NSRP | National Shipbuilding Research Program

Certificate Program: Shipyard Industry Surface Prep and Coating Training

Final Report

Prepared by
J. Scott Christman, Ph.D.
General Dynamics Bath Iron Works

For the
NSRP Workforce Development Panel
National Shipbuilding Research Project
Chair: Ryan Lee

September 2020

Contents

Introduction and Project Overview 3
Curriculum Foundation 6
Surface Prep and Coating Training Content 15
Content and Instructional Pilots 17
Curriculum Evaluation 19
Technology Transfer Activities 24
Acknowledgements 25
Appendices 26
Appendix A: Project Statement of Work (SOW) 27
Appendix B: Sample Schedule of Work used with State of National DOL 31
Appendix C: Curriculum Foundation 35
Appendix D: Unit 1, General Proficiencies 39
Appendix E: Unit 2, Surface Preparation 45
Appendix F: Unit 3, Coating & Application Methods 52
Appendix G: Unit 4, Inspection 58

Introduction and Project Overview

This is the final report of the NSRP Workforce Development Panel's 2019 –2020 research project, entitled "Certificate Program: Shipyard Industry Surface Prep and Coating Training". The project was approved by the ECB and the ATI Task Order Agreement 2018-447 stipulated work to be performed from May 2019 through September 15, 2020. The project's thesis is based on the following assumptions:

- The shipbuilding industry is experiencing a short-fall in entry-level qualified applicants.
- National low unemployment, lack of entry-level shipyard production craft training program options and the loss of technically skilled shipyard craft mechanics due to retirement has created a need for an industry-wide certificate program to train shipyard craft mechanics for entry level positions.
- Maintaining and growing a skilled workforce is paramount to meeting the new construction and repair support needs of military and commercial customers.

The goals/objectives of this project were to:

Design a one-year Certificate Program to train entry level shipyard painters. Increase skill level of new hires and applicant pools.

a. Provide an opportunity for new hires to improve their knowledge and skills.
b. Improve the number of qualified applicants for skilled craftsman positions.

The following methods and procedures were required to accomplish the goals and objectives:

<u>Task 1 – Project Research - Curriculum, Classroom and Shop Criteria</u>

Lead Shipyard will partner with Participating Shipyards, Educational Consultant and Industry Consultant to establish research objectives, and determine attainable training goals and industry best practices to develop a training program that aligns with shipyard paint industry standards.

- Develop survey to collect data relating to current state and preferred method of paint training and safety, new coating systems and spray equipment training gaps for new hires.

- Survey select group to include NSRP members, industry vendors, and trade organizations.
- Based on survey data and industry research, collaborate with Project Participants to validate the establishment of curriculum, classroom and shop criteria outlined below in Tasks 2 and 3.

Task 2 – Develop Curriculum

The Shipyard Industry Surface Prep and Coating Training will include the "Core Body of Knowledge" requirements for surface preparation and application as well as safety in painting.

- Identify training gaps of current workforce
- Develop training goals and objectives
- Develop training program assessment
    - How do we identify success
- Develop effective training program evaluation
- Identify required training manuals
    - Manufactures manuals
    - Trade manuals

Task 3 – Establish Classroom and Shop Criteria

- Identify training methods:
    - Classroom Instruction
    - Classroom/Shop Hands-on Instruction
    - E-Learning Modules
    - OJT
- Identify training location and environment requirements
- Identify required resources

This course was to provide individuals with the basic fundamental training needed to qualify for shipyard industry surface preparation and coating application certifications.

In doing so, the course content was initially expected to include the following.

- Shipbuilding Basics
- PPE/Safety
- Surface Preparation (SSPC-SP Standards)
- Surface Preparation Tools
- Abrasive Materials
- Equipment (pump, guns, lines, tips etc.)
- Coating Materials (Product Data Sheets, ASTM F 718 , SDS reviews)
- Application Methods & Techniques of Protective Coatings
- Process Control Procedures
- Inspection Equipment (SPG, DFT's, DPM, Environmental Conditions)
- Marine Decking Materials - Installation
- Corrosion 101 (Why we paint)

Task 4 – Audit and Evaluate the Certification Program

- Develop a criteria to use while auditing and evaluating training
- Audit and evaluate training
- Collect and review lessons learned
- Revise training program based on test audit outcomes

Task 5 –Facilitate an Information Sharing Workshop

The project will provide a Panel Project Briefing and Final Report, to include a roadmap for development of Shipyard Industry Surface Prep and Coating Training curriculum which may be tailored to individual shipyard needs. The project will also facilitate a workshop during an NSRP SPC panel meeting. BIW will also identify and secure equipment and trainers as needed to implement the program at BIW. The project Statement of Work (SOW) is included as Attachment A.

Curriculum Foundation

Definition of Surface Prep and Coating Training

The Certificate Program: Shipyard Industry Surface Prep and Coating Training provides shipbuilding industry paint training and enhances workforce excellence for shipyard painters. The curriculum foundation may be found in Appendix C. The training includes marine and industrial applications for new hires as well as the general public. This project relied on US shipyard best practices and industry consultants when developing the one-year training certificate program criterion which aligns with shipyard paint industry standards. The primary focus of the program will be the training of new hires through an apprenticeship model. While the program is not formally registered with a State or National Departments of Labor, it is incumbent on the provider – company, community college, to do so if desired.

The program culminates in the attendee earning a one-year certificate distinguishing the person as a knowledgeable and competent marine and industrial painter. Using apprenticeship as a backdrop, the thrust of the project focused on the development of an Instructor's Guide for the Related Instruction portion of an apprenticeship. It includes classroom lecture, hands-on learning, demonstrations, as well as testing for knowledge and competency.

Rationale for Surface Prep and Coating Training

The shipbuilding industry has experienced a short-fall in mid-level shipbuilding industry painters because of the lengthy periods of time when shipyards were not hiring and training painters, creating a gap between lower level skilled painters and highly skilled painters. Shipyards and contractors are now experiencing a significant loss of highly skilled mechanics due to retirement without a mid-level bench to support on the job training (OJT) that occurred in the past and was the preferred method of training for many shipyards.

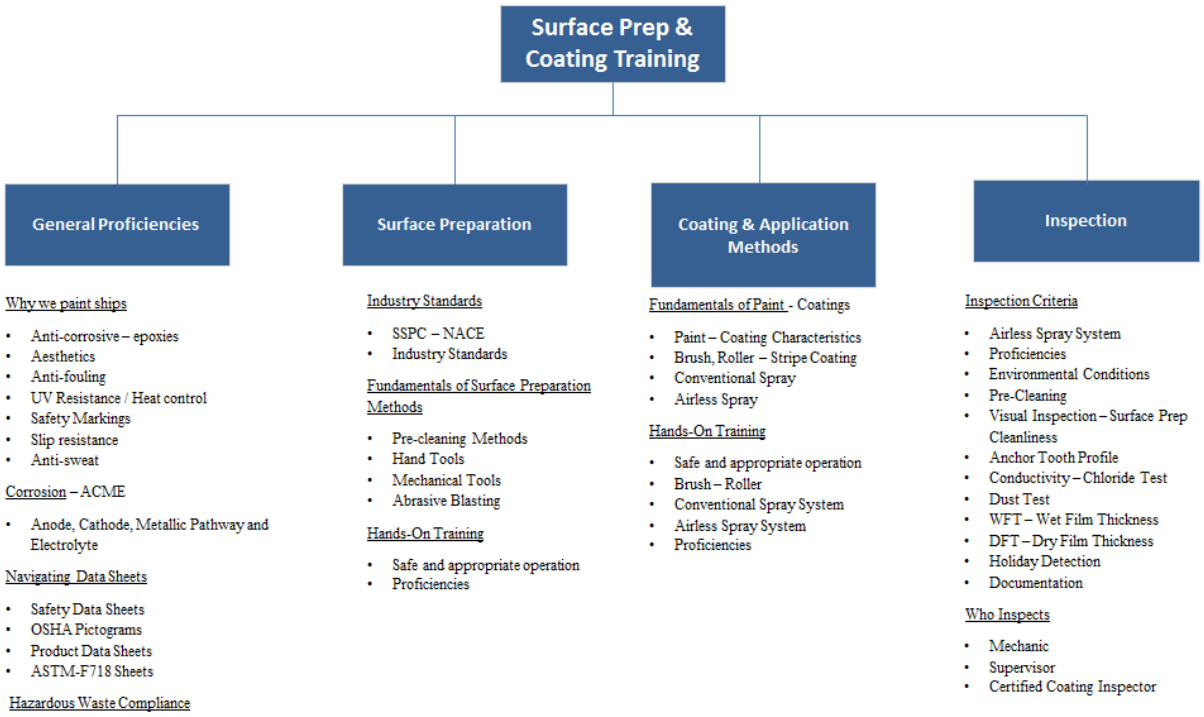
In addition, Marine/Navy coating system and coating application science has changed dramatically over the past ten years. New coating systems and spray equipment are designed for high performance and long-term lifecycle cost benefits. The new equipment and coatings are becoming more prevalent to the shipbuilding industry with challenges such as single-coat rapid

cure coatings with seven minute pot life and plural component airless pump equipment. This project envisions incorporating state-of-the art training for shipyard industry coating systems and equipment.

Content Source for Surface Prep and Coating Training

When designing a curriculum on Surface Prep and Coating aimed at new-hires, it is necessary to identify a common body of knowledge for organizing the instructional content. The content for this curriculum was derived from the subject matter experts within the industry - participating shipyards, educational consultants and industry consultants. Synthesizing the best wisdom from innovators in the industry, this training culminates in the attendee earning a one-year certificate distinguishing the person as a knowledgeable and competent marine and industrial painter.

Content Structure for Surface Prep and Coating Training



Goals for Surface Prep and Coating Training

Upon completion of this course, participants will be able to:

1. Perform surface preparation and coatings tasks on ships in a safe and effective manner
2. Follow the industry standards and requirements for preparing surfaces prior to painting
3. Use hand and power tools safely during different methods of surface preparation
4. Prepare a surface using the abrasive blasting (dry) method
5. Prepare and apply paint and coatings according to paint specifications and industry standards
6. Operate spray equipment safely and appropriately for different application methods
7. Read technical documents to locate and determine how to use the information, practices and procedures described
8. Prepare and paint ship surfaces competently, in order to pass inspections

Scope and Sequence

The Surface Prep and Coating Related Instruction can be adapted for class meeting in any number of ways. The instruction averages 136 hours to complete, however it can be adjusted depending on constraints.

