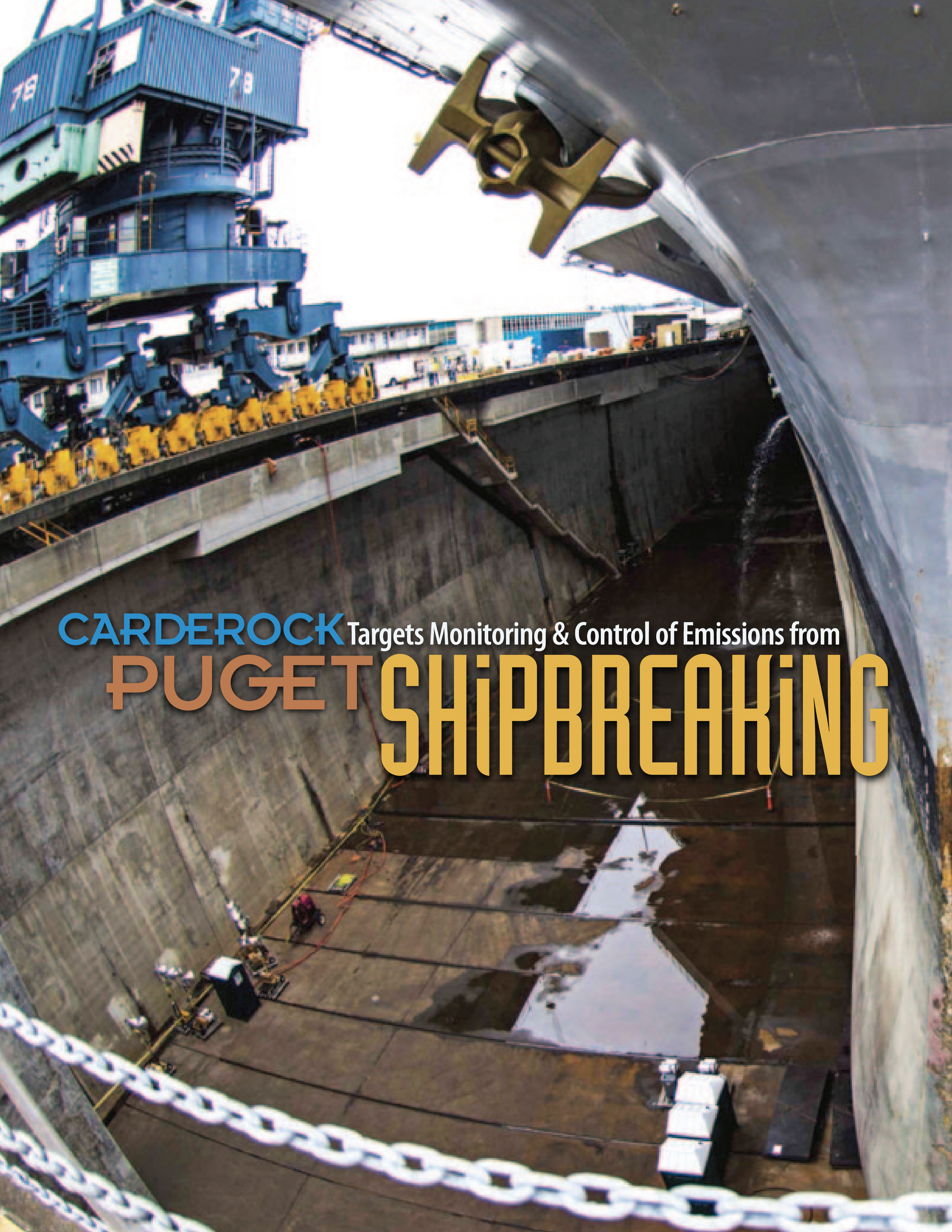


CARDEROCK Targets Monitoring & Control of Emissions from PUGET SHIPBREAKING

New Technologies Target Thermal Cutting Operations & Fugitive Emissions

Personnel from the Naval Surface Warfare Center, Carderock Division (NSWCCD) with resources provided by the Navy Environmental Sustainability Development to Integration (NESDI) program are tackling the mounting challenges posed by tighter and tighter air emission standards associated with shipbreaking processes at Puget Sound Naval Shipyard and Intermediate Maintenance Facility (PSNS&IMF).

