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CHAPTER 081

WATERBORNE UNDERWATER HULL CLEANING OF NAVY SHIPS

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CHAPTER 081

WATERBORNE UNDERWATER HULL CLEANING OF NAVY SHIPS

SECTION 1

GENERAL INFORMATION

081-1.1 BACKGROUND

081-1.1.1 GENERAL. Biological fouling of the underwater hull and appurtenances of surface ships and submarines can be removed mechanically between regularly scheduled drydockings to restore effectiveness of intact antifouling paint systems and the performance of various ship systems including; but not limited to, propulsion (e.g., propulsors, shafts), sonar and masker air. This chapter provides the criteria for evaluating fouling severity, antifouling/anticorrosive (AF/AC) coating system condition, thresholds for cleaning, and equipment and methods to be used.

081-1.1.1.1 Total ship performance and Fleet capability can be enhanced by waterborne cleaning and maintenance (in place of drydocking for cleaning). This practice increases ship availability and minimizes associated costs. Removal of fouling while the ship is waterborne can restore most, if not all, of the post-drydocking performance and economy of operation. Regular hull cleaning prevents calcareous fouling from progressing to a point where fouling damages underlying anticorrosive paint coatings. The specific advantages are described in the following paragraphs.

080-1.1.2 ENERGY SAVINGS. Commercial and Naval experience has demonstrated that appreciable savings in energy are obtainable by preserving smooth underwater hull and propeller surfaces. Fuel savings of more than 15 percent have been realized as a result of hull cleaning and propeller polishing of fossil-fueled ships. Trials conducted before and after cleaning nuclear-powered ships have demonstrated significant speed increases, or reductions in power necessary to attain a given speed. Progressive biological fouling causes increased energy consumption resulting from increased hull drag, diminished propeller performance, and clogged sea chests and associated piping.

081-1.1.3 ENHANCED SONAR EFFICIENCY. Fouling of the sonar dome diminishes sonar efficiency; cleaning of the surface ship and submarine sonar domes restores the effectiveness of the sonar system.

081-1.1.4 REDUCED SHIP SELF-NOISE. Removal of fouling reduces ship self-noise, thus increasing the ships antisubmarine warfare effectiveness.

081-1.1.5 EXTENDED PAINT SERVICE LIFE. The service life of a properly applied non-ablative vinyl antifouling paint system, normally 2 years, can be extended to as much as 7 or more years when supported over its lifetime by regularly scheduled inspections and periodic cleanings as part of the hull cleaning program. The service life of a properly applied ablative antifouling paint system, normally 5 to 7 years, can be maintained and extended when supported over its lifetime by regularly scheduled inspections and periodic cleanings as part of the hull cleaning program.

081-1.1.6 CORROSION CONTROL. Calcareous fouling accelerates paint system failure, thereby increasing the hull structure's susceptibility to corrosion.

081-1.2 PROGRESSIVE FOULING PATTERNS

081-1.2.1 GENERAL. The biological fouling of Navy ships is a recurring process following identifiable patterns of growth. Relatively few types of organisms are responsible for hull fouling and they tend to develop in the order listed in paragraphs 081-1.2.2.1 through 081-1.2.2.3 (depending on geographical locality).

081-1.2.2 TYPES AND CATEGORIES OF FOULING. The types of fouling are separated into soft, hard, and composite categories. Soft fouling typically algae, slime and grasses, have a minimum effect on the coating systems and the performance of the ship. Hard fouling is more tenacious having a calcareous structure which may become detrimental to the performance of the ship and coating systems. Composite fouling includes both hard and soft fouling organisms and is extremely detrimental to the ship's performance and coating and machinery systems.

081-1.2.2.1 SOFT FOULING. The dominant organisms in this stage of fouling are slime and grass.

081-1.2.2.1.1 SLIME. Formation of slime is the first step in the fouling process. Almost any object immersed in seawater rapidly accumulates a coating of slime, consisting of bacteria, fungi, protozoa, and algae. Bacteria frequently are attached within one-half hour of wetting the surface, and slime can often be felt by hand within an hour. The coating of slime is smooth and generally follows hull contours.

081-1.2.2.1.2 GRASS AND OTHER SOFT FOULING. Grass is a form of multicellular green and brown algae. It forms most heavily near the water-line, where adequate light is available for photosynthesis. It is less evident as depth increases, and the dominant color changes from green to brown.

081-1.2.2.2 HARD FOULING. The dominant forms of hard biofouling are barnacles (usually acorn) and tubeworms (serpulids). Some underwater components, such as the bare metal of a propulsor, can experience severe conditions where a combination of biofouling (hard and soft) and calcareous deposits can form.

081-1.2.2.2.1 BARNACLES. Acorn barnacles have conical hard shells with jagged tops.

081-1.2.2.2.2 TUBEWORMS. Tubeworms form intertwined tubes lying along or projecting out from the hull.

081-1.2.2.2.3 CALCAREOUS DEPOSITS. A result of an active cathodic protection system is the deposition of magnesium and calcium carbonate on bare metal surfaces. The bare nickel-aluminum-bronze-surfaces of a propulsor are highly susceptible to a uniform accumulation of calcareous deposit. The thickness will depend upon the time from the last cleaning and the functionality of the cathodic protection system and although usually more fragile than biological hard-fouling, can still be tenacious and difficult to remove.

081-1.2.2.3 COMPOSITE FOULING. In advance stages of fouling, mature barnacles and tubeworms may be present along with calcareous bivalves organisms such as mussels or oysters, or hydroids with calcareous cellular structure such as coral or anemones. In advanced stages of fouling, the ship will be affected by slime, grass, barnacles, and tubeworms. In addition, this stage of fouling will include soft shell-less animal forms, such as hydroids, anemones, and tunicates (sea squirts).

081-1.2.3 FOULING RATING (FR). The fouling rating scale (Table081-1-1) describes the 10 most frequently encountered fouling patterns in order of increasing severity. Representative photographs of each fouling pattern are provided in Figure 081-1-1.

081-1.2.4 FOULING RATING (FR) SCALE. A rating number has been assigned to each of the 10 fouling patterns on a scale of 0 to 100 in 10-point increments. The lowest number represents a clean hull and the higher numbers represent fouling organism populations of increasing variety and severity.

081-1.2.5 FOULING PERCENTAGES. The fouling percentage quantifies the density of fouling which covers a particular component or area of the hull (i.e., rudder, strut, propeller, stern, port side bow, starboard mid ship, sea chest, etc.).

081-1.3 FOULING CRITICAL SURFACES

081-1.3.1 GENERAL. In addition to generalized hull fouling, a ship has a number of specific locations where fouling can be particularly harmful. Fouling on the propeller can account for as much as 50 percent of the increased energy demand associated with a light to moderately fouled hull. The critical locations and the types of fouling most likely to impair function are described in the following paragraphs.

081-1.3.2 PROPUSORS. The dominant form of fouling on propusors is hard fouling, such as barnacles and tubeworms. The presence of even immature barnacles or tubeworms causes a severe loss in propusor efficiency. Examples of such fouling are defined in Table 081-1-1 and illustrated in Figure 081-1-1. In addition, the presence of surface roughness can result in a loss in propusor efficiency. Propusor surface roughness is determined by use of a Ship Propeller Roughness Gauge (Rubert Comparator Scale).

081-1.3.3 SONAR DOMES. On sonar domes with a rubber antifouling coating, slime and grass (fouling ratings of FR-10 to FR-30) are the predominant fouling forms to be expected. Failure of that antifouling coating, however, will allow hard fouling (FR-50 and above) to form. Sonar performance deteriorates rapidly after fouling progresses beyond a fouling rating of FR-30.

081-1.3.4 DOCKING BLOCK BEARING SURFACES. The unpainted surfaces that rested on the docking blocks during the most recent drydocking are more susceptible to fouling than the rest of the underwater body. These surfaces often can be identified by the sharp delineation of fouling at their boundaries. Fouling ratings of FR-70 or above are common over these bearing surfaces. Particular attention to hull plating condition is critical in these areas because of their greater susceptibility to corrosion.

081-1.3.4.1 As time out of dry dock increases, the outline of the docking block bearing surfaces becomes less well defined because of the outward spread of fouling. The rate at which the fouling spreads outward also reflects the effectiveness of the antifouling paint.

Table 081-1-1 FOULING RATINGS (FR) IN ORDER OF INCREASING SEVERITY

Type	Fouling Rating (FR)	Description
Soft	0	A clean, foul-free surface; red and/or black AF paint or a bare metal surface.
Soft	10	Light shades of red and green (incipient slime). Bare metal and painted surfaces are visible beneath the fouling.
Soft	20	Slime as dark green patches with yellow or brown colored areas (advanced slime). Bare metal and painted surfaces may by obscured by the fouling.
Soft	30	Grass as filaments up to 3 inches (76 mm) in length, projections up to 1/4 inch (6.4 mm) in height; or a flat network of filaments, green, yellow, or brown in color; or soft non calcareous fouling such as sea cucumbers, sea grapes, or sea squirts projecting up to 1/4 inch (6.4 mm) in height. The fouling can not be easily wiped off by hand.
Hard	40	Calcareous fouling in the form of tubeworms less than ¼ inch in diameter or height.
Hard	50	Calcareous fouling in the form of barnacles less than ¼ inch in diameter or height.
Hard	60	Combination of tubeworms and barnacles, less than ¼ inch (6.4 mm) in diameter or height.
Hard	70	Combination of tubeworms and barnacles, greater than ¼ inch in diameter or height.
Hard	80	Tubeworms closely packed together and growing upright away from surface. Barnacles growing one on top of another, ¼ inch or less in height. Calcareous shells appear clean or white in color.
Hard	90	Dense growth of tubeworms with barnacles, ¼ inch or greater in height; Calcareous shells brown in color (oysters and mussels); or with slime or grass overlay.
Composite	100	All forms of fouling present, Soft and Hard, particularly soft sedentary animals without calcareous covering (tunicates) growing over various forms of hard growth.

081-1.3.5 SEA CHESTS A fouling rating of FR-40 is generally first observed over covers and around the perimeter of sea chest gratings. Fouling ratings of FR-50 and above are later observed around and over the gratings and on the inner surfaces of sea chests. Fouling on the interior surfaces of gratings and sea chests is inaccessible to rotary brushes used for hull cleaning, and must be cleaned by other means, for example, hand-held scrapers and water jets.

081-1.3.6 MASKER EMITTER BELTS. The dominant form of fouling on masker emitter belts is hard fouling, such as barnacles and tubeworms. These hard calcareous organisms block emitter holes and rapidly deteriorate emitter belt performance. Emitter holes also become blocked by calcium deposits or silt ingestion.

081-1.3.7 PROPULSION SHAFTS. Fiberglass (GRP) coated shafts are normally covered with antifouling paint. As time out of drydock increases, paint can wear off, thereby exposing the white fiberglass (GRP) coating. This coating then tends to foul at an accelerated rate when compared to the painted shaft coating surface. The presence of any hard fouling on the shaft can be detrimental to the efficient rotation of the shaft in the water.

081-1.4 PAINT DETERIORATION RATING (PDR) SCALE

081-1.4.1 The paint deterioration ratings describe the hull coating condition and assigns a numerical rating of increasing severity on a scale from PDR-10 to PDR-100 in 10-point increments. Figure 081-1-2 provides photographs representing this scale. The first three ratings (PDR-10 through PDR-30) represent antifouling painted surface appearances associated with normal physical wear due to underwater cleaning action or hydrodynamic effects. The rating of PDR-40 is significant in that it indicates either excessive cleaning actions or blistering due to internal failure of the paint system. Such blisters are not the result of cleaning, but may not be noticed until after a cleaning operation. Failure at the anticorrosive/antifouling interface results in a softer blister (PDR-40) which is more likely to be broken by cleaning. Relatively hard blisters (PDR-50) which have survived cleaning indicate a probable failure at the anticorrosive/steel interface. Subsequent ratings of PDR-60 to PDR-100 indicate advancing deterioration of the entire anticorrosive/antifouling paint system. Whenever a rating of PDR-40 or higher is found over a substantial portion of the hull, consult paragraphs 081-2.1.8 and 081-2.1.8.1 before planning any future hull cleaning actions.

Figure 081–1–1. Typical Fouling Ratings (FR) in Order of Increasing Severity (22 Photos)

Figure 081-1-1 (SH1) FR-10, Over 30 Percent Of Area (Sheet 1 of 22).

Figure 081-1-1 (SH2) FR-10, Over 100 Percent Of Area (Sheet 2 of 22).

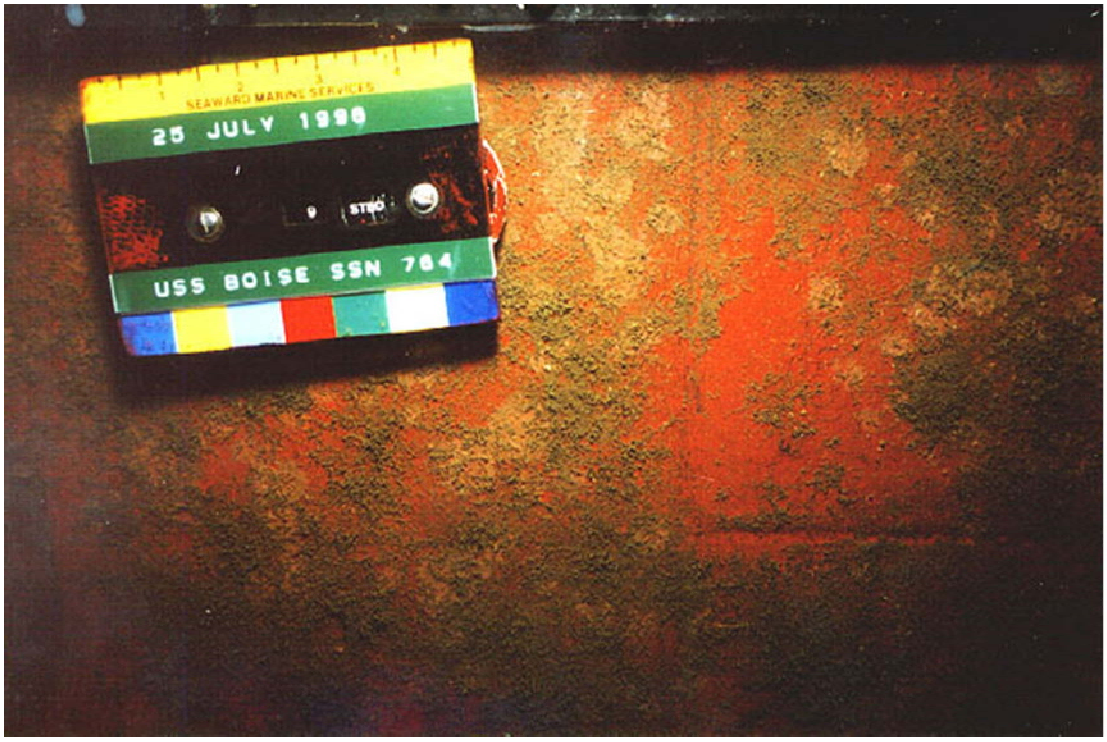


Figure 081-1-1 (SH3) FR-20, Over 80 Percent Of Area (Sheet 3 of 22).

Figure 081-1-1 (SH4) FR-30, Over 40 Percent Of Area (Sheet 4 of 22).

