U. S. NAVAL
NUCLEAR POWERED SHIP
INACTIVATION, DISPOSAL,
AND RECYCLING

2019 Edition

UNITED STATES
DEPARTMENT OF THE NAVY

SUMMARY

The U.S. Navy has developed and implemented a program to safely dispose of decommissioned nuclear-powered ships. This involves defueling the reactor, inactivating the ship, demilitarizing components, removing the reactor compartment for land disposal, recycling the remainder of the ship to the maximum extent practical, and disposing of the remaining non-recyclable materials.

Planning for the disposal of submarine reactor compartments began in the late 1970s, culminating in the issuance of a Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants (May 1984) and National Environmental Policy Act Record of Decision for the Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants (Dec 1984). The Navy decided to dispose of the reactor compartments at the Department of Energy's Hanford Site. The first reactor compartment was shipped from Puget Sound Naval Shipyard to the Hanford Site for disposal in 1986.

In 1990, the Navy authorized a program to recycle submarines at Puget Sound Naval Shipyard. Using available technology, the program consists of a systematic dismantling of the submarine's equipment and parts, and cutting up the hull. Equipment having value is refurbished and made available for use elsewhere; metals and other material having resale value are segregated and sold. Non-recyclable materials are properly disposed of as waste.

The first nuclear-powered ship recycling was performed on two submarines in 1991, demonstrating that environmental, safety and health protection requirements could be met, the removed equipment could be satisfactorily demilitarized, and the project could be completed within the projected cost and schedule.

In early 1995, the Navy prepared a second Environmental Impact Statement for the disposal of nuclear-powered cruisers and newer class submarines. The issuance of the Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, OHIO Class, and LOS ANGELES Class Naval Reactor Plants (April 1996) and National Environmental Policy Act Record of Decision (August 1996) completed this planning process. Reactor compartment disposal of these submarines and cruisers began soon after with the first LOS ANGELES Class submarine completely disposed of in 1997 and the first cruiser disposed of in 1999.

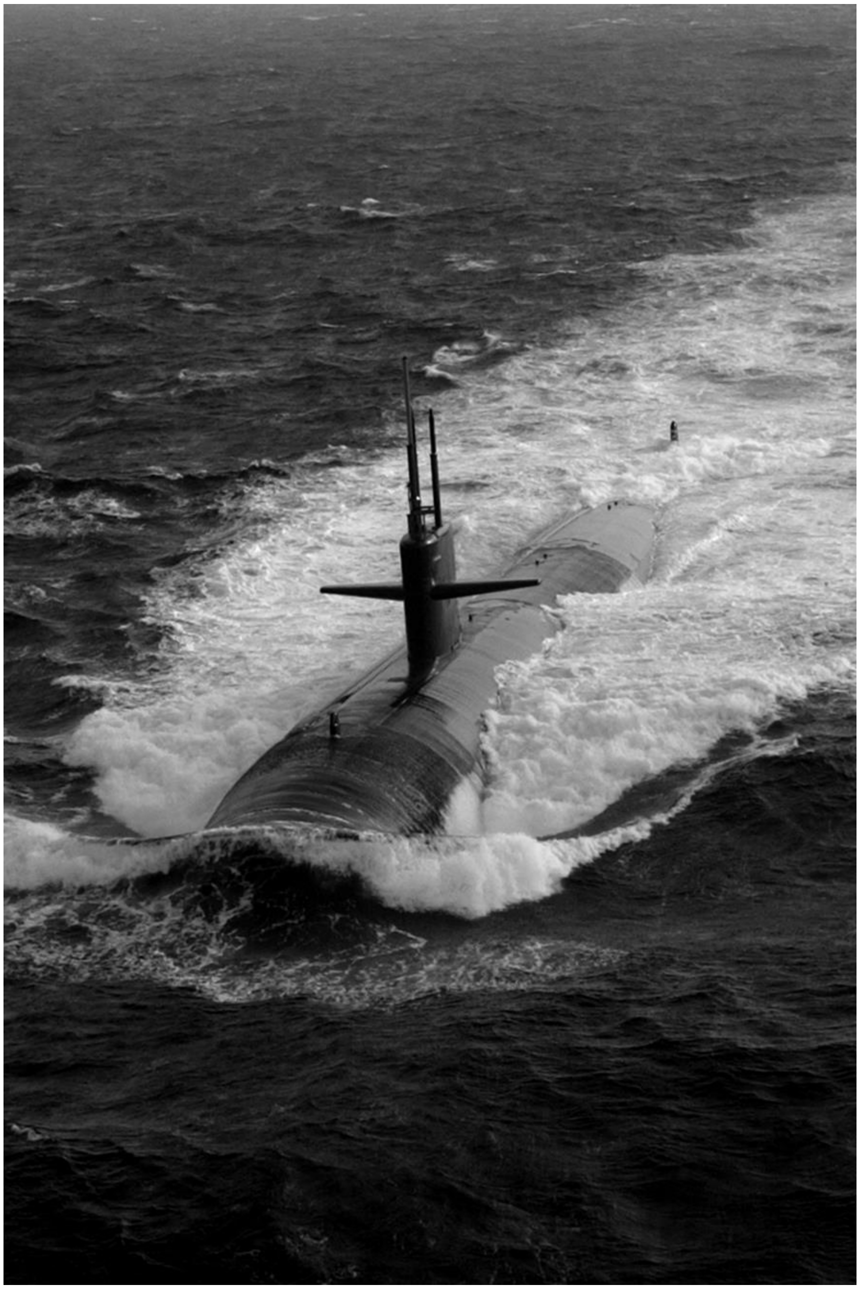
The Navy’s disposal program has also shown that accomplishing the reactor compartment removal, missile compartment removal (for ballistic missile submarines), and recycling in a single drydocking evolution, is efficient and economical. Improved efficiency and reduced costs are achieved at the Shipyard by typically drydocking two or more ships together.

The disposal of nuclear-powered ships is accomplished using proven technology and procedures which have been available at shipyards for many years. The equipment used to remove the reactor compartment is simple, rugged, and reliable. Recycling the rest of the ship involves straightforward disassembly, component removal, heavy lifting, packaging, and transporting.

Once the nuclear fuel has been removed, the most significant technical issues relate to the control of the parts of the ship that contain radioactivity and hazardous materials. Removing the reactor compartment removes all the remaining radioactivity. Hazardous materials such as asbestos, lead, and polychlorinated biphenyls (PCBs) are controlled in a manner that assures the Navy, the regulating agencies, and the public that handling and disposing of these materials will not now or in the future pose a risk to human health or the environment. This involves meeting the complex regulatory requirements of a number of agencies including the Department of Energy, the Environmental Protection Agency, the Washington State Department of Ecology, and the Puget Sound Air Pollution Control Agency. The Navy has worked closely with these and other federal agencies as well as the state of Oregon to ensure successful implementation of the program.

