

Dry-Docking Hull Surface Maintenance and Repair Standard Practice

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Foreword

This document contains the maintenance and repair standard for all parties involved in hull surface and coating application work during dry-dock. It provides a uniform standard for success that can be followed by everyone.

Scope

This standard is intended for vessels with steel hulls with displacement greater than 500 gross tons. It covers the steps required for achieving a smooth and clean hydrodynamically performing hull for its next in-service period.

Rationale

The importance of fuel savings, reduction of emissions and the threat of invasive species are all reasons for developing a standard practice for the successful refurbishment of a vessel's hull in dry-dock. Class Societies allow for 60-month dry-docking cycles, thus putting great importance on hull repair procedures that will optimize hull – and, consequently, vessel – performance.

Referenced Standards and Other Consensus Documents

The latest edition, revision, or amendment of the referenced standards in effect shall govern unless otherwise dated.

AMPP/NACE/SSPC, www.ampp.org:

NACE SP0616	Standard for Hull Roughness Measurements on Ship Hulls in Dry-dock
NACE/ASTM G193	Standard Terminology and Acronyms Relating to Corrosion
NACE-WJ-1/SSPC-WJ-1	Waterjet Cleaning of Metals – Clean to Bare Substrate
NACE WJ-2/SSPC-SP WJ-2	Waterjet Cleaning of Metals – Very Thorough Cleaning
SSPC-PA 2	Procedure for Determining Conformance to Dry Coating Thickness Requirements
SSPC-SP 3	Power Tool Cleaning
SSPC-SP 5 (WAB)/NACE WAB-5	White Metal Wet Abrasive Blast Cleaning
SSPC-SP 10 (WAB)/NACE WAB-2	Near-White Metal Wet Abrasive Blast Cleaning
SSPC-VIS 1	Guide and Reference Photographs for Abrasive Blast Cleaned Steel
SSPC-SP 4/NACE VIS 7	Guide and Reference Photographs for Steel Surfaces Prepared by Waterjetting
SSPC-VIS 5/NACE VIS 9	Guide and Reference Photographs for Steel Surfaces Prepared by Wet Abrasive Blast Cleaning

ASTM International, www.astm.org:

ASTM F1130	Standard Practice for Inspecting the Coating System of a Ship
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International Organization for Standardization (ISO), www.iso.org:

ISO 8501-3	Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 3: Preparation grades of welds, edges and other areas with surface imperfections
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ISO 8502-3	Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
ISO 8502-9	Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 9: Field method for the conductometric determination of water-soluble salts
ISO 8504-2	Preparation of steel substrate before application of paints and related products – Abrasive blast cleaning
ISO 8504-3	Preparation of steel substrates before application of paints and related products – Surface preparation methods – Part 3: Hand- and power-tool cleaning
ISO 8503-1	Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces

Swedish Institute for Standards, www.sis.se/en:

SIS 05 59 00 (1967)	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after removal of previous coating (Withdrawn)
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In AMPP standards, the terms *shall* and *must* are used to state requirements and are considered mandatory. The term *should* is used to state something that is recommended, but is not considered mandatory. The term *may* is used to state something considered optional.

Section 1: General

This document is intended to guide shipowners/operators in the planning and execution of hull preservation of their vessels while in dry-dock. The standard is not exhaustive as there are so many variables, including type of vessel, condition, expected trading pattern, location of dry-dock, and shipyard capability. This standard is not designed to be a job specification for hull preservation, but rather as an adjunct to a shipowner's specification.

Section 2: Definitions

The definitions of many of the corrosion-related terms used in this standard may be found in NACE/ASTM G193. Other terms not included therein that have been used in this standard are defined as follows:

Specification: A detailed specification is the contract between the vessel owner and service provider. The specification will be the standard document from which the project flows. The specification shall be reviewed in all of its details. The single most important consideration to a successful coating operation in dry-dock is the existence of a coating specification and a set of working procedures that clearly identify the surface preparation and the coating scheme(s) that will be applied and any limitations (curing temperature, minimum/maximum overcoating intervals, time to flood) that need to be followed.