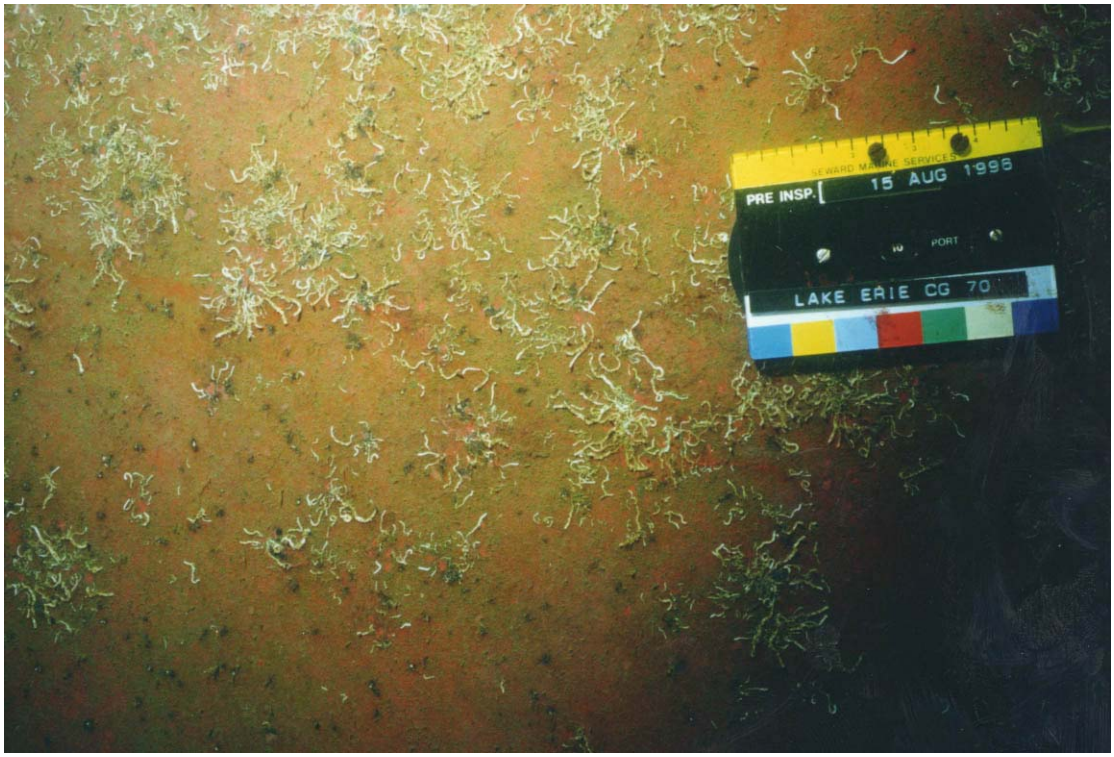


Figure 081-1-1 (SH5) FR-40, Over 20 Percent Of Area (Sheet 5 of 22).

Figure 081-1-1 (SH6) FR-40, Over 30 Percent Of Area (Sheet 6 of 22).

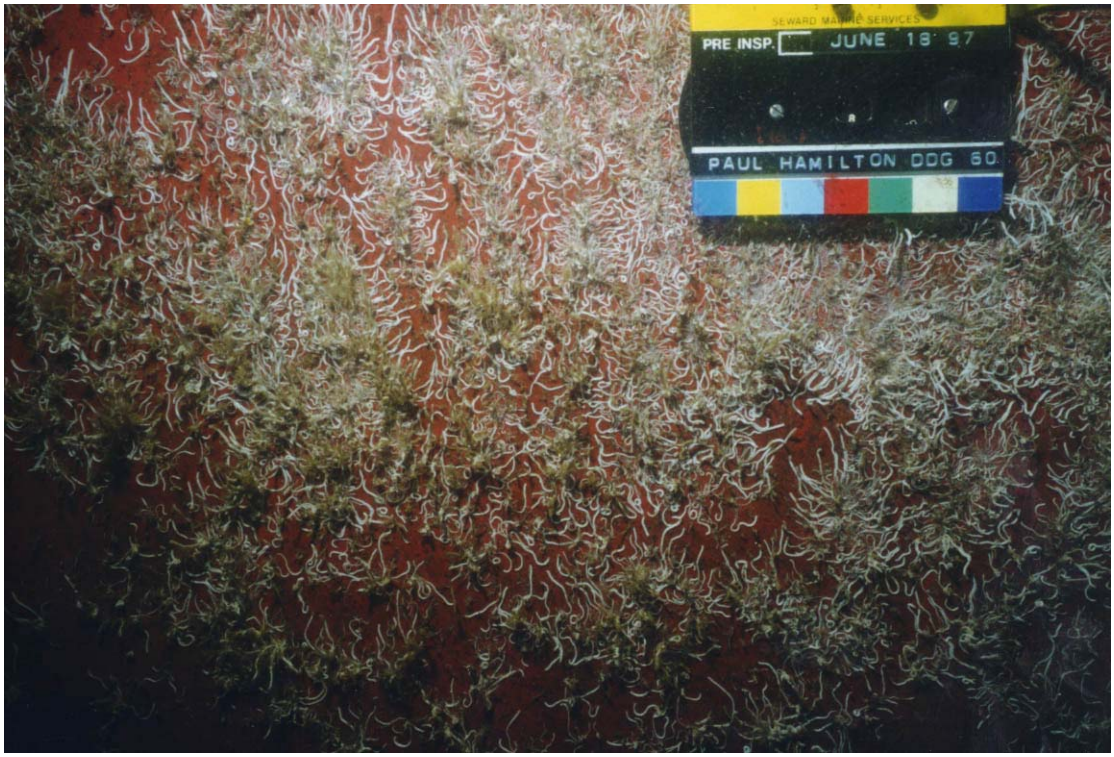


Figure 081-1-1 (SH7) FR-40, Over 90 Percent Of Area (Sheet 7 of 22).

Figure 081-1-1 (SH8) FR-50, Over 20 Percent Of Area (Sheet 8 of 22).

Figure 081-1-1 (SH9) FR-50, Over 40 Percent Of Area (Sheet 9 of 22).

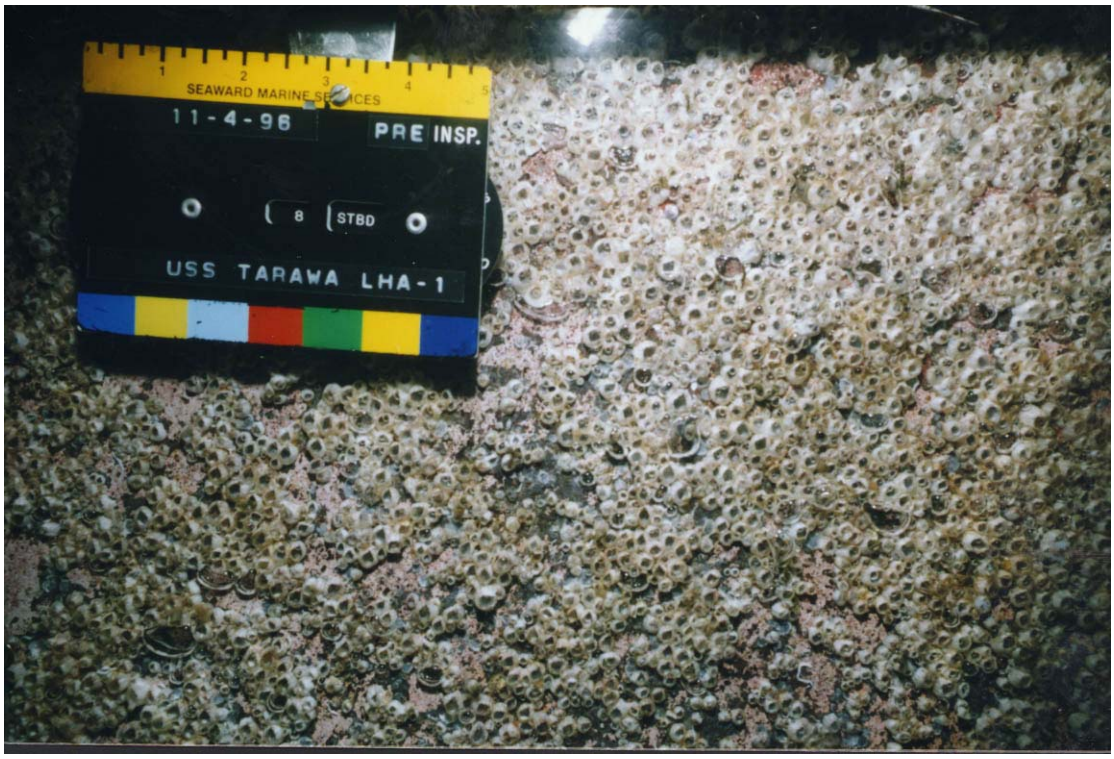


Figure 081-1-1 (SH10) FR-50, Over 100 Percent Of Area (Sheet 10 of 22).

Figure 081-1-1 (SH11) FR-60, Over 15 Percent Of Area (Sheet 11 of 22).

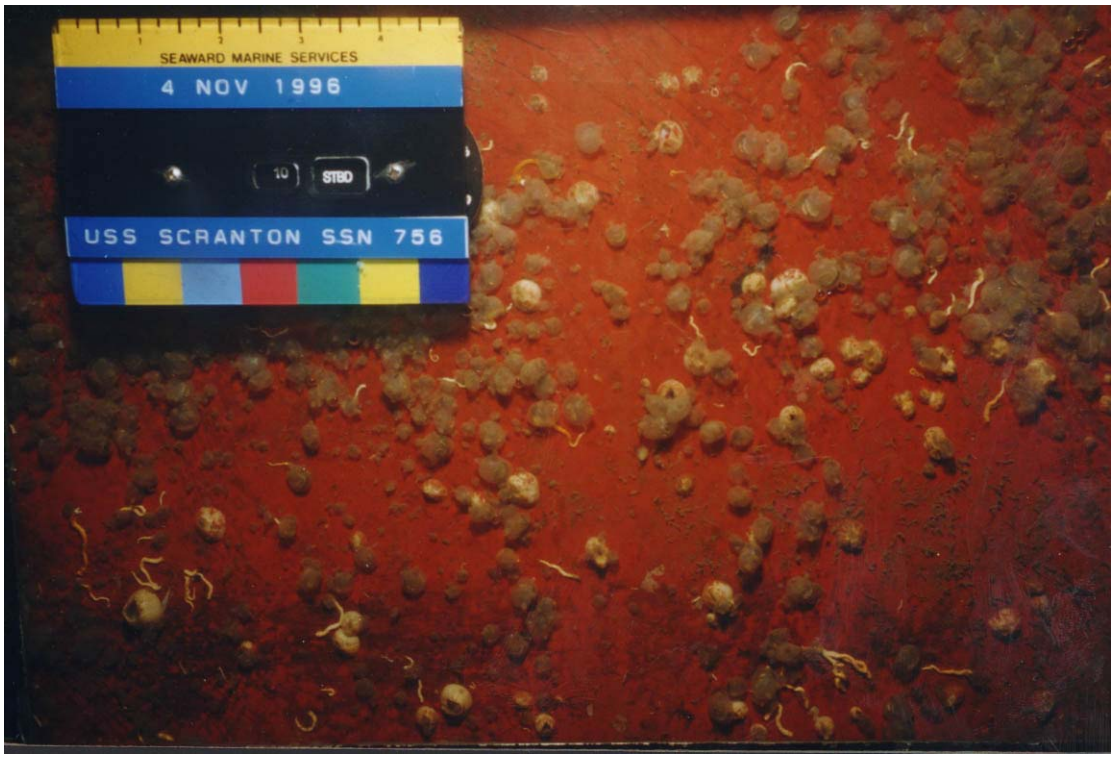


Figure 081-1-1 (SH12) FR-60, Over 20 Percent Of Area (Sheet 12 of 22).

Figure 081-1-1 (SH13) FR-60, Over 90 Percent Of Area (Sheet 13 of 22).

Figure 081-1-1 (SH14) FR-70, Over 20 Percent Of Area (Sheet 14 of 22).

Figure 081-1-1 (SH15) FR-70, Over 80 Percent Of Area (Sheet 15 of 22).

Figure 081-1-1 (SH16) FR-80, Over 60 Percent Of Area (Sheet 16 of 22).

Figure 081-1-1. (SH17) FR-80, Over 80 Percent Of Area (Sheet 17 of 22).

Figure 081-1-1 (SH18) FR-80, Over 90 Percent Of Area (Sheet 18 of 22).

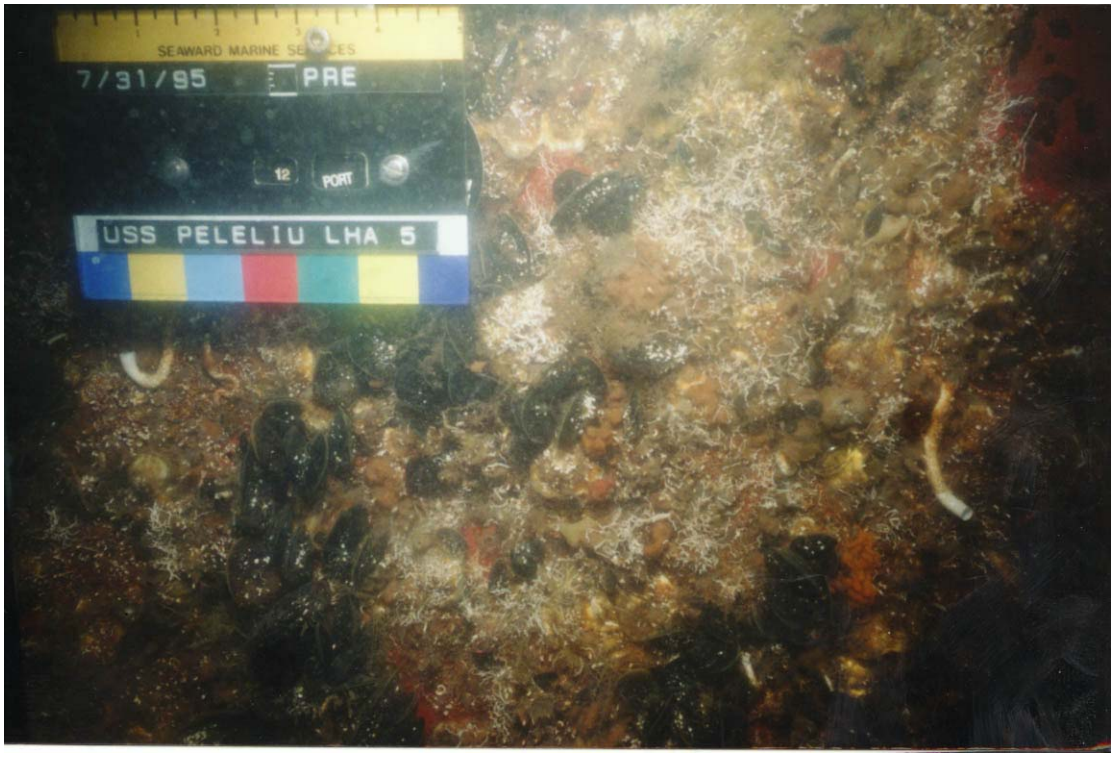


Figure 081-1-1 (SH19) FR-90, Over 90 Percent Of Area (Sheet 19 of 22).

Figure 081-1-1 (SH20) FR-90, Over 90 Percent Of Area (Sheet 20 of 22).

Figure 081-1-1 (SH21) FR-100, Over 50 Percent Of Area (Sheet 21 of 22).

Figure 081-1-1 (SH22) FR-100, Over 100 Percent Of Area (Sheet 22 of 22).