As of January 2019, the Navy has successfully shipped 133 reactor compartments to Hanford and safely recycled 116 nuclear-powered submarines and 8 cruisers.

TABLE OF CONTENTS



LOS ANGELES Class Submarine

1. INTRODUCTION

This report provides a review of the U.S. Navy's program to dispose of nuclear-powered ships when they have reached the end of their useful life and includes a description of ship inactivation, reactor compartment disposal, and recycling the rest of the ship. The report describes planning efforts and decisions, as well as current execution of the program.

Navy ships are inactivated when their military capability does not justify the cost of continued operation, when necessary to comply with treaty requirements that limit ballistic missile capacity, or when the ships are no longer needed. When the decision is made to inactivate a nuclear-powered ship, it must be defueled and appropriate actions must be taken to dispose of the reactor plant and the remainder of the ship.

In the late 1970s the Navy recognized that a number of nuclear-powered submarines would require inactivation and disposal in the coming years. In accordance with the National Environmental Policy Act, the Navy began evaluating alternatives for disposal. Two basic options were evaluated:

1) disposal of the defueled reactor compartment (the section of the submarine containing the reactor plant) at an existing land burial site, with the non-radioactive remainder of the submarine disposed of either by sinking at-sea or by cutting up for sale as scrap metal; or

2) disposal by sinking the entire defueled submarine in the deep ocean.

The Navy's 1984 Final Environmental Impact Statement (EIS) (ref a) found that either land or sea disposal of the reactor compartments would be environmentally safe and feasible. The Record of Decision (ref b) issued by the Navy on December 6, 1984, concluded that "Based on consideration of all current factors bearing on a disposal action of this kind contemplated, the Navy has decided to proceed with disposal of the reactor compartments by land burial". In 1986, the first reactor compartment was shipped to the Hanford Site burial grounds.

In 1996 the Navy completed a second Final Environmental Impact Statement (ref c), which evaluated disposal options for nuclear-powered cruisers, and LOS ANGELES and OHIO Class submarines. The Record of Decision (ref d) issued by the Navy and the Department of Energy (DOE) on August 8, 1996 concluded that land burial of reactor compartments at a federal government disposal site would not have significant adverse environmental impact. The first LOS ANGELES Class reactor compartment was shipped to the Department of Energy's disposal grounds at Hanford, Washington in September 1997. To date, all nuclear powered cruisers have been removed from seagoing service and all but the ex-Longbeach (CGN-9) have completed reactor compartment disposal and recycling.

In 2012, The Navy issued an Environmental Assessment (ref e), which evaluated the disposal of defueled reactor plants from the aircraft carrier ex-Enterprise (CVN-65) as eight individual reactor compartment packages. In 2016, the Navy decided to initiate preparation of an EIS that would consider a broader range of alternatives for disposal of the defueled reactor plants from ex-Enterprise.

Disposal of the Navy's nuclear-powered ships can generally be broken down into four major processes: inactivation, missile compartment dismantlement (for ballistic missile submarines), reactor compartment disposal, and recycling. All nuclear-powered ships undergo inactivation prior to any of the other three processes. Initially, the forward and aft sections of the defueled and decommissioned submarines were separated to allow for missile compartment dismantlement (for ballistic missile submarines) and reactor compartment disposal and then rejoined and placed in floating storage. In 1991, the Navy began to recycle these rejoined submarine sections. Since 1991, recycling the remaining sections of the ship has been accomplished in parallel with the reactor compartment removal work. The recycling process removes and refurbishes components having value to the Navy and cuts apart the remainder of the ship to allow segregation and recycling of metals and other materials of value.

Submarines in Drydock for Defueling, Reactor Compartment Removal, and Recycling

The ship disposal operations developed by the Navy do not involve any sophisticated technology, but use basic engineering principles, common industrial practices, close attention to detail, and careful management oversight. From the outset, the major program goals are minimizing radiation exposure, meeting state and federal environmental and safety regulations, and controlling cost. The technology to perform ship inactivation and recycling is straightforward and well within the capability of a large shipyard. It consists of basic disassembly, component removal, heavy lifting, packaging, and transporting, which are comparable to ship construction and repair activities. The most time consuming actions are those needed to meet regulatory requirements which are relevant to the disposal of all U.S. warships.

Ship inactivation and disposal work employs the same safety and environmental controls that are used for work on nuclear-powered ships undergoing overhaul. Work involving radioactivity, lead, asbestos, PCBs, or other hazardous materials, is accomplished by personnel trained to work with these materials. They are equipped with the proper personal protective equipment where needed, and the work is accomplished in areas that are controlled to prevent the spread of contaminants. Waste is controlled and disposed of in accordance with applicable state and federal regulations, using licensed transportation contractors and approved disposal sites.

The control of radiation exposure to shipyard workers is discussed in detail in the Navy's annual report NT-18-2 (ref f). This report shows that the average occupational exposure of each person monitored in the shipyard workforce since 1954 is less than two-tenths of a rem per year. For comparison, the amount of radiation exposure a typical person in the United States receives each year from natural background radiation is three-tenths of a rem. Individual worker exposure is strictly controlled, resulting in an average exposure of approximately three percent of the federally established limit of 5 rem per year and no shipyard worker has exceeded 2 rem in any given year since 1980.

As of January 2019, the Navy has safely recycled 116 submarines and 8 cruisers, and shipped 133 reactor compartments to the Department of Energy's Hanford Site for disposal (refer to Appendix D). This work has been accomplished safely and ensures protection of the public, the workforce, and the environment.

The following sections of this report describe the processes involved in ship inactivation, missile compartment dismantlement, reactor compartment disposal, and ship recycling.