When a ship or submarine reaches the end of its service life, PSNS&IMF—the Navy's nuclear shipbreaking facility—is tasked with dismantling it and turning it into scrap metal. Presently, oxygen-fuel cutting is the most prevalent method utilized for these large-scale metal cutting operations, as it is both efficient and cost-effective. Unfortunately, this process, also known as hot cutting, generates visible emissions, metal fumes and debris containing chromium, manganese, iron oxides and other metals that may pollute the air and be harmful to human health. Clean Air Act (CAA) regulations require that visible emissions not exceed a specified opacity limit, and the National Pollutant Discharge Elimination System (NPDES) program regulates the concentration of metals in discharged water.

When a ship or submarine reaches the end of its service life, PSNS&IMF—the Navy's nuclear shipbreaking facility—is tasked with dismantling it and turning it into scrap metal.

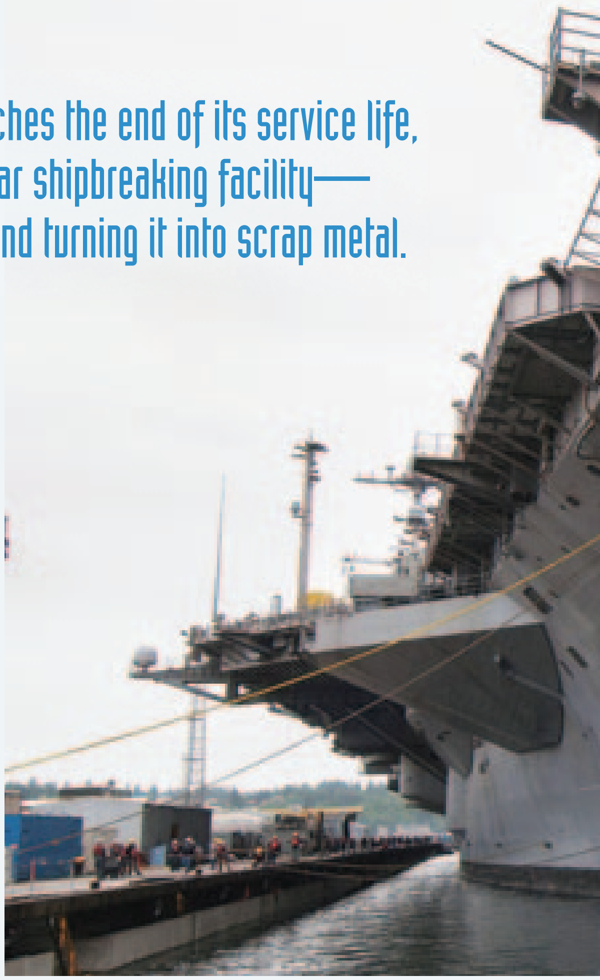
At PSNS&IMF, the fumes generated during hot cutting have the potential to exceed the Puget Sound Clean Air Agency's (PSCAA) Visible Emission Standard—a stringent 20 percent opacity.

The Inactivation, Reactor Compartment Disposal, and Recycling (IRR) program at PSNS&IMF spends a significant level of effort and resources mitigating visible air emissions associated with this process.

The IRR program has certified personnel to conduct visible emission monitoring using U.S. Environmental Protection Agency (EPA) Method 9, but the results provided an unacceptable margin of error, and place excessive burden on the certified opacity readers and the production personnel who rely on the timely receipt of these readings.

