment and machinery foundations.

Coatings on larger surface areas may be removed using power tools, but these practices are generally performed on flat surfaces such as flight decks and weather decks utilizing large, self-contained deck crawlers or wheel abrator machines. These machines have self-contained filtration systems for recovery of fugitive emissions. If exposure above the AL or PEL is anticipated, these machines may be equipped with HEPA filters.

- 7.4.3 The selection of power tools will depend upon the varying factors of type and uniformity of substrate, access to substrate, volume of coating to be removed and concentration of metals in the coating system.

Power tools can be divided into two categories: standard power tools and power tools equipped with High Efficiency Particulate Air filter vacuum system (HEPA-VAC).

- 7.4.3.1 Power tools equipped with HEPA-VAC systems can, in most cases, reduce or eliminate airborne concentrations of heavy metals below regulatory levels. Removing this potential for exposure is the primary goal of any engineering control. (See Section 6.5.)

HEPA-VAC assisted power tools generally consist of needle guns, grinders/sanders, chisels and various other power tools which have been modified to include HEPA filter vacuum systems.

The goal of the HEPA-VAC power tool is to capture the contaminate at the source of generation, thereby reducing or eliminating the exposure. These tools provide a number of cost saving benefits.

These benefits include:

- Reduction or elimination of expensive containment systems.
- Minimized cleaning effort upon completion of coating system removal.
- Reduced monitoring.
- Assurance of space clearance objectives.

There are limitations to the ability of these HEPA-VAC assisted power tools to eliminate exposure. Not all types of tooling will capture all emissions. Particular attention should be paid to sanders and grinders. These tools, when used on coating systems with high concentrations of heavy metals may produce airborne concentrations above acceptable levels.

Severe corrosion of the substrate may also prevent adequate abatement. These corroded surfaces may retain coatings which escape abatement and will be brought out as fume if heated.

- 7.4.3.2 Standard power tools which do not utilize attached vacuum systems may be used when concentrations of heavy metals are very low and exposure above the AL or PEL is not anticipated.

If it is anticipated that airborne concentration of heavy metals are going to exceed the AL or PEL and HEPA-VAC assisted tooling cannot be used, then all of the steps in Section 4.0, Health and Safety, must be complied with.

7.5 Abrasive Blasting

7.5.1 Dry Blasting

- 7.5.1.1 The more common dry-blasting method uses abrasive material propelled at high speed using compressed air.
- 7.5.1.2 This method generates a large amount of dust and requires extensive cleanup. This includes, but is not limited to, the use of trucks, vacuum equipment, and significant manual labor.
- 7.5.1.3 The dust being generated may contain heavy metals removed from the substrate.
- 7.5.1.4 The risk of employee exposure is significantly increased.

7.5.2 Wet Blasting

- 7.5.2.1 The wet-method is identical to the dry, except that a stream of water is injected into the blast nozzle, completely saturating the blast media.
- 7.5.2.2 Wet blasting generates wastewater that may contain heavy metals from the blast material and/or the substrate.

7.5.2.3 Employee inhalation exposure is minimal, but potential dermal exposure has to be evaluated.

7.5.2.4 A wastewater collection system has to be capable of capturing all the free liquid, holding it in a storage tank, and a means for disposing of the wastewater.

7.5.3 Personnel Safety and Environmental Compliance

7.5.3.1 Employee respiratory protective equipment and supplied air systems shall meet OSHA Regulations as noted in Sections 4.5 and 4.6 of this document.

7.5.3.2 Measures shall be taken to prevent the discharge and/or disposal of blast material, including dust, into the waterways (rivers, lakes, streams, creeks, bays, etc.).

7.5.3.3 Measures shall be implemented to reduce or minimize the discharge of dust and/or other pollutants into the atmosphere. Air emissions must be in compliance with all applicable federal, state, and local laws and regulations.

7.5.3.4 Disposal or recycling of spent abrasive material, including wastewater from wet-blasting, shall be in accordance with all applicable federal, state, and local laws and regulations.