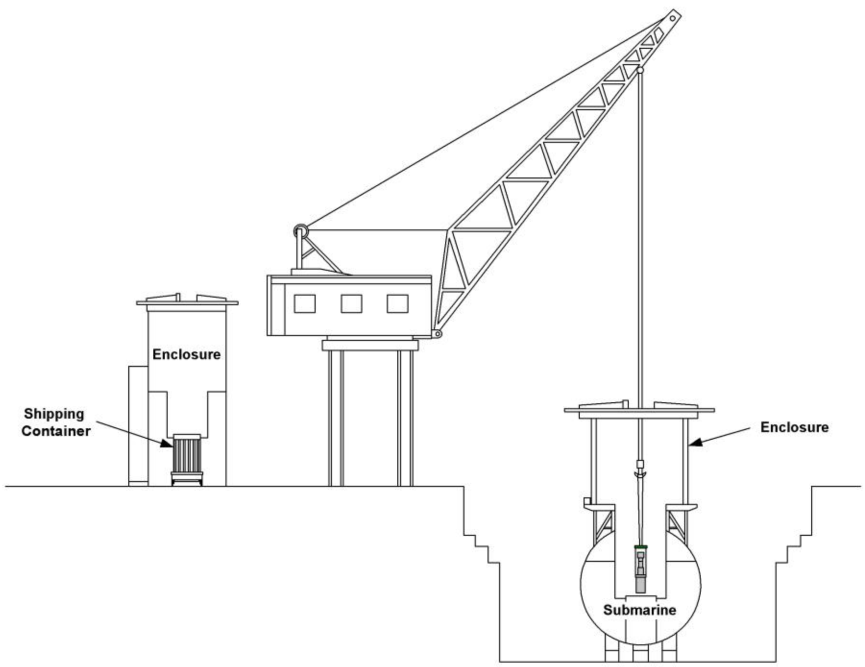
2. INACTIVATION

Ships scheduled for inactivation have their weapons removed prior to arrival at the Shipyard. Upon arrival, the ship’s reactor is shut down, and the ship will either enter a dry dock where the ship is inactivated and defueled in a planned sequence, or the ship will undergo a pier side process to place the ship, including the reactor, in a safe, static condition while it awaits a dry dock window to complete the inactivation and defueling sequence.

Expendable materials, technical manuals, tools, spare parts, and loose furnishings are removed, including items such as linen, kitchen supplies, and utensils. Classified/sensitive equipment and materials, including the cryptographic equipment are removed. Industrial gases such as refrigerant and oxygen are offloaded. Piping for sea water, main steam, potable water, fuel oil, and other systems not needed for defueling operations are drained. Hydraulic systems are drained. Tanks containing fuel oil and other fluids are drained and cleaned. Sanitary systems are drained, cleaned, and disinfected. The ship's electrical and lighting systems are de-energized and temporary ventilation, lighting, power, and compressed air services are installed. For submarines, the main storage battery is removed.

With the ship in drydock, openings are cut in the hull, interferences are removed, and a refueling enclosure is installed on the ship over the reactor to provide a controlled work area with filtered ventilation. Access is provided into the reactor and fuel is removed into a shielded transfer container which is then moved by crane to a dockside enclosure. The fuel is placed into specially-designed shipping containers. Defueling operations employ the same proven procedures and equipment to remove nuclear fuel that have been used successfully in over 400 Naval reactor defuelings.

The defueling process removes the nuclear fuel including unused uranium and fission products which are fully contained within the fuel elements. Although this removes over 99 percent of the radioactivity, a small amount remains in the reactor plant after the nuclear fuel is removed. This radioactivity was created by neutron irradiation of the iron and alloying elements in the metal components during operation of the plant. Approximately 99.8 percent of this radioactive material is an integral part of the structural metals forming the plant components. The remaining 0.2 percent is radioactive corrosion and wear products which have been deposited on the inside of piping systems.



Submarine Defueling

After defueling, preparations are made to facilitate reactor compartment removal. The pressure vessel, piping, tanks, and fluid system components that will remain in the reactor compartment are drained to the maximum extent practical, while keeping radiation exposure to workers as low as reasonably achievable. Absorbent is added to the pressure vessel to absorb the residual liquid that may be present. The system draining procedures remove nearly all (over 98 percent) of the liquid originally present. Only a small amount of liquid remains trapped in discrete locations such as pockets in valves, pumps, tanks, vessels, and other inaccessible piping system components. All openings into radioactive systems are sealed.

Upon completion of inactivation the ship is ready for missile compartment dismantlement (for ballistic missile submarines), reactor compartment disposal and recycling. Ships typically undergo a period of waterborne storage after inactivation which allows for further decay of remaining radioactive material and reduced radiation exposure to shipyard workers for follow on work.

3. MISSILE COMPARTMENT DISMANTLEMENT

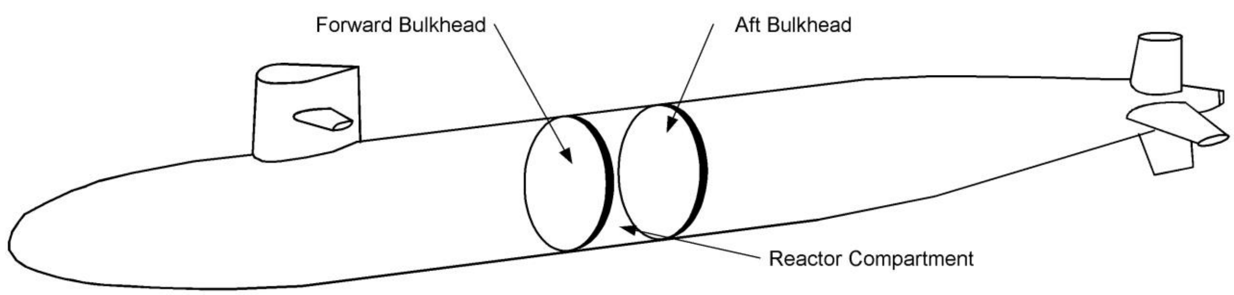
Because of SALT II Treaty limits, the Navy began retiring ballistic missile submarines in 1980. Under the terms of the treaty, the missile launchers were required to be removed from the submarine and cut apart in a verifiable manner. Initially, submarines were inactivated and the missile compartment sections dismantled using cutting torches and other tools. The remaining forward and aft sections of the ship were welded together and placed in floating storage. After the initiation of reactor compartment disposals at Puget Sound Naval Shipyard in the mid-1980s, the missile compartments were dismantled simultaneously with removal of the reactor compartment. The remaining sections of the submarine were welded back together and the ship was placed in waterborne storage. With the initiation of total ship recycling in 1991, Puget Sound Naval Shipyard began accomplishing missile compartment dismantlement, reactor compartment removal, and ship recycling in a single drydocking evolution.