Therefore, PSNS&IMF has moved to using tent-like structures with ventilation to control potential visible emissions from hot cutting operations on submarines. These structures are an added cost and impediment to daily mission execution. In addition, this approach is not practical for recycling large surface ships, which cannot be tented due to their size.

An ever-increasing workload at PSNS&IMF is only compounding the problem. In addition to dismantling two submarines per year, the IRR program is currently dismantling the ex-USS Long Beach (CGN 9), an 800-foot cruiser. Another large ship, the aircraft carrier USS Enterprise (CVN 65), is scheduled for dismantling beginning in 2018. As Kurt Doehnert from the Naval Sea Systems Command (NAVSEA) stated, "These opacity abatement NESDI demonstration projects are the highest priority in our corporate naval shipyard technology program project portfolio."



The Nimitz-class aircraft carrier USS John C. Stennis (CVN 74) enters dry dock at PSNS&IMF.
Wendy Hallmark

EARLY EFFORTS

Over the last several years, numerous projects, sponsored by the NESDI and other programs, have been launched to mitigate the air emissions associated with the shipbreaking process.

The Nimitz-class aircraft carrier USS John C. Stennis (CVN 74) enters dry dock at PSNS&IMF to begin a scheduled docking planned incremental availability. The dry dock provides Sailors and shipyard workers access to the ship below the waterline for maintenance, repairs and refurbishments.
Wendy Hallmark

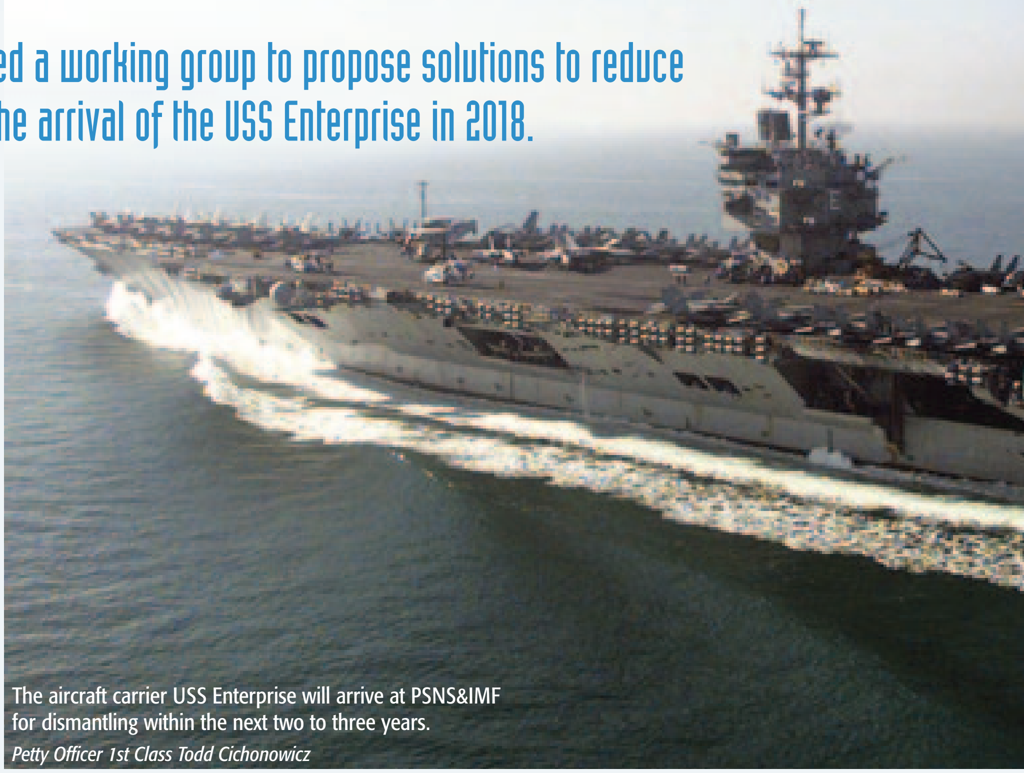
The first NESDI project, "Innovative Technologies to Control/Reduce Emissions from Metal Cutting Operations" (no. 452), an Initiation Decision Report (IDR), identified the best available alternatives to oxy-fuel cutting to bring daily opacity levels below air quality limits. The IDR was developed by NSWCCD personnel in partnership with personnel from the former Naval Facilities Engineering Service Center now the Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC). The IDR recommended the exploration of an alternative hot cutting gas, MagneGas™ to replace propane, as well as an alternative process, cold cutting, which