Unit	Topic	Content	Hours
1	General Proficiencies	Why we paint ships • Anti-corrosive – epoxies • Aesthetics • Anti-fouling • UV Resistance / Heat control • Safety Markings • Slip resistance • Anti-sweat Corrosion – ACME • Anode, Cathode, Metallic Pathway and Electrolyte Navigating Data Sheets • Safety Data Sheets • OSHA Pictograms • Product Data Sheets • ASTM-F718 Sheets Hazardous Waste Compliance	8

Unit	Topic	Content	Hours
2	Surface Preparation	Industry Standards • SSPC – NACE • Industry Standards Fundamentals of Surface Preparation Methods • Pre-cleaning Methods • Hand Tools • Mechanical Tools • Abrasive Blasting Hands-On Training • Safe and appropriate operation • Proficiencies	80
3	Paint – Coatings & Application Methods	Fundamentals of Paint - Coatings • Paint – Coating Characteristics • Brush, Roller – Stripe Coating • Conventional Spray • Airless Spray Hands-On Training • Safe and appropriate operation • Brush – Roller • Conventional Spray System • Airless Spray System • Proficiencies	40
4	Inspection Criteria	Inspection Criteria • Airless Spray System • Proficiencies • Environmental Conditions • Pre-Cleaning • Visual Inspection – Surface Prep Cleanliness • Anchor Tooth Profile • Conductivity – Chloride Test • Dust Test • WFT – Wet Film Thickness • DFT – Dry Film Thickness • Holiday Detection • Documentation Who Inspects • Mechanic • Supervisor • Certified Coating Inspector	8

Apprenticeship Model

Apprenticeship has as its objective, the training of skilled professionals versed in all phases and aspects of the identified occupation. As a provider (registered or not), it is recognized that to accomplish this, there should be well-developed on-the-job learning experiences combined with related technical instruction leading to a nationally recognized credential.

OJT and Related Instruction Experience

The Certificate Program: Shipyard Industry Surface Prep and Coating is designed as a one-year experience inclusive of 2000 hours of On-the-Job-Learning supplemented by the required Related Instruction as stated in the Surface Prep and Coating Schedule of Work Experience (sample). A sample Schedule of Work follows, but a stand-alone copy may be found in Appendix B of this document.

_____ APPRENTICESHIP PROGRAM
SCHEDULE OF WORK EXPERIENCE

Apprentices will receive on the job learning/training in the various work areas listed below. The order in which the training is given is to be determined by the flow of work and may not necessarily be in the order listed. The times allotted to these various processes are the estimated time frames in which an average apprentice will learn and become proficient in the skill area. They are intended only as a guide; the apprentice may require more time on one area and less in another. The total term of apprenticeship is indicated below. The columns at the right constitute a record of progress for the apprentice. Each apprentice will be provided with a separate sheet in which to log their hours of experience. When the apprentice has both completed the required hours and attained proficiency in the specific skill area the Supervisor/Mentor will initial the far right column. Items for which previous credit have been given upon registration into the program should also be initialed. This sheet should be provided to the program office along with documentation of successful completion of related technical instruction when a request for completion of apprenticeship training program is submitted.

OCCUPATION: Preservation Tech

SOC: 47-2141.00 **NAICS Code: 336611**
TERM: 2000 hours **RTI Hours: 144 hours**

SKILLS TO BE LEARNED ON THE JOB	Hours Required	Hours Attained	Proficient As of Date	Supervisor Signature
Fill cracks, holes, or joints with caulk, putty, plaster, or other fillers, using caulking guns or putty knives				
Cover surfaces with drop cloths or masking tape and paper to protect surfaces during painting				
Smooth surfaces, using sandpaper, scrapers, brushes, steel wool, or sanding machines				
Read work orders or receive instructions from supervisors to determine work requirements				
Apply primers or sealers to prepare new surfaces, such as bare wood or metal, for finish coats				
Apply paint, stain, varnish, enamel, or other finishes to ships, equipment, buildings, or other structures, using brushes, spray guns, or rollers				
Mix and match colors of paint, stain, or varnish with oil or thinning and drying additives to obtain desired colors and consistencies				
Calculate amounts of required materials and estimate costs, based on surface measurements or work orders				
Polish final coats to specified finishes				
Wash and treat surfaces with oil, turpentine, mildew remover, or other preparations, and sand rough spots to ensure that finishes will adhere properly				

SKILLS TO BE LEARNED ON THE JOB	Hours Required	Hours Attained	Proficient As of Date	Supervisor Signature
Select and purchase tools or finishes for surfaces to be covered, considering durability, ease of handling, and methods of application				
Remove old finishes by stripping, sanding, wire brushing, burning, or using water or abrasive blasting				
Use special finishing techniques such as sponging, ragging, layering, or faux finishing				
Cut stencils and brush or spray lettering or decorations on surfaces				
Waterproof buildings, using water proofers or caulking				
Protect structures or surfaces near work areas to avoid damage				
Apply material to fill gaps in surfaces				
Smooth surfaces with abrasive materials or tools				
Review blueprints or specifications to determine work requirements				
Prepare surfaces for finishing				
Apply paint to surfaces				
Assemble temporary equipment or structures				
Mix substances or compounds needed for work activities				
Estimate construction project costs				
Estimate materials requirements for projects				
Clean surfaces in preparation for work activities				
Order construction or extraction materials or equipment				
Select construction equipment				
Apply sealants or other protective coatings				
Apply decorative or textured finishes or coverings				
Cut carpet, vinyl or other flexible materials				
TOTALS	**2000**			

RELATED INSTRUCTION

Each trainee will complete Related Instruction coursework as outlined in the Content Structure below. Intermediary Agencies and/or Employers providing related in-house instruction should utilize instructors trained in teaching techniques and adult learning styles.

The Surface Prep and Coating Related Instruction can be adapted for class meeting in any number of ways. The instruction averages 136 hours to complete, however it can be adjusted depending on constraints.

Unit	Topic	Content	Hours
1	General Proficiencies	Why we paint ships • Anti-corrosive – epoxies • Aesthetics • Anti-fouling • UV Resistance / Heat control • Safety Markings • Slip resistance • Anti-sweat Corrosion – ACME • Anode, Cathode, Metallic Pathway and Electrolyte Navigating Data Sheets • Safety Data Sheets • OSHA Pictograms • Product Data Sheets • ASTM-F718 Sheets Hazardous Waste Compliance	8
2	Surface Preparation	Industry Standards • SSPC – NACE • Industry Standards Fundamentals of Surface Preparation Methods • Pre-cleaning Methods • Hand Tools • Mechanical Tools • Abrasive Blasting Hands-On Training • Safe and appropriate operation • Proficiencies	80

Unit	Topic	Content	Hours
3	Paint – Coatings & Application Methods	Fundamentals of Paint - Coatings • Paint – Coating Characteristics • Brush, Roller – Stripe Coating • Conventional Spray • Airless Spray Hands-On Training • Safe and appropriate operation • Brush – Roller • Conventional Spray System • Airless Spray System • Proficiencies	40
4	Inspection Criteria	Inspection Criteria • Airless Spray System • Proficiencies • Environmental Conditions • Pre-Cleaning • Visual Inspection – Surface Prep Cleanliness • Anchor Tooth Profile • Conductivity – Chloride Test • Dust Test • WFT – Wet Film Thickness • DFT – Dry Film Thickness • Holiday Detection • Documentation Who Inspects • Mechanic • Supervisor • Certified Coating Inspector	8

WAGE SCHEDULE

A. Pre-Apprenticeship **B.** Apprentice's starting hourly wage **$** **C.** Journeyworker's Hourly Wage **$**

	Period 1	2	3	4	5
D. Term in Hours	**500**	**500**	**500**	**500**	**Complete**
E. % JW Rate	**75%**	**80%**	**85%**	**90%**	**100%**
F. $ Rate per hour					

Surface Prep and Coating Training Content

BIW completed an initial draft of the Surface Prep and Coating Training in December 2019. The curriculum topics and units were chosen based on current best practices in production needs. BIW surveyed trainees and supervisors from the Paint Shop that participated in the training and identified areas where key information was neglected. Those topics as well as training information gathered from surveying other major US Shipyards allowed the team to validate the curriculum.

The topics aligned into four pertinent units: General Proficiencies, Surface Preparation, Coating and Application Methods, and Inspection. The units, ranging from 8- to 80-hours in duration, formed the scope and sequence spelled out in the Curriculum Foundation. Unit lesson plans, PowerPoint slides with instructor notes, and resources may be found in Appendices D through G. Information critical to each unit was obtained through extensive research, process review, discussions with subject matter experts, and onsite production observations. Each unit was thoroughly developed based on the information gathered and course materials were put into PowerPoint format. Finally, an Instructor's Guide was developed and will be available by request to NSRP.

About the Instructor Guide

An instructor guide was developed and provides a comprehensive tool for facilitating the course in Surface Preparation and Coating characteristics and application. A thorough review of the document, as well as all related course materials and resources, will prepare an instructor to teach the course. The format for each section of the guide and its instructional content is listed and described below. This information is provided so any instructor can utilize the elements appropriately and effectively as he or she prepares to teach.

> Curriculum Foundation – The opening section includes the components that influence and control the content and organization of the curriculum. They are based upon values the development team believes perceives pertaining to knowledge, society, learning, and the individuals taking the training.

Units – The Surface Prep and Coating curriculum contains four individual units. Each unit includes a Lesson Plan and a PPT Slide Presentation (available upon request to NSRP).

Lesson Plan - Appearing at the beginning of every unit, the lesson plan indicates the unit goal, rationale, and objectives. It also gives the suggested activities and materials to teach the lesson and any ancillary resources used to develop the content (see Appendices D-G).

PPT Slide Presentation – The facilitation of the course is supported by four unit PPT presentations. Each slide in the presentation is displayed on the upper half of the page, with relevant instructor's notes in the bottom half. While the instructor notes give a general explanation to the slide, it is expected that, as a subject matter expert, little guidance is needed on what to say for each slide beyond that which is provided on the slide itself. However, often a slide could require questions or activities. In these instances, instructions are provided so you are able to facilitate the content as the course designer intended. Additionally, the PPT's can be easily printed and fashioned a student manual.