Section 3: Hull Preservation of a Vessel in Dry-Dock

3.1 Pre-docking – General guidelines

A successful dry-docking requires a detailed Job Specification. As a minimum, the shipowner's Job Specification for the external hull, shall include:

- Areas to be treated, sufficient pressure and stand-off distance to be used for High Pressure Fresh Water Washing (HPFW)
- Methods of surface preparation, extent of surface preparation
- Cleanliness standard to adhere to
- Type and number of coats to be applied
- Overcoating intervals
- Minimum time before undocking
- Other specific requirements (i.e., hull roughness measurements at in-docking/out-docking, biofouling survey at in-docking before HPFW commences, areas to be coated with specialized coatings). If available at this stage, Technical Paint Specification from Paint Manufacturer shall be attached.

Once the docking location and the dates are confirmed, the shipowner shall inform the paint maker, so the paint products and quantities, as well as technical service resources can be allocated.

Before the vessel arrives, the shipyard shall be provided with the last dock-block arrangement plan, current ballast condition at in-docking, vessel trim on arrival, etc. The shipyard shall prepare a block arrangement avoiding, as much as possible, the block arrangement of the previous docking. The owner shall review and approve this plan before in-docking.

3.2 On site (before in-docking)

- 3.2.1** In case of an extended refit period (i.e., greater than 21 days), shipowners should consider, as far as practical, postponing the dry-docking (and, consequently, the hull treatment and application of a new antifouling system (AFS) to the end of the refit period. This will minimize the idle period pier side and will preserve the AFS antifouling system from being exposed to static conditions.

- 3.2.2** The shipowner's representative on site shall have a pre-docking meeting with the shipyard personnel and its various relevant vendors – including the coating supplier – involved in the refit. Normally a ship repair manager is appointed, by the shipyard, for the project and he/she will be the person in charge for coordinating the entire project.
- 3.2.3** During the pre-docking meeting, as a minimum the following shall be reviewed:
- a. Docking block arrangements
 - b. Vessel arrival condition in terms of ballasted tanks. This pertains only to tanks adjacent to the skin of the ship. It is recommended that any disposal of ballast water to facilitate hull coating be covered in the specification.
 - c. In-docking sequence (i.e., time allowed for de-ballasting)
 - d. Review the priority of jobs related to external hull. A list of typical dry-dock jobs related to hull treatment follows:
 1. Commencement of shipyard works (HPFWW, scaffold erection around the hull, opening of drain plugs, rudder, and tail shaft clearances, turn the propeller or the rudder blade, opening of gratings, etc.)
 2. Any steel work planned (internal or external) that will interfere with hull coating
 3. Review details of any mechanical works to be carried out (i.e., propeller work, shaft work, removal of rope-guard(s), thruster tunnel(s), over-board discharge valves/outlets, and other hull appendages)
 4. Propeller polishing or coating
 5. Works related to sea-chest internal and gratings
 - e. Protection of exposed sensitive areas during surface preparation
 - e. Deck and scupper drainage during hull surface treatment
 - g. Shipowner and paint manufacturer inspection points (i.e., biofouling inspection, coating inspection, washing, and blasting inspection, coating inspection per coat application, in-docking/out-docking hull roughness measurement, final inspection.)
 - h. Coating sequencing when both the freeboard and the underwater hull are to be coated – vertical sides, rudder, flat bottom, topsides, bulbous bow
 - i. Review of the shipyard's hull treatment plan – job specification
- 3.2.4** In case items not covered during the pre-docking meeting, the shipowner representative shall have a separate meeting with the paint maker representative(s) and the shipyard hull treatment supervisor. Shipyard personnel involved in hull treatment inspections shall be certified to a minimum qualification of AMPP Senior Certified Coatings Inspector Level 3, or FROSIO Inspector Level III. Typically, the following at a minimum shall be reviewed during this meeting:
- a. Paint specification
 - b. Any specific requirement in terms of surface preparation or paint application
 - c. Sequence of hull treatment jobs; verify availability and lead time required by the local warehouse in case additional paints may be required
 - d. Agree on the hold points for shipowner and paint maker representative inspections
 - e. Confirm the communication channels for regular updates during the project
- 3.2.5** At this stage, the paint maker's representative shall highlight any queries he/she may have about the paint specification, any limitations in terms of product availability and supply of additional paints. He shall confirm the timeline for in-docking inspection, the water pressure and type of equipment to be used during the HPFWW process.
- 3.2.6** During the dry-dock period, it is recommended that the paint maker's representative attend the daily meetings to be aware of the overall dry-dock schedule progression and to highlight any concerns related to hull treatment.
- 3.2.7** Prior to flooding the dock, the shipowner's on-site representative shall visually inspect and approve the following:
- a. Make sure the dock is free from grit and debris
 - b. Approve the keel block arrangement. This involves:
 1. Checking the quality of the blocks (strength, presence of rust)