Cutting Missile Tube Section

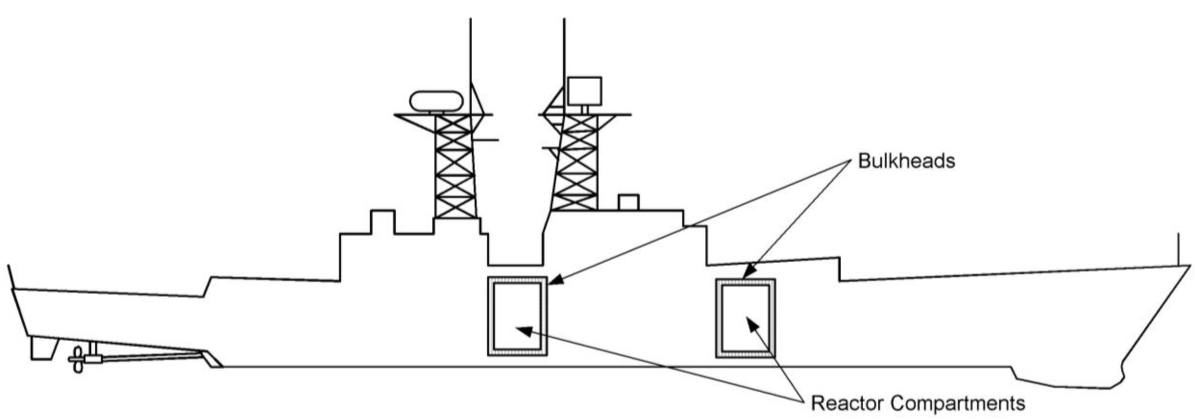
Missile compartment dismantlement employs the same cleaning, cutting, and removal methods described in Appendix C of this report for dismantling the rest of the submarine. The missile hatches and the missile launcher tube liners are removed. The interior spaces are cleared to allow the hull to be cut apart. The hull and missile tube structure is dismantled using cutting torches. Equipment within the missile compartment removed prior to and during dismantlement, includes electrical equipment, piping, air flasks, lockers, partitions, and berthing furnishings. Where required, components are demilitarized to remove sensitive or classified design information. PCB impregnated sound damping material is removed and the residue is cleaned from exposed surfaces. Asbestos insulating material and removable ballast lead are also removed from the ship. Currently all ballistic missile submarines have been removed from seagoing service except for the OHIO Class submarines.

4. REACTOR COMPARTMENT DISPOSAL

The nuclear propulsion plants in U.S. Navy ships, while differing somewhat in size and component arrangements, are all rugged, compact, pressurized water reactor plants designed to exacting criteria in order to withstand severe power transients and battle shock. For submarines, the compact plant designs are enclosed within the high strength steel pressure hull. The pressure hull is used as part of the reactor compartment package, simplifying disposal planning.

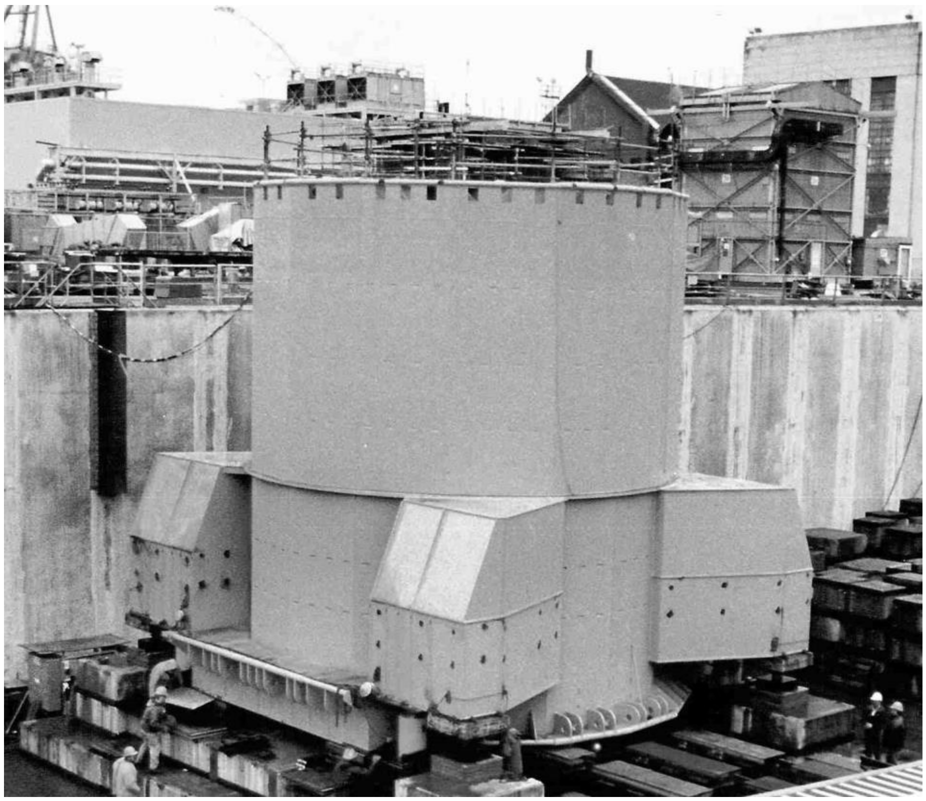


Typical Submarine with Reactor Compartment Location



Typical Cruiser with Reactor Compartment Locations

The reactor plants in nuclear-powered cruisers are also housed within a rugged compartment, but do not share the advantage of the submarine pressure hull. Therefore, a steel containment structure is built around each reactor compartment, enclosing it to form the disposal package. To assist moving the disposal package, support fixtures are welded to the containment structure.