The hot cutting process on a submarine hull sample.

METAL CUTTING TECHNOLOGIES: HOT VERSUS COLD

A METAL CUTTING TECHNOLOGY can usually be distinguished as either cold or hot. Oxy-fuel, plasma arc, and laser are examples of hot cutting technologies. These technologies generally have high lineal cutting speed, but tend to have high levels of visible particulate matter emissions and can cause heat-affected zones that lead to re-fusion, hampering demolition work. Mechanical cutting instruments are usually synonymous with cold cutting, and are generally slower than hot cutting; however, they benefit from little or no particulate matter emissions.

PSNS&IMF personnel established a working group to propose solutions to reduce smoke emissions in time for the arrival of the USS Enterprise in 2018.



The aircraft carrier USS Enterprise will arrive at PSNS&IMF for dismantling within the next two to three years.
Petty Officer 1st Class Todd Cichonowicz

completely eliminates opacity. Two follow-on NESDI projects were initiated to demonstrate this technology.

A follow-on project, "Alternative Metal Hot Cutting Operations for Opacity" (NESDI project no. 480), performed a demonstration to test MagneGas against the current gas in use at PSNS&IMF. This effort, conducted by NAVFAC EXWC personnel, determined that the alternative fuel did not produce significantly less opacity than propane.

Another project, "Controlling Opacity During Ship Hull Cutting and Cold Work" (NESDI project no. 481), focused on a different approach to ship dismantling. Mechanical or "cold" cutting instruments benefit from little or no particulate matter emissions. However, these technologies are generally slower and pose increased risks for workers. Despite provisions for some user convenience, heavy, hand-held cold cutting tools have been linked to increased risks for repeated movement injuries. This project, also conducted by NAVFAC EXWC personnel at PSNS&IMF, has developed a prototype reciprocating saw that has the potential to minimize user risk while delivering acceptable performance. This saw is currently being modified so that it can be mobile, fully automated, and able to attach easily to the hull of a ship. For more about this project, visit www.nesdi.navy.mil and search for project number 481.

The 25-foot-long prototype test enclosure.
Jim Howell

NSWCCD personnel with funding provided by the NESDI program and the Office of Naval Research (ONR), are currently working with PSNS&IMF on two more new technologies designed to better manage thermal cutting operations and mitigate the use of containment units (e.g., tents) to collect fugitive emissions.

EMISSIONS CAPTURE TECHNOLOGY FOR OXY-FUEL HULL CUTTING OPERATIONS

In early 2013, PSNS&IMF personnel, under the direction of NAVSEA, established a working group to propose solutions to reduce smoke emissions in time for the arrival of the USS Enterprise in 2018. The working group was tasked with identifying both current surface ship breaking limitations and new technologies/requirements needed to successfully dismantle such a large vessel. After meeting with the working group, it was determined that personnel from the Plant Equipment Engineering Group would develop and test a system for surface ship bulkheads

(interior spaces) while NSWCCD personnel would address exterior hull emissions capture and ventilation.

In 2014, Plant Equipment Engineering Group personnel designed and developed an internal bulkhead system to capture emissions at the cutting source. Initial bench testing of this system showed that it successfully achieved the objectives for an easily deployable opacity control unit. Plant Equipment Engineering Group personnel are now making minor system design changes to improve the installation and durability of the system.