Instructor Resources – A tab following each unit provide supplemental information to the slide content. Although you, as a subject matter expert, may have your own documents which are relevant to your community, it may serve as a reminder of any content that should be communicated to participants before advancing to the next topic or serve as a handy resource for detailed content.

Final Note to the Instructor – It is likely that you will not have the time or need to cover the foundational material and work through all lab scenarios described in the guide. The strategy calls for you to review the document ahead of time and pick what you find helpful, necessary and most comfortable teaching.

Content and Instructional Pilots

Several content pilot/technical reviews were conducted to test for and ensure the effectiveness of the curriculum, and to suggest changes before the final product gets distributed publically. Pilot inquiries included the following.

- Was the content at the appropriate depth and breadth for the audience?
- Was the reading level of the curriculum too difficult/easy?
- Were the right topics covered?
- Were there topics missing?
- Were there examples and cases mentioned during the workshop that could be incorporated into the curriculum?

Week of Nov. 11, 2019

Five salaried individuals from the Paint Shop participated in a workshop setting. The NSRP Project SME from BIW led the event and took the participants through the first draft of the Training Manual Instructor's Guide (5 hours). Feedback was collected and revisions made.

Instructional Pilot (Shipyard)

An instructional pilot was next conducted to evaluate the teaching methods, appropriateness of content, materials, issues of timing and flow, and general effectiveness of the training.

Week of Jan. 20, 2020

A lead trainer for the Paint Shop (BIW) facilitated an 8-hour pilot with six novice deck-plate painters. The revised Instructor's Guide along with the newly developed Participant's guide was used. Feedback was collected and revisions made.

Key areas focused on the following.

- Teaching: Were the teaching methods (lecture, discussion, group work, etc.) used in the training successful in increasing participant knowledge/understanding? Did some methods work particularly well? Did some methods not work and need to be changed?
- Materials: Were the materials user friendly for both trainers and participants? Did the trainer use all of the materials (PowerPoint slides, handouts, worksheets)? Did

participants refer to the training materials? Were there additional materials and resources that would enhance the training?

- Effectiveness: Did participants acquire the intended skills and knowledge from the training? If not, what were the weak areas?
- Timing and flow: Was there too little or too much time allocated for individual activities? Was there too little or too much time allocated for the workshop as a whole?

Instructional Pilot (Community College)

A full pilot of the entire 136-hour training course was conducted to eight individual participants (non-employees) at the local community college on August 10, 2020, and ran for three weeks. The same format was used as in each of the previous content reviews. The difference here, however, was that the local community college used adjunct faculty to conduct the training course. Having the community college instructors, individuals not familiar with the internal working of a shipyard, test the materials provided great insight to the validity of the curriculum.

Curriculum Notes and Revisions

After receiving feedback from the community college instructor on several concepts that were ineffective when presented, revisions were made to addresses production needs. The overall feedback from the trainees on the course was positive. Each trainee identified with the topics and expressed enthusiasm in coming to work for the associated shipyard.

Curriculum Evaluation

An evaluation of the curriculum was performed by sending the Instructor- and Student-Guides to shipyards willing to participate in reviewing the materials. BAE, NNS, and NASSCO, provided critical feed which helped validate the degree of success. In doing so, the following sample letter and questionnaire was sent with the curriculum package.

Sample Letter

Date

Participating Stakeholder
Manager, Training
Address
Address

Dear Participating Stakeholder:

Bath Iron Works has developed a draft curriculum for the use in training new-hire painters in Surface Prep and Coating. Given your experience in the field and your position with Company Name, we are asking if you would assist in the further development and validation of the curriculum. We have identified three additional panel members to complete the process. Once complete, we hope that you will find the curriculum to be valid and useful for incoming painters at your organization.

I have enclosed a questionnaire form and a copy of the curriculum for your review. I will be scheduling a teleconference meeting with you and the other participating member to formally gather feedback from your experience and freely discuss the curriculum and the questionnaire. After our initial teleconference, we will mesh your company's ideas with the other participants in hopes of developing a well-rounded curriculum.

Sincerely,

Name

Questionnaire Form

Please answer the following questions and give explanations and suggestion as necessary.

1. Is the definition of Surface Prep and Coating Training appropriate, or does it need revising?

2. Does the rationale convince the reader of the need for state-of-the art training in Surface Prep and Coating for the shipbuilding industry?

3. Does the content source clearly explain the background of achieving the training?

4. Does the content structure provide a logical plan for the curriculum?

5. Are the program goals for Surface Prep and Coating easily comprehendible?

6. Does the scope and sequence provide an easy to follow overview for the Surface Prep and Coating curriculum?

For each of the four units, please answer the following questions.

7. Are the unit goals reasonable and attainable?

Unit	Reasonable (comments)	Attainable (comments)
1		
2		
3		
4		

8. Is the rationale for each unit appropriate and convincing?

Unit	Appropriate (comments)	Convincing (comments)
1		
2		
3		
4		

9. Do the objectives relate to the suggested activities and are they easy to understand?

Unit	Related (comments)	Understandable (comments)
1		
2		
3		
4		

10. Do the suggested unit activities present a variety of ways to learn the material and relate to the objectives of the units?

Unit	Variety (comments)	Related (comments)
1		
2		
3		
4		

11. Based on the materials in the curriculum, quizzes, unit exams, checklists, and survey questionnaires serve as appropriate evaluations of the learner?

12. Does the entire curriculum flow together with cohesiveness?

13. What changes would you suggest be made to the curriculum?

14. What are some of the weaknesses in the curriculum, if any?

15. What are some of the strengths in the curriculum?

16. What are other remarks, suggestions, observations, or explanations that you might have?

Technology Transfer Activities

The project team attended numerous technology transfer activities to make the Surface Prep and Coating communities aware of the efforts being taken to produce curriculum that addresses the needs associated with today's shipyard industry. These events also allowed the team to solicit feedback and information from other US Shipyards on their current training programs. Presenting at these events was very beneficial in the success of this project and the interest in using the final product when released. A summary of the events the project was presented are listed below.

- NSRP Joint Panel Meeting (Weld Tech & Workforce Dev): August 13 -14, 2019 – Ohio; presented updates to the project
- NSRP Joint Panel Meeting (EH&S & SP&C): September, 2019 – Newport, RI; presented updates to the project
- NAVSEA 2019 NSRP Day: November 20, 2019 - Washington, DC; presented project updates
- BAE Systems On-Site Visit: March 4-6, 2020 – Jacksonville, FL; presented final draft to their Paint Shop for validation
- NASSCO Virtual Visit: August 17, 2020 – presented final draft to their Paint Shop for validation

Acknowledgements

Bob Cloutier – General Dynamics Bath Iron Works

Arlene Thomas – General Dynamics Bath Iron Works

Brenda Downey – Southern Maine Community College

Lilly DeMille – Southern Maine Community College

Bob Turcotte – Southern Maine Community College

Mike Jury – General Dynamics NASSCO

Stephen Cogswell – BAE Systems

Appendices

Appendix A: Project Statement of Work (SOW)

Appendix B: Sample Schedule of Work used with State of National DOL

Appendix C: Curriculum Foundation

Appendix D: Unit 1, General Proficiencies

Appendix E: Unit 2, Surface Preparation

Appendix F: Unit 3, Coating & Application Methods

Appendix G: Unit 4, Inspection

Appendix A: Project Statement of Work (SOW)

STATEMENT OF WORK SUBMITTED BY GENERAL DYNAMICS BATH IRON WORKS

CERTIFICATE PROGRAM: SHIPYARD INDUSTRY SURFACE PREP AND COATING TRAINING

PTR:

Brian McVey
Manager, EHS Engineering
Ingalls Shipbuilding
P. O. Box 149
Pascagoula, MS 39568-0149
228- 935-7757
brian.mcvey@hii-ingalls.com

PROJECT LEAD (PRIME CONTRACTORS WITH ATI):

J. Scott Christman
Program Manager Training & Apprenticeship
General Dynamics Bath Iron Works
700 Washington Street
Mail Stop 3200
Bath, ME 04530
Joseph.Christman@gdbiw.com
207-751-0842

BIW CONTRACTS

Donald T. Klein
Contracts Specialist
General Dynamics Bath Iron Works
Donald.Klein@gdbiw.com
207-442-1764

PROJECT PARTICIPANTS

General Dynamics Bath Iron Works
BAE Systems, Southeast Shipyards
Newport News Shipbuilding
Southern Maine Community College
Elzly Technology Corp.

SCOPE

Description:
The Certificate Program: Shipyard Industry Surface Prep and Coating Training will provide shipbuilding industry paint training and enhance workforce excellence of shipyard painters. The training will include marine and industrial applications to new hires as well as the general public. This project will rely on US shipyard best practices and an industry consultant to develop a training certificate program criterion which aligns with shipyard paint industry standards. The primary focus of the program will be the training of new hires.

The program will culminate in the attendee earning a certificate distinguishing the person as a knowledgeable and competent marine and industrial painter. The certificate program will include classroom lecture, hands-on learning, demonstrations, as well as testing for knowledge and competency.

Project Goals and Objectives:
Design a one-year Certificate Program to train entry level shipyard painters. Increase skill level of new hires and applicant pools.

2. Provide an opportunity for new hires to improve their knowledge and skills.
3. Improve the number of qualified applicants for skilled craftsman positions.

Tasks:

Task 1 – Analysis & Design – Curriculum Data Gathering
Lead Shipyard will partner with Participating Shipyards, Educational Consultant and Industry Consultant to establish research objectives, and determine attainable training goals and industry best practices to develop a training program that aligns with shipyard paint industry standards.

- Develop survey to collect data relating to current state and preferred method of paint training and safety, new coating systems and spray equipment training gaps for new hires.
- Survey select group to include NSRP members, industry vendors, and trade organizations.
- Based on survey data and industry research, collaborate with Project Participants to validate the establishment of curriculum, classroom and shop criteria outlined below in Tasks 2 and 3.

Task 2 – Develop Course(s)
The Shipyard Industry Surface Prep and Coating Training will include the "Core Body of Knowledge" requirements for surface preparation and application as well as safety in painting.