7.6 Hydroblasting

7.6.1 Hydroblasting utilizes high-pressure water (up to 20,000 psi) and ultra-high pressure water (up to 40,000 psi) directed against the work surface to remove surface coatings. Abrasive material is not used. This method is typically used for removal of sea growth from underwater hulls, general surface cleaning, and interior storage tank cleaning.

7.6.2 Special equipment requirements for this type of operation include:

7.6.2.1 High-pressure pump, lance, and nozzle.

7.6.2.2 A supply of water with rust inhibitor to prevent flash rusting of the exposed (steel) surface.

7.6.2.3 A screening system for separating the particulate from the blast-water.

7.6.2.4 A collecting system for channeling the blast-water for disposal or reuse. This collection system has to be capable of capturing all the free liquid, holding it in a storage tank, and a means for disposing of the wastewater.

7.6.3 Water jetting reduces dust formation, which greatly reduces the potential for employee exposure to heavy metals. However, personal protective equipment should be utilized as a precautionary means.

7.7 Component Removal

7.7.1 Component removal involves the total removal of any structural component or piece of equipment with a marine coating containing heavy metals and replacement with a like component, or piece of equipment free of coatings containing heavy metals.

7.7.2 The condition or state of repair of a structural component or piece of equipment will dictate whether component removal is an appropriate abatement method.

7.7.3 Component removal is a permanent solution that can be implemented with minimal containment and dust generation.

7.8 Combination of Methods

7.8.1 The various abatement methods discussed in this section may be used in combination. This combination of methods may be a viable alternative to an individual method depending on the specific component or area to be abated.

7.8.2 Combination of methods must be performed in conjunction with the use of engineering controls.

7.8.3 A combination of methods such as chemical stripping, hand tool abatement, small quantity (spot) removals and component removal may reduce requirements for containments and reduce abatement cost.

7.9 Encapsulation

7.9.1 Encapsulation refers to processes that would render marine coatings containing heavy metals inaccessible. This is achieved by covering or sealing the marine coating with a coating specifically designed for the purpose of encapsulation.

7.9.2 Documentation and reporting of encapsulation work is important for the protection of workers performing normal maintenance or repair activities. Activities which penetrate encapsulated surfaces may result in employee exposure to underlying coatings containing heavy metals.

7.9.3 Encapsulants require periodic inspection and routine maintenance to ensure proper performance.

7.10 In-Place Management

7.10.1 In-Place Management refers to strategies or methods for controlling exposure to heavy metals contained in marine coatings pending testing, abatement, and/or routine maintenance activities.

7.10.2 In-Place Management involves:

7.10.2.1 Assessing general conditions.

7.10.2.2 Preventing acceptable conditions from deteriorating into hazardous conditions with employee exposures.

7.10.2.3 Stabilizing hazardous conditions to prevent both present and future exposure.

7.10.2.4 Development and implementation of maintenance practices which include worker training and protection from exposure to heavy metals contained in marine coatings.

7.11 Waste Disposal

7.11.1 Shipyards and/or their subcontractors shall comply with USEPA, state, and local requirements for waste disposal, as well as RCRA and applicable state waste management requirements.

7.11.2 Hazardous Waste Definition and Classification: As a result of the land disposal restriction portion of the Hazardous Waste Amendment, land disposal (i.e., burial in a landfill) of untreated hazardous wastes is not permitted in the United States. The EPA has several criteria for determining whether a waste is hazardous. Certain wastes, known as "listed wastes," are

automatically established to be hazardous. Waste is also hazardous if it possesses any of the following four characteristics: ignitability, corrosivity, reactivity, or toxicity.

Testing of waste shall be by Toxicity Characteristic Leaching Procedure (TCLP) as required by federal regulations for waste classification.

The following are the regulatory limits for waste classification by TCLP for heavy metals:

<u>Heavy Metal</u>	<u>EPA Haz. Waste No.</u>	<u>Limit</u>
Cadmium	D006	1 ppm
Chromium	D007	5 ppm
Lead	D008	5 ppm

States may have their own requirements for waste classification, as is the case in California.