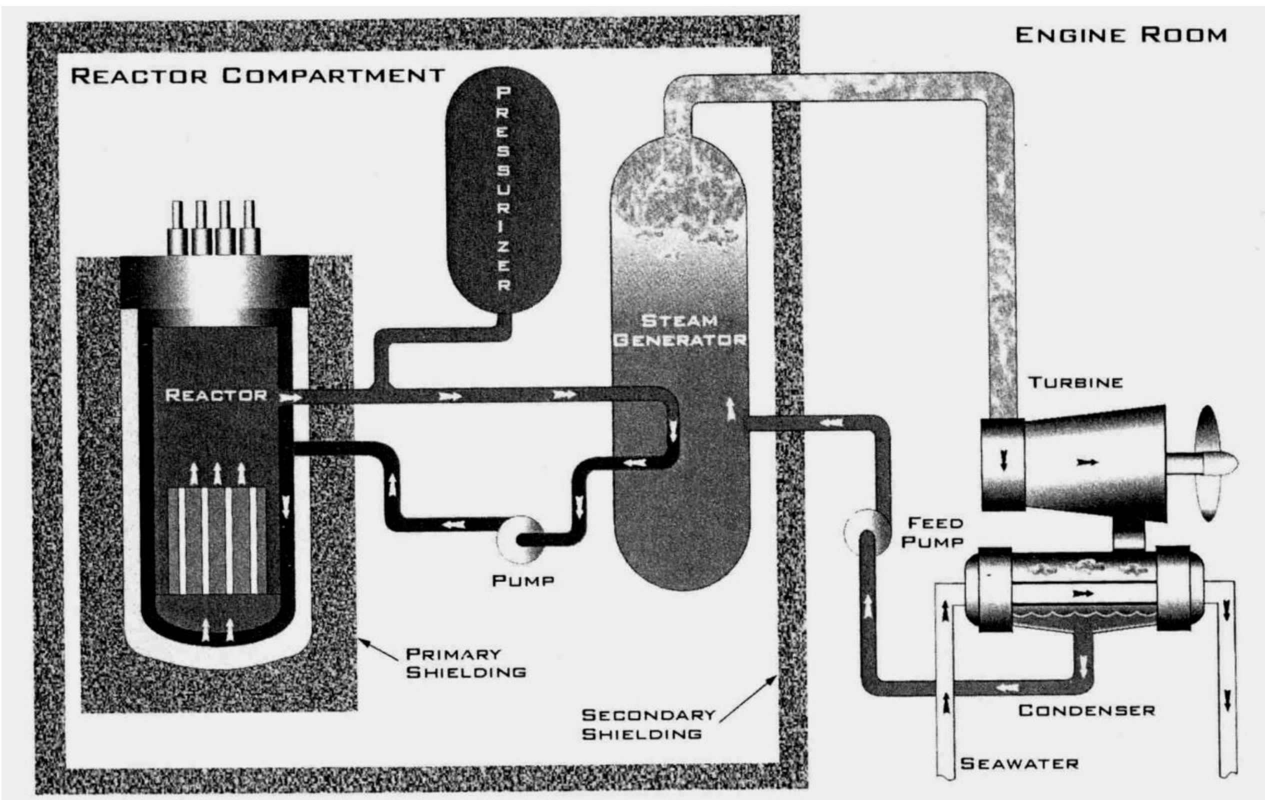
Cruiser Disposal Package

After defueling, cobalt 60, which has a half life of 5.27 years, is the dominant residual corrosion and wear product radioactive nuclide. It emits gamma radiation and is the primary source of radiation in the defueled reactor plant during reactor compartment preparation and shipment to the burial site. Experience shows the external radiation levels on the reactor compartments are low - below 1 mrem per hour at the package surface except submarine disposal packages may have one or two localized areas which do not exceed 30 mrem per hour. These levels generally drop to 1 mrem per hour or less at a distance of two meters from the package. The radioactive corrosion and wear products are contained within two boundaries, the first being the sealed piping systems, and the second the welded hull and package containment structure which make up the completed reactor compartment disposal package.

The planning for reactor compartment disposal began in the late 1970's, and evolved in the early 1980's into a comprehensive public process under the National Environmental Policy Act. The EIS published in 1984 (ref a) concluded that land burial of submarine reactor compartments at a federal government disposal site would not have any significant adverse environmental impact. On December 6, 1984, the Navy issued a Record of Decision (ref b) to dispose of these reactor compartments at the Department of Energy's Hanford Site in eastern Washington.

The Hanford Site was selected because it was close to a navigable river, in a desert, and relatively close to Puget Sound Naval Shipyard where eight defueled submarines were already in floating storage. The other federal radioactive waste disposal sites did not have all of these features. Shortly after the 1984 Record of Decision was issued, the 1985 Low Level Radioactive Waste Policy Amendment Act became law, which identified disposal of reactor compartments from Naval ships to be a federal responsibility.

In preparation for the decommissioning and disposal of nuclear-powered cruisers and newer class submarines, the Navy, with the Department of Energy as a cooperating agency, began preparation of a second EIS in early 1995. This EIS concluded that land burial of the reactor compartments at a federal government disposal site would not have any significant adverse environmental impact. The Navy issued the Final EIS (ref c) in April 1996. The Record of Decision (ref d) was issued by the Department of Energy on August 8, 1996.



Schematic of Naval Nuclear Propulsion Plant

Reactor compartments also contain regulated quantities of lead, a hazardous material. The lead is in the form of permanently installed shielding which is not removed because of the great difficulty and significant personnel radiation exposure that would be involved (ref g). For older submarines, felt sound damping material containing PCB is found on the interior of the hull, on bulkheads, and in other locations outside of the reactor compartment that are part of the disposal package. This material and any PCB residue is removed from the reactor compartment before disposal in accordance with Environmental Protection Agency (EPA) requirements. In addition, PCBs are found in solid materials, such as rubber and insulation, widely distributed throughout the reactor compartment. The total amount of solid PCBs present ranges from about 5 pounds on some older submarines to trace amounts on newer ships. These PCBs are found tightly bound in the chemical composition of the solid materials. The Environmental Protection Agency allows this type of PCBs to be disposed of in a solid waste landfill. It is not feasible to remove these components and insulation, and they are left in place for disposal with the reactor compartment.

Reactor compartments are prepared for shipment and burial in accordance with Department of Transportation and Nuclear Regulatory Commission requirements for packaging and transportation of low level radioactive material, Department of Energy requirements for burial of low level radioactive material, Environmental Protection Agency requirements for disposal of PCBs, and Washington State Department of Ecology requirements for disposal of lead (ref h through k).

Because of their radioactive content, the reactor compartment packages are designed to meet the packaging requirements of Title 49 Code of Federal Regulations - Transportation, and Title 10 Code of Federal Regulations - Energy. The reactor compartment packages will effectively protect the public and environment when subjected to normal conditions of transport as well as hypothetical conditions relating to heat, cold, pressure, vibration, drop, and puncture. The potential damage to the reactor compartment and its contents under the hypothetical accident conditions has been shown to not exceed specified limits for release of radioactivity.

When performing the reactor compartment shipments, the Navy has maintained close coordination with state and local officials. In 1986, Navy, Coast Guard, and Department of Energy officials met in Olympia, Washington, with representatives of the Washington State Department of Ecology, the Washington State Office of Radiation Protection, and the Nez Perce and Yakama Indian Nations, to review preparations for the first reactor compartment shipment.