- Identify Course Content
- Develop Course Assessments
- Identify Trade and Manufacturing Manuals
- Develop Classroom and Shop Criteria
- Create Storyboard and Script

Task 3 – Implement Pilot

- Deploy Course(s)
- Qualitative Analysis

This course will provide individuals with the basic fundamental training needed to qualify for shipyard industry surface preparation and coating application certifications.

Task 4 – Evaluate and Revise

- Learning Audit
- Revise Curriculum/Course(s)

Task 5 –Report and Share

The project will provide a Panel Project Briefing and Final Report, to include a roadmap for development of Shipyard Industry Surface Prep and Coating Training curriculum which may be tailored to individual shipyard needs. The project will also facilitate a workshop during an NSRP SPC panel meeting. BIW will also identify and secure equipment and trainers as needed to implement the program at BIW.

DELIVERABLES (WITH DUE DATES)

Title	Description	Team Member(s)	Receiver	Due Date
Analysis & Design - Curriculum Data Gathering	Gather Data from Community Shipbuilders and Partners to define what is to be learned and the process by which learning will occur	BIW Elzly NNS BAE	BIW	6/22/2019
Quarterly Report - at 3 Months	Create Report of Progress	BIW	ATI	7/15/2019
Course Development	Process of authoring and producing the course materials - "Core Body of Knowledge"	BIW Elzly NNS BAE	BIW	9/1/2019
Implement Pilot	Process of installing the project into real-world context	BIW	BIW	12/1/2019
Qurterly Report - at 6 Months	Create Report of Progress	BIW	ATI	10/15/2019
Evaluation and Revise	Process of determining the adequacy of the instruction	BIW SMCC Elzly	BIW	1/1/2020
Quarterly Report - at 9 Months	Create Report of Progress	BIW	ATI	1/15/2020
Final Report - at 12 Months	Generate a Report of Findings & Recommendations	BIW Elzly	ATI	9/15/2020

TECNOLOGY TRANSFER / IMPLEMENTATION APPROACH

To the greatest extent possible, the project team will make project components accessible to the public, and industry at large, using the following methods.

- Presentations at relevant NSRP technology transfer events
- Project results posted to the NSRP website that can be accessed by authorized recipients
- List implementation approach at participating shipyards (as applicable)
- Provide expected implementation timeline (as applicable)

Appendix B: Sample Schedule of Work used with State of National DOL

_____ APPRENTICESHIP PROGRAM
SCHEDULE OF WORK EXPERIENCE

Apprentices will receive on the job learning/training in the various work areas listed below. The order in which the training is given is to be determined by the flow of work and may not necessarily be in the order listed. The times allotted to these various processes are the estimated time frames in which an average apprentice will learn and become proficient in the skill area. They are intended only as a guide; the apprentice may require more time on one area and less in another. The total term of apprenticeship is indicated below. The columns at the right constitute a record of progress for the apprentice. Each apprentice will be provided with a separate sheet in which to log their hours of experience. When the apprentice has both completed the required hours and attained proficiency in the specific skill area the Supervisor/Mentor will initial the far right column. Items for which previous credit have been given upon registration into the program should also be initialed. This sheet should be provided to the program office along with documentation of successful completion of related technical instruction when a request for completion of apprenticeship training program is submitted.

OCCUPATION: Preservation Tech

SOC: 47-2141.00 NAICS Code: 336611
TERM: 2000 hours RTI Hours: 144 hours

SKILLS TO BE LEARNED ON THE JOB	Hours Required	Hours Attained	Proficient As of Date	Supervisor Signature
Fill cracks, holes, or joints with caulk, putty, plaster, or other fillers, using caulking guns or putty knives				
Cover surfaces with drop cloths or masking tape and paper to protect surfaces during painting				
Smooth surfaces, using sandpaper, scrapers, brushes, steel wool, or sanding machines				
Read work orders or receive instructions from supervisors to determine work requirements				
Apply primers or sealers to prepare new surfaces, such as bare wood or metal, for finish coats				
Apply paint, stain, varnish, enamel, or other finishes to ships, equipment, buildings, or other structures, using brushes, spray guns, or rollers				
Mix and match colors of paint, stain, or varnish with oil or thinning and drying additives to obtain desired colors and consistencies				
Calculate amounts of required materials and estimate costs, based on surface measurements or work orders				
Polish final coats to specified finishes				
Wash and treat surfaces with oil, turpentine, mildew remover, or other preparations, and sand rough spots to ensure that finishes will adhere properly				

SKILLS TO BE LEARNED ON THE JOB	Hours Required	Hours Attained	Proficient As of Date	Supervisor Signature
Select and purchase tools or finishes for surfaces to be covered, considering durability, ease of handling, and methods of application				
Remove old finishes by stripping, sanding, wire brushing, burning, or using water or abrasive blasting				
Use special finishing techniques such as sponging, ragging, layering, or faux finishing				
Cut stencils and brush or spray lettering or decorations on surfaces				
Waterproof buildings, using water proofers or caulking				
Protect structures or surfaces near work areas to avoid damage				
Apply material to fill gaps in surfaces				
Smooth surfaces with abrasive materials or tools				
Review blueprints or specifications to determine work requirements				
Prepare surfaces for finishing				
Apply paint to surfaces				
Assemble temporary equipment or structures				
Mix substances or compounds needed for work activities				
Estimate construction project costs				
Estimate materials requirements for projects				
Clean surfaces in preparation for work activities				
Order construction or extraction materials or equipment				
Select construction equipment				
Apply sealants or other protective coatings				
Apply decorative or textured finishes or coverings				
Cut carpet, vinyl or other flexible materials				
TOTALS	**2000**			

RELATED INSTRUCTION

Each trainee will complete Related Instruction coursework as outlined in the Content Structure below. Intermediary Agencies and/or Employers providing related in-house instruction should utilize instructors trained in teaching techniques and adult learning styles.

The Surface Prep and Coating Related Instruction can be adapted for class meeting in any number of ways. The instruction averages 136 hours to complete, however it can be adjusted depending on constraints.

Unit	Topic	Content	Hours
1	General Proficiencies	Why we paint ships • Anti-corrosive – epoxies • Aesthetics • Anti-fouling • UV Resistance / Heat control • Safety Markings • Slip resistance • Anti-sweat Corrosion – ACME • Anode, Cathode, Metallic Pathway and Electrolyte Navigating Data Sheets • Safety Data Sheets • OSHA Pictograms • Product Data Sheets • ASTM-F718 Sheets Hazardous Waste Compliance	8
2	Surface Preparation	Industry Standards • SSPC – NACE • Industry Standards Fundamentals of Surface Preparation Methods • Pre-cleaning Methods • Hand Tools • Mechanical Tools • Abrasive Blasting Hands-On Training • Safe and appropriate operation • Proficiencies	80

Unit	Topic	Content	Hours
3	Paint – Coatings & Application Methods	Fundamentals of Paint - Coatings • Paint – Coating Characteristics • Brush, Roller – Stripe Coating • Conventional Spray • Airless Spray Hands-On Training • Safe and appropriate operation • Brush – Roller • Conventional Spray System • Airless Spray System • Proficiencies	40
4	Inspection Criteria	Inspection Criteria • Airless Spray System • Proficiencies • Environmental Conditions • Pre-Cleaning • Visual Inspection – Surface Prep Cleanliness • Anchor Tooth Profile • Conductivity – Chloride Test • Dust Test • WFT – Wet Film Thickness • DFT – Dry Film Thickness • Holiday Detection • Documentation Who Inspects • Mechanic • Supervisor • Certified Coating Inspector	8

WAGE SCHEDULE

A. Pre-Apprenticeship **B.** Apprentice's starting hourly wage **$** **C.** Journeyworker's Hourly Wage **$**

	Period 1	2	3	4	5
D. Term in Hours	**500**	**500**	**500**	**500**	**Complete**
E. % JW Rate	**75%**	**80%**	**85%**	**90%**	**100%**
F. $ Rate per hour					

Appendix C: Curriculum Foundation

Definition of Surface Prep and Coating Training

The Certificate Program: Shipyard Industry Surface Prep and Coating Training provides shipbuilding industry paint training and enhances workforce excellence for shipyard painters. The training includes marine and industrial applications for new hires as well as the general public. This project relied on US shipyard best practices and industry consultants when developing the one-year training certificate program criterion which aligns with shipyard paint industry standards. The primary focus of the program will be the training of new hires through an apprenticeship model. While the program is not formally registered with a State or National Departments of Labor, it is incumbent on the provider – company, community college, to do so if desired.

The program culminates in the attendee earning a one-year certificate distinguishing the person as a knowledgeable and competent marine and industrial painter. Using apprenticeship as a backdrop, the thrust of the project focused on the development of an Instructor's Guide for the Related Instruction portion of an apprenticeship. It includes classroom lecture, hands-on learning, demonstrations, as well as testing for knowledge and competency.

Rationale for Surface Prep and Coating Training

The shipbuilding industry has experienced a short-fall in mid-level shipbuilding industry painters because of the lengthy periods of time when shipyards were not hiring and training painters, creating a gap between lower level skilled painters and highly skilled painters. Shipyards and contractors are now experiencing a significant loss of highly skilled mechanics due to retirement without a mid-level bench to support on the job training (OJT) that occurred in the past and was the preferred method of training for many shipyards.