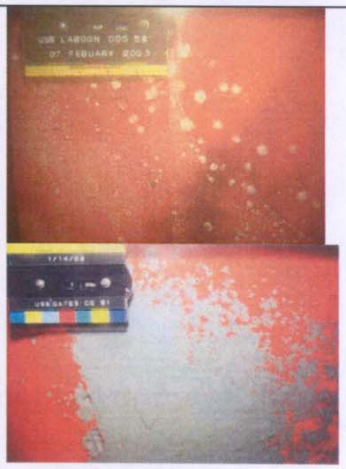
PDR-10	AF paint intact, red in color or with mottled pattern of light and dark red (no brush swirl marks)		
PDR-20	AF paint missing from edges, corners, seams, welds, rivet or bolt heads to expose AC paint		
PDR-30	AF paint missing from slightly curved or flat areas to expose underlying AF or AC paint or an AF paint with visible brush swirl marks within the outermost layer; not extending into any underlying layers of paint.		
PDR-40	AF paint missing from intact blisters to expose AC paint or an AF coating with visible brush swirl marks exposing the next underlying layer of AF or AC paint.		
PDR-50	AF blisters ruptured to expose intact AC paint		

Figure 081-1-2 (SH1) Paint Deterioration Ratings (Sheet 1 of 2)

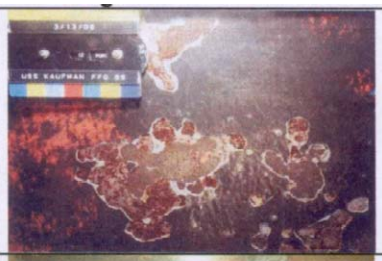
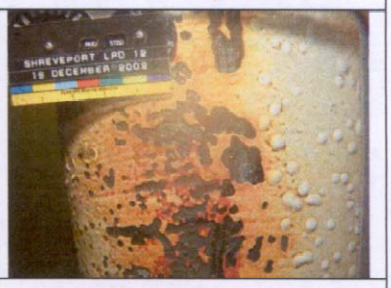
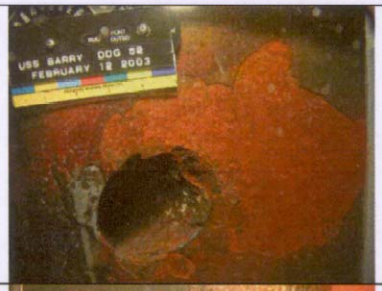
PDR-60	AF/AC paint missing or peeling to expose steel substrate, no corrosion present		
PDR-70	AF/AC paint removed from edges, corners, seams, welds, rivet or bolt heads to expose steel substrate with corrosion present		
PDR-80	Ruptured AF/AC blisters on slightly curved or flat surfaces with corrosion or corrosion stains present		
PDR-90	Area corrosion of steel substrate with no AF/AC paint cover due to peeling or abrasion damage		
PDR-100	Area corrosion showing visible surface evidence of pitting, scaling, and roughening of steel substrate		

Figure 081-1-2 (SH2) Paint Deterioration Ratings (Sheet 2 of 2)

SECTION 2
CLEANING GUIDANCE

081-2.1 CLEANING INTERVAL CRITERIA AND SCHEDULING

081-2.1.1 GENERAL. Since the effects of fouling on speed and power may vary among ship classes, and since the rates of fouling growth will vary with the condition of the antifouling paint system, the quality and number of prior cleanings, and the ship's geographical area and operational profile, no specific cleaning intervals can be stated. It is therefore imperative that all ships be scheduled for precleaning inspection on regular intervals to determine if cleaning is necessary. Delaying full hull cleaning to the point where a significant amount of hard fouling has formed (fouling rating (FR) 50 and above for non-ablative anti-fouling paints; FR-40 for ablative and self-polishing paints) can result in damage to the paint system.

081-2.1.1.1 For hull cleaning and scheduling purposes, the following definitions apply:

• FULL CLEANING: The term full cleaning refers to the removal of fouling from the entire underwater hull surface (i.e., painted surfaces), appendages, including propulsors and shafts, and openings.

• INTERIM CLEANING: The term interim cleaning refers to the removal of fouling from propulsors, shafts, struts and rudders. Cleaning of other submerged ship systems (i.e., openings, appendages) may occur during this period. Interim cleanings are normally scheduled for all ships between regular full cleanings to take advantage of the significant fuel savings benefits of operating with clean, smooth running gear, see Figure 081–2–1. Approximately 50 percent of the entire fuel savings benefit of cleaning an entire hull (that is, full cleaning) is attributable to the cleaning of propulsors and shafts. All ships, irrespective of the hull coating formulation, will benefit from routine interim cleanings and inspections.

• PARTIAL CLEANING – The term partial cleaning refers to any cleaning where only discrete sections of the hull (e.g., forward one-third or forward two-thirds of the hull), appendages (e.g., rudders, sonar dome, fin stabilizers), and systems (e.g., masker air, hull openings) are cleaned. This reduced cleaning effort is intended to provide the greatest payoff when time or other resources are limited. Partial hull cleaning are occasionally performed in conjunction with an interim cleaning.

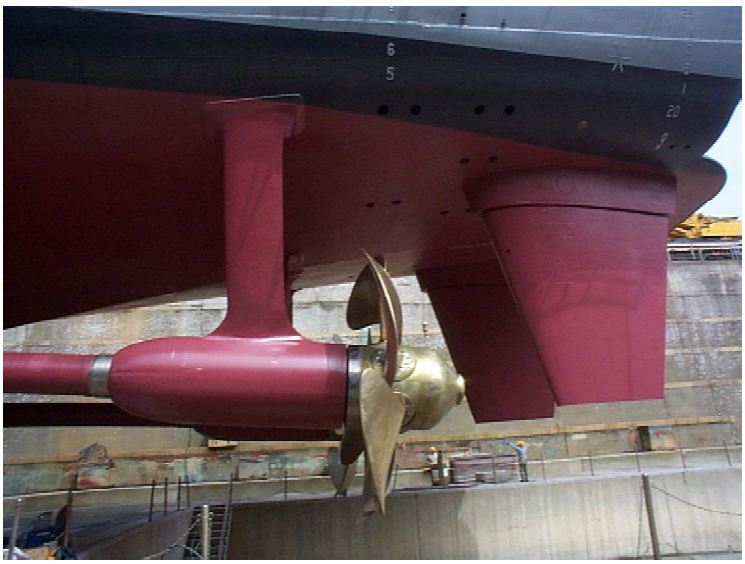


Figure 081-2-1 Running Gear

081-2.1.1.2 Differences in ship employment schedules and geographic operating areas may require variations in cleaning scheduling intervals, however, full hull cleaning shall not be accomplished on intervals of less than 6 months. Under normal circumstances, cleaning shall be conducted only when the fouling reaches the thresholds established in paragraph 081-2.1.1.3. Except in extenuating circumstances, cleaning properly prepared, newly painted hull surfaces should be unnecessary during the first 12 to 18 months after undocking. Ships which remain pierside in warm waters for extended periods of time after undocking will develop fouling more quickly and may require earlier cleaning. This 12 to 18 month window does not apply to unpainted surfaces such as propellers and masker emitter belts; therefore, ships should be scheduled for interim (propeller) cleanings on regular intervals immediately after undocking.

081-2.1.1.3 The decision to initiate a hull cleaning operation should be based on the results of precleaning hull inspections performed on regularly scheduled intervals. A secondary indication for the need to perform an underwater hull inspection is evidenced by ship performance indicators provided in paragraphs 081-2.1.6 and 081-2.1.6.1. The fact that these changes are due to fouling must be verified by underwater inspection of the ship's hull. Full hull cleaning shall be accomplished when a fouling rating of FR-50 or higher (over 10 percent of the hull) for non-ablative paints; FR-40 or (over 20 percent of the hull)higher for ablative and self-polishing paints, exclusive of docking block areas and appendages, is observed; interim cleaning when FR-30 or greater is observed on propeller surfaces. Rubber sonar domes shall be cleaned when FR-30 or greater is observed. Masker belts shall be cleaned when 15 percent blockage is observed on any belt section (that is, waterline to centerline). Propulsion shafts shall be cleaned when FR-40 or greater is observed (localized fouling concentrations should be spot-cleaned).

081-2.1.2 SCHEDULED DRYDOCKING. A ship's cleaning schedule should be adhered to until drydocking for new paint application. Deferral or cancellation of a ship's hull cleaning because of a scheduled upcoming drydocking often results in significant fuel penalties caused by dry-docking deferral. Underwater hull cleaning costs are quickly recouped by fuel savings, thereby justifying the decision to clean although a drydocking may be scheduled within 1 or 2 months. A ship's intended employment schedule must be reviewed prior to deferring cleaning for a near time scheduled drydocking for painting to determine if the fuel savings benefit recognized by cleaning can recoup the cost of cleaning. Should the drydocking schedule remain firm, once in dry dock a clean hull will reduce time and consequently dollars for the docking package.

081-2.1.3 PARTIAL VS. COMPLETE CLEANING. To ensure the greatest payoff for limited cleaning efforts, when time or other resources are limited, the priorities for underwater cleaning are:

a. Propellers

b. Forward one-third of the hull

c. After two-thirds of the hull.

081-2.1.3.1 Tests indicate that energy usage penalties caused by fouling occur in the forgoing order.

081-2.1.4 ABLATIVE AND SELF-POLISHING ANTIFOULING PAINTS. Ablative and self-polishing antifouling paints are softer than non-ablative vinyl antifouling paints and designed to wear away in small quantities while the ship is underway. Ships painted with these systems should still be regularly scheduled for interim cleaning and precleaning inspections. Precleaning inspections should be conducted over the entire hull to assess and document the paint system's performance. If, during a hull inspection or interim cleaning, fouling of FR-40 or greater, over 20 percent of the hull, exclusive of docking block areas and appendages, is observed on a hull coated with ablative or self-polishing paint, then a full hull cleaning should be accomplished. This decision to clean, when an FR-40 condition is noted, is critical regardless of the ship's employment schedule. Cleaning a fouled hull prior to an extended underway period will obviously improve performance and save fuel. Cleaning a fouled hull prior to an extended pier-side availability, especially in warm water, will slow fouling progression and extend the service life of the paint system even though it will not immediately save fuel.

081-2.1.5 FOULING RELEASE COATING SYSTEMS. Fouling release coating systems are designed with a low surface energy to reduce marine fouling's ability to permanently adhere to the coating when the ship is underway. The hydrodynamic forces cause the marine fouling to wash off the hull. Therefore hull cleaning is not permitted. However, ships coated with these systems should still be regularly scheduled for an interim cleaning and inspection. A precleaning inspection should be conducted over the entire hull to assess and document the coating system's performance. In the event that the ship is unable to reach the design speed of the coating or if the fouling was not removed during the last period in which ship speed exceeded the design speed, then hull cleaning may be required. If during a hull inspection or interim cleaning, fouling of FR-50 or greater is observed over 10 percent of a hull coated with a fouling release coating system, photographic documentation by Navy or Contractor divers should be obtained and forwarded immediately to NAVSEA Code 00C. NAVSEA will provide cleaning advice for ships coated with fouling release coating systems on a case basis. All requests should be submitted by fleet activities in the form of Naval messages utilizing the subject line: **WATERBORNE UNDERWATER HULL CLEANING.** Messages should include date of inspection, inspection activity, hull paint date and type, date of last underway period, maximum ship speed and duration within the last underway period, date of next scheduled drydocking, and inspection results. In no case should fouling release coating systems be cleaned without specific written approval by NAVSEA.

081-2.1.6 SHIP PERFORMANCE INDICATORS. Observed performance changes that lower a ship's ability to perform its mission or operate efficiently may be indications of the need for hull cleaning. When such deterioration occurs, conduct an underwater hull inspection to verify that fouling is the probable cause. Typical performance changes which may indicate a need for cleaning include the following:

a. A reduction of one knot in speed with shaft revolutions per minute (r/min) set for standard speed

b. An increase in excess of 5 percent in fuel required to maintain a specified shaft r/min (such as for standard speed), with propulsion and auxiliary machinery at optimum efficiency

c. An increase in shaft r/min in excess of 5 percent to maintain a given speed.

081-2.1.6.1 There are other performance parameters that may indicate excessive fouling. For steam-propelled ships, an increase in main turbine first stage shell pressure needed to maintain a given shaft r/min can generally be attributed largely to hull or propeller fouling assuming a constant main condenser vacuum and main steam supply pressure and temperature. For ships equipped with main shaft torsion-meters, an increase in torque at a given shaft r/min may also indicate the need for cleaning. There are, however, other explanations for deterioration in any performance parameter and it is therefore imperative that an underwater hull inspection be conducted before initiating any cleaning.

081-2.1.7 DIVER INSPECTION. In addition to observing the ship performance indicators and conducting precleaning inspections, the Commanding Officer should take advantage of any other scheduled underwater hull inspections to observe the condition of the antifouling paint as well as the degree and type of hull fouling. These inspections should be documented as outlined in paragraph 081-2.2. Postcleaning inspections, preferably by the same diving team, should immediately follow the cleaning evolution. These ensure adequate quality control of the cleaning operations and identify any hull or paint damage that may have been hidden by the fouling.

081-2.1.8 CLEANING ASSESSMENT. The decision to clean any individual hull which shows signs of a failing paint system requires a thorough assessment of that hull's cleaning history. An informative assessment of a ship's underwater hull condition cannot be made if the hull fouling is FR-60 or greater. In this case, the decision to not clean must be weighed against the importance of a thorough hull inspection. Normally, the risks associated with additional cleaning are justified by the necessity of performing an unobstructed inspection to allow a thorough compilation of hull system conditions and facilitate intelligent maintenance planning.

081-2.1.8.1 Should areas of significant paint failure be discovered during a precleaning or postcleaning hull in spection, the painted areas of the hull shall not be subjected to further cleaning without specific Type Commander (TYCOM) approval. A guide for assessing risk to failing paint is provided in Table 081-2-1. Assistance in determining severity of failure and hull protection is provided in paragraph 081-2.1.9, ,and Figure 081-1-2.

081-2.1.9 HULL PROTECTION SYSTEMS. The two systems which protect a ship's hull from corrosion deterioration are the anticorrosive paint system and the impressed current or sacrificial anode cathodic protection system. The interaction of these two systems and their ability to adequately protect the hull from corrosion is interdependent on several factors. Because hull cleaning inspections reveal the most comprehensive information on these system activities, thresholds are provided which indicate marginal or failing hull protection systems. The threshold for ships outfitted with impressed current cathodic protection systems is 10 percent bare metal observed on the underwater hull. Thresholds for ships with sacrificial anode systems are 5 percent bare metal or an observation of any inactive anodes. For ships with sacrificial anode systems, a hull potential survey should be conducted whenever either of these thresholds is observed.