To capture external emissions, NSWCCD personnel designed a prototype containment shroud that can be moved by a crane or shipyard high-reach device and utilized with large ships such as aircraft carriers. The enclosure is not only designed to contain the fumes/emissions generated during cutting and welding, but also incorporates a means of deflecting the molten slag stream produced by cutting torches to the drydock floor.

NSWCCD personnel conducted two rounds of laboratory testing of the device. The goals of the first round of testing were to:

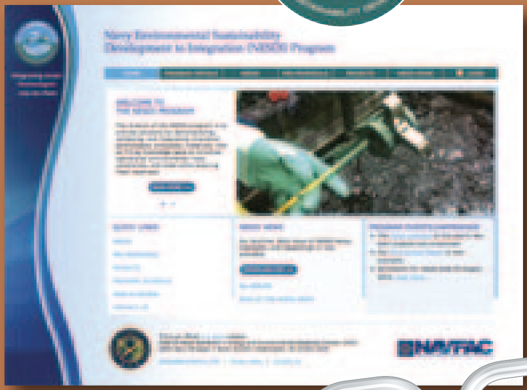
- Determine slag and smoke plume generation rates, velocities, and volumes.
- Evaluate the ability and performance of various flame-retardant materials to withstand the impact and high temperatures associated with the cutting process.
- Determine effective and practical geometries for a possible slag shield.

Based on the data received from this testing, NSWCCD personnel were able to construct and test a conceptual enclosure design made of lightweight aluminum with Plexiglass windows. The second round of testing was completed in January 2015. The objectives for this round of testing were to:

- Test air flow/blower and filter requirements to move a high volume of smoke across a 25-foot distance (the optimal "cut size" for a section of ship).
- Test the enclosure's variable air intake section at various opening distances.
- Test hot-cutting temperature threshold data (on both stainless steel and actual submarine hull section) to help determine the unit's movement scheme along the hull surface.

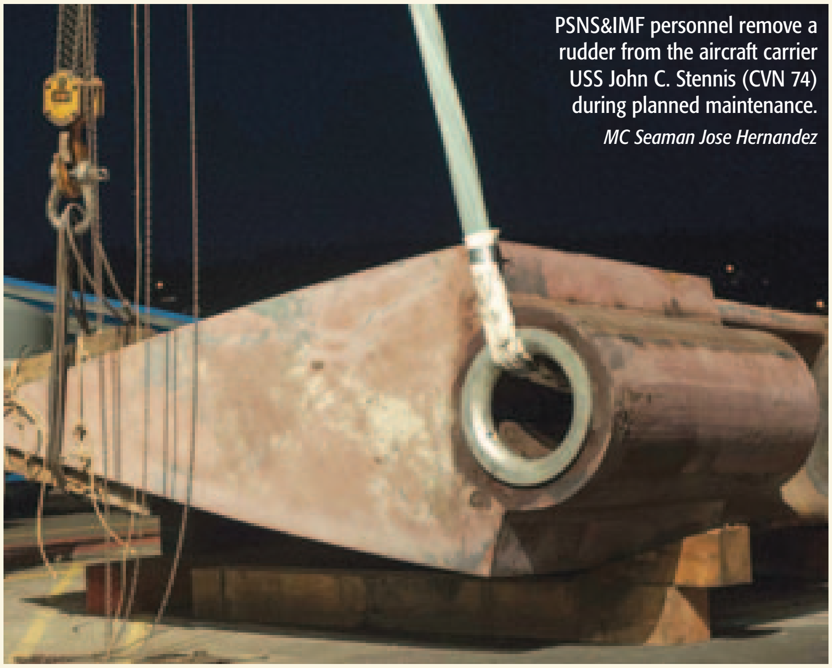
THE BASICS ABOUT THE NESDI PROGRAM

THE NESDI PROGRAM seeks to provide solutions by demonstrating, validating and integrating innovative technologies, processes, materials, and filling knowledge gaps to minimize operational environmental risks, constraints and costs while ensuring Fleet readiness. The program accomplishes this mission through the evaluation of cost-effective technologies, processes, materials and knowledge that enhance environmental readiness of naval shore activities and ensure they can be integrated into weapons system acquisition programs.