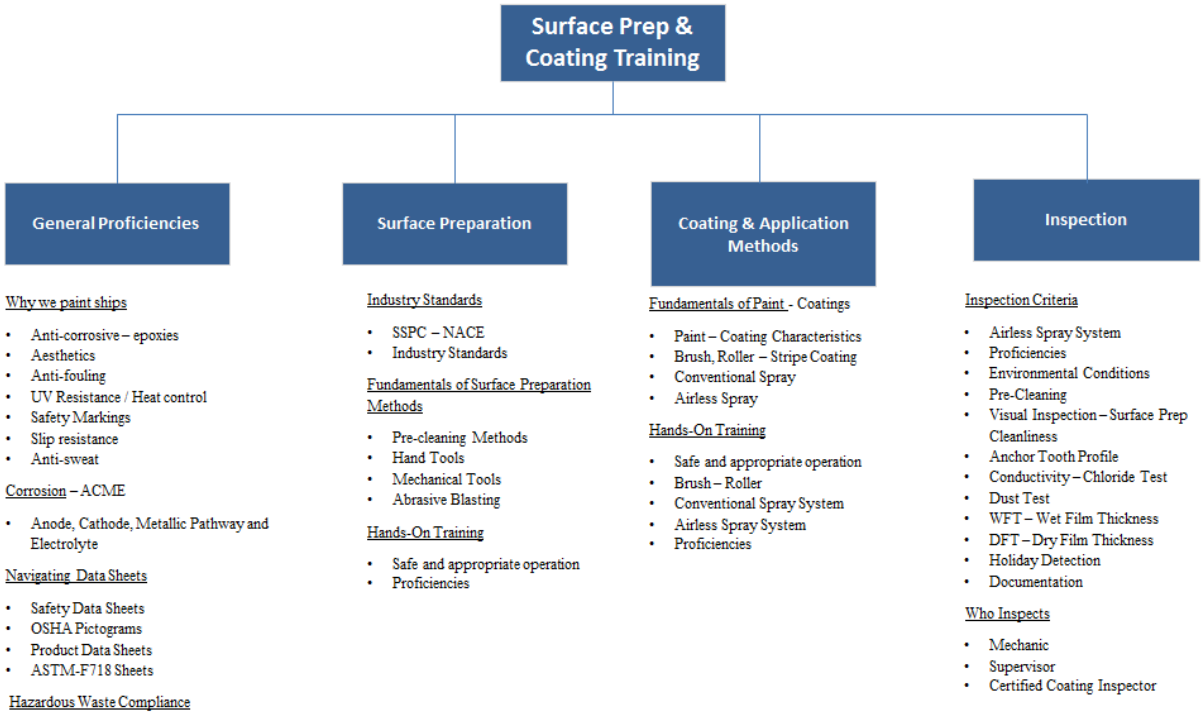
In addition, Marine/Navy coating system and coating application science has changed dramatically over the past ten years. New coating systems and spray equipment are designed for high performance and long-term lifecycle cost benefits. The new equipment and coatings are

becoming more prevalent to the shipbuilding industry with challenges such as single-coat rapid cure coatings with seven minute pot life and plural component airless pump equipment. This project envisions incorporating state-of-the art training for shipyard industry coating systems and equipment.

Content Source for Surface Prep and Coating Training

When designing a curriculum on Surface Prep and Coating aimed at new-hires, it is necessary to identify a common body of knowledge for organizing the instructional content. The content for this curriculum was derived from the subject matter experts within the industry - participating shipyards, educational consultants and industry consultants. Synthesizing the best wisdom from innovators in the industry, this training culminates in the attendee earning a one-year certificate distinguishing the person as a knowledgeable and competent marine and industrial painter.

Content Structure for Surface Prep and Coating Training



Goals for Surface Prep and Coating Training

Upon completion of this course, participants will be able to:

9. Perform surface preparation and coatings tasks on ships in a safe and effective manner
10. Follow the industry standards and requirements for preparing surfaces prior to painting
11. Use hand and power tools safely during different methods of surface preparation
12. Prepare a surface using the abrasive blasting (dry) method
13. Prepare and apply paint and coatings according to paint specifications and industry standards
14. Operate spray equipment safely and appropriately for different application methods
15. Read technical documents to locate and determine how to use the information, practices and procedures described
16. Prepare and paint ship surfaces competently, in order to pass inspections

Scope and Sequence

The Surface Prep and Coating Related Instruction can be adapted for class meeting in any number of ways. The instruction averages 136 hours to complete, however it can be adjusted depending on constraints.

Unit	Topic	Content	Hours
1	General Proficiencies	Why we paint ships • Anti-corrosive – epoxies • Aesthetics • Anti-fouling • UV Resistance / Heat control • Safety Markings • Slip resistance • Anti-sweat Corrosion – ACME • Anode, Cathode, Metallic Pathway and Electrolyte Navigating Data Sheets • Safety Data Sheets • OSHA Pictograms • Product Data Sheets • ASTM-F718 Sheets Hazardous Waste Compliance	8
Unit	**Topic**	**Content**	**Hours**

2	Surface Preparation	Industry Standards • SSPC – NACE • Industry Standards Fundamentals of Surface Preparation Methods • Pre-cleaning Methods • Hand Tools • Mechanical Tools • Abrasive Blasting Hands-On Training • Safe and appropriate operation • Proficiencies	80
3	Paint – Coatings & Application Methods	Fundamentals of Paint - Coatings • Paint – Coating Characteristics • Brush, Roller – Stripe Coating • Conventional Spray • Airless Spray Hands-On Training • Safe and appropriate operation • Brush – Roller • Conventional Spray System • Airless Spray System • Proficiencies	40
4	Inspection Criteria	Inspection Criteria • Airless Spray System • Proficiencies • Environmental Conditions • Pre-Cleaning • Visual Inspection – Surface Prep Cleanliness • Anchor Tooth Profile • Conductivity – Chloride Test • Dust Test • WFT – Wet Film Thickness • DFT – Dry Film Thickness • Holiday Detection • Documentation Who Inspects • Mechanic • Supervisor • Certified Coating Inspector	8

Appendix D: Unit 1, General Proficiencies

Unit Goal:
In this unit you will learn the basics of painting ships, corrosion, and shipyard environmental, health and safety considerations.

Unit Objectives:
The learner will be able to:

- Describe the course objectives, structure and agenda.
- Follow procedures for emergency evacuation and ground rules for an effective learning environment.
- Explain the reasons for painting different areas of ships for particular purposes.
- Identify the type of paint or coating system suitable for each particular purpose and area of the ship.
- List the basic components of paint.
- Explain the difference between Wet Film Thickness and Dry Film thickness.
- List the items of Personal Protective Equipment (PPE) commonly used.
- Locate and describe elements of Safety Data Sheets, OSHA labels, Product Data Sheets, and ASTM-F718 sheets.
    - Locate and describe each section of a Safety Data Sheet
    - Locate and describe each element of a typical or sample OSHA label
    - Identify each OSHA pictogram and the type of hazard represented
    - Locate and describe each section of a typical Product Data Sheet
    - Explain when you would be required to use an ASTM-F718 sheet instead of a Product Data Sheet
    - Provide an example of a NAVSEA Standard Item (NSI) that may differ from the paint vendor Product Data Sheet
- Handle and dispose of Hazardous Waste properly.

Materials Needed:

Hard copies for each student: *PPG – Amercoat 235 (TBD)*

- SDS (parts A & B)
- PDS
- ASTM F718 (if applicable)

SSPC Painting Manual, Volume 2: Systems and Specifications
SSPC Visual Standards

- SSPC-Vis 1: (Dry Abrasive Blast Cleaning)
- SSPC-Vis 2: (Degree of Rusting on Painted Steel Surfaces)
- SSPC-Vis 3: (Prepared by Power and Hand Tool Cleaning)

Activity 1.1: Why we paint ships
Activity 1.2: Locating Label information
Activity 1.3: Product Data Sheet

Unit Outline & Activities:

I. Introductory Lesson, Course Introduction and Overview
Purpose: Establish participant expectations for the course and classroom logistics.
ACTIVITY: Participant Introductions icebreaker

II. Lesson 1: Why We Paint Ships
Purpose: Build foundational understanding of the unique conditions requiring painting on ships, and the types of paints used.

Topics:
Why Do We Paint Ships?
Corrosion (to prevent rusting)
Aesthetics (to ensure ship looks good)
Marine Growth (to prevent marine growth)
UV Protection (to manage heat, UV Resistance)
Safety (to mark safety hazards and guides)
Slip Resistance (to provide traction)
Condensation (to manage/control condensation)
A Closer Look at Corrosion: Anode, Cathode, Metallic Pathway, Electrolyte
Corrosion Cell
Galvanic Series
Types of Corrosion, Environmental Factors, Ship Surfaces
Types of Paints, Painting Ships, Coating System
Industrial/Marine Paint: Single Part Paints, Two Part/Multi-Part Paints
Basic Components of a Paint or Coating
Binder or Resin
Pigments
Solvents
Additives
Film Formation
Wet Film Thickness
Dry Film Thickness
ACTIVITY 1.1: Reasons Recall – Why We Paint Ships

III. Lesson 2: Shipyard Environmental, Health and Safety Considerations
Purpose: Enable performance of surface preparation and coating tasks in a safe and effective/productive manner.

Topics:
Personal Protective Equipment (PPE)
Basic, PPE for Surface Prep and/or Blasting, PPE for Paint and Spray Painting
Safety Information Sources
Occupational Safety and Health Administration (OSHA) Labels and Pictograms

OSHA - Label contents, Standard Pictograms
Health Hazard, Flame, Exclamation Mark, Gas Cylinder, Corrosive, Exploding Bomb, Flame over Circle, Environmental, Skull and Crossbones
ACTIVITY 1.2: Locating Label Information
Sample Label Quiz
Pictogram Quiz
Safety Data Sheets
Sections 1 through 8
Section 8 Activity: Instructor Demonstration and participant examination of PPE items
Sections 9 through 16
SDS Quiz: True/False
Product Data Sheet (PDS) Technical Data Sheets (TDS) ASTM-F718 NAVSEA Reviewed
Product Description, Recommended/Intended Uses, Product Characteristics, Product Performance Information (Mixing the Paint/mix ratio), Environmental Conditions, WFT/DFT Requirements, Application Equipment, Thinning and Clean-Up
ASTM-F718 Sheets, NAVSEA Standard Items (NSI)
Hazardous Waste Disposal
ACTIVITY 1.3: Locating Product Information: Product Data Sheets and ASTM-F718 Sheets

References:

Definition: What are some Corrosion, Paints and Coatings?

Corrosion is a natural process that converts a refined metal into a more chemically-stable form such as oxide, hydroxide, or sulfide. It is the gradual destruction of materials (usually a metal) by chemical and/or electrochemical reaction with their environment. Corrosion engineering is the field dedicated to controlling and preventing corrosion.
In the most common use of the word, this means electrochemical oxidation of metal in reaction with an oxidant such as oxygen or sulfates. Rusting, the formation of iron oxides, is a well-known example of electrochemical corrosion. This type of damage typically produces oxide(s) or salt(s) of the original metal and results in a distinctive orange coloration. Corrosion can also occur in materials other than metals, such as ceramics or polymers, although in this context, the term "degradation" is more common. Corrosion degrades the useful properties of materials and structures including strength, appearance and permeability to liquids and gases.
Many structural alloys corrode merely from exposure to moisture in air, but the process can be strongly affected by exposure to certain substances. Corrosion can be concentrated locally to form a pit or crack, or it can extend across a wide area more or less uniformly corroding the surface. Because corrosion is a diffusion-controlled process, it occurs on exposed surfaces. As a result, methods to reduce the activity of the exposed surface, such as passivation and chromate conversion, can increase a material's corrosion resistance. However, some corrosion mechanisms are less visible and less predictable.