081-2.2 DOCUMENTATION

081-2.2.1 GENERAL. In addition to the obvious fuel savings benefits realized by an underwater hull cleaning program an equally important benefit is the underwater hull condition data compiled before, during, and after cleaning operations. The time spent during a cleaning operation is the most comprehensive inspection of a ship's underwater body. By its very nature hull cleaning requires the diver to look at every square foot of the underwater hull and it is therefore imperative that the complete underwater hull condition be documented after a cleaning operation. Contractor and Navy diving activities must report the observed conditions on identical forms so that the data obtained from individual inspections can be compiled to produce meaningful trends. The NAVSEA forms identified herein should be used to document all underwater hull inspections. All entries must be completed on the forms. If conditions will not permit the inspection of a particular area, that fact should be so noted on the form. Before commencing cleaning operations, the type, degree, and distribution of fouling present will be documented. Hull condition documentation will be provided when cleaning has been completed. Paragraph 081-2.2.1.1 will be adhered to when providing documentation. Documentation for cleaning efforts accomplished by activities other than the NAVSEA Hull Cleaning Contractor must be forwarded to NAVSEA Code 00C.

a. NAVSEA 4730/3 (NSN 0116-LF-115-1600) **Diver Hull Inspection Data**

b. NAVSEA 4730/4 (NSN 0116-LF-047-3025) **Sonar Dome Rubber Window Inspection Data**

c. NAVSEA 4730/5 (NSN 0116-LF-047-3030) **Sonar Keel Dome Inspection Data**

d. NAVSEA 4730/6 (NSN 0116-LF-047-3035) **Propeller Inspection Data**

e. NAVSEA 4730/7 (NSN 0116-LF-047-3040) **Impressed Current Cathodic Protection Inspection Data**

f. NAVSEA 4730/8 (NSN 0116-LF-047-3045) **Auxiliary Propulsion Units Inspection Data**

g. NAVSEA 4730/3A (NSN 0116-LF-115-1500) **Preclean Biofouling Inspection Data**

Table 081-2-1 OBSERVED HULL CONDITIONS AND RECOMMENDED ACTIONS

Schedule of Inspection	Observation of Underwater Hull*	Action Options	Consequences
6 months from undocking	No serious blistering	Clean hull when required	None
	Significant unbroken blisters	Recognize ship as possible future risk	None
Prior to first underwater cleaning	No serious blistering but some hull fouling (FR-60 or greater)	Clean hull -OR-	None
	Significant blistering and some hull fouling (FR-60 or greater)	Clean hull	Possibility of rupturing blisters, increasing corrossion and refouling
		Do not clean hull	Reduce chance of corrosion; increasing fuel penalty due to continued fouling
	Paint not visible due to fouling	Clean hull	If no blisters, no danger; if blistered, possibility of rupturing blisters, increasing corrosion and refouling
After first cleaning	Wear of paint on edges and welds; no blisters	Reinspect prior to next cleaning	None
	Significant unbroken blisters	Reinspect prior to next cleaning	Possibility of rupturing blisters with future cleaning
	Signigicant ruptured blisters and rust staining	Remove ship from cleaning program and plan near-term drydocking to repair paint -OR-	If drydocked quickly, none -OR-
			If drydocking is postponed, increased fuel penalty due to fouling or corrosion
		Continue scheduled cleanings; no drydocking	Moderate fuel penalty; but increasing hull corrosion
Prior to second cleaning	No serious blistering but hull continuing to foul	Clean hull	None
	Significant unbroken blistering, increased fouling growth (rating of 60 or greater)	Clean hull -OR-	Possibility of rupturing blisters, resulting in increased corrosion and refouling
		Do not clean hull	Reduced corrosion; fuel penalty due to fouling
	Paint not visible due to fouling	Clean hull	Depends on paint condition at post-cleaning inspection
After second cleaning	Continuing paint wear on edges and welds, no blisters	Reinspect prior to next cleaning	None
	Significant unbroken blisters	Reinspect prior to next cleaning	Possibility of rupturing blisters during future cleanings
	Significant ruptured blisters and corrosion	Remove ship from cleaning program and plan near term drydocking to repair paint -OR-	If drydocked quickly, none -OR-

Table 081-2-1 OBSERVED HULL CONDITIONS AND RECOMMENDED ACTIONS - Continued

Schedule of Inspection	Observation of Underwater Hull*	Action Options	Consequences
			If drydocking is postponed, increased fuel penalty due to fouling of failed point or increasing hull corrosion
		Continue scheduled cleanings; no drydocking	Significant fuel penalty due to rapid refouling will require increased cleaning -AND-
			Serious corrosion may exceed capacity of cathodic protection system to control
After subsequent cleanings	Continued wear of paint, but major flat areas intact	Clean hull	Increase refouling rate and cleaning frequency to maintain performance Should consider interim drydocking based on expected mission requirements and paint life
	Large areas of failed paint due to broken blisters, peeling, or wear	Schedule interim drydocking at earliest possible time	Ship will be restored to good condition in drydock

*Observations to be conducted by Navy/commercial diver experienced in underwater paint observations.

081-2.2.1.1 In addition to the NAVSEA forms identified in paragraph 081-2.2.1, the surveys described in paragraphs 081-2.2.2 through 081-2.2.2.2 should be documented using color still photography or underwater color television systems when unusual damage or fouling is noted. These methods of fouling documentation are described in more detail in paragraphs 081-2.2.3 through 081-2.2.4.1. Photographic services should be requested through local Intermediate Maintenance Activities (IMA's), Readiness Support Groups (RSG's), Regional Maintenance Centers (RMC's), Mobile Diving and Salvage Units (MDSU's) or Consolidated Divers Unit (CDU).

081-2.2.2 SURVEY PLAN. A Survey Plan is recommended to ensure that documentation of fouling conditions and damage includes critical areas of the underwater body. Use the ship Drydocking Drawing in preparing the Survey Plan, since it provides the principal dimensions and the locations of easily recognized underwater hull components.

081-2.2.2.1 In particular, the following areas should be identified on the Survey Plan and shall be inspected and documented for both fouling and damage during each precleaning and postcleaning inspection:

a. All sonar domes or unpainted surfaces (particularly propellers and masker belts)

b. All protruding appendages (that is, bilge keels)

c. Cathodic protection systems; zincs, impressed current anodes, references cells, and dielectric shields

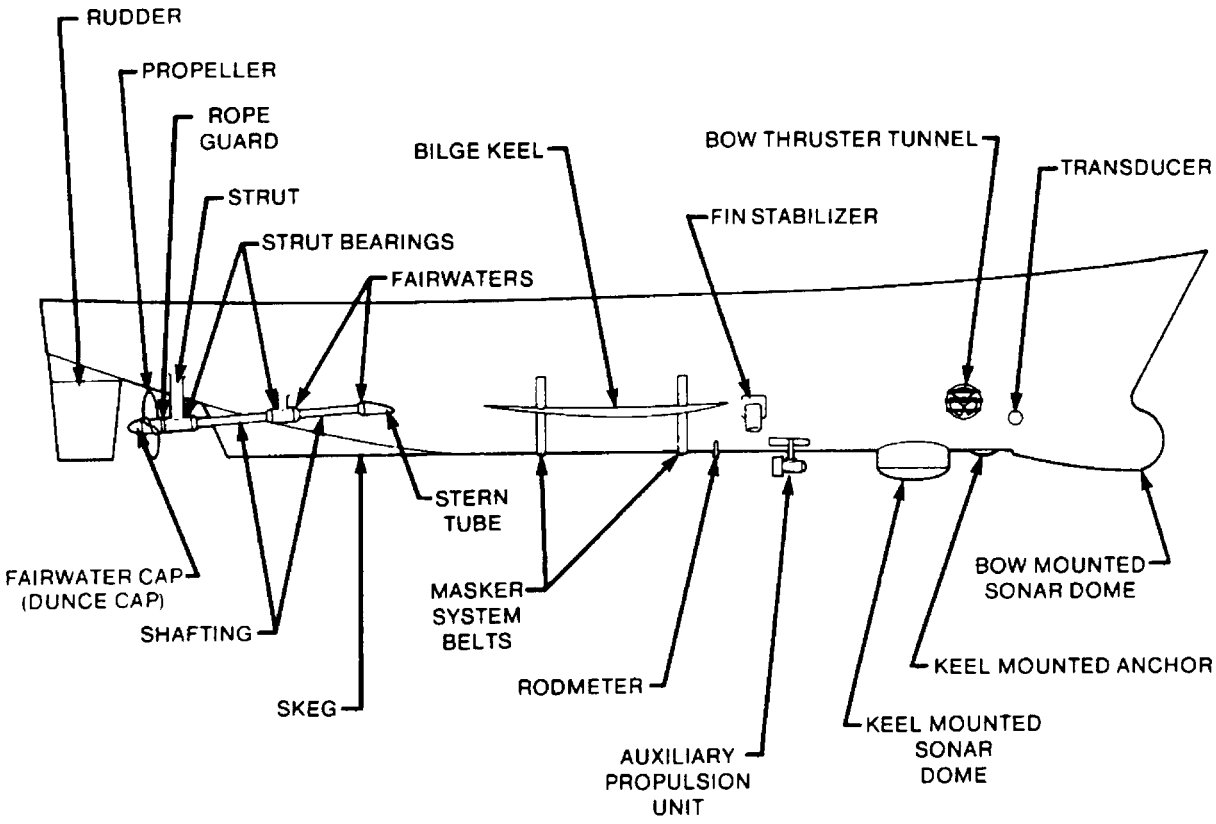
d. Junctions of hull surface with struts, stern tubes, sonar dome, and other appendages

e. Keel block and side block areas from last drydocking

f. Sea chests, ballast tanks, and hull openings

g. Previously identified damaged areas.

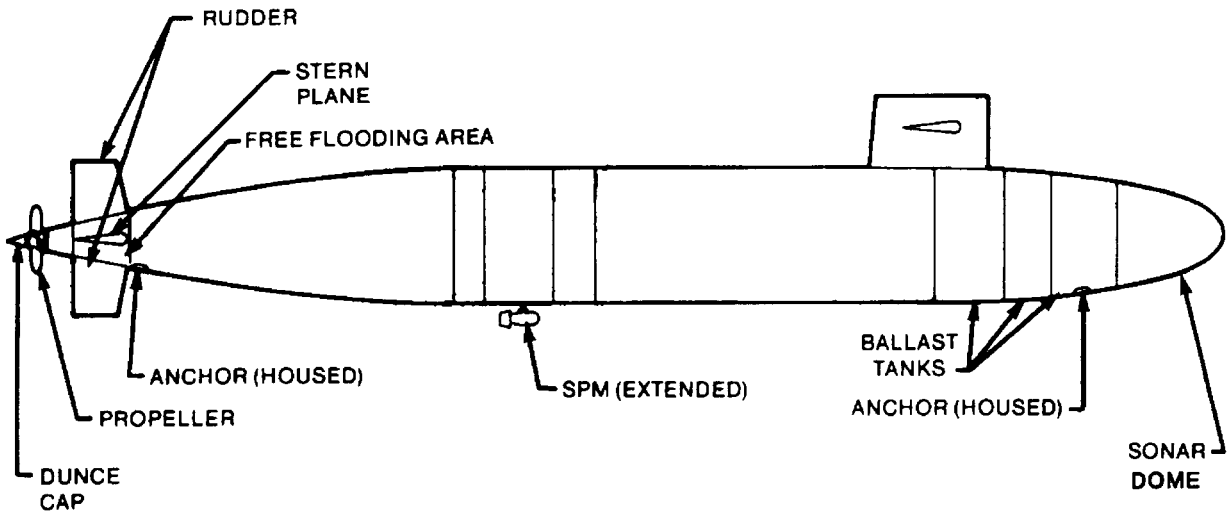
081-2.2.2.2 A Survey Plan for surface ships is shown in Figure 081-2-2. A representative Survey Plan for a submarine, with the different locations defined, is shown in Figure 081-2-3



NOTES:

1. IN ADDITION TO THE ABOVE APPENDAGES, THE CONDITION OF THE HULL PLATING (FOULING AND PAINT SYSTEM) SHOULD BE NOTED FOR THE BOW AREA, STERN AREA, FLAT BOTTOM, SIDES, BOOTTOPPING, AND DOCKING BLOCK . BEARING AREAS.
2. NOTE CONDITION OF ZINC ANODES, IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM ANODES AND REFERENCE CELLS.
3. NOTE CONDITION OF SEACHESTS/HULL PENETRATIONS.
4. PHOTOGRAPHS SHOULD BE TAKEN BEFORE AND AFTER CLEANING AND ANNOTATED IN ACCORDANCE WITH THE ABOVE NOMENCLATURE.

Figure 081-2-2 Example of Survey Plan for Surface Ships.



NOTES:

1. IN ADDITION TO THE ABOVE APPENDAGES, THE CONDITION OF THE HULL PLATING (FOULING AND PAINT SYSTEM) SHOULD BE NOTED FOR THE BOW AREA, STERN AREA, BOOTTOPPING, HULL AREA BELOW BOOTTOPPING, AND DOCKING BLOCK BEARING AREAS.
2. NOTE CONDITION OF ZINC ANODES.
3. NOTE CONDITION OF SEACHESTS/HULL PENETRATIONS.
4. PHOTOGRAPHS SHOULD BE TAKEN BEFORE AND AFTER CLEANING AND ANNOTATED IN ACCORDANCE WITH THE ABOVE NOMENCLATURE.

Figure 081-2-3 Example of Survey Plan for Submarines.

081-2.2.3 UNDERWATER TELEVISION SYSTEMS. The Divers Underwater Color Television System (DUCTS) may be used to transmit color video description to topside personnel during the survey, and for pictorial documentation of the hull. Television systems approved for fleet use are listed in NAVSEAINST 10560.2, **Diving, Equipment Authorized for Navy Use.**

081-2.2.3.1 Underwater television systems provide quick on-the-spot assessment of fouling conditions. The taped transmission should be retained for comparison with the results of the next survey. Black and white video does not allow accurate evaluation of paint condition nor quality of cleaning. Black and white television systems are adequate to identify general fouling density and distribution; however, to adequately assess hull cleaning effectiveness, hull damage, and paint condition, color television systems are required. For correlation purposes, visual documentation after cleaning should depict the same areas and special features as documentation before

cleaning. Good coverage requires that the television operator make a series of passes at 6 foot intervals. During the use of the various systems, two-way communication between the topside decision maker and the diver shall be used to identify paint color and surface condition to supplement video transmission. A scale and color reference indicator shall be used to assist in the analysis of the video transmission. The video tape should include ship name, hull number, location or component on the hull, and the date.

081-2.2.4 PHOTOGRAPHY. Whenever underwater still photographic equipment is available, color photographs of all areas of interest should be obtained to provide identification of fouling type, density, and distribution, as well as verification of properly cleaned surfaces (as identified in paragraph 081-2.3 through 081-2.3.2).

081-2.2.4.1 Photographs will be identified with the ship name or hull number, the location or component on the ship, and the date. A size scale and color reference indicator shall be used in each photographic view.

081-2.2.5 WATER CONDITIONS. In most Navy ports, little can be done to control water conditions. If a choice exists however, expedite cleaning by choosing the area of clearest water for improved visibility. A slight current, on the order of one-half knot, is desirable to carry debris away from the worksite during cleaning. Cleaning in currents over two knots shall be avoided, unless dictated by operational necessity.

081-2.3 CRITERIA FOR A CLEAN HULL SURFACE

081-2.3.1 The purpose of underwater hull cleaning is to remove fouling and regain propulsion efficiency. An added benefit from cleaning anti-fouling coatings is to restore or rejuvenate the effectiveness of the antifouling paint. The underwater cleaning process, therefore, should remove all traces of biological fouling.

081-2.3.1.1 Ablative and self-polishing antifouling paints, when properly cleaned with the least aggressive brush to remove all biofouling, should have a bright red surface (or black surface on boot tops and submarine hulls above the maximum beam). Cleaning shall not result in scratches or swirl marks on the surfaces or abrasion of edges, corners, seams, welds, rivet or bolt heads, that expose or extend into the underlying layer of coating. Below the boot top on surface ships, repeated cleanings will yield a mottled pattern of the red antifouling paint and a black (second) layer of antifouling paint. Ships may have a three layer anti-fouling paint system (e.g., red, black, red). Extreme diligences must be taken when observing the results of the cleaning process to differentiate between each exposed layer and ensure an intermediate layer has not been completely removed thus exposing the next layer having the same color as the outer layer. Immediately suspend cleaning and contact NAVSEA Code 00C when any of these conditions appear and document the coating condition as specified in section 081-2.2. The progressive deterioration of a properly cleaned ablative hull coating system is described and illustrated in Figure 081-1-2.

081-2.3.1.2 After a fouling release coating systems is cleaned the surface shall be free of fouling and exhibit no evidence of damage resulting from the cleaning.