2. Confirming that they match the plan
3. Ensuring that all are of the correct height
- c. Check general block arrangement and making sure all items are covered
- d. Verify locations of ship's sensitive items (e.g., speed-log transducer, depth transducer, drain plugs are not obstructed by block arrangement)

3.3 In-docking

- 3.3.1** Upon arrival in the dry-dock, and once the dock is dry, an initial hull condition survey shall take place. This may include an immediate view of the hull structure, gratings, propeller, rudder, checking that the vessel is "sitting" properly on the docking blocks, etc.
- 3.3.2** Biofouling condition – Dividing the hull into areas - top to bottom (Topsides, Boottop, Vertical Sides, Flat Bottom) and fore to aft (Forward, Midships and Aft) assess and record the biofouling condition of each area for the main types of biofoulings: slime, weed/algae, and animal fouling. The assessment shall include the severity, the extent, and the type of fouling.
- 3.3.3** The biofouling inspection can be concurrent with the yard setting up for hull cleaning but is to be carried out before the HPFWW commences.

3.4 Hull cleaning

Once a vessel has entered DD, the outside hull shall be cleaned before other work is undertaken. The cleaning process is the first stage of surface preparation, and it can generally be divided into three distinct operations as follows:

- HPFWW – which removes soluble salts, the soft type of spent biofouling present on the hull, to some extent the hard macrofouling, dirt, any loose coatings, the leached layer of biocidal type AF paints, etc.
- Manual scraping – which removes tightly adherent hard biofouling and post-freshwater rinsing
- Degreasing – which removes oil and grease contamination

- 3.4.1** HPFWW is an essential operation for the hull treatment process. It is expected to remove the marine biofouling (all slime and weed and most of hard fouling) and the leached layer of biocidal type AF. HPFWW removes all salt contaminants due to seawater and marine environment as well as all loose paint. The process will give an indication about the existing paint system condition, whether the intracoat adhesion is sound or weak. This will help to determine correctly what further hull treatments might be required (i.e., blasting, or additional washing at higher pressures).

General requirements for an optimum process of hull washing will include, but not limited to, the following:

- a. HPFWW shall take place while the underwater hull is still wet
- b. HPFWW shall commence from a top-down approach only – never from the bottom up. Washing shall proceed from the rail to the keel. This is irrespective of whether any preservation work is planned for the topsides
- c. There shall be good access
- d. Water shall be clean fresh water with a maximum chloride level of 450 µS/cm
- e. Water pressure shall follow the paint manufacturer's recommendation. As a general guidance:
 1. SPC (Self Polishing Copolymer) AF are recommended to be HP fresh water washed at pressures between 200-250 bars (~3,000 – 3,500 psi).
 2. CDP (controlled depletion polymer) AF requires thoroughly HPFWW to remove the thick leached layer: close distance (<10 cm from the surface) and pressure above 300 bars (~5,000 psi)
 3. FRC (foul release coating) AF – "silicone" type AF requires sufficient equipment, washing pressure and care of workmanship to adequately clean surfaces without causing damage to the existing foul release coating. An area shall be selected and agreed upon by all parties involved to test various pressures and hold off distances. Test area shall be visually inspected for damage prior to further work.

- f. The distance between the nozzle and the work surface shall be between 200 to 300 mm (8 to 12 inches) and a swing range of the nozzle of 800 to 1,000 mm (2.5 to 3.5 ft).
- g. Recommend a fan jet to minimize coating roughness increases caused by a rotating nozzle
- h. All HPFWW machines engaged for Hull washing should have fitted calibrated manometer gauges to indicate the washing pressure
- i. Note: During HPFWW process, randomly check the water pressure, observe the washing process, how effective it is and if properly done. If unsure of washing efficiency, a test patch shall be witnessed and washing technique shall be observed.
- j. Check for soluble salt on the washed surface. If salt content on the hull is too high repeat washing till salt content is below acceptable limit

3.4.2 Scraping

If hard fouling is present and there are areas where barnacle bases were not removed by pressure washing, it will be necessary to scrape these areas to remove them.