7.11.3 The following materials should be tested to determine whether or not they are hazardous (TCLP may not be necessary based on previous test results or other historical data):

- Abatement materials such as paint chips, spent abrasives, sludges, chemicals, etc.
- Containment materials such as plastic sheets, duct tape, or tape used to cover floors and other services during the abatement.
- Liquid waste, including wash water.
- Rags, sponges, mops, HEPA filters, respirator cartridges, scrapers, and other materials used for testing, dust control and cleanup.
- Disposable PPE.
- Any other contaminated items.

7.11.4 **Storage:** On-site storage of Hazardous Waste shall comply with RCRA, as well as applicable state and local laws and regulations governing hazardous waste.

Waste Containers: Shall comply with EPA, DOT, and state regulations for shipping containers. The more stringent regulations shall apply. Once material has been declared hazardous waste, it must be treated or moved to a hazardous waste facility within the allowed time limit. The limit may be 90, 180, or 270 days, or an unlimited number of days depending on applicable regulations.

7.11.5 **Hazardous Waste Transportation:** Waste characterized as hazardous (see Section 7.11.2 for hazardous waste classification limits) shall be transported by a certified hazardous waste transporter, using Uniform Hazardous Waste Manifests, to an EPA-approved Treatment, Storage, and Disposal (TSD) facility for proper disposal.

8.0 POST ABATEMENT CLEANLINESS LEVELS

8.1 Background ,

8.1.1 In 1993, OSHA incorporated subpart Z into 29 CFR 1915, which includes the toxic substance standards and certain related standards applicable to shipyards, including 1915.1025 for Lead and 1910.1027 for Cadmium. The Naval Environmental Health Center (NEHC) performed a study on U.S. Navy coating systems containing lead and chromate with the following conclusion, ". . .there exists a good likelihood for workers to be exposed to lead during any mechanical paint removal operation. Collectively, a risk exists for lead, chromium, or chromate exposure during such tasks." The risk of exposure to cadmium may be added to lead and chromium based on 29 CFR 1910.1027. In addition to worker exposure to these heavy metals during coating removal, reasonable concern for exposure to occupants after removal work is completed is justified. OSHA requires the measurement of airborne levels of lead, cadmium, and other potentially toxic substances. OSHA measurements do not take into account residual surface dust generated during coating removal. There are presently no federal standards for the identification of lead, cadmium, chromium or other metals in residual surface dust.

8.1.2 Concern with lead dust levels in residential housing projects caused the United States Department of Housing and Urban Development ("HUD") to propose stringent guidelines for lead-based paint hazard identification and abatement. A brief description of HUD recommendations is as follows:

- Lead-Based Paint (LBP) Inspection Testing and Reporting
- Written Abatement Specification for each Project (including worker training requirements)
- Bidding and Abatement Contractor Selection
- LBP Abatement:

- Pre-cleaning of work area
- Containment of work area
- Lead Hazard Reduction (Abatement)
- Initial clean-up using HEPA Vacuum, Phosphate Wash,
Repeat HEPA Vacuum Technique (Triple Clean)
- Visual Inspection (with Contractor and Hygiene Consultant
to ensure proper abatement
- Final Clean-up (Triple Clean)
- Final Visual Inspection
- Clearance Wipe Sample Collection and Analysis
- Area Clearance for Reoccupancy

The recommended method for sampling post abatement dust levels is wipe sampling. Wipe sampling must be carried out in a controlled manner to ensure the validity and reproducibility of the sampling results. Refer to Section 5.3 of this document for information on Wipe Sample Collection and Analysis.

8.1.3 Although there are presently no Federal Standards, the EPA has recently released guidance for residential LBP clearance. The EPA recommends dust wipe sampling as the protocol for clearance of lead-based paint abatement work areas. The EPA guidance levels are as follows:

Floors: 100 micrograms per square foot

Interior Window Sills: 500 micrograms per square foot

Exterior Window Sills and Horizontal Surfaces: 800 micrograms per square foot

- 8.1.4 The above levels were chosen in an effort to protect children ages 0-6 years and women of child bearing age from exposure to lead in HUD and private residences. These levels do not apply to the ship repair industry.