081-2.3.1.3 Non-ablative vinyl antifouling paint, although no longer specified for use on Navy ships since the MIL-P-15931 specification was cancelled in 2005, will form a green chemically insoluble layer on the surface that will become harder to remove as the paint system ages. This layer of cuprous oxide is insoluble, nontoxic and will not prevent marine growth from adhering to the surface. The degree of removal of this green layer is proportional to the age of the paint system and the time between cleanings. Cleaning should partially remove the green chemical layer to expose a mottled pattern of 40 to 60 percent red antifouling paint. Cleaning the coating to alternate mottled pattern and continuous red will allow rejuvenation of antifouling (AF) paint with minimum damage to intact AF paint and prevent the formation of a tough insoluble layer over the AF paint. The lower portion of a submarine hull from maximum beam to keel may be painted with red formula 121 AF paint. However,

in the area from maximum beam to maximum load line, black formula 129 AF is normally used. There is usually no green chemical layer formed on formula 129 AF paint; therefore, removal of the green slime layer cannot be used as a cleaning criterion. This lack of visual criterion requires exercising of great care to prevent removal of excessive amounts of formula 129 AF paint. Removal of the heavy slime layer will expose a black hull. A mottled pattern on this hull paint system is not desirable, as this indicates removal of paint exposing different colored anticorrosion paint.

081-2.3.2 Cleaning the non-ablative vinyl anti-fouling paint to alternate mottled pattern and continuous red will allow rejuvenation of antifouling (AF) paint with minimum damage to intact AF paint and prevent the formation of a tough insoluble layer over the AF paint. Progressive paint deterioration from a properly cleaned hull with the mottled pattern to a hull with advanced corrosion is described in and illustrated in Figure 081-1-2

081-2.3.3 Ablative and self-polishing antifouling paints do not generate a green chemical layer of cuprous oxide. When properly cleaned with the least aggressive brush to remove all biofouling, a bright red surface (or black surface on boot tops and submarine hulls above the maximum beam) should be present. Below the boot top on surface ships, repeated cleanings will yield a mottled pattern of the red antifouing paint and a black (second) layer of antifouling paint. Suspend cleaning and contact NAVSEA code 00C when this mottled pattern appears and document the coating condition as specified in paragraph 081-2.2.

081-2.4 CRITERIA FOR A CLEANED PROPULSOR SURFACE

081-2.4.1 UNPAINTED PROPULSOR - The purpose of underwater propulsor cleaning is to remove fouling and provide a smooth surface. Therefore the underwater cleaning process should remove all traces of fouling and calcareous deposits. Propulsor polishing shall follow the cleaning process to remove any remaining basal plates, all calcium deposits and produce a smooth finish (Rubert Scale B or better). For ships with a PRAIRIE system the exterior air emitter holes shall be free of fouling. The system shall be tested by ships force in accordance with Maintenance Requirement Cards to ensure design flow rates can be obtained. The first five emitter holes at the hub and the last five emitter holes at the tip shall be clear, no two adjacent holes may be blocked, and no more than two holes in any series of 10 shall be blocked, and the maximum number of blocked holes shall not exceed 5 percent of the total number of holes.

081-2.4.2 PAINTED PROPULSOR - The purpose of underwater propulsor cleaning is to remove fouling and provide a smooth surface. Therefore the underwater cleaning process should remove all traces of fouling. The painted surface shall meet the hull coating criteria.

081-2.4.3 DUCTED PROPULSOR - The painted surface of the ducted propulsor shall meet the hull coating criteria and the unpainted surfaces of the ducted propulsor shall be polished following the cleaning process to remove any remaining basal plates, all calcium deposits and produce a smooth finish (Rubert Scale B or better). Adjacent surfaces and components that are painted shall meet the hull coating criteria.

081-2.5 CRITERIA FOR A CLEANED PROPULSION SHAFT SURFACE

081-2.5.1 The purpose of underwater cleaning of the propulsion shaft is to remove all biofouling, produce a smooth surface, and faciliate inspection of the shaft for any indications of damage (i.e., fiberglass disbondment, cracks in the coating and possible corrosion and pitting of the underlying metal shaft). The cleaned shaft will be red in color (for ablative antifouling paints), or red to mottled red (for non-ablative vinyl antifouling paints). A clean fiberglass shaft with no remaining paint will be white in color.

081-2.6 CRITERIA FOR A CLEANED SONAR DOME

081-2.6.1 When a sonar system is cleaned the surface shall be free of fouling. Typical damage that could occur from improper cleaning includes scratches and gouges. There shall be no evidence of damage resulting from the cleaning.

081-2.7 CRITERIA FOR A CLEANED MASKER AIR SYSTEM

081-2.7.1 When a masker air system is cleaned the exterior and interior surface shall be free of fouling. The system shall be tested by ships force in accordance with Maintenance Requirement Cards to ensure design flow rates can be obtained.

081-2.8 CRITERIA FOR A CLEANED SEA CHEST

081-2.8.1 Typically the surfaces of a sea chest are treated with the same coating system as the adjacent hull. When a sea chest is cleaned, the exterior hull and fairing surface, surfaces of the sea chest grates, screens or splitter bars, and the internal walls; within the reach of the diver and the employed tools, shall be free of any biofouling. Due to the increase water flow and geometry of the grates, screens, and splitter bars fouling is often greater than on the surrounding hull and after cleaning the coating may appear worn more than the surrounding hull coating.

081-2.9 CRITERIA FOR A CLEANED PRAIRIE FIN STABILZER SYSTEM

081-2.9.1 When a fin stabilizer is cleaned the exterior painted surface shall be free of fouling (see hull coatings). The bare metal surfaces found on the leading edge shall be free of fouling. The exterior air emitter nozzles and interior surface of the air system shall be free of fouling. The system shall be tested by ships force in accordance with Maintenance Requirement Cards to ensure design flow rates can be obtained.

SECTION 3
OPERATIONS

081-3.1 GENERAL

081-3.1.1 Navy diving operations shall be conducted in accordance with the **U.S. Navy Diving Manual.** If contractor services are being used, the contractor shall conduct such operations in accordance with Federal, State, and OSHA regulations in effect at the time of commencement of efforts. All operations may be supplemented by local base and Senior Officer Present Afloat (SOPA) instructions. All standard and local safety precautions shall be observed. Prior to any cleaning operation, observe the diver precautions and warning of paragraphs 081-3.2. Navy and commercial cleaning equipments shall comply with Section 4.

081-3.1.2 Hull cleaning operations shall comply with the best management practices set forth in the Underwater Ship Husbandry Manual, Underwater Ship Husbandry, Pollution Prevention, NAVSEA S0600-AA-PRO-280.

081-3.2 PREPARATION

081-3.2.1 For diver safety and efficient cleaning operations:

a. The ship shall be breasted out a minimum of 4 feet from the pier and clear on the outboard side. In the case of aircraft carriers, the ship shall be breasted out a minimum of 20 feet.

b. There shall be sufficient depth of water under the keel, a minimum of 6 feet at Mean Low Water (MLW).

c. The underwater hull shall be free of obstruction.

d. Retractable speed log rod-meters will be in the fully raised position. On those ships with fixed rod-meters, mark the locations with visual or auditory warning devices.

e. Main and auxiliary circulating pumps shall be secured.

f. The ship and any adjacent ships shall be properly tagged out for diving. All ships in the vicinity will also be informed of the diving operation to prohibit unauthorized operations of underwater systems such as, but not limited to, sonar, masker air, PRAIRIE, and main propulsion tests.

g. Cofferdams or other obstructions that would impede the cleaning operations or become dislodged or damaged from cleaning shall be identified to the divers prior to commencing with cleaning operation.

CAUTION

It is important that the impressed current cathodic protection system be reenergized after cleaning to prevent corrosion.

h. The impressed current cathodic protection system on the ship being cleaned shall be de-energized and the limits of the dielectric shield shall be marked with visual or auditory warning devices to enable the cleaning personnel to keep the cleaning equipment clear of the shield and anodes.

i. The limits of submarine bow sonar domes or rubber-coated surfaces shall be marked with visual or auditory warning devices to enable the cleaning personnel to keep multi-brush cleaning units clear of these areas.

j. The most recent Docking Report will be available.

k. When contractor divers are engaged in hull cleaning of nuclear ships, they shall be trained in accordance with the applicable Radiological Controls manual (NAVSEA 389-0288 or NAVSEA S9213-33-MMA-000/(v)).

l. Prior to contractor diving on nuclear ships, a hull survey of the ship shall be conducted in accordance with the applicable Radiological Controls manual (NAVSEA 389-0288 or NAVSEA S9213-33-MMA-000/(v)) using Navy divers. The surveys shall determine extent, if any, of hull surface contamination. Areas with contamination must be marked in such a way that the contractor divers can avoid them.

m. Prior to diving on nuclear ships, contractor divers shall be issued dosimetry and briefed in accordance with the requirements of the applicable Radiological Controls manual (NAVSEA 389-0288 or NAVSEA S9213-33-MMA-000/(v)). Hull surveys performed and boundaries established shall be discussed as part of this briefing. Completion of this briefing shall be documented by signature on the applicable, local diving permit/ Lead Maintenance Activity documentation.

n. Diving around active sonars shall be conducted in accordance with the U.S. Navy Diving Manual, Appendix 1A, Safe Diving Distances from Transmitting Sonar.

o. When diving in the vicinity of PRAIRIE and masker air systems the main generators and bleed air shall be secured until requested by the diving supervisor to verify cleaning effectiveness.

081-3.3 CLEANING GUIDELINES

The diver shall inspect the surface requiring cleaning and determine which equipment is required to effectively remove the fouling with the least aggressive force. The most effective tool shall be used to remove the fouling efficiently while at the same time preventing damage to the underlying system (e.g. hull coating, GRP shaft coating, rubber window, etc.). The following paragraphs provide requirements for cleaning the hull and appurtenances; including but not limited to, cathodic protection systems, propulsors, sonar systems, masker emitter belts, prairie system components, sea chests, submarine hulls, wood and fiberglass hulls, propulsion shafts, auxiliary propulsion units and secondary propulsion motors, and bow thrusters. Table 081-3-1 summarizes the cleaning criteria and equipment approved for cleaning various ship components.

Table 081-3-1 CLEANING CRITERIA AND APPROVED EQUIPMENT

				Ship System	Ablative Anti-Fouling Coating System	Non-Ablative Anti-Fouling Coating System	Fouling Release Coating System	Masker Air Emitter Belts	Prarie Masker Air Emitter Holes	Hub Masker Air	Fin Stabilizers	Sea Chest Gratings	Sea Chest Inside	Bilge Keels	Auxiliary Propulsion Unit	Secondary Propulsion Motor	Underwater Log / Pitsword	Bow Thrusters	ICCP Anode	ICCP Dielectric Shield	ICCP Reference Cell	Sonar Systems	Special Hull Treatment (SHT/MIP)	Struts and Rudder	GRP Coated Propulsion Shaft	Propulsion Shaft Bearings	Propulsor
		Product Identifier (1)	Size	Criteria	FR40 (over 20%)	FR50 (over 10%)	FR50 (over 10%)	FR50 (w/5% flow restriction)	FR50 (w/10% flow restriction)	FR50 (w/10% flow restriction)	FR40 (over 20% w/10% flow restriction)	FR40 (over 20%)	FR40 (over 20%)	Same as hull coating	Same as hull coating and propeller	Same as hull coating and propeller	FR30 or greater	Same as hull coating and propeller	FR30 or greater	Same as hull coating	FR30 or greater	FR30 or greater	Same as hull coating	Same as hull coating	Same as hull coating		Painted surfaces: FR40 or greater (over 10%), Unpainted surfaces Rupert ″C″ or greater
Single- Brush/Disc Units																											
	A-1	18	in		x	x	x	x	x	x	x	x		x	x	x		x		x	x	x	x	x	x	x(7)	x(8)
	A-2	9, 11, 13	in		x	x		x	x	x	x	x		x	x	x		x		x	x	x	x	x	x	x(7)	x(8)
	A-3	11, 13	in		x	x																		x		x(7)	x(8)
	A-4	9, 11	in				x																			x(7)	x(8)
	C	9, 11, 13	in		x(2)	x(2)		x										x						x(2)	x(2)	x(7)	x(8)
	D	5, 7, 12	in					x(5)			x(3)												x			x(7)	x(8)
	D3	7.5, 9	in					x(5)			x(3)							x				x				x(7)	x(8)
	D5	7.5, 9	in					x(5)																			x(7)	x(8)
	SCD (Blue)	3	in								x(3)				x(4)	x(4)		x									x(7)	x(8)
	CRD (Black)	3	in					x(5)			x(3)				x(4)	x(4)		x									x(7)	x(8)
	Clean N Strip XT (Purple)	4.5, 6, 7	in					x(5)			x(3)																x(7)	x(8)
	H-1	280	mm		x	x		x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x(7)	x(8)
	H-2	280	mm		x	x		x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x(7)	x(8)
	H-3	280	mm		x	x		x																x	x	x(7)	x(8)
	H-4	280	mm		x(2,6)	x(2,6)																		x(2,6)		x(7)	x(8)
	H-5	280	mm		x(6)	x(6)																		x(6)		x(7)	x(8)
Multi-Brush Units																											
	E-1	19, 22	in		x	x																	x				
	E-2	19, 22	in		x	x																	x				
	E-3	19, 23	in		x	x																	x				
	E-4	19, 23	in		x	x																x	x				
	E-5	19, 23	in				x																				
	M-1	350	mm				x																				
	M-2	350	mm		x	x		x			x	x		x	x	x		x		x	x	x	x	x	x		

Table 081-3-1 CLEANING CRITERIA AND APPROVED EQUIPMENT - Continued

				Ship System	Ablative Anti-Fouling Coating System	Non-Ablative Anti-Fouling Coating System	Fouling Release Coating System	Masker Air Emitter Belts	Prarie Masker Air Emitter Holes	Hub Masker Air	Fin Stabilizers	Sea Chest Gratings	Sea Chest Inside	Bilge Keels	Auxiliary Propulsion Unit	Secondary Propulsion Motor	Underwater Log / Pit sword	Bow Thrusters	ICCP Anode	ICCP Dielectric Shield	ICCP Reference Cell	Sonar Systems	Special Hull Treatment (SHT/MIP)	Struts and Rudder	GRP Coated Propulsion Shaft	Propulsion Shaft Bearings	Propulsor
		Product Identifier (1)	Size	Criteria	FR40 (over 20%)	FR50 (over 10%)	FR50 (over 10%)	FR50 (w/5% flow restriction)	FR50 (w/10% flow restriction)	FR50 (w/10% flow restriction)	FR40 (over 20% w/10% flow restriction)	FR40 (over 20%)	FR40 (over 20%)	Same as hull coating	Same as hull coating and propeller	Same as hull coating and propeller	FR30 or greater	Same as hull coating and propeller	FR30 or greater	Same as hull coating	FR30 or greater	FR30 or greater	Same as hull coating	Same as hull coating	Same as hull coating		Painted surfaces: FR40 or greater (over 10%), Unpainted surfaces Rupert ″C″ or greater
	M-3	350	mm		x	x		x			x	x		x	x	x		x		x	x	x	x	x	x		
	M-4	350	mm		x	x					x	x		x	x	x								x	x		
Water Jet Systems																											
Gun, Noncavitating	Various	10,000	psi					x	x	x	x(5)	x	x(5)					x								x(7)	x(8)
Hydrolance	Various	10,000	psi					x				x	x(5)													x(7)	x(8)
Hydrolance	Various	3,000	psi								x(5)	x	x													x(7)	x(8)
Hydrolance	Various	2,500	psi							x																x(7)	x(8)
Hand Scrapers																											
Wood		Various			x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x(7)	x(8)
Plastic		Various			x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x(7)	x(8)
Brass		Various						x	x		x					x		x	x							x(7)	x(8)
Ferrous Metal		Various			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	x(7)	x(8)
Hand Pads and Brushes																											
White (33)	48011-33012	6 x 12	in		x	x		x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x(7)	x(8)
White (7445)	48011-16976-7	6 x 9	in		x	x		x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x(7)	x(8)
Green (96)	48011-08293-1	6 x 9	in		x	x		x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	x(7)	x(8)
Green (86)	48011-05509-6	6 x 9	in		x	x		x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	x(7)	x(8)
Maroon (7447)	48011-04029-5	6 x 9	in		x	x		x	x	x	x	x	x		x	x	x	x		x	x		x	x		x(7)	x(8)
Duddle-bug™	48011-14020-4	4 x 9	in				x												x		x	x				x(7)	x(8)