If this step is necessary, then an additional freshwater wash is needed in the affected areas.

In case of heavy barnacle colonies, hard scraping shall be carried out before HPFWW commences. The resulting bases may be either tightly adherent to the coating or have bitten into the coating. In this situation, the use of abrasive cleaning may be the only way to remove large amounts of barnacle bases, as there could be tens of thousands on a heavily fouled hull. Grit sweeping may increase the hull roughness and should be considered.

3.4.3 Degreasing

Removal of oil or grease is essential, because even a very thin layer can destroy or seriously impair the adhesion of paint films. On ships, this contamination is found mainly on topsides (under the fairlead rollers or mooring chocks), or along the wind and water line. If oil is present on the surface of the water in the dry-dock, then it may also contaminate the underwater areas of the ship as the water is pumped out. It is important to HPFWW after degreasing has taken place.

There are two methods of degreasing commonly used by yards:

3.4.3.1 Water soluble degreasing fluid

The most effective method of degreasing is to apply a water-soluble oil and grease-removing fluid. This is either brushed or sprayed onto the surface, usually through the high-pressure fresh water washing equipment. The resultant emulsified oil is then washed off with fresh water so that the contamination is removed. In cases of severe contamination, several degreasing operations may be necessary, and crude oil spillages often need scraping to remove sludge prior to degreasing.

3.4.3.2 Solvent washing

Solvents such as white spirit can also be used to dissolve the oil or grease, but the problem then becomes one of completely removing the solution of oil in solvent. Drying with rags or cloths invariably means spreading the solvent oil solution over a larger area and, unless repeated washing with clean rags and solvent is carried out, total removal of the contamination is not achieved.

3.5 Coating inspection after hull washing

Once the vessel has been HPFWW to remove salts and biofouling, a hull paint inspection shall be carried out by the coating inspector and the ship representatives. At this stage, all of the slime and weed and most of the animal fouling will have been removed and the paint condition will be clearly visible (although the yard may still be in the process of manually scraping off tightly adherent shell fouling.) Usually, this inspection is also used

to check the hull cleaning by picking up any missed areas that may require additional washing or degreasing. It is best to have this inspection carried out when the hull surface is dry, so any missed areas with slime or leached layer not properly removed can be identified for correction.

3.5.1 For reporting purposes, when carrying out the paint inspection, similar to the biofouling inspection, the ship shall be divided into distinct areas for both port and starboard (i.e., topsides, boottop, vertical sides and flat bottom, or individual tank areas). For each area, the various types of paint damage/breakdown shall be reported.

3.5.2 All coating defects shall be reported for type, extent/severity, and location. For estimating the defect extent, it is best to use extent diagrams as per ASTM F1130 or the paint manufacturer's diagrams.

- At this stage, although not exactly defined as a paint defect, particularly for vessels coated with an SPC antifouling, the areas with "polishing through" shall be recorded for extent and location, as this record will help to assess the antifouling system performance.
- Most types of coating defects will require further surface treatment, so having an accurate estimation with extent and location will assist in finalizing the extent and method of surface preparation needed.
- Typical defects that will require further treatment, based on their likelihood and area of appearance, are shown in Table 1:

Table 1
Common Defects and Locations

Type of Defect	Area Likely to Be Found
Mechanical damages	All vessel areas
Corrosion	All vessel areas
Blistering and cathodic disbondment	Immersed area (vertical sides, flat bottom)
Detachment	All vessel areas
Cracking	All vessel areas
Barnacle basis	Immersed areas
Fender damages (rubber marks)	Boottop and vertical sides
White stains	Topsides
Anchor chain damages	Vertical sides
Previous docking block supports	Flat bottom
Polished through areas	Vertical sides

3.5.3 In addition, the following items shall be inspected and reported at the time of in-docking but after hull washing:

- Cathodic protection system and condition of sacrificial anodes – condition/consumption as well as the protective shield around the anodes of the Impressed Current Cathodic Protection (ICCP) units
- ICCP anode blanket
- ICCP, cathodic disbondment from previous dockings
- Sea chests internal, thruster tunnels, gratings
- Sacrificial anodes inside the sea chests, record percentage wasted
- Previous hull surface preparation condition for all areas including rudder/propeller
- Inspect bilge keels and previous dock block marks for coating and fouling

3.5.4 Before surface preparations commence, the following information is to be recorded by taking photographs of:

- The waterline
- Draft marks
- Vessel name
- Port of registry, and other hull marks

If the vessel requires underwater inspection in lieu of dry-docking (UWILD) markings, ensure where these are located on the hull – and, if necessary, make a photographic record

- 3.5.5** Dry Film Thickness (DFT) and hull roughness measurements (before surface preparation). Measurements to be taken after HPFWW – perform a hull roughness measurement in accordance with NACE SP0616.