Examples of Corrosion:

Galvanic corrosion:

Galvanic corrosion of metals occurs when the plate was connected to a mild steel structural support.

Galvanic corrosion occurs when two different metals have physical or electrical contact with each other and are immersed in a common electrolyte, or when the same metal is exposed to electrolyte with different concentrations. In a galvanic couple, the more active metal (the anode) corrodes at an accelerated rate and the more noble metal (the cathode) corrodes at a slower rate. When immersed separately, each metal corrodes at its own rate. What type of metal(s) to use is readily determined by following the galvanic series. For example, zinc is often used as a sacrificial anode for steel structures. Galvanic corrosion is of major interest to the marine industry and also anywhere water (containing salts) contacts pipes or metal structures.

Factors such as relative size of anode, types of metal, and operating conditions (temperature, humidity, salinity, etc.) affect galvanic corrosion. The surface area ratio of the anode and cathode directly affects the corrosion rates of the materials. Galvanic corrosion is often prevented by the use of sacrificial anodes.

Galvanic series:

In any given environment (one standard medium is aerated, room-temperature seawater), one metal will be either more *noble* or more *active* than others, based on how strongly its ions are bound to the surface. Two metals in electrical contact share the same electrons, so that the "tug-of-war" at each surface is analogous to competition for free electrons between the two materials. Using the electrolyte as a host for the flow of ions in the same direction, the noble metal will take electrons from the active one. The resulting mass flow or electric current can be measured to establish a hierarchy of materials in the medium of interest. This hierarchy is called a *galvanic series* and is useful in predicting and understanding corrosion.

Rust:

Is an iron oxide, a usually red oxide formed by the redox reaction of iron and oxygen in the presence of water or air moisture. Several forms of rust are distinguishable both visually and by spectroscopy, and form under different circumstances. Rust consists of hydrated iron (III) oxides $Fe_2O_3 \cdot nH_2O$ and iron (III) oxide-hydroxide (FeO (OH), Fe (OH).

Given sufficient time, oxygen, and water, any iron mass will eventually convert entirely to rust and disintegrate. Surface rust is flaky and friable, and it provides no protection to the underlying iron, unlike the formation of patina on copper surfaces. Rusting is the common term for corrosion of iron and its alloys, such as steel. Many other metals undergo similar corrosion, but the resulting oxides are not commonly called rust.

Other forms of rust exist, like the result of reactions between iron and chloride in an environment deprived of oxygen. Rebar used in underwater concrete pillars, which generates green rust, is an example. Although rusting is generally a negative aspect of iron, a particular form of rusting, known as "stable rust," causes the object to have a thin coating of rust over the top, and if kept in

low relative humidity, makes the "stable" layer protective to the iron below, but not to the extent of other oxides, such as aluminum.

Coatings and painting:

Flaking paint, exposing a patch of surface rust on sheet metal
Rust formation can be controlled with coatings, such as paint, lacquer, varnish, or wax tapes that isolate the iron from the environment. Large structures with enclosed box sections, such as ships and modern automobiles, often have a wax-based product (technically a "slushing oil") injected into these sections. Such treatments usually also contain rust inhibitors. Covering steel with concrete can provide some protection to steel because of the alkaline pH environment at the steel–concrete interface. However, rusting of steel in concrete can still be a problem, as expanding rust can fracture or slowly "explode" concrete from within.
As a closely related example, iron bars were used to reinforce stonework of the Parthenon in Athens, Greece, but caused extensive damage by rusting, swelling, and shattering the marble components of the building.
When only temporary protection is needed for storage or transport, a thin layer of oil, grease, or a special mixture such as Cosmoline can be applied to an iron surface. Such treatments are extensively used when "mothballing" a steel ship, automobile, or other equipment for long-term storage.
Special ant seize lubricant mixtures are available, and are applied to metallic threads and other precision machined surfaces to protect them from rust. These compounds usually contain grease mixed with copper, zinc, or aluminum powder, and other proprietary ingredients.

Coatings:

A coating is a covering that is applied to the surface of an object, usually referred to as the substrate. The purpose of applying the coating may be decorative, functional, or both. The coating itself may be an all-over coating, completely covering the substrate, or it may only cover parts of the substrate. An example of all of these types of coating is a product label on many drinks bottles- one side has an all-over functional coating (the adhesive) and the other side has one or more decorative coatings in an appropriate pattern (the printing) to form the words and images.
Paints and lacquers are coatings that mostly have dual uses of protecting the substrate and being decorative, although some artist's paints are only for decoration, and the paint on large industrial pipes is presumably only for the function of preventing corrosion.
Functional coatings may be applied to change the surface properties of the substrate, such as adhesion, wettability, corrosion resistance, or wear resistance. In other cases, e.g. semiconductor device fabrication (where the substrate is a wafer), the coating adds a completely new property, such as a magnetic response or electrical conductivity, and forms an essential part of the finished product.
A major consideration for most coating processes is that the coating is to be applied at a controlled thickness, and a number of different processes are in use to achieve this control, ranging from a simple brush for painting a wall, to some very expensive machinery applying coatings in the electronics industry. A further consideration for 'non-all-over' coatings is that control is needed as to where the coating is to be applied. A number of these non-all-over coating processes are printing processes.

Many industrial coating processes involve the application of a thin film of functional material to a substrate, such as paper, fabric, film, foil, or sheet stock. If the substrate starts and ends the process wound up in a roll, the process may be termed "roll-to-roll" or "web-based" coating. A roll of substrate, when wound through the coating machine, is typically called a web.
Coatings may be applied as liquids, gases or solids.

Appendix E: Unit 2, Surface Preparation

Unit Goal:

In this unit you will learn how to prepare ship surfaces for painting by 1) pre-cleaning, then 2) preparing the surface using different methods depending on the situation, in order to create the surface that best enables the paint to adhere to it. You will also learn the safe and appropriate operation of hand and power tools, and abrasive blasting tools and equipment.

Unit Objectives:

The learner will be able to:

- Explain each of the two main tasks involved in the surface preparation process: pre-cleaning and surface preparation.
- Assess the initial condition of a substrate surface in order to predict which preparation methods might be chosen by a supervisor.
- Pre-clean a substrate surface to remove all visible oil, grease and contaminants prior to the actual surface preparation.
- Prepare a pre-cleaned substrate surface using each one of the following methods:
    - Hand Tool
    - Power Tool
    - Abrasive Blasting (Dry)
- Achieve the specified surface profile that will best enable the paint to adhere.
- Feather intact paint edges to create a smooth transition from the bare steel to the existing paint.

Materials Needed:

Recommended List – Depending on shipyard needs or usage

Surface Prep

- Hand: scrapper, chipping hammer, wire brush, sandpaper/emery cloth
- Grinder: 3”, 5”, 7” with associated grinding disc
- Needle gun
- Off-set wire brush (wheel)
- Acorn wire brush
- Die type grinders
- Associated spanner tools/wrenches
- Inspection Equipment

Abrasive Blasting

- Blast hose with couplings, dead-man trigger
- Nozzle (s)
- Blast medias: Grit, sand, shot
- Illustration of various blasting units
- Inspection Equipment

Unit Outline & Activities:

I. Lesson 1: Overview of the Surface Preparation Process

Purpose: To provide a basic understanding of each of the two main tasks involved in the surface preparation process: pre-cleaning and surface preparation.

Topics:
Main Tasks in Surface Preparation (Pre-cleaning, Preparing the pre-cleaned surface)
Importance of Surface Preparation
Initial Pre-Cleaning
Preparing the Surface
Industry Standards
Hand or Power Tool Cleaning Standards
Quick Quiz

II. Lesson 2: Pre-Cleaning

Purpose: To enable participants to pre-clean substrate surfaces according to industry standards.

Topics:
SSPC-SP1 Solvent Cleaning – standard to follow
DEMONSTRATION – Solvent cleaning
Tool(s) and materials used
How to do it: PPE and safety, procedures, instructions, including preparation of work area

ACTIVITY 2.1: Pre-Cleaning Hands-on Practice
Note: To be done in classroom using prepared panels with vegetable oil; or can be done in lab/garage/shop environment with grease, and/or other visible contaminants.

III. Lesson 3: Preparing the Surface

Purpose: To enable participants to prepare surfaces according to industry standards, including hand tool cleaning, power tool cleaning and abrasive blasting.

Topics:
SSPC-VIS 3 Guide and Photographs
SSPC-VIS 3 Initial Condition - Assessing the initial condition of the substrate surface

Hand Tool Cleaning
SSPC-SP2: Hand Tool Cleaning - Definitions/Desired Results
Tools used
How to use them safely: PPE, procedures, instructions, including preparation of work area
ACTIVITY 2.2: Hand Tool Cleaning – DEMONSTRATION and PRACTICE

Power Tool Cleaning
Hand-held Power Tools:
Impact Cleaning Tools
Rotary Cleaning Tools
Rotary Impact Tools
Standards:
SSPC-SP3 Power Tool Cleaning
SSPC-SP11 Power Tool Cleaning to Bare Metal
SSPC-SP15 Commercial Grade Power Tool Cleaning
Feathering Paint Edges
Tool Inspection – Pneumatic or Electric
Personal Protective Equipment (PPE)
Preparation of Work Area
Safe use of Power Tools
Ergonomics – Vibratory Tools
Power Tools Quick Quiz
Inspecting Your Work, Prepared Area
DEMONSTRATIONS How to use them safely: PPE, procedures, instructions, including preparation of work area

1. Grinding – Rotary Tools
2. Impact Tools

ACTIVITY 2.3: Power Tool Cleaning – DEMONSTRATION and PRACTICE

IV. Lesson 4: Abrasive Blasting

Purpose: To provide participants with an understanding of the various blasting requirements and processes in order to be able to perform abrasive blasting successfully.