Table 081-3-1 CLEANING CRITERIA AND APPROVED EQUIPMENT - Continued

			Ship System	Ablative Anti-Fouling Coating System	Non-Ablative Anti-Fouling Coating System	Fouling Release Coating System	Masker Air Emitter Belts	Prarie Masker Air Emitter Holes	Hub Masker Air	Fin Stabilizers	Sea Chest Gratings	Sea Chest Inside	Bilge Keels	Auxiliary Propulsion Unit	Secondary Propulsion Motor	Underwater Log / Pit sword	Bow Thrusters	ICCP Anode	ICCP Dielectric Shield	ICCP Reference Cell	Sonar Systems	Special Hull Treatment (SHT/MIP)	Struts and Rudder	GRP Coated Propulsion Shaft	Propulsion Shaft Bearings	Propulsor
	Product Identifier (1)	Size	Criteria	FR40 (over 20%)	FR50 (over 10%)	FR50 (over 10%)	FR50 (w/5% flow restriction)	FR50 (w/10% flow restriction)	FR50 (w/10% flow restriction)	FR40 (over 20% w/10% flow restriction)	FR40 (over 20%)	FR40 (over 20%)	Same as hull coating	Same as hull coating and propeller	Same as hull coating and propeller	FR30 or greater	Same as hull coating and propeller	FR30 or greater	Same as hull coating	FR30 or greater	FR30 or greater	Same as hull coating	Same as hull coating	Same as hull coating		Painted surfaces: FR40 or greater (over 10%), Unpainted surfaces Rupert ″C″ or greater

Notes:
1. This table represents all equipment approved for use on a ship system. Some systems may require cleaning of various surfaces and materials that will limit the available tools approved for use. See applicable ship system in Section 3 for specific cleaning requirements and restrictions. Refer to the Qualified Products List (section 5) for specific equipment and manufacturers.
2. Wire brushes shall only be used to clean severely fouled ablative and non-ablative (excluding foul release) hull coating systems after all other brushes have failed.
3. Abrasive brushes and dics may be used to clean bare monel surface on leading edge of fin stabilzers.
4. For use on bare metal surface of propeller only.
5. For use on bare metal surfaces.
6. For use on 100% FR90 or greater.
7. See Underwater Ship Husbandry Manual Chapter 18, Propulsion Shaft Bearings for specific cleaning procedures.
8. See Table 081-3-2 for equipment approved for cleaning specific propulsor surfaces.

081-3.3.1 HULL CLEANING

CAUTION

The use of barnacle busters, coach bolt brushes or similar devices is prohibited.

CAUTION

Consult the latest Docking Report to determine the type of antifouling coating on a ship's hull.

CAUTION

During the cleaning the diver shall routinely monitor the performance of the cleaning and its impact on the coating system. Cleaning shall not result in scratches or swirl marks on the surfaces or abrasion of edges, corners, seams, welds, rivet or bolt heads, that expose on extend into the underlying layer of coating. Extreme diligences must be taken when monitoring the results of the cleaning process to differentiate between each exposed layer and ensure an intermediate layer has not been completely removed thus exposing the next layer having the same color as the outer layer.

CAUTION

If the paint is extremely soft and excessive material is being removed, discontinue cleaning immediately and contact NAVSEA Code 00C.

CAUTION

If during the cleaning process more than five (5) percent of the exposed surface of the outer most layer of an ablative anti-fouling paint system is removed, discontinue cleaning immediately and contact NAVSEA Code 00C.

081-3.3.1.1 The cleaning guidance provided in paragraphs 081-3.3.1.2 through 081-3.3.1.6 applies to painted surfaces of the hull and appurtenances.

081-3.3.1.2 Where convex hull curvature permits, multi-brush units may be used. The brushes used on these units shall be in good condition and conform to Section 4. The least aggressive brush necessary to achieve a properly cleaned surface while minimizing any impact on coating system shall be used. All rotating brushes shall be turned off or retracted from the hull during idle periods when the machine is resting on the hull as well as when the machine is being turned on the hull at the end of each swath.

081-3.3.1.3 In areas of smaller convex curvature, areas of concave curvature (such as found between the skeg and the ship's bottom) and areas of limited access, hand-held single brush units are permissible. The brushes used on these units shall be in good condition and conform to Section 4. The least aggressive brush necessary to achieve a properly cleaned surface while minimizing any impact on coating system shall be used.

081-3.3.1.4 All marine fouling shall be removed from painted surfaces painted with Formula 121, although this occurs less common since the paint specification was cancelled in 2005, along with a sufficient amount of the chemical surface layer

which forms on antifouling (AF) formula 121 so that a mottled pattern of the red AF paint is visible interspersed with the green. Extreme caution should be exercised to prevent damage to the paint. A properly cleaned painted surface is described in section 081-2.3.

081-3.3.1.5 All marine fouling shall be removed from surfaces coated with ablative or self-polishing paints so that a bright red or black surface should be present. On subsequent cleanings of ablative and self-polishing paints, a mottled pattern of red and black (representing the second coat of antifouling paint) shall be achieved. Extreme caution shall be exercised to prevent damage to the paint; the paint shall be cleaned with the least aggressive brush necessary to achieve a properly cleaned surface, as described in section 081-2.3.

081-3.3.1.6 All marine fouling shall be removed from painted surfaces treated with a fouling release system. Refer to section 081-2.1.5 prior to cleaning. Brushes approved for use on fouling release coatings shall be conditioned on a dry concrete surface to remove any sharp bristle tips prior to use. When cleaning, extreme caution shall be exercised to prevent damage to the paint. A properly cleaned painted surface is described in section 081-2.3.

081-3.3.2 CATHODIC PROTECTION SYSTEM CLEANING

CAUTION

The calcareous deposit formed on the dielectric shield shall be preserved.

CAUTION

Cleaning of an impressed current cathodic protection system anode with power tools is prohibited.

CAUTION

Devices (audible or visible) shall be placed in the vicinity of impressed current anodes, reference cells, and dielectric shields to guard these items against damage during the cleaning operation. The location of these items shall be obtained from the ship's dry docking drawing and ship's engineer prior to commencing the cleaning operation. The shield area is approximately 16 feet wide by 13 feet high with the anodes located in the geometric center.

081-3.3.2.1 The fouling on a dielectric shield shall be removed as prescribed for cleaning the surrounding hull coating utilizing single brush units.

081-3.3.2.2 Fouling on the surfaces of reference cells shall be removed with wooden or plastic hand scrapers.

081-3.3.2.3 Fouling on the surfaces of the impressed current cathodic protection system anode shall be cleaned by hand with either wooden or plastic scrapers and white or green abrasive hand pads. Extreme care shall be exercised to prevent damaging the glass reinforced plastic (GRP) holder and the platinum coated wire rod.

081-3.3.2.4 Fouling on sacrificial zinc anodes shall be removed with a wire hand brush, or wooden, plastic or metal hand scraper.

081-3.3.3 PROPULSOR CLEANING

CAUTION

Multi-brush units shall not be used on any propulsor surfaces.

081-3.3.3.1 There are a few different types of propulsors found on US Navy vessels; these include mono-bloc propellers, ducted propulsors, built-up propellers, and controllable-pitch propellers. There are unique components and feature of each type of propulsor; including the hub, blades, tips, edges, palms, bolts, cover plates, bolt on tips, tail cone, cap, Most Aggressive Features (MAF's) and devices. Each requires specific techniques, materials and equipment to effectively and safely perform the cleaning.

081-3.3.3.2 CLEANING TECHNIQUES. Each surface shall be cleaned by the least aggressive, but effective, tool. Table 081-3-2 provides the approved equipment and material for use on specific propulsor surfaces.

CAUTION

When cleaning submarine propellers, no abrasive power tools or devices shall be used for cleaning the 3-inch area adjacent to the propulsor leading edges, trailing edges, tips, cusps, and fillets (excluding hub to blade interface). Wire brushes shall not be used on the outer 3-inch periphery of any of the propulsor blades. Hand held Scotch-Brite pads (green and maroon), brass, hard plastic or wooden scrapers, nylon, polypropylene and polyester brushes, and authorized high-pressure water jets may be used to clean all areas of all propellers. Extreme care must be taken to retain the proper contour of these critical surfaces. Multi-brush units shall not be used on any of the propeller surfaces.

Table 081-3-2 PROPULSOR CLEANING MATERIALS

	Color	Size	Disc/ Brush Number (3M UPC)	Back-up Pad / Holder (3M UPC)	Blade Faces	Tip (Standard) Fairing Radius	Leading Edge	Trailing Edge (without knuckle)	Trailing Edge (with knuckle)	Hub Fillet	Hub	Dunce Cap (Standard)	Blade Palm	CPP Bolt Covers	CPP Closure Plate	CPP End Cover Plate	MAF - L/E	MAF - T/E	MAF - ID/OD	MAF -Cusps and Fillets	Tips (Bolt on)	Devices	Painted Surface
Hand Pads and Brushes																							
A-1 (Nylon)	Black	18 (in)	See note 3	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
A-2 (Polypropylene)	Red	9, 11, 13 (in)	See note 3	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C (Flat Wire)	Steel	9, 11, 13 (in), 330 (mm)	See note 3	N/A	x(5)					x(5)	x(5)	x(5)	x(5)	x	x	x							
H-1 (Polyester)	White	280 (mm)	See note 3	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
H-2 (Polyester)	Yellow	280 (mm)	See note 3	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
H-3 (Wire)	Stainless	280 (mm)	See note 3	N/A	x(5)					x(5)	x(5)	x(5)	x(5)	x	x	x							
D (Silicon Carbide Impregnated Nylon)	Black	5, 7, 12 (in)	See note 3	N/A	x					x	x	x	x	x	x	x			x(6)				
Marine Cleaning Disc																							
D3 extra coarse (silicon carbide)	Black	7.5 (in)	48011-04417-0	Aluminum 807 (048011-04241-1)	x				x (1)	x	x	x	x	x	x	x			x(6)			x(7)	
D5 extra coarse (silicon carbide)	Black	7.5 (in)	48011-32958	Aluminum 807 (048011-04241-1)	x				x (1)		x	x	x	x	x	x			x(6)			x(7)	
D3 extra coarse (silicon carbide)	Black	9 (in)	48011-32957-9	Aluminum 808 (048011-04242-8)	x				x (1)	x	x	x	x	x	x	x			x(6)			x(7)	
D5 extra coarse (silicon carbide)	Black	9 (in)	48011-32959-3	Aluminum 808 (048011-04242-8)	x				x (1)		x	x	x	x	x	x			x(6)			x(7)	
Hand Pads																							
Scotch-Brite™ 33 - Super Fine	White	6x12 (in)	48011-33012	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scotch-Brite™ 7445 - Super Fine (aluminum silicate)	White	6x9 (in)	48011-16976-7	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scotch-Brite™ 96 - Very Fine (aluminum oxide)	Green	6x9 (in)	48011-08293-1	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scotch-Brite™ 86 - Very Fine (aluminum oxide)	Green	6x9 (in)	48011-05509-6	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scotch-Brite™ 7447 - Very Fine (aluminum oxide)	Maroon	6x9 (in)	48011-04029-5	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Hand Scrapers																							
Plastic	Various	Various	Various	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x (4)
Wood	Various	Various	Various	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x (4)
Soft metallic	Various	Various	See note 2	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	

Table 081-3-2 PROPULSOR CLEANING MATERIALS - Continued

	Color	Size	Disc/ Brush Number (3M UPC)	Back-up Pad / Holder (3M UPC)	Blade Faces	Tip (Standard) Fairing Radius	Leading Edge	Trailing Edge (without knuckle)	Trailing Edge (with knuckle)	Hub Fillet	Hub	Dunce Cap (Standard)	Blade Palm	CPP Bolt Covers	CPP Closure Plate	CPP End Cover Plate	MAF - L/E	MAF - T/E	MAF - ID/OD	MAF -Cusps and Fillets	Tips (Bolt on)	Devices	Painted Surface
Water Jet Systems																							
Water Jet Gun, Non-Cavitating (for painted surfaces)	N/A	2,000 psi	N/A	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x (4)
Water Jet Gun, Non-Cavitating (for unpainted surfaces)	N/A	10,000 psi	N/A	N/A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	

Notes:
1. For use on trailing edge of surface ships only.
2. All metallic scrappers shall comply with NAVSEA Drawing 245-7605783 VIRGINIA CLASS PROPULSOR SCRAPERS
3. Refer to the Qualified Products List (section 5) for specific equipment and manufactures.
4. Refer to the section 3 for specific operating parameters.
5. Not permitted on submarine propellers
6. Not permitted for use within 3 inches of edges and adjacent surfaces.
7. For use on unrestricted surfaces. Not permited within 3 inches of any unique features.

081-3.3.3.2.1 For effective cleaning of bare nickel aluminum bronze surfaces of a propulsor with a fouling rating of FR-50 and above, the upper calcareous wall of the barnacles structure is best removed using a scraper, water jet gun, or rotary brush which severs it from the basal plate. The basal plate can then be removed, and the surface cleaned, by using an abrasive disc or brush. For growth that is FR-40 and less effective cleaning can be accomplished in a one-step process using an abrasive brush or disc or abrasive hand held pad. Abrasive brushes and discs must be kept moving across the surface of the propulsor to ensure a clean and smooth surface.

081-3.3.3.2.2 When using abrasive discs, unique configurations of the materials and cleaning techniques shall be used for specific areas being cleaned. Discs shall be mounted to the appropriate disc/brush back-up pad or holder and power unit (refer to Table 081-3-2). When cleaning flat surface (e.g., face) the disc shall be kept flat. When cleaning trailing edges with a knuckle the discs and back-up pad or holder shall be rigid to prevent the disc from rounding the distinct edge, break, knuckle and trailing edge radius. When cleaning convex surface such as the leading edges, tip fairing radius, and trailing edges with a fairing radius (no distinct knuckle or break) the discs shall be flexible (D3) to allow the disc to conform around the curvature. When cleaning concave areas (e.g., fillets) the discs and back-up pad or holder shall be flexible to allow the disc to conform to the geometry. When cleaning the convex areas (e.g., hub, dunce cap, bolt on tips) the disc and back-up pad or holder shall be flexible to allow the disc to conform to the curvature.

081-3.3.3.2.3 When cleaning painted propulsor surfaces hand scrapers, and rotary brushes with nylon, polypropylene and polyester bristle may be used to remove the fouling.

081-3.3.3.2.4 The diver shall maintain positive control of the equipment to prevent water jet guns and rotary tool motors, housings and controls from contacting the propulsors surface. Care must be taken to prevent the quick disconnect fittings on hydraulic hoses, metallic equipment housing and nozzles from contacting the painted and unpainted propulsor surfaces. Equipment shall be protected with energy absorbing coatings (e.g. rubber) to prevent it from denting or scratching the propulsor surfaces during cleaning.

081-3.3.3.3 EQUIPMENT AND MATERIAL SELECTION Proper tool selection is essential in preventing damage to the surface. Table 081-3-2 provides the approved equipment and material for use on specific propulsor surfaces. Improper cleaning may result in changes to the propulsor's acoustic signature, and induce singing or cavitation. The selection of the cleaning equipment and material is based upon the type of propulsors being cleaned and severity of the fouling. The following precautions must be taken.