The NESDI program is the Navy's environmental shoreside (6.4) Research, Development, Test and Evaluation program. The program is sponsored by the Chief of Naval Operations Energy and Environmental Readiness Division and managed by NAVFAC out of NAVFAC EWXC in Port Hueneme, California. The program is the Navy's complement to the Department of Defense's Environmental Security Technology Certification Program which conducts demonstration and validation of technologies important to the tri-Services, the U.S. Environmental Protection Agency and the Department of Energy.

For more information, visit the NESDI program web site at www.nesdi.navy.mil or contact Ken Kaempffe, the NESDI Program Manager at 805-982-4893, DSN: 551-4893 or ken.kaempffe@navy.mil.



PSNS&IMF personnel remove a rudder from the aircraft carrier USS John C. Stennis (CVN 74) during planned maintenance.
MC Seaman Jose Hernandez

- Test a high-temperature hose's ability to withstand a molten slag stream.

NSWCCD personnel will continue to work with PSNS&IMF personnel to refine and test the external enclosure design configuration in terms of optimal size, point of exhaust, optimal materials/coatings for enclosure and deflection area, and means of portability. Full operational testing will be conducted at PSNS&IMF later in 2015.

For more about this project, visit www.nesdi.navy.mil and search for project 498.

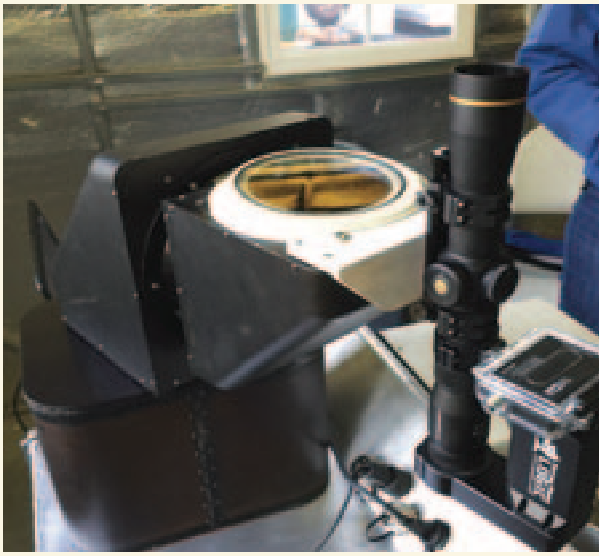
DEVELOPMENT OF A REAL-TIME OPACITY READER

The technologies traditionally used to measure opacity present their own challenges for PSNS&IMF personnel as they seek to maintain compliance with their established opacity limits. The currently accepted procedure is known as EPA Method 9. This is a visual monitoring method which depends on trained observers to measure the smoke plume. Not only is this a somewhat subjective process, Method 9 also relies on a specific set of conditions that are not always readily available in the dynamic environment of the shipyard, including ambient and background light levels as well as proximity and angle of the observer to the operation in question.

There is an available "upgrade" to the Method 9 procedure, known as a Digital Opacity Compliance System. In this system, a digital camera takes a picture of the smoke plume which is then e-mailed or uploaded to a Method 9 certified operator, who then analyzes the image, and provides the results. However, this system still holds the potential for human error, takes several minutes for results, and generates substantial paperwork.

Development of a real-time opacity monitor would circumvent these problems, without requiring the use of a containment shroud.