8.2 Maritime Vessels vs. Private Residences

- 8.2.1 There are few similarities between maritime vessels and HUD or private residences. Most residences will be occupied by children ages 0-6 years and older, and women of child bearing age. Most maritime vessels will not be occupied by children ages 0-6 years for any long duration and have relatively few women of child bearing age on board.

- 8.2.2 Maritime vessels and residential structures differ in materials and type of construction; required maintenance activities; primary usage; and occupancy.

- 8.2.3 The abatement steps for residential abatement are briefly listed in the Section 8.1.2. Coatings removal in the ship repair industry typically involves the following:

- Containment
- Surface preparation
- Coatings removal (Abatement)
- Repainting (coatings replacement)
- Reoccupancy

Final clean-up and clearance sampling are not part of a typical ship repair coatings removal project.

8.3 Correlation Between Post Abatement Pb and Other Metals in Residual Dust

- 8.3.1 Pre-abatement and post abatement wipe samples collected and analyzed for Lead, Chromium, and Cadmium indicated that there is no correlation between levels for Lead and either Chromium or Cadmium in residual dust wipe samples were above the pre-abatement levels in 53% of the samples collected. Chromium levels increased in 80% of the samples collected. Cadmium levels increased in 60% of the samples collected. These sample results may be attributed to the following factors:

- Triple clean method is not utilized due to potential flash rust from moisture on abated surfaces.
- Samples were collected and analyzed prior to repainting (coating replacement).

9.0 REFERENCES

29 CFR 1915, Incorporation to General Industry Safety Health Standards Applicable to Shipyard Employment: Final Rule

29 CFR 1915.1000, Subpart Z, Shipyards

29 CFR 1910.134, Respiratory Protection

29 CFR 1926.62, Lead Exposure in Construction; Interim Final Rule, 1993

29 CFR 1915.1200, Hazard Communication Standard

40 CFR Part 50, National Primary and Secondary Ambient Air Quality Standards

Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public and Indian Housing

Industrial Lead Paint Removal Handbook, 2nd Edition, Author: Kenneth A. Trimber, KTA-Tator, Inc., 1991

NAVSEA Standard Items: 009-32

DOSH P&P No. C-11J, November, 1989

ACGIH 1993-94, Threshold Limit Values and Biological Exposure Indices, American Conference of Government Industrial Hygienists, 1993

ANSI Z9.2, Fundamentals in Governing the Design and Operation of Local Exhaust Systems

Lead Exposure in Ship Overhaul Facility During Paint Removal. AIHA Journal. 49(3): 121-127 (1988). Booher, L.E.

Lead Exposures During Shipboard Chipping and Grinding Paint-Removal Operations. AIHA Journal. 54: July 1993. H. Zeld, Y. Walker, J. Hernandez, R. Thomas

Lead Toxicity in the Shipbreaking Industry: The Ontario Experience. Canadian Journal of Public Health, Vol. 81, July/August 1990. R. Nosal, W. Wilhelm

NIOSH Health Hazard Report, HETA 92-095-2317, May, 1993. A. Sussell, A. Weber, D. Wild, K. Ashley, D. Wall

HUD Lead-Based Paint Abatement Demonstration Project. HETA 90-070-2181, February, 1992. NIOSH Investigators: A. Sussell, L. Elliott, D. Wild, E. Freund

Recommended Health Based Limits in Occupational Exposure to Heavy Metals. World Health Organization, 1980

Lead Exposure Safe Working Procedure; Professional Coating Management, Inc., Orlando, Florida, 1993.