081-3.3.3.4 UNPAINTED PROPULSOR

CAUTION

At no time should high-pressure water jets being used on bare propulsor surfaces be allowed to operate at pressures above 10,000 pounds per square inch (psi).

CAUTION

Although approved for limited use on unpainted propulsors, wire brushes shall be used only as a last resort by a highly trained diver to remove severe fouling. Because of its configuration, wire brushes can cause scratches and gouges on the surfaces if used by an inexperienced diver. Wire brushes shall not be used to clean the outer 3-inch periphery of propulsor blades, critical areas and areas of high curvature.

NOTE

Any suspected use of wire brushes or hard tool on the outer 3-inch periphery of propulsor blades, critical areas and areas of high curvature shall be documented and reported to the Type Commander and NAVSEA Code 00C.

CAUTION

Use only the most experienced personnel when cleaning the outer 3-inch periphery of propulsor blades. These personnel shall be familiar with the critical areas and areas of high curvature geometry.

081-3.3.3.4.1 Surface ship propulsors have a range of complex geometries that will require periodic cleaning. All areas of an unpainted propulsor, except critical areas (the 3-inch area adjacent to the propulsors leading edges, trailing edges), may be cleaned with non-abrasive nylon, polypropylene, and polyester brushes, wire brushes, silicon carbide impregnated nylon brushes, abrasive discs, high-pressure water jet guns, abrasive hand pads, and hand scrapers. The critical areas shall be cleaned by abrasive hand pads, hand scrapers, nylon, polypropylene, and polyester brushes, water jet guns and abrasive discs.

081-3.3.3.4.2 Submarine propulsors have a range of complex geometries that will require periodic cleaning. All areas of an unpainted propulsor, except critical areas (the 3-inch area adjacent to the propulsors leading edges, trailing edges, tips, MAF's, cusps, fillets and leading and trailing edges), may be cleaned with non-abrasive nylon, polypropylene, and polyester brushes, silicon carbide impregnated nylon brushes, abrasive discs, high-pressure water jet guns, abrasive hand pads, and hand scrapers. The critical areas shall be cleaned by abrasive hand pads, hand scrapers, nylon, polypropylene, and polyester brushes, and water jet guns.

081-3.3.3.5 PAINTED PROPULSORS

CAUTION

At no time should pressure water jets being used on a painted propulsor surfaces be allowed to operate at pressures above 2,000 psi.

CAUTION

Use only the most experienced personnel when cleaning the outer 3-inch periphery of propulsor blades. These personnel shall be familiar with the critical areas and areas of high curvature geometry.

081-3.3.3.5.1 Surface ship propulsors that are painted will require periodic cleaning. All areas of a painted propulsor may be cleaned with non-abrasive nylon, polypropylene, and polyester brushes, water jet guns, and wooden or plastic hand scrapers.

081-3.3.3.6 UNPAINTED PORTION OF A DUCTED PROPULSORS

CAUTION

At no time should high-pressure water jets being used on bare ducted propulsor surfaces be allowed to operate at pressures above 10,000 psi.

CAUTION

Use only the most experienced personnel when cleaning the outer 3-inch periphery of ducted propulsor blades. These personnel shall be familiar with the critical areas and areas of high curvature geometry.

NOTE

Any suspected use of improper cleaning shall be documented and reported to the Type Commander and NAVSEA Code 00C.

081-3.3.3.6.1 The unpainted surfaces of ducted propulsors have a range of complex geometries that will require periodic cleaning. All areas of an unpainted propulsor, except critical areas (the 3-inch area adjacent to the propulsors leading edges, trailing edges, tips, MAF's, cusps, fillets and leading and trailing edges), may be cleaned with non-abrasive nylon, polypropylene, and polyester brushes, silicon carbide impregnated nylon brushes, abrasive discs, high-pressure water jet guns, abrasive hand pads, and hand scrapers. The critical areas shall be cleaned by abrasive hand pads, hand scrapers, nylon, polypropylene, and polyester brushes, and water jet guns.

081-3.3.3.7 PAINTED PORTION OF A DUCTED PROPULSORS

CAUTION

At no time should pressure water jets being used on painted ducted propulsor surfaces be allowed to operate at pressures above 2,000 psi.

CAUTION

Metallic scrapers are not authorized on painted portions of ducted propulsors

CAUTION

Use only the most experienced personnel when cleaning the outer 3-inch periphery of propulsor blades. These personnel shall be familiar with the critical areas and areas of high curvature geometry.

081-3.3.3.7.1 Ducted propulsors that are painted will require periodic cleaning. All areas of painted propulsors may be cleaned with nonabrasive nylon, polypropylene, and polyester brushes, water jet guns, abrasive hand pads, and hand scrapers. Isolated unpainted surfaces found on a painted propulsor shall be cleaned with hand scrappers and abrasive pads working in the direction away from the paint transition.

081-3.3.4 SONAR SYSTEMS CLEANING

CAUTION

Multi-brush units are forbidden on sonar domes or on rubber-coated surfaces. It is not permissible to drive such machines across these surfaces.

CAUTION

Wire brushes are forbidden on rubber or glass reinforced plastic (GRP) sonar domes or rubber-coated surfaces.

CAUTION

High-pressure water jets are prohibited from use on rubber or rubber-coated sonar domes and surfaces, or GRP sonar domes.

081-3.3.4.1 Surface ship bow mounted and keel no-foul rubber sonar domes (Figure 081-3-1 and Figure 081–3–2) may be cleaned using single brush units employing nylon brushes or abrasive disc (D3). Submarine GRP sonar domes may be cleaned using nylon brushes only. Extreme caution shall be exercised when cleaning these surfaces to prevent scratches or damage to the sonar dome or rubber-coated surface.

081-3.3.4.2 On both rubber and GRP domes, heavy calcareous growth should first be broken down using wooden or plastic hand-held scrapers. Extreme care shall be exercised to prevent damage. Abrasive discs (D3) may be used on rubber domes to remove heavy grass and calcareous fouling. The disc must be used with caution and kept in flat contact with the rubber surface. Do not allow the disc to operate on edge. Difficulty in handling the single brush unit due to excessive bouncing and chattering of the disc when in contact with the rubber surface is typically caused by low revolutions per minute. If any signs of damage to the sonar dome caused by cleaning are noted, discontinue dome cleaning immediately and notify NAVSEA Code 00C.

081-3.3.4.3 Fouling of acoustic windows made of rubber or Ethylene Propylene Diene Monomer (EPDM) may be cleaned with wooden scrapers, black nylon Duddlebug hand brushes, white abrasive hand pads, and nylon, polypropylene, and polyester brushes. Before rotary brushes may be used on the rubber surface they shall be conditioned by running on dry concrete or asphalt until the sharp bristle tips been worn down.

Figure 081-3-1 Bow-Mounted Sonar Dome Rubber Window.

Figure 081-3-2 Bow-Mounted Sonar Dome Rubber Window (NO-FOUL).

081-3.3.5 MASKER AIR EMITTER BELT CLEANING

CAUTION

Prior to cleaning the masker air system, the hull isolation valves must be secured.

NOTE

Table 081-3-3 is provided for guidance in identifying the masker air system hull isolation valves on various ship classes.

081-3.3.5.1 This cleaning is a three step process which will improve the performance of the masker belts. Experience has shown that each of these processes is equally important and serves several distinct cleaning objectives. These steps can neither be done in random order, nor consolidated.

081-3.3.5.2 Remove marine growth and calcium from the external surfaces of the masker belt using a single brush unit equipped with a nylon, polypropylene, or polyester brush for painted masker belts or wire brush, or abrasive discs for unpainted copper-nickel masker belts. Caution must be exercised to avoid contacting epoxy and/or painted edges with the brush or disc.

081-3.3.5.3 Internal surfaces of the belts should be cleaned using a 10,000 psi flexible lance to remove all fouling and calcification that has accumulated. The lance should be inserted into the cleanout opening at a rate of one foot per minute (FPM) until the lance has traveled five feet. Once this distance is reached, the lance should be retracted at the same continuous rate. Several passes of the lance will be required until this five foot section is thoroughly clean. During retraction, debris will be expelled from the cleanout opening until the interior surfaces are clean. Once the section is clean, proceed to insert the lance to the next increment.

CAUTION

Any damage (i.e., dents, crushing, or twisting) to the belt could interfere with the ability of the lance to be inserted and could cause the lance to become lodged inside. Therefore a precise measurement of any damage from the cleanout plug is mandatory. The lance should be clearly marked to prevent the lance from being inserted beyond the point of damage.

081-3.3.5.4 Marine fouling and calcification that restricts the emitter holes can be removed by external hydroblasting the individual holes using the 10,000 psi zero thrust gun. With an eductor installed in the cleanout opening and operating, hydroblast each of the holes until they are clean. Caution must be exercised to avoid contacting epoxy and/or painted edges with the high pressure water stream.

081-3.3.5.5 Upon completing the external hydroblasting, conduct a visual inspection of the belts to determine cleanliness. This can be accomplished by divers' supplying fresh water through the cleanout opening or by ship's force supplying bleed air to the belt. By using either test, divers can visually verify the flow out of the emitter holes.

CAUTION

Before pressurizing the masker emitter belt with fresh water, ensure that the masker emitter shut off (isolation) valve is secured. This valve is located inboard of the hull penetration for the emitter belt supply line.

081-3.3.5.5.1 Flow Check Using Fresh Water. Connect the fresh water supply line to the cleanout opening and supply 35 psi water. Examine each hole to determine the cleanliness. If more than 5 percent of the holes are restricted, repeat the external hydroblasting.

WARNING

During the initial activation of the masker air system, divers should stand clear of the emitter system until the air has been adjusted to a low flow rate. Otherwise the diver could by blown off the system and up to the surface.

081-3.3.5.5.2 Flow Check Using Bleed Air. Have the ship light off the masker air systems and adjust the flow to a bleed. Once flow rate has stabilized, the diver examines each hole to determine the cleanliness. If more than 5 percent of the holes are restricted, repeat the external hydroblasting.

081-3.3.6 HUB MASKER AIR EMITTER CLEANING. The hub masker air systems are located on the rope guards and fairwaters of the main struts on various ship classes.

081-3.3.6.1 This cleaning is a three step process which will improve the performance of the hub masker air system. Experience has shown that each of these processes is equally important and serves several distinct cleaning objectives. These steps can neither be done in random order, nor consolidated.

CAUTION

CAUTION Prior to cleaning the air system, the hub masker air supply hull isolation valves must be secured.

NOTE

Table 081-3-3 is provided for guidance in identifying the masker air system hull isolation valves on various ship classes.

NOTE

Use of water jets on painted masker air emitter systems is permitted when it is necessary to clean masker emitter holes.

081-3.3.6.2 Remove marine growth and calcium from the tops of the emitter holes on the rope guards and fairwaters. A nylon, polypropylene, or polyester brush should be used for rope guards and fairwaters with emitter holes drilled directly into the rolled plating. An abrasive disc should be used on copper-nickel nozzles which have emitter holes drilled into the nozzle. A nylon, polypropylene, or polyester brush should be used on Teflon nozzles.

081-3.3.6.3 Marine fouling and calcification within the hub masker air supply tube can be removed by using a 2,500 psi flexible lance inserted into the cleanout openings. These openings are found at the top and bottom of the rope guards and fairwaters and should have a plug installed. If extreme corrosion exists around a plug and damage could occur, do not attempt removal; inform the ship and the Navy's Fleet hull cleaning representative, and proceed with the external hydroblasting. Some rope guards are installed in two halves which may be connected internally with flexible hoses and fittings that will prevent the lance from passes to the other half. Clean both inboard and outboard sides of the supply tube and then transfer to the other cleanout opening to clean the other half. Do not internally hydrolance if the hub masker air nozzles are Teflon.

081-3.3.6.4 Marine fouling and calcification that restrict the emitter holes can be removed by external hydroblasting the individual holes using the 10,000 psi zero thrust gun. With an eductor installed in the cleanout opening and operating, hydroblast each of the holes until they are clean. When two cleanout openings are available, install the eductor on the lower opening. Caution must be exercised to prevent the high pressure water jet from contacting the painted surfaces around the holes and nozzles. Do not externally hydroblast if the nozzles are Teflon.

CAUTION

During the initial activation of the hub masker air system, divers should stand clear of the emitter system until the air has been adjusted to a low flow rate. Otherwise the diver could by blown off the system and up to the surface.

081-3.3.6.5 Have the ship light off the hub masker air systems and adjust the flow to a bleed. Once flow rate has stabilized, the diver examines each hole to determine the cleanliness. If more than 5 percent of the holes are restricted, repeat the cleaning process.

Table 081-3-3 MASKER AIR SYSTEM HULL ISOLATION VALVES

	SHIP CLASS			
	FFG-7	DD-963 DDG-993	CG-47	DDG-51
Hub Air Cut Off Valves	N/A	MA-627	MA-627	MA-V-97
Emitter Belt Hull Stop Valves	2-175-2	MA-23	MA-23	MA-V-(2-122-2)
	2-177-1	MA-31	MA-39	MA-V-(2-122-1)
	PMA-V5A	MA-39	MA-47	MA-V-(2-172-1)
	PMA-V5B	MA-47	MA-63	MA-V-(2-172-2)
		MA-55	MA-102	MA-V-(1-232-1)
		MA-63	MA-110	MA-V-(1-232-2)
		MA-102	MA-126	
		MA-110	MA-134	
		MA-118		
		MA-126		
		MA-134		
		MA-142		
NOTE: The valves presented in Table 081-3-3 are provided as guidance only. System configurations should be verified on each ship to ensure the proper valves are identified and secured.				

081-3.3.7 PRAIRIE EMITTER CLEANING. On ships outfitted with PRAIRIE systems, air emitter holes are located near the edge of each fin stabilizer and on propeller blade leading edges.

CAUTION

Do not attempt to clean PRAIRIE emitter holes without a minimum of 10 feet of water below the lowest emitter hole (propeller or stabilizer). This system will ingest stirred up silt from the shallow bottoms when air is secured after cleaning, resulting in clogged internal piping. System shall not be cleaned without the PRAIRIE system operating.

081-3.3.7.1 PRAIRIE PROPELLER CLEANING. After cleaning propeller blade surfaces, provide normal PRAIRIE air pressures to propeller blades. Fin stabilizer cutout valves should be closed. Using an approved waterjet system, begin cleaning at the uppermost emitter holes and work downward using the lowest water jet pressure possible to clear emitter holes. In no instance shall water jet pressure be allowed to rise over 10,000 psi.

081-3.3.7.2 PRAIRIE FIN STABILIZER CLEANING. After cleaning the fin stabilizer surfaces with either a nylon, polypropylene, polyester, or wire brush, secure the inboard isolation valve, install an eductor on the cleanout opening and clean each hole with an approved water jet system, begin cleaning at the uppermost emitter holes and work downward using the lowest water jet pressure possible to clean emitter holes.

081-3.3.8 SEA CHEST CLEANING. Sea chest cleaning shall be accomplished using hand scrapers, single brush units fitted with nylon, polypropylene, or polyester brush or water jets.

CAUTION

When using high-pressure water jets to clean sea chests and gratings, do not allow jet stream to contact painted hull surfaces adjacent to sea chests.