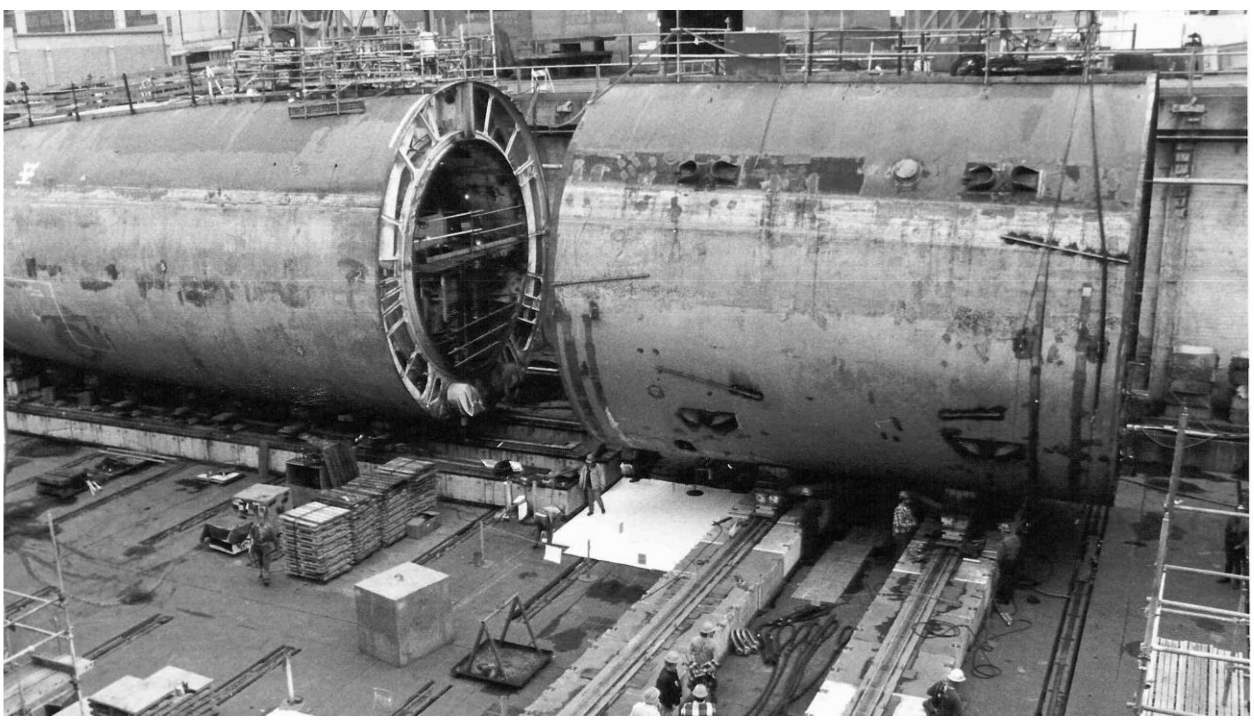
Officials of the states of Washington and Oregon have been to the Shipyard to review the transport barge and reactor compartment packages and to confirm the packages' radiation levels. This close coordination provides continuing assurance to the states and the public that these shipments meet all of the necessary requirements for transporting radioactive material, and do not represent a danger.

The following sections describe reactor compartment disposal operations, including the measures taken to ensure there is no significant risk to the public and the environment.

Shipyard Operations.

Piping, electrical cabling, and other components that penetrate the reactor compartment bulkheads, or would otherwise interfere with reactor compartment removal, are cut and removed. This work is accomplished with hand held saws, grinders, pipe cutters, hydraulic cutters, and cutting torches. Special care is taken with piping containing radioactivity. These are high integrity systems designed to prevent any leakage. Any pipes which are cut are sealed to maintain the system integrity and, in combination with the package hull and bulkheads, provide redundant boundary containment of radioactivity. Additional system drains are performed and absorbents added as necessary to ensure the reactor compartment disposal packages comply with the Washington State Department of Ecology disposal regulations regarding residual liquids. PCB bearing felt is manually removed and the surfaces cleaned either by abrasive blasting or by hand scraping and wire brushing, followed in some cases by wiping with chemical and detergent rinses. Ballast lead is manually removed.

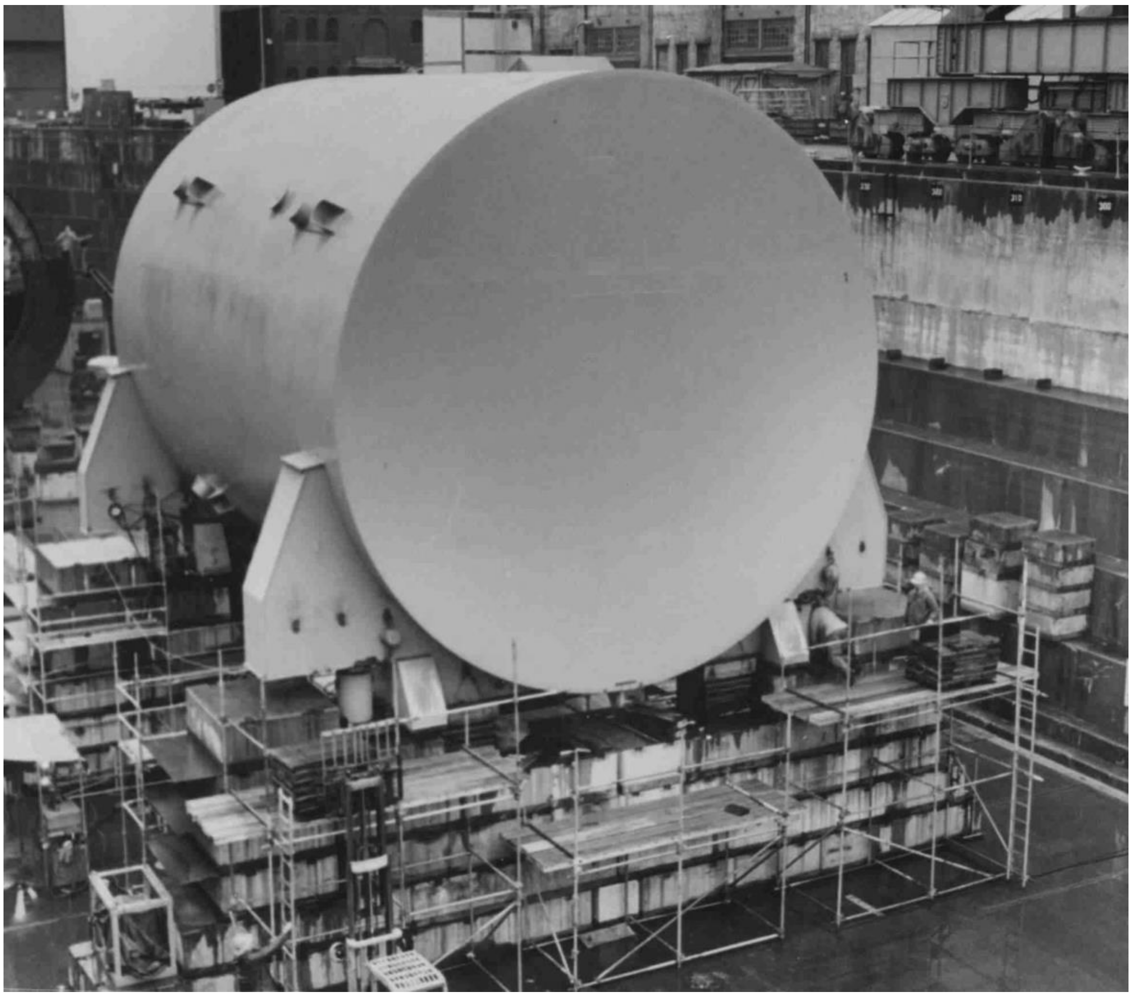
For submarines, the ship is drydocked with the reactor compartment supported by cradles. Tracks with rollers are installed under the cradles to allow the reactor compartment to be slid away from the ship once it is cut free. The reactor compartment is cut from the rest of the ship's structure with standard cutting equipment, predominantly torches and hand held saws, pipe cutters, and grinders. The hull cuts are made several feet forward and aft of the shielded reactor compartment to allow installation of shipyard fabricated end bulkheads. These bulkheads are a minimum of three-quarter inch thick steel plates.