Navy Environmental Health Center Shipboard Paint Removal Study, NEHC LTR 6290, Ser 351/2658, May 4, 1993

NSRP Task #NI-93-8, Filtration of Runoff from Pressure Washing a Vessel Hull in Dry Dock

US EPA, Guidance on Residential Lead Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil, July, 1994

APPENDIX 10.1

San Diego Ship Repair Association
Standard Operating Procedure for
Control of Airborne Heavy Metals

1.0 Title:

1.1 Control of Airborne Lead, Chromium and Cadmium during Shipboard Surface Coating Removal Operations

2.0 References

- A. Paint & Coating Removal Notification (Attachment 1)
- B. 29 CFR Part 1915 Subpart Z
- C. NAVSEA Standard Items
- D. Process Information Form (Attachment 2)
- E. Paint & Coating Samples & Analysis Form (Attachment 3)
- F. Personal/Area Sample Collection & Analysis Form (Attachment 4)

3.0 Requirements

3.1 Scope and Application:

3.1.1 This procedure applies to all coatings that contain heavy metals, i.e., lead, chromium, and/or cadmium. Work shall be performed in accordance with written contracts, federal, state, and local laws and regulations.

3.2 Definitions:

3.2.1 Action Level (AL) means employee exposure, without regard to respiratory protection, to an airborne concentration of the heavy metal. See Table 1 for individual action levels for the heavy metals.

3.2.2 Permissible Exposure Limit (PEL) means the maximum employee exposure, to an airborne concentration of a heavy metal, allowed in one 8-hour period. See Table 1 for the PEL for the specific heavy metals.

Table 1

Heavy Metal	Action Level	Exposure Limit
Lead	30 \square gm/M ³	50 \square gm/M ³
Cadmium	2.5 \square gm/M ³	5.0 \square gm/M ³
Chromium	N/A	1,000 \square gm/M ³

3.3 Notification

3.3.1 Each contractor must provide a written notice to the Supervisor and the Commanding Officer of potential exposure to heavy metals. Reference (A) provides notification form.

3.3.2 The notice shall be posted at the ship's Quarterdeck or other designated location for each job or separate area at least four hours, but not more than 24 hours, prior to the start of work.

3.3.3 The notice shall contain the following information:

3.3.3.1 Ship's name and hull number

3.3.3.2 Work item number

3.3.3.3 Compartment or frame number

3.3.3.4 Identification of hazard

3.3.3.5 Date and time of work process

3.3.3.6 Identification of engineering and work practice controls

3.4 Exposure Control

3.4.1 The contractor shall ensure that no employee is exposed to heavy metal concentrations greater than the permissible exposure limit averaged over an 8-hour period. Except as provided in part(s) 3.4.3.1, implementation of part(s) 3.4.3.2 through 3.4.3.9 and 3.4.4 shall not be required as long as the action level is not exceeded. The contractor shall implement measures, including but not limited to, engineering and environmental controls, to reduce the airborne concentration of heavy metals when the concentration is above the action level but below the PEL.

3.4.2 If an employee is exposed to a heavy metal for more than 8-hours in any one work day, the PEL shall be calculated by the following formula:

$$PEL_T = \frac{PEL_8}{T}$$

For example, for the PEL for lead work during a 12 hour shift would be:

$$PEL_{12} = \frac{50 \times 8}{12} = 33.3 \mu\text{g}/\text{M}^3$$

3.4.3 Control of Exposure and Sampling Methods

3.4.3.1 Full shift personal air samples shall be collected, for at least 7 continuous hours, including at least one sample from each shift, for each trade classification, in each work area, to generate a baseline database of airborne concentration(s) of heavy metals. Air monitoring for this initial determination may be limited to a representative sample of the exposed employees who the contractor reasonably believes are exposed to the greatest airborne concentration of heavy metals in a given environment for the work area. Employees in the work/sampling area shall be wearing personal protective equipment (PPE) provided by the contractor. This includes, but is not limited to TYVEK® bodysuit, gloves, boots, hoods, and air purifying respirator with High Efficiency Particulate Air (HEPA) filters.