081-3.3.9 SUBMARINE SPECIAL HULL TREATMENT (SHT) CLEANING. Hull cleaning on SHT is restricted to multi-brush units fitted with nylon, polypropylene or polyester and/or wire brushes, and single brush units fitted with nylon (with or with out silicone carbide), polypropylene or polyester brushes. The least aggressive, but effective, brush shall be used. In the event that tenacious filaments (e.g., grass) are present, NAVSEA Code 00C approved wire brushes may be used on multi-brush unit only after the less aggressive brushes have proven ineffective in removal of this fouling. However, when the wire brushes are utilized they shall be new at the start of the operation. If at any time scratching or gouging of the SHT surface is noted, cleaning shall be suspended and new brushes installed prior to resuming work. If damage persists, the cleaning operation shall be canceled and NAVSEA Code 00C notified.

081-3.3.10 WOOD AND FIBERGLASS HULL COATINGS. Hull cleaning on wood and fiberglass hulls is restricted to single brush units operating with nylon, polypropylene or polyester brushes and multi-brush units operating with brush composed of nylon, polypropylene or polyester, wire or a combination of these materials. Hard calcareous fouling must be removed using handheld scrapers.

081-3.3.11 FIBERGLASS (GRP) COVERED PROPULSION SHAFTS. Cleaning of fiberglass covered shafts is restricted to single brush units. Nylon, polypropylene or polyester brushes should be used to remove biofouling up to FR-50; wire brushes may be used to remove any residual fouling or fouling of a higher rating. Exercise extreme caution when using wire brushes to prevent damaging the glass reinforced plastic (GRP) covering. If at any time scratching or gouging of antifouling coating or underlying GRP is noted, cleaning shall be suspended and new brushes installed prior to resuming work. If damage persists, the cleaning operation shall be canceled and NAVSEA Code 00C notified.

081-3.3.12 AUXILLARY PROPULSION UNITS AND SECONDARY PROPULSION MOTORS

CAUTION

When using high-pressure water jets to clean the propeller, do not allow jet stream to be directed towards adjacent painted surfaces, the water cooling ports, or between the propeller hub and motor housing.

The auxiliary propulsion units and secondary propulsion motors consist of a fairing plate, electric motor and propeller, and support column. The painted fairing plate and motor housing shall be cleaned as prescribed for the surrounding hull coating. The propeller shall be cleaned wooden and brass scrapers, green, maroon or black abrasive hand pads, 3-inch diameter black coating removal discs and blue surface conditioning discs, and water jets. The support column shall not be cleaned.

081-3.3.13 BOW THRUSTERS. The inlet to the bow thruster, grates and bars, and inside surfaces shall be cleaned as prescribed for the surrounding hull coating. The propeller shall be cleaned with wooden and brass scrapers, green, maroon or black abrasive hand pads, 3-inch diameter black coating removal discs, blue surface condiitoning discs, and wsterjets.

SECTION 4
HULL CLEANING EQUIPMENT

081-4.1 AVAILABLE CLEANING METHODS

081-4.1.1 Several types of tools are available for waterborne cleaning. Authorized contractor personnel have single-brush and multi-brush equipment which provides efficient results for underwater hull cleaning. Navy personnel have access to a variety of cleaning equipment provided the equipment conforms to NAVSEAINST 10560.2, Diving Equipment Authorized for Navy Use. All equipment (Contractor and Navy) shall meet Section 5 requirements and shall conform to the following.

081-4.2 CLEANING EQUIPMENT

081-4.2.1 GENERAL. Five categories of cleaning equipment: single brush units, multi-brush units, rotary brushes and discs, water jets (guns and hydrolances), and hand tools (abrasive pads and scrapers), are approved for cleaning various ship systems. Refer to Table 081-3-1 for specific applications and Figure 081-4-1 for photographs of typical equipment. There is a wide range of brushes and discs available for use on the single- and multi-brush units. Due to the special configuration of Navy ships and critical areas such as propellers and propulsors, impressed current cathodic protection system, sonar domes, special appendages and special paint formulas, all underwater hull cleaning equipment shall be diver operated and controlled. The diver shall have voice communications with the surface, and shall have the means, on the equipment, to stop, start, and maneuver cleaning equipment.

081-4.2.1.1 SINGLE BRUSH UNITS. These hand-held units are powered either hydraulically or pneumatically and utilize one brush or disc. The brushes and discs used on these units shall be in good condition. Hand-held rotary single brush units may be employed to clean those areas inaccessible to multi-brush units or those areas in which multi-brush units are prohibited. Rotary diver tools operate at wide range of revolutions per minute (r/min) based upon the size and material of the brush or disc being utilized.

081-4.2.1.2 MULTI-BRUSH UNITS. The self-propelled, multi-brush units are powered either hydraulically or electrically and have several large brushes thus permitting a wide swath to be cleaned on each pass along the hull. Multi-brush units rely on the rotating motion of the brushes or on an impeller to provide the suction force which holds the machine against the hull. The machine must be controlled by a diver-operator who guides the machine along the hull, steering it around obstructions and along the desired cleaning path. All brushes shall be in good condition. All rotating brushes on multi-brush units shall be turned off or retracted from the hull during idle periods when the machine is resting on the hull as well as when the machine is being turned on the hull at the end of each swath. Metal type traction grippers are prohibited on any machines as is any device on the wheels which will damage the hull paint.

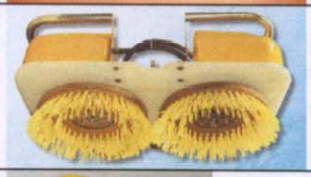
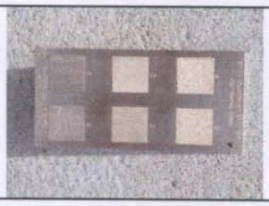
Tools	Product Num.	
Multi-Brush Units	SCAMP-C	
	UMC: Mini-Pamper	
	UMC: Twin Brush (Pee-Jay)	
Single Brush Units	Stanley: GR-29 (with propeller polishing disc installed)	
	UMC: MK11 Hydraulic Tool	
Brushes for Single- and Multi- Brush Units	Various	
	UMC: Various	
Rupert's Propeller Roughness Comparator	Rubert & Co. Ltd. Demmings Road Cheadle, Cheshire England 4461-428-6058	

Figure 081-4-1 (SH 1) Typical Cleaning Equipment (Sheet 1 of 2)

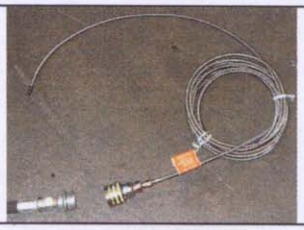
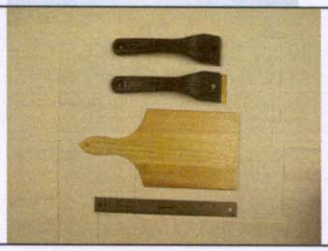
Zero Thrust Waterjet Gun	Typical shown	
Hydrolance	Typical shown	
Abrasive Hand Pad	Typical shown	
Hand Scraper	Typical shown	

Figure 081-4-1 (SH 2) Typical Cleaning Equipment (Sheet 2 of 2)

081-4.2.1.3 BRUSHES AND DISCS. There is a wide range of brush and disc compositions that can clean a ship. Typically brushes are made of synthetic (nylon, polypropylene, polyester) and natural metallic (ferrous and non-ferrous) materials. The bristle size, strength, orientation and density of can make these brushes more or less aggressive in removing fouling. The discs are typically made of synthetic (Cubitron) and natural (silicon carbide and aluminum oxide) materials embedded in a matrix of synthetic fibers. The abrasive grit size and matrix and density of the fiber can make these discs more or less aggressive in removing fouling. Many of these materials can aggressively remove fouling while reducing the cleaning effort and time. However, the complex and delicate nature of many ship systems (e.g., hull coatings, propulsors, sonar, masker air, etc.) make these systems susceptible to damage and expensive repair costs. Choosing a brush or disc that efficiently removes the fouling while minimizing the potential to cause damage to the underlying ship system is paramount. Brushes and discs may be used on various ship systems, refer to Section 3 for the specific application for which each is approved for use. The least aggressive brush or disc that is effective to achieve a properly cleaned surface shall be used.

081-4.2.1.4 WATER JETS. Authorized high-pressure water jets; such as guns and hydrolances, are to be used predominantly on unpainted surfaces such as masker air systems and propellers. Use of water jets on painted surfaces is restricted to sea chests, painted masker air emitter systems when it is necessary to clean masker emitter holes and painted portions of propulsors. The configuration and maximum operating parameters shall be restricted to the ship system being cleaned; refer to Section 3.

081-4.2.1.4.1 WATER JET GUNS. Water jet gun systems may be used to remove fouling as prescribed in Section 3. Two types of systems are available: cavitating systems and noncavitating systems. Cavitating systems utilize a nozzle especially designed to induce cavitation at the surface being cleaned. The advantage of this type system is that a lower water pressure can be used to remove fouling, since much of the cleaning energy needed is provided by the cavitation effect itself. Noncavitating systems rely solely on the energy contained in the water

jet itself, and thus require a higher operating pressure to achieve the same cleaning effectiveness as cavitating systems. Unlike conventional water jets used for surface operations, diver operated water jets contain a zero thrust nozzle which discharges a second stream of water in the opposite direction of the cleaning stream to negate the thrust and permit the diver to work more easily and efficiently.

081-4.2.1.4.2 HYDROLANCES. Authorized high pressure flexible lances are to be used predominantly for internal cleaning of masker air emitter belts, hub air (rope guard and fairwater), and propulsion shaft bearing staves. At no time shall the hydrolance be allowed to operate at pressures exceeding the limits specified in the applicable cleaning procedures.

081-4.2.1.5 HAND-HELD TOOLS. There are many types of hands tools available for cleaning. Many hand tools may seem benign but can actually cause damage if used improperly. Only approved hand tools shall be utilized to clean ship systems.

081-4.2.1.5.1 HAND-HELD SCRAPERS. Various types of wooden, plastic, and soft metallic scrapers shall be used to remove fouling. All metallic scrappers shall comply with NAVSEA Drawing 245-7605783 VIRGINIA CLASS PROPULSOR SCRAPERS . Soft metallic scrapper shall utilize material with yield strength less than 24 ksi (e.g. ASTM B36 UNS C22000). Some typical scrapers are shown in Figure 081-4-1.

081-4.2.1.5.2 HAND-HELD ABRASIVE PADS. Abrasive hand pads can be used to clean a variety of fouled surfaces. A typical abrasive pad is shown in Figure 081-4-1.

081-4.2.1.5.3 PROPELLER SURFACE ROUGHNESS COMPARATOR SCALE. The Rubert's propeller surface roughness comparator scale can be used to gauge the condition of the propeller surface. A machinist surface comparator can also be used and provide a direct visual comparison to the propeller finish requirements.

SECTION 5
EQUIPMENT PERFORMANCE QUALIFICATION TESTS

081-5.1 GENERAL.

All equipment utilized for underwater hull cleaning must be approved prior to use. New equipment must be tested and evaluated to ensure it is effective in cleaning and does not damage the underlying surface. Any activity (Contractor or Navy) proposing a new piece of cleaning equipment shall demonstrate the safe and effective use of the equipment and provide adequate documentation to NAVSEA Code 00C for review and approval prior to its use. The tests may be performed by the activity proposing its use. Approved equipment (Contractor and Navy) will appear on the Qualified Product List (QPL). The QPL is available on the NAVSEA Code 00C web site
http://www.supsalv.org.

081-5.2 TEST REQUIREMENTS.

Equipment and materials shall be tested in accordance with a NAVSEA Code 00C approved test plan. The test shall be observed by NAVSEA Code 00C or a duly authorized representative.

081-5.2.1 EFFECT ON THE UNDERLYING SURFACE. The primary objective is to determine the effects the equipment has on the surface being cleaned. A tank test shall consist of cleaning the specific surface material (e.g. steel coated with an anti-fouling coating system, nickel aluminum bronze, rubber sonar dome, masker air emitter belt, etc‴) and documenting the equipments effect on the cleaned surface. The surface shall be quantitatively measured before and after cleaning. The test activity shall be responsible for the testing and documentation. To ensure operational and statistical validity the test shall be accomplished a minimum of 3 times.

081-5.2.2 EFFECTIVENESS IN REMOVING FOULING. The secondary, but equally important, objective is to determine the effectiveness of the equipment to remove fouling. The presence of fouling on the surface of the ship system is essential for evaluating the equipment's effectiveness to remove the fouling. The surface shall be fouled to a minimum of the cleaning criteria for the ship system as defined in Section 3. The fouled surface area shall be quantitatively measured and incrementally marked prior to testing. The area shall be cleaned and the time and effort required to achieve the cleaned condition shall be recorded. The test activity shall be responsible for the testing and documentation of the material selected during the tests and evaluate its effectiveness in cleaning. To ensure operational and statistical validity the test shall be accomplished a minimum of 3 times.

081-5.3 DOCUMENTATION.

Proper documentation is crucial in ensuring the validity of the test and the timely review and approval. The final report to be submitted to NAVSEA Code 00C for approval shall include a copy of the approved test plan, equipment description and specifications, operating parameters, results, observations and conclusions.

081-5.3.1 TEST PROCEDURE. The test procedure shall contain the detailed requirements of the test to be conducted. This shall include, at a minimum, a description of the surface being cleaned, description and specification of the cleaning equipment, test fixture design, set-up and operation, preparing the surface for cleaning (i.e., exposing the surface to fouling), the operating parameters, and reporting requirements.

081-5.3.2 EQUIPMENT DESCRIPTION AND SPECIFICATION. The report shall contain a detailed description of the materials and the physical characteristics of the equipment.

081-5.3.3 FOULING. The level of fouling shall be recorded both in tabular form and with digital imagery.

081-5.3.4 OPERATING PARAMETERS. The performance characteristic of the tools shall be recorded. This includes, but is not limited to, flow, pressure, speed, translation, force and the duration of time applied to the surface.

081-5.3.5 VISUAL INSPECTION. The surface being cleaned shall be inspected before and after cleaning. The report shall contain a digital record of the visual inspection. When documenting the effect a material has on the surface cleaned in a tank the specimen shall be removed from the water, allowed to dry and the surface inspected under magnification. The digital images shall be done at sufficient magnification to clearly detect and record changes in the surfaces caused by the cleaning. For example, the surface of an ablative coating may require magnification of 1x, 50x and 100x, while the surface of an unpainted propulsor may require magnification of 1x, 50x, 100x, 250x, and 500x. When documenting the effectiveness fouling removal and efficiency on a waterborne vessel magnification is not required.

081-5.3.6 QUANTITATIVE INSPECTION. The surface being cleaned shall be quantitatively inspected before and after cleaning. The sensitivity of measure shall detect a change within one-half of the tolerance in the system design. For example, the accuracy of measuring the linear surface of a propeller should be +/- 0.0005 inches and for measuring a change thickness of an ablative coating should be +/- 0.05 mils. Various forms of measure may be required depending upon the surface being cleaned. This includes, but is not limited to, thickness, roughness, and weight.

APPENDIX A

TECHNICAL MANUAL DEFICIENCY/EVALUATION REPORT (TMDER)

NOTE

Ships, training activities, supply points, depots, Naval Shipyards, and Supervisors of Shipbuilding are requested to arrange for the maximum practical use and evaluation of NAVSEA technical manuals. All errors, omissions, discrepancies, and suggestions for improvement to NAVSEA technical manuals shall be reported to the Commander, NAVSURFWARCENDIV, 4363 Missile Way, Port Hueneme, CA 93043-4307 on NAVSEA/ SPAWAR Technical Manual Deficiency/Evaluation Report (TMDER), NAVSEA Form 4160/1. To facilitate such reporting, print, complete, and mail NAVSEA Form 4160/1 below or submit TMDERS at web site https://nsdsa2.phdnswc.navy.mil/tmder/tmder-generate.asp?lvl=1. All feedback comments shall be thoroughly investigated and originators will be advised of action resulting therefrom.

TMDER / MAILER