PSNS&IMF personnel remove a propeller from the aircraft carrier USS John C. Stennis (CVN 74) for maintenance.
MC Seaman Jose Hernandez



The Mini-MPL system consists of the laser, a 2-axis scanner for beam steering, a camera for co-registered screen capture, a weather station for surface observations, and a Global Positioning System for location information. The camera is programmed to follow the LIDAR beam to capture images of the measurement region. A sealed, all-weather enclosure contains the system power supply, cooling fan and equipment interfaces.

A goal of this project is to add an alarm to the system that would sound within 30 seconds if an exceedance of 20 percent opacity is reached.

To achieve the real-time capture of opacity information, NSWCCD and PSNS&IMF personnel are testing Laser Illuminated Detection And Ranging (LIDAR) technology. LIDAR is similar to radar in concept, using light instead of radio waves to detect obstructions and determine ranges. LIDAR works by illuminating a target with a laser and analyzing the reflected light.

LIDAR was first tested and proven to quantitatively measure smoke plume (visible emissions) in the late 1960's and 1970's, and it is currently used extensively by meteorologists, atmospheric and environmental regulators, airports and air traffic controllers, and more recently, wind farm planners.

NSWCCD personnel are teaming with Sigma Space Corp. to optimize their Mini-Micro Pulse LIDAR (MPL) for operations within the shipyard facilities environment. The Mini-MPL captures data through its camera which is programmed to capture images of smoke emission; and opacity reporting can be obtained from raw data to prove compliance. A goal of this project is to add an alarm to the system that would sound within 30 seconds if an exceedance of 20 percent opacity is reached.

The current Mini-Micro Pulse product line is designed for long range (far-field) sensing; however, opacity measurements at Navy shipyards require a short range LIDAR with a minimal blind zone of less than 100 feet. This project effort is directed at modifying and validating the Mini-MPL for drydock utilization. Once the new prototype is available, it will be tested during actual thermal cutting operations at PSNS&IMF.

EPA has determined that LIDAR is an accurate technology to measure plume opacity during all hours of the day, independent of lighting conditions or the contrast between backgrounds. This is in contrast to EPA Method 9, which requires ambient sunlight exposure to accurately determine opacity. This requirement has made Method 9 unreliable for use at ship breaking facilities. This project team is working with PSCAA and local EPA officials to gain acceptance from the EPA on the use of this method as an alternative to Method 9. As part of this effort, a custom software package was developed that follows this alternate procedure.

This technology will provide a means to reduce the burden of employing large-scale containment and ventilation solutions currently employed at Navy shipyards. With EPA acceptance, the LIDAR-based method could be incorporated into shipyard air permits as an alternative to EPA Method 9.

For more about this project, visit www.nesdi.navy.mil and search for project 516.

While PSNS&IMF is the only organization currently affected by the opacity limit, the emerging trend of increasing stringency on regulatory enforcements for environmental compliance is expected to involve more organizations in similar predicaments. The extensive work done by these project teams is available for shipyards and others who may face problems with opacity in the future.

View through the optics of the MPL during an EPA stack opacity test in Pueblo, Colorado.
Daniel Garver

OTHER NESDI SHIPYARD PROJECTS

The NESDI program is making some other investments in the safe and efficient management of other shipyard industrial processes including the proper management of cooling water and protecting oil booms from biofouling.

Managing Cooling Water

In addition to tightened limits for air emissions, shipyards are facing a similar water-related challenges. A large ship requires a constant supply of cooling water to pass through its heat exchangers and equipment to keep them functioning properly. This water, called once-through cooling water, is simply drawn from the ocean and discharged back into the sea when a ship is underway.

However, when a ship is in drydock, many of its systems remain active, requiring millions of gallons per day of cooling water, creating challenges going into and coming out of the ship's heat exchangers and other equipment.

The amount of water required for system cooling has the potential to entrain and impinge large numbers of fish, fish eggs and larvae. A new EPA rule is poised to affect cooling water intake structures at all Navy facilities. This rule requires that all intake structures be designed and operated such that flow rates through the intake screen holes are less than six inches per second. A project team from the Space and Naval Warfare Systems Command (SPAWAR) Systems Center Pacific is studying the ramifications of this new requirement under NESDI project no. 506, "Compliance Options for NPDES for Cooling Water Intake Structures at Existing Facilities." After existing intake structures are reviewed, the team will present options for achieving compliance.