- 3.4.3.2 All samples shall be analyzed by a Certified Laboratory in accordance with EPA 7000 test method. Test results shall be kept on file at the contractor's facility, and can be made accessible to the Supervisor. If the initial determination for a specific environment in work area or subsequent air monitoring reveals employee exposure to be at or above the action level but below the PEL, the contractor shall stop work operations until engineering controls can be implemented to reduce the airborne concentration below the AL. Monitoring shall be repeated every 6-months or when the specific environment is changed. If the initial monitoring reveals that employee exposure is above the PEL, the contractor shall repeat monitoring every 3 months or when there is an environmental change.
- 3.4.3.3 The contractor may implement HEPA-based engineering controls in lieu of containment procedures to minimize and control exposure of employees and other personnel. This includes but is not limited to, mechanical ventilation, recirculation of (filtered) air, and vacuum assisted equipment, to minimize or maintain the exposure of airborne heavy metals below the AL. Mechanical ventilation shall be performed with the use of a blower which shall continuously move the ambient air away from the immediate work area and discharge it outside the vessel (through a HEPA filter).
- 3.4.3.4 The contractor shall provide air purifying respirators with HEPA filters to employees who may be exposed above the AL. The contractor shall provide full facepiece, air purifying respirators with HEPA filters to employees who may be exposed to 50 times the PEL. Supplied-air respirators shall be provided to employees who may be exposed to 1,000 times the PEL. Supplied-air respirators, with full faceplate hood, helmet, or suit, shall be provided to employees who may be exposed to 2,000 times the PEL.
- 3.4.3.5 If an employee is exposed to lead above the AL, the contractor shall provide, at no cost to the employee, coveralls or similar full-body work clothing, gloves, hats, shoes, or disposable coverlets, face-shields, and an air purifying respirator with HEPA filter.
- 3.4.3.6 The contractor shall provide clean change rooms, with separate storage facilities for street clothes, for employees who work in areas where the airborne concentration exceeds the PEL.
- 3.4.3.7 The contractor shall ensure that employees who work in areas where the airborne concentration of the heavy metal is above the PEL shower at the end of the work shift. Employees are not to leave the workplace wearing any clothing or equipment worn or used during the work shift.
- 3.4.3.8 The contractor shall ensure that all protective clothing is removed at the completion of a work shift only in change rooms provided for that purpose. Used or contaminated protective clothing shall be placed in a closed container, which prevents the dispersion of the heavy metal, labeled as follows:

CAUTION: CLOTHING CONTAMINATED WITH LEAD. DO NOT REMOVE DUST BY BLOWING OR SHAKING. DISPOSE OF LEAD CONTAMINATED WASH WATER IN ACCORDANCE WITH APPLICABLE LOCAL, STATE, OR FEDERAL REGULATIONS.

And

**DANGER
CONTAINS CADMIUM
CANCER HAZARD
AVOID CREATING DUST
CAN CAUSE LUNG AND KIDNEY DISEASE**

3.4.3.9 The contractor shall institute a medical surveillance program, in accordance with reference (B), for all employees who are or may be exposed above the AL for more than 30 days per year.

3.4.4 Process Procedure(s)

3.4.4.1 Any and all painted surfaces that require air-arc, welding, grinding, sanding, or any other method or process that would cause these surfaces to become airborne, shall have the painted surfaces removed, by needle-gun or any other process which, in accordance with section 3.4.3.1, has been proven to cause minimal airborne concentrations, where the welding, grinding, etc., is to occur.

3.4.4.2 Air-arc, welding, grinding, sanding, etc. shall be performed subsequent to 3.4.4.1, and procedures referenced in 3.4.3 may be implemented to control employee exposure. During these operations, contractor personnel shall have the appropriate clothing and respiratory protection provided to them to minimize the level(s) of exposure to airborne concentrations of heavy metals.

3.4.4.3 All dust, debris, or any other by-products of the operations described in 3.4.4.1, shall be cleaned up and removed using HEPA vacuum equipment, wet sweeping/brushing, and/or any other method which minimizes the re-entry of airborne heavy metals into the workplace. All waste and/or by-products collected shall be properly disposed of in accordance with applicable federal, state, and local laws and regulations.

3.4.4.4 Work areas in which painted surfaces are caused to become airborne, and the PEL is exceeded, shall be labeled with the following sign(s):

**“WARNING
LEAD WORK AREA
POISON
NO SMOKING OR EATING”**

and

**“Danger
Cadmium
Cancer Hazard
Can Cause Lung and Kidney Disease
Authorized Personnel Only
Respirators Required in This Area”**

3.4.4.5 Regardless of section 3.4, all employees (of the contractor) who are, or may be exposed to airborne concentrations of heavy metals in the workplace, shall undergo a training session provided by the contractor, as required by reference (B).

3.4.5 Personnel Qualification Requirements

3.4.5.1 All personnel utilized in accomplishing these assigned tasks shall be knowledgeable in their field of work. Supervisory personnel shall have had a minimum of one year experience and training in the field of paint removal processes. All personnel shall be required to have a direct knowledge of their assigned job, as well as a complete understanding of the entire scope of work, quality assurance requirements, and foreseeable problems, in order to complete assigned tasks in a timely manner.

3.4.6 Method Utilized to Ensure Personnel Have Complete Knowledge of the Job

3.4.6.1 Prior to commencement of any paint removal work covered by this procedure, all personnel involved shall be briefed on the work requirements. A copy of this operating procedure shall be on the job site, with the work supervisor, available for review.

3.4.7 Method Utilized to Control Procedure

3.4.7 The control procedure shall be the operating procedure itself and on-site inspections by cognizant contractor supervisory and quality control personnel to confirm compliance with this procedure. References (D), (E), and (F) shall be utilized to document exposure monitoring. Reference (A) shall be utilized to document each individual abatement project.

3.5 Hazardous Materials/Waste Generated

3.5.1 Contractor shall dispose of all related solids and/or liquids removed from the work site. Any residual materials shall be analyzed and properly disposed of as mandated by federal and state laws and regulations.

San Diego Ship Repair Association

**Standard Process Control Procedure,
Amendment for
Control of Shipboard Lead, Chromium and Cadmium
Found in Shipboard Surface Coating**

Amendment Number: _____

Ship: _____

Contract Number: _____

Qualified Person: _____

Work Item	Compartment	Description	Approx. Quantity	Date/ Time	Removal Routes

Process Information Form

- 1) Ship Name/Hull No.: _____
- 2) Contract No.: _____ 3) Specification No.: _____
- 4) Compartment No.: _____
- 5) Frame: _____ U/L L/L Bilge Port Stbd (Abatement Area)
- 6) Machinery ID: _____ 7) Valve or Pipe ID: _____
- 8: Dimensions of Work or Containment Area:
- A) HT: _____ ft B) LG: _____ ft
- C) Wd: _____ ft D) Total Volume: _____ ft³
- 9) Ventilation:
- A) Negative
- B) Measured CFM Exhaust: _____ ft³/min
- 10) Process Information:
- A Abrasive Blasting: _____ (Blast Medium)
- B Grinding
- C Needle Gunning
- D) Welding/Cutting
- E) Other: _____

Paint & Coating Samples & Analysis

- 1) Sample Control Number: _____
- 2) Ship Name/Hull No.: _____
- 3) Contract No.: _____ 4) Specification No.: _____
- 5) Compartment No. _____
- 6) Frame: _____ U/L L/L Bilge Port Stbd (Abatement Area)
- 7) Machinery ID: _____ 8) Valve or Pipe ID: _____
- 9) Speical Notes or Comments: _____

- 10) Sample Submitted:
- A) Laboratory: _____
- B) Date: ___/___/___ Time: _____
- C) Requested Analysis: Lead Chromium Cadmium All

Personal/Area Sample Collection & Screening Form

Employee Name: _____ Badge: _____ SSN: _____

Shop No.: _____ Ship: _____ Date: ___/___/___

Contract No.: _____

Specficiation No.: _____

Job Description

Personal _____ Area _____

Pump Nr. _____ Cassette No.: _____

Calibration: Pre: _____ LPM Post: _____ LPM

Start Time: _____ Stop Time: _____

Type of Respirator Used: _____

Protective Clothing Used: Yes _____ No _____

Person Filling Out Form: _____