3.6 Surface preparation

Surface preparation is dictated by the level of surface cleanliness and, if required, the surface profile (roughness) of the selected coating system to be applied to the steel surface. This shall be stated in the paint specification from the paint manufacturer. Typically, the method of surface preparation and an approximate extent of the area to be treated are specified in the initial Job Specification by the shipowner/manager, and this would allow the yard to plan the equipment and manpower resources accordingly. Findings from the coating inspection, as described above in [Paragraph 3.5.2](#), will confirm the extent of surface preparation and the suitable method to be applied.

- 3.6.1** Determine type and extent of surface preparation (finalizing the work scope for surface preparation). The final estimate of the areas to be treated shall be agreed between the yard, the ship's superintendent, and the coating advisor after hull washing has been completed.

The choice of surface preparation greatly impacts the hull coating condition which, in turn, affects the vessel's performance while in operation. The coating advisor shall make recommendation of surface preparation method and extent to the superintendent and include this in the daily report.

Coating defects and their suitable method of surface preparation can be classified based on their impact on hull performance. Topside's coating defects affect steel preservation and the vessel's appearance, while coating defects on the underwater hull affect hull smoothness and AF protection, thus impacting the vessel's performance at sea.

A sample matrix of typical surface preparation methods for external hulls and their assessment criteria – pros and cons – are shown in Appendix A (nonmandatory) – Surface Preparation.

Depending on the extent and type of coating damage – and taking into consideration any local restrictions that apply as to the method for surface preparation – different treatment options can be used, such as:

- 3.6.1.1 Spot blasting** – Use spot blasting when the damages are spread randomly, and the coating is largely still in good condition. Typically for topsides areas, or on vessels with a relative new paint system, as shown in Figures 1 and 2.



Figure 1



Figure 2

**Figures 1 and 2: Examples of Hull Condition after Hull Washing;
Isolated Corroded Spots and Areas of Mechanical Damage
can Be Treated by Localized Spot Blasting**



Figure 3



Figure 4

Figures 3 and 4: Examples of Use of Square Blast Patterns

3.6.1.2 Square blasting – Figures 3 and 4 show the use of square blasting where there are coating damages that can be contained in a compact shape. Scattered spots in proximity over a relatively small area shall be connected to create one bigger “square.” For localized areas with mixed defects such as mechanical damages, corroded spots, blisters, or localized detachment, overlapping or in proximity, these should be confined into a compact larger square for blasting.

3.6.1.3 Full blasting – [Figures 5 and 6](#) below show where full blasting is recommended. When there is severe coating degradation (i.e., the coating system is showing general defects such as cracking/detachment/blistering that are scattered throughout the entire surface of the hull), and where the ratio of surfaces to be prepped is equal or greater than the remaining intact coating, a full blast is recommended. Full blast can be applied to the entire ship or to a specific hull area (i.e., the vertical side or the boottop only).

Full blast can be either down to bare substrate or to an intermediate coating layer.

Full blast can be used when extensive barnacle bases are scattered all over the underwater area and remain even after hull washing.



Figure 5



Figure 6

Figures 5 and 6: Damaged or Deteriorated Areas where Full Blasting is Recommended

Figures 7 and 8 show hulls where the underwater portion is fully blasted to bare metal while the topsides has been spot blasted.



Figure 7



Figure 8

Figures 7 and 8: Fully Blasted Underwater Areas and Spot Blasted Topsides

For proper paint coverage and to avoid areas of low DFT, the following practices shall be applied and observed during surface preparation:

- 3.6.1.1** Spot blasting shall be carried out as far as possible in rectangular shapes, with straight edges and with good feathering into the surrounding coating ("square blasting").

[Figure 9](#) is an example of high-quality spot blasting (regular shapes, good edge feathering, previous layers exposed). These areas can be easily repainted for optimum performance.