Submarine Reactor Compartment Section

Submarines are designed for deep ocean operations and to survive the rigors of combat engagements. Thus, the rugged design of the submarine reactor plant, the inherent strength of the ship's pressure hull and shielded bulkheads, and the additional end bulkheads installed by the shipyard provide the structural integrity that exceeds the packaging criteria for transporting the radioactive material contained in the reactor compartment.

For cruisers, the reactor compartments are nested within the ship's structure and are housed within a rugged compartment designed for combat shock loads, but do not share the advantage of the strong submarine pressure hull. The surrounding structure is cut away and the reactor compartments are encased in a heavy steel (at least three-quarters of an inch thick) containment structure. The structural steel and bulkhead plating needed to package a reactor compartment is transported to the drydock, crane lifted into position, and welded into place.

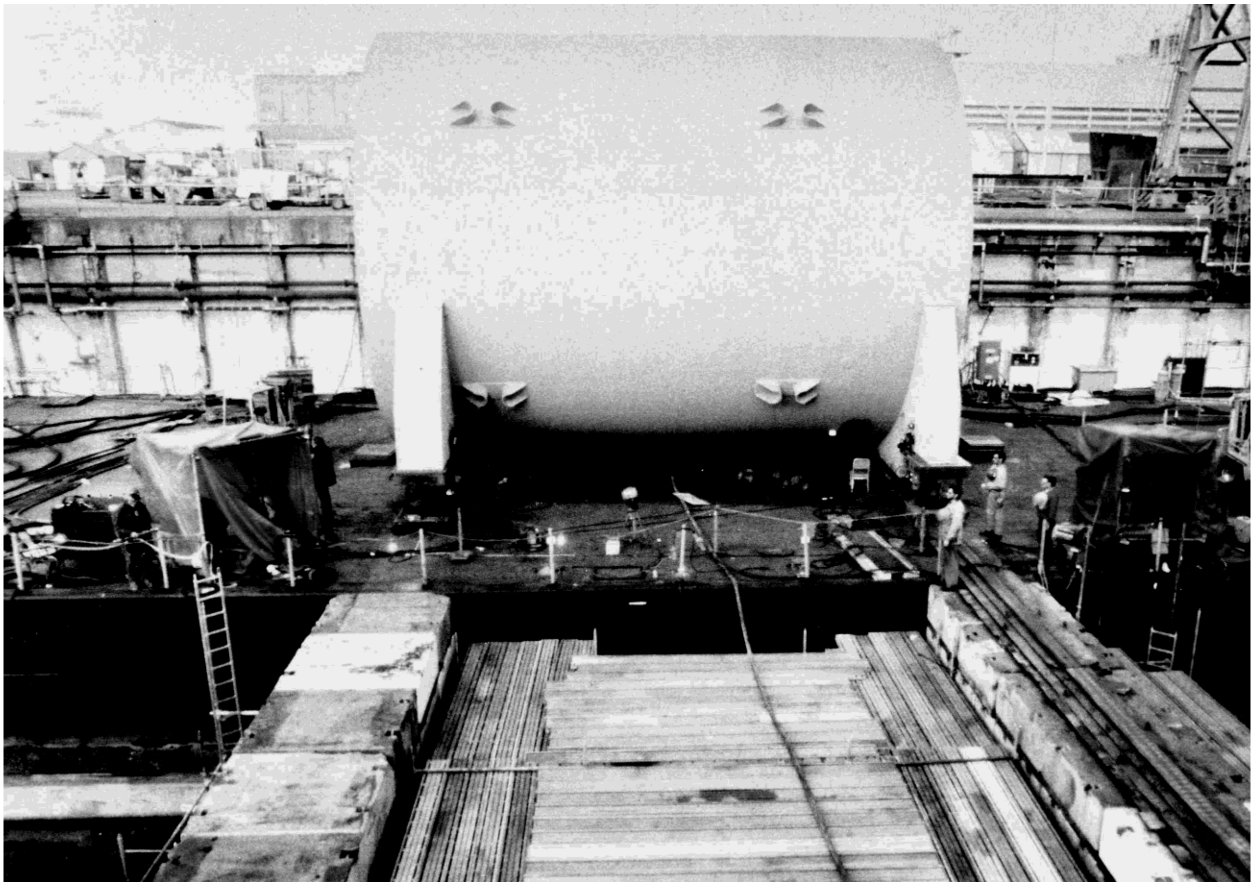


Submarine Reactor Compartment Jacking

Completed packages are air tested to ensure package integrity. The Shipyard also fabricates heavy steel support fixtures which are welded to the package to facilitate jacking and transporting the reactor compartment. Jacking is accomplished in small increments, with blocks and shims placed under the compartments as they are raised to ensure that the compartments do not drop in case of a loss of hydraulic jacking pressure.

Once package construction has been completed, the reactor compartment packages are placed on compartmented, specially reinforced ocean barges. These barges are maintained to both Navy and commercial standards and are routinely inspected by the American Bureau of Shipping and the United States Coast Guard.

The reactor compartment package is moved onto the barge using track-mounted, high capacity rollers for horizontal movement, and large hydraulic jacks for vertical movement. When in place, the compartments are welded to the steel barge deck.



Loading Submarine Reactor Compartment on Barge

Appendix A provides further details of transport operations and the actions taken to ensure their safety. Appendix B provides further details on the Hanford Site and the studies that demonstrate the site is well suited for reactor compartment disposal.