Cooling water discharges typically contain heavy metals such as copper, usually in the 10–12 parts per billion (ppb) range (based on a monthly average). NPDES permit levels in Washington State are currently set at 19 ppb, but a draft permit will drastically reduce the level to 2.5 ppb in the near future. New permit levels at Pearl Harbor Naval Shipyard have also just been reduced to 3.5 ppb.

The aircraft carrier USS John C. Stennis (CVN 74) exits drydock after undergoing maintenance at PSNS&IMF.
MC3 Jordan Crouch

Two NESDI-sponsored projects have been initiated to address this problem. The first, "Design Closed-loop Cooling Water System to Accommodate Ship Cooling Water Needs" (NESDI project no. 513) is researching, evaluating and ranking various options to be compiled into an IDR. One of the most promising technologies is a closed-loop system, in which cooling water would be discharged directly into a system of pipes with no leakage into adjacent waters. This type of system would also aid in addressing a related problem, biofouling of intake water which sometimes occurs when saltwater from a harbor location enters a ship's cooling water system. This project is being conducted by personnel from NAVFAC EXWC.

FOR MORE INFORMATION

FOR MORE INSIGHTS into this NESDI project, read our article "Carderock Testing New Oil Boom Fouling Release Material: New Material Reduces Biofouling, Simplifies Cleaning" from the summer 2015 issue of *Currents*. You can browse the *Currents* archives at the Department of the Navy's Energy, Environment and Climate Change web site at http://greenfleet.dodlive.mil/currents-magazine.

One of the most promising technologies is a closed-loop system, in which cooling water would be discharged directly into a system of pipes with no leakage into adjacent waters.

A second NESDI project (no. 507) is exploring the feasibility of creating a closed-loop system based on the principals of radiant heating, a technology widely used in homes and office buildings. In this system, pipes would be embedded underground to take advantage of the ground's natural cooling abilities. The project, "Radiant Cooling for Closed-loop Water Containment" is exploring what materials would be feasible for such a system, what the layout requirements are, and whether it would be cost-effective. Team members from SPAWAR envision PSNS&IMF as an ideal first customer for this technology, should it prove viable.

Protecting Oil Booms from Biofouling

When a ship arrives in port for maintenance, a protective barrier known as an oil boom is deployed to prevent the possibility of oil migrating into the water body. These booms experience extensive marine biofouling (sea grasses, tubeworms, and/or hard-shelled organisms) when left in the water for long periods of time. This can compromise the performance of the boom. For this reason, booms need to be cleaned twice yearly at significant expense.

To help mitigate the need for frequent cleaning, the NESDI program sponsored a project (no. 489) to test a protective, silicone-based coating that has previously been used on oceanographic instrument platforms such as offshore buoys and autonomous gliders. Three prototype boom sections (with and without coating) were installed in 2014. Results of the first field test indicate that the coated boom cleaned twice as easily as the uncoated boom in out-of-water cleaning. The results were promising for in-water cleaning as well. The project team needs to complete additional cleaning and mechanical testing to qualify this boom for use.

There are approximately 300 NESDI-sponsored projects in various stages of development. Fact sheets summarizing each of these projects and detailing their goals and accomplishments are available to the public on the NESDI program's web site. Go to www.nesdi.navy.mil, select "Projects" then select the "Fact Sheet" link for the project you're interested in. ⚓

The aircraft carrier USS Nimitz (CVN 68) moors pierside at its new home port at Naval Base Kitsap Bremerton. Nimitz underwent a planned incremental availability at PSNS&IMF where the ship will receive scheduled maintenance and upgrades.
MC2 Ryan J. Mayes

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