Abrasive Blasting (Dry) Method of Surface Preparation

Topics/Sections:
Principles of Abrasive Blasting Surface Preparation
What is Abrasive Blasting? How is Abrasive Blasting Accomplished?
Principles of Surface Preparation
Surface Defects Requirements, Defects Example
Pre-Cleaning – SSPC-SP1 Solvent Cleaning
Non-Visible Contaminants
SSPC-VIS Guide & Standard, Before and After photo examples
Abrasive Blast Cleaning Reminders
Abrasive Blasting SSPC/NACE Standards (explanations of 5 standards, with photos)
Surface Profile/Anchor Tooth Profile, Surface Profile Variables
Surface Profile Reading Methods (A, B, C)

- Surface Comparator, Profile Gauges, Testex Tape
- Quick Quiz

Summary-Section 1

Abrasive Media: Grit, Shot – Non-metallic

Abrasive Media Characteristics
Types: Steel Grit, Steel Shot, Sand - Non-metallic Mineral Grits
Numerous types of Abrasive Media

Abrasive Blasting Systems – Components
Abrasive Blasting System diagram
Compressor
Air Hoses and Fittings
Blast Pot
Blast Nozzle
Deadman Switch
Moisture Separator
Nozzle Air Pressure

Abrasive Blasting – Operation
Blast Machines and Buildings
Abrasive Blasting – Operation overview
Prior to Abrasive Blasting
Physical Task Analysis
Abrasive Blasting Techniques
OSHA Abrasive Blasting Regulations
Health Hazards
Precautions for Abrasive Blasting
Personal Hygiene Practices
Safety Concerns of Abrasive Blasting
Personal Protective Equipment
Quick Quiz
Inspecting Your Work

Equipment Operation – Hands-on
Hands-On Outline: How to do it safely: PPE, procedures, instructions including preparation of work area
Compressors and Dryers, Blast Machines, Grit recovery, Blast Hose and nozzles, Methodology, Finish Product

ACTIVITY 2.4: Abrasive Blasting DEMONSTRATION and PRACTICE

Lab Day: For the Final ACTIVITY, instructor may wish to have participants pre-clean, prepare the surface, and verify the surface profile, combined.

Reference:

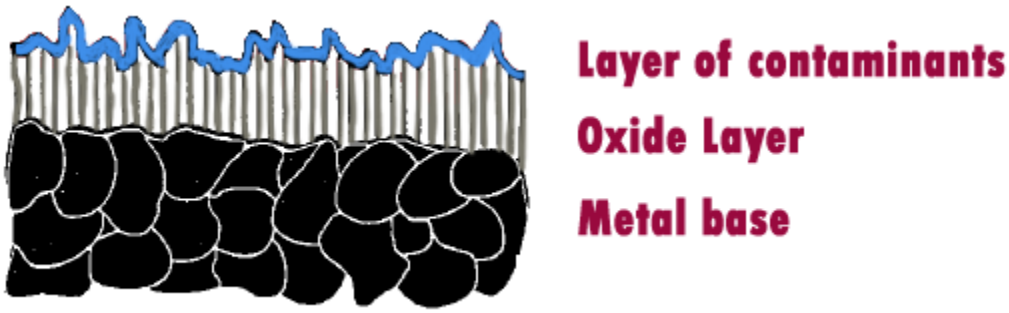
Definition: What are Surface preparation, Hand or Power tools?
Surface Preparation:

The main objective in the preparation of metal surfaces is to improve the wetting properties and adhesion of the metal surface before to apply the adhesive.

On the surface of a metal we find the following layers:

- Layer of contaminants.
- Oxide layer.
- Metal Base.

The contaminant layer is a thin layer of dust or chemicals agents adsorbed onto the surface of the metal, to the elimination of that kind of contaminants cleaning agents are used.



All metals react with oxygen in the atmosphere, resulting in an oxide layer. Depending on the material of the metal, this oxide layer it can provide an active or passive surface and it may need one treatment or another to ensure a good adhesion of the adhesive on the surface of the metal.

For example, the steel forms different oxide layers depending on its level of alloy with other metals:

- The carbon steel or low alloy reacts so fast with oxygen to form a porous oxide layer that is not bond to the metal base, which is why it is necessary to completely remove that oxide layer before to apply the adhesive.
- The steel alloyed with chromium or nickel reacts with oxygen to form a thin and firmly attached oxide layer to the base material, the layer acts as a passivity agent avoiding the phenomenon of corrosion. But on the contrary, it reduces the surface energy of the metal surface, producing worst wetting properties on the surface.

If you need to remove the metal oxide layer before to apply the adhesive, you can use the following techniques or processes such as surfaces pretreatment:

If you need to remove the metal oxide layer before to apply the adhesive, you can use the following techniques or processes such as surfaces pretreatment:

Mechanical processes:

- Sanding
- Grinding
- Blasting

Chemical Processes:

- Anodized
- Etching

Coating processes:

- Saco - Sand blasting Coating
- Pyrosil
- Pretreatment by laser

The choice of surface pretreatment to use is determined by:

- The type of metal and adhesive
- The requirements of the adhesive joint
- The cost of preparation

After making the correct pre-treatment on the metal surface, this surface produces active sites that react with the environment becoming an inactive surface, to avoid such effects activators and primers are used before adhesive application.
Generally the adhesive manufacturer indicated in the technical data sheet recommended surface preparation products or methods for every type of metal that can bond the adhesive.

Definition: What is Abrasive Blasting?

Abrasive Blasting:
More commonly known as **sandblasting**, is the operation of forcibly propelling a stream of abrasive material against a surface under high pressure to smooth a rough surface, roughen a smooth surface, shape a surface or remove surface contaminants. A pressurized fluid, typically compressed air, or a centrifugal wheel is used to propel the blasting material (often called the *media*). The first abrasive blasting process was patented by Benjamin Chew Tilghman on 18 October 1870.

There are several variants of the process, using various media; some are highly abrasive, whereas others are milder. The most abrasive are shot blasting (with metal shot) and sandblasting (with sand). Moderately abrasive variants include glass bead blasting (with glass beads) and plastic media blasting (PMB) with ground-up plastic stock or walnut shells and corncobs. Some of these substances can cause anaphylactic shock to individuals allergic to the media. A mild version is soda blasting (with baking soda). In addition, there are alternatives that are barely abrasive or nonabrasive, such as ice blasting and dry-ice blasting.

Sandblasting

Sand blasting is also known as abrasive blasting, which is a generic term for the process of smoothing, shaping and cleaning a hard surface by forcing solid particles across that surface at

high speeds; the effect is similar to that of using sandpaper, but provides a more even finish with no problems at corners or crannies. Sandblasting can occur naturally, usually as a result of particles blown by wind causing Aeolian erosion, or artificially, using compressed air.

Sandblasting equipment typically consists of a chamber in which sand and air are mixed. The mixture travels through a hand-held nozzle to direct the particles toward the surface or work piece. Nozzles come in a variety of shapes, sizes, and materials. Boron carbide is a popular material for nozzles because it resists abrasive wear well.

Hydro-blasting

Hydro blasting is not a form of abrasive blasting as no abrasive media is used. Hydro-blasting, commonly known as water blasting, is commonly used because it usually requires only one operator. In hydro-blasting, a highly pressured stream of water is used to remove old paint, chemicals, or buildup without damaging the original surface. This method is ideal for cleaning internal and external surfaces because the operator is generally able to send the stream of water into places that are difficult to reach using other methods. Another benefit of hydro-blasting is the ability to recapture and reuse the water, reducing waste and mitigating environmental impact.

Appendix F: Unit 3, Coating & Application Methods

Unit Goal:

In this unit you will learn about paint specifications and requirements, the safe and appropriate operation of spray equipment, and how to use technical documents when mixing and applying paint.

Unit Objectives:

The learner will be able to:

- Mix single and multi-part paints for specific application methods.
- Calculate the Wet Film Thickness requirement to achieve the desired Dry Film Thickness using a Product Data Sheet.
- Apply paint using a brush and roller such that the result will pass inspection.
- Apply paint using conventional spray equipment so that the result will pass inspection, including:
    - Set-up for using conventional spray guns
    - Applying the paint
    - Clean-up after using conventional spray guns and tanks
- Apply paint using airless spray equipment so that the result will pass inspection, including:
    - Set-up for using airless spray equipment
    - Applying the paint
    - Clean-up after using airless spray equipment
- Inspect a paint applied to a substrate surface in order to ensure adequate coverage and high quality application.

Materials Needed:

Painting: Brush, roll, conventional and airless spray

- Brushes, rollers, roller pan/screen, mix paddles
- Conventional gun (Illustration of conventional spray cups, tanks_
- Airless guns (Illustration of various airless spray pumps)
- Inspection Equipment (See Day 5, listing)

Unit Outline & Activities:

I. Lesson 1: The Basics of Paint

Purpose: To enable participants to mix single part and multi-part paints, following instructions in technical documents.

Topics:
Paint Storage

Opening the Container
Mixing Paint
Mix Ratio
Partial Kits
Induction Time
Pot Life
Overcoat Intervals
Application Methods
Quick Quiz
Calculating WFT to achieve DFT, Calculation Examples, Typical DFT requirements
ACTIVITY 3.1: Calculating Required WFT

II. Lesson 2: Applying Paint with Brush and Roller

Purpose: To enable participants to apply paint by hand using a brush and roller.

Topics:
Brush and Roller Applications
Shipyard Brushes
Shipyard Rollers
What is Stripe Coating?
Stripe Coating Applications
Stripe Coating Results
Safety & PPE for Brush and Spray Painting
Respirator Protection
Ventilation Requirements
Bonding and Grounding
Quiz: Paint Product Information
ACTIVITY 3.2: Brush and Roller Painting DEMONSTRATION and Practice

III. Lesson 3: Applying Paint with Spray Equipment

Purpose: To enable participants to apply paint using conventional spray equipment and airless spray equipment.