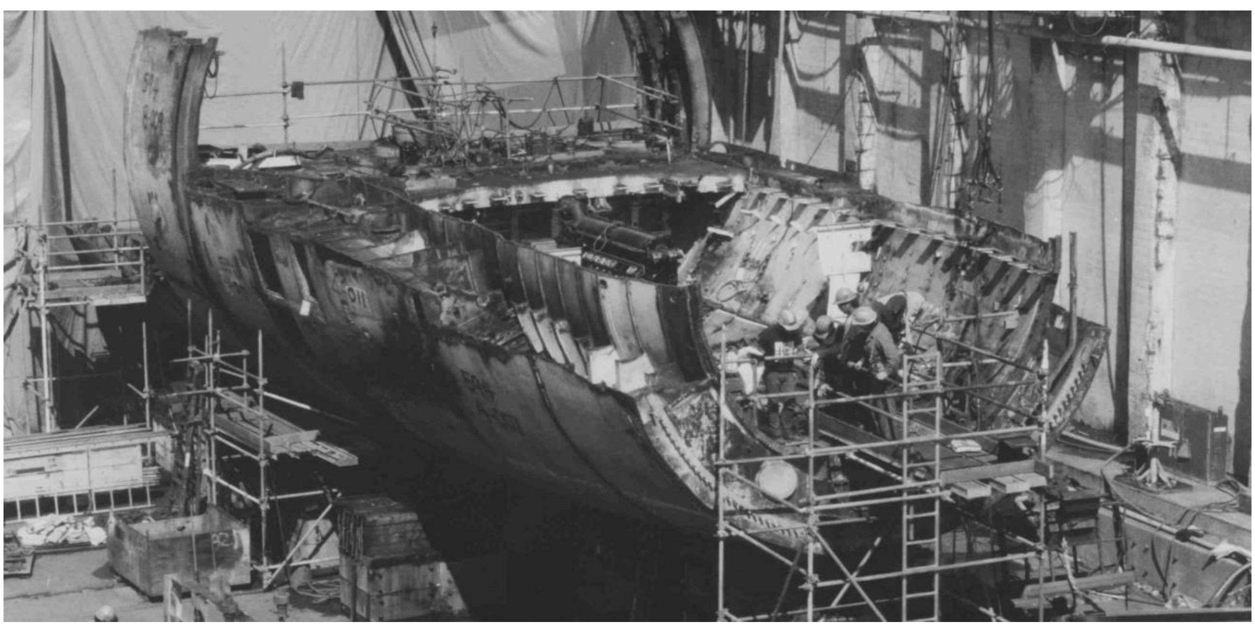
5. RECYCLING

The program for total ship recycling was developed directly from experience gained in dismantling submarine missile compartments. The development of procedures for demilitarization and handling of hazardous materials also evolved from this experience. Following a review of options for disposal of the remainder of the ships, the Navy instituted a total ship recycling program in 1991.

Based on the successful demonstration in 1991 recycling two submarines, all subsequent submarines and surface ships brought into Puget Sound Naval Shipyard for disposal have been recycled in conjunction with reactor compartment removal. Recycling has proved to be an environmentally sound program, adhering to the principles of minimizing waste and maximizing reuse of materials.

After an extensive review of the Navy's program to dispose of nuclear-powered submarines, the General Accounting Office independently observed that the program is sound and published the findings in a report issued in July 1992 (ref l).

The ship's equipment, internal parts, and hull are systematically dismantled using available technology and equipment. Equipment having remaining value is removed and refurbished for reuse. Metal having resale value, such as aluminum, copper-nickel, carbon steel, stainless steel, brass, and electrical wire is segregated to ensure the highest cost return. Non-recyclable material is disposed of as waste in accordance with the applicable regulatory requirements.
Returning ship's equipment and materials to industry through recycling requires engineered processes and procedures to ensure the materials meet state and federal requirements for recyclable materials. Materials removed from these ships for disposition in a recycling or non-radioactive waste stream are also evaluated to confirm that no detectable radioactivity associated with the Naval Nuclear Propulsion Program is present on the items. Just as with other hazardous materials, this involves a careful and systematic program.



Partially Recycled Submarine

Sensitive and classified information is safeguarded and total ship disposal complies with all applicable environmental regulations. This latter aspect continues to be the most challenging aspect of recycling.

The recycling work at Puget Sound Naval Shipyard also demonstrates the efficiency and cost savings associated with accomplishing reactor compartment removal and ship recycling in a single drydock evolution. Further savings are typically achieved at the Shipyard by placing several ships in the same large drydock at once for concurrent reactor compartment removal and recycling. The experience gained from submarine recycling work has been extended to the recycling of nuclear-powered cruisers.

Depending on the ship's availability, some initial work to remove equipment and internal interferences is accomplished with the ship moored alongside the pier; however, the access cuts are well above the waterline to ensure floating integrity.

The need to remove hazardous materials such as asbestos, lead, and PCBs, makes ship dismantlement in compliance with all the applicable environmental regulations a challenging task. The complexity of these regulations and the scope of the recycling effort require that the Shipyard continue to work closely with the U.S. Environmental Protection Agency, the Washington State Department of Ecology, and the Puget Sound Air Pollution Control Agency.

6. CONCLUSIONS

This review of the ship inactivation, recycling, and disposal process demonstrates that there is no sophisticated technology required; although new technologies are pursued to ensure compliance and reduce cost of operations. The process involves straightforward planning and engineering, using common industrial practices.

The only significant technical issues in the disposal process relate to the control of radioactivity and hazardous materials. An essential element of the disposal effort is the accomplishment of the work in a manner that assures the Navy, the regulating agencies, and the public that handling and disposing of these materials does not pose risk to human health or the environment. The Navy has an established Occupational Safety and Health Program which ensures a safe and healthful workplace. The ultimate goal is to reduce the occupational injuries and health exposure to as low as possible. The Navy's Occupational Safety and Health Program is consistent with Department of Labor OSHA regulations, existing federal law, executive orders, and applicable labor agreements. Providing this assurance requires thoroughness and diligence.

The continued success of the program has clearly rested on a strong and continuing cooperation between the Navy, the state and federal regulatory agencies, and others who provide services to support the process.

7. REFERENCES

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c. *"Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, OHIO Class, and LOS ANGELES Class Naval Reactor Plants"*, U.S. Department of the Navy, Washington, D.C., April 1996

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h. Code of Federal Regulations, Title 10 (Nuclear Regulatory Commission), Part 71, *"Packaging and Transportation of Radioactive Material"*

i. Code of Federal Regulations, Title 49 (Department of Transportation), Part 173, *"Shippers - General Requirements for Shipments and Packagings"*

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o. Code of Federal Regulations, Title 29 (Occupational Safety and Health Administration), Part 1910, *"Occupational Safety and Health Standards"*

p. Code of Federal Regulations, Title 40 (Environmental Protection Agency), Part 260, *"Hazardous Waste Management System: General"*

q. Code of Federal Regulations, Title 40 (Environmental Protection Agency), Part 61, *"National Emission Standards for Hazardous Air Pollutants"*

r. Washington Administrative Code, WAC 173-400-075, *"Emission Standards for Sources Emitting Hazardous Air Pollutants"*

s. Regulation III of the Puget Sound Clean Air Agency