Topics:
Spray Painting
Learn to be a Spray Painter

Conventional Air Spray
Conventional Spray Gun
Air Cap or Nozzle
Conventional Spray Tanks
Hand Held Conventional Spray Guns
How to Operate a Conventional Gun
Spray Paint Tank Operation
Spray Painting Techniques
Perpendicular to the Surface

Gun Distance
Triggering the Gun
Spray Pattern Techniques
Spray Painting Shipboard
ACTIVITY 3.3: Conventional Air Spray Painting DEMONSTRATION and PRACTICE

Airless Spray
Airless Spray Gun
Airless Spray Equipment
#1 Hazard of Airless Spray is Injection
If You Do Get Injected…
Inspecting Your Work
ACTIVITY 3.4: Airless Spray Painting DEMONSTRATION and PRACTICE

References:

Definitions:

Paint Storage
Paint is any pigmented liquid, liquefiable, or mastic composition that, after application to a substrate in a thin layer, converts to a solid film. It is most commonly used to protect, color, or provide texture to objects. Paint can be made or purchased in many colors—and in many different types, such as watercolor or synthetic. Paint is typically stored, sold, and applied as a liquid, but most types dry into a solid. Most paints are either oil-based or water-based and each have distinct characteristics. For one, it is illegal in most municipalities to discard oil based paint down household drains or sewers. Solvents for clean- up are also different for water based paint than they are for oil based paint. Water-based paints and oil-based paints will cure differently based on the outside ambient temperature of the object being painted (such as a ship.) Usually the object being painted must be over 10 °C (50 °F), although some manufacturers of external paints/primers claim they can be applied when temperatures are as low as 2 °C (35 °F).

Easy access to Safety Data Sheets and Product Data Sheets
In the store facility, there must be an area clearly defined where the Material Safety Data Sheets (MSDS) are available for the stored products. The Safety Data Sheets are useful to establish the paint handling procedures, what protective equipment should be used, or - in case of an accident - for doctors to determine the appropriate treatment method. When using the products, copy of Safety Data Sheets will be available near the areas where paint is applied (the entrance of the painting cabin or at the working site, near the painting pump).

The Product Data Sheets provide information on how to apply the paint, how to prepare it, the drying time, the time to apply a second coat etc. These are essential information to provide a quality painting. The best place to store the Product Data Sheets is right in the storage area.

Opening the Container

Temperature control

All paints have specific temperature requirements when stored. For example, vinyl esters that are kept at temperatures above 35 °C start to become solid whether or not the components are mixed. Another example, water-based paints - the range of Xylan, products - are irremediably damaged in case of negative temperatures.
In order to keep the paints in optimal conditions to apply them properly, the paints must be kept in a temperature range between 15 and 25 °C. This can be achieved if heating the storage space during the winters and cooling the air during the summers. For low energy consumption, the entire facility must be properly insulated.

Temperature monitoring

Any paint has a certain storage time also called "Shelf Life". The period of time described in the technical specifications is usually, three or six months, or one year or more, depending on the type of paint. Some paint manufactures may extend this term if evidence is found that the paint has been kept in optimal temperature conditions. Alp Access's storage facilities are equipped with temperature data loggers which record the temperature minute by minute.

Proper ventilation

Many industrial paints are solvent-based. These, even when stored in special cans, may release solvent vapours and produce a toxic or potentially explosive atmosphere. Therefore, the store facility is recommended to be mechanically ventilated. Our storage facilities are properly ventilated and the low explosion limit is constantly monitored. When positioning the ventilation system and the sensors it should be considered that the solvent is heavier than the air and gathers in the lower part of the room.

Sufficient lighting

Any industrial paint storage facility should be light enough to allow operators to proper identify the products that are to be used. A sufficient amount of light is somewhere over 50 ft.-candela (538 Lux).

Fire protection

Since most paints in use are flammable, we need to make sure that the risk of a fire is as low as possible. To accomplish this, we must:

- Build the facility using fireproof materials: fireproof sandwich panels, metal panels, OSB fire stop
- Use flameproof electrical equipment: luminaires, heaters, solvent recovery equipment, certified air conditioners
- Use mechanical ventilation to remove the solvent vapours
- Use explosion vapours detectors (LEL), temperature, fire and smoke sensors
- Equip the facility with verified fire extinguishers, placed in visible areas and marked accordingly
- Install warning signals on the content of the storage facility to forbid smoking, working with fire etc.

Accidental anti-spill protection
A complying paint storage facility use protection against accidental spills of products to prevent leaking the paints or their chemical components into the soil or the groundwater. Our facilities are equipped with a secondary containment insulated with polyurethane coating (an elastomeric paint with good chemical resistance and impact strength) in a layer with a thickness of 3-5 mm. Polyurethane insulation ensures easy cleaning of the floor and total removal of the leaked product.
Another protection measure is to keep a spill kit in a visible area and marked accordingly. The kit consists of absorbent materials, tools to clean the absorbent material and hermetic bags or cans to store the absorbent material soaked with paint.

Proper inventory management and evidence of the stored product lots
It is very important to have a correct inventory of the products in the store facility. Lot number help us establish the traceability between paint used and the painted items, which is evidence that for a certain item we used the proper paint, in accordance with the technical requirements.

Mixing Paint
Paints should be mixed, or blended, in the paint shop just before they are issued. Mixing procedures vary among different types of paints. Regardless of the procedure used, try not to over mix; this introduces too much air into the mixture. Table 8-3 outlines the types of equipment and remarks for various coatings. Mixing is done by either a manual or mechanical method. The latter is definitely preferred to ensure maximum uniformity. Manual mixing is less efficient than mechanical in terms of time, effort, and results. It should be done only when absolutely necessary and be limited to containers no larger than 1 gallon. Nevertheless, it is possible to mix 1-gallon and 5-gallon containers by hand. To do so, first pour half of the paint vehicle into a clean, empty container. Stir the paint pigment that has settled to the bottom of the container into the remaining paint vehicle. Continue to stir the paint as you return the other half slowly to its original container. Stir and pour the paint from can to can. This process of mixing is called boxing paint. The mixed paint must have a completely blended appearance with no evidence of varicolored swirls at the top. Neither should there be lumps of undispersed solids or foreign matter.

Mix Ratio
The mix ratio for a two component coatings is the correlation between the resin and catalyst, also known as the hardener or curing agent, required to realize a full cure of the system. Mix ratios are typically expressed by either weight or volume. In the examples below, we show some common and not so common mix ratios and provide detailed information of how much of each material a customer could expect to receive with different order sizes.

Sizing options featuring a 1:1 mix ratio:
½ Pint Kit = 1 pint of material
Pint Kit= 2 pints of material
Quart Kit= 2 quarts of material
Gallon Kit= 2 gallons of material
5 Gallon Kit= 10 gallons of material

Sizing options featuring a 2:1 mix ratio:
½ Pint Kit = 0.75 pint of material
Pint Kit= 1.5 pints of material
Quart Kit= 1.5 quarts of material
Gallon Kit= 1.5 gallons of material
5 Gallon Kit= 7.5 gallons of material

Pot Life
Is the length of time in which multiple part coatings or paints can be applied to a surface. Pot life begins when the mixing is complete, and ends when the mix is unsuitable for application or has set. Pot life can be used to refer to any mixture that increases in viscosity as time passes.

Pot life is also known by a few other names, including gel time, usable life and working life. These terms do have subtle differences from pot life though. The term pot life stems from the amount of time a mixture can sit in a container (pot). Components that are not cured by other materials but by other means such as ultraviolet light are considered to have an infinite pot life. Pot life is a very important consideration when applying coatings to a material's surface. If the mixture is mixed inadequately and the pot life never even begins then the coating could fail. On the other hand, if the mixture has been left to rest too long and the pot life has expired then the coating could also fail. Care must be taken to ensure that the proper amounts of mixture components are added and that the pot life of the mixture is not allowed to expire

Overcoat Intervals
Maximum over coating time is a term used to specify the allowable time period within which over coating (or the application of an additional layer of paint or coating) should occur. The purpose of the maximum over coating time is to ensure that adequate inter coat adhesion is achieved between subsequent coating layers. This crucial parameter is usually quoted on product data sheets for various temperatures. Over coating is intended to extend the service life of a metal's surface by providing extra protection via additional layers of paint or coating. While this procedure is effective and cost-efficient, it possesses certain risks.
Maximum over coating times should be strictly observed because the adhesion of subsequent coats is significantly affected with time. If the maximum over coating time is exceeded, then the cured surface should be treated accordingly with light abrasive cleaning or other suitable surface preparation processes before additional coatings are applied. It is important to note that this parameter varies according to the coating composition, ambient temperatures and climatic conditions.

Application Methods
Air-atomized spraying, Airless Spraying, HVLP Spraying, Non-Spray Methods

Appendix G: Unit 4, Inspection

Unit Goal:

Review the criteria for passing inspections during surface preparation and painting, and ensure that participants/shipyard workers know their own responsibilities as well as what to expect when various types of inspections are done by others.

Unit Objectives: The learner will be able to:

- List things to verify or inspect in the course of surface preparation and painting work.
- Explain your responsibilities for inspecting your own work.
- Describe who else may conduct different types of inspections, and the instruments and techniques they may use.

Materials Needed:

Recommended List – *Depending on shipyard needs or usage

- SSPC Vis Standards and Painting Volume 2 (Hard or electronic copies of standards)
- Psychrometer or Dew Point Meter Tool(s) to determine environmental readings
- Anchor Tooth Profile gages and test plate with a blasted surface to demonstrate
- *Conductivity, Chloride, Soluble Salt testing equipment
- Dust Test kit
- WFT gages
- DFT gages with painted test plates to demonstrate
- *Holiday detection – Low and/or high voltage testers, with test plate to demonstrate
- *Documentation (Examples)

Unit Outline & Activities:

Lesson 1: What to Expect When Being Inspected

Purpose: To enable participants to be prepared for different kinds of inspections, and to have confidence that they have already inspected their own work to the best of their ability.

Topics:
Inspection Criteria
Types of Inspections
Environmental Conditions, Measuring Environmental Conditions
Pre-Cleaning: SSPC-SP1 Solvent Cleaning, Visible Surface Contaminants
Visual Inspection – Cleanliness, SSPC-VIS 1-89 Guide & Standard
Surface Profile/Anchor Tooth Profile
    Measurement Methods A: Visual Comparator, B: Pointed Probe, C: Replica Tape
Non-Visible Contaminants, Non-visible Oils & Grease, Non-Visible Chlorides – Soluble Salts
Dust Test
Wet Film Thickness “WFT” Gauges

DFT – Dry Film Thickness, DFT Readings iaw SSPC-PA2
Holiday Detection
Documentation
Course Summary and Wrap-Up
Written Assessment

Lab or Onsite: Hands-on Skill Check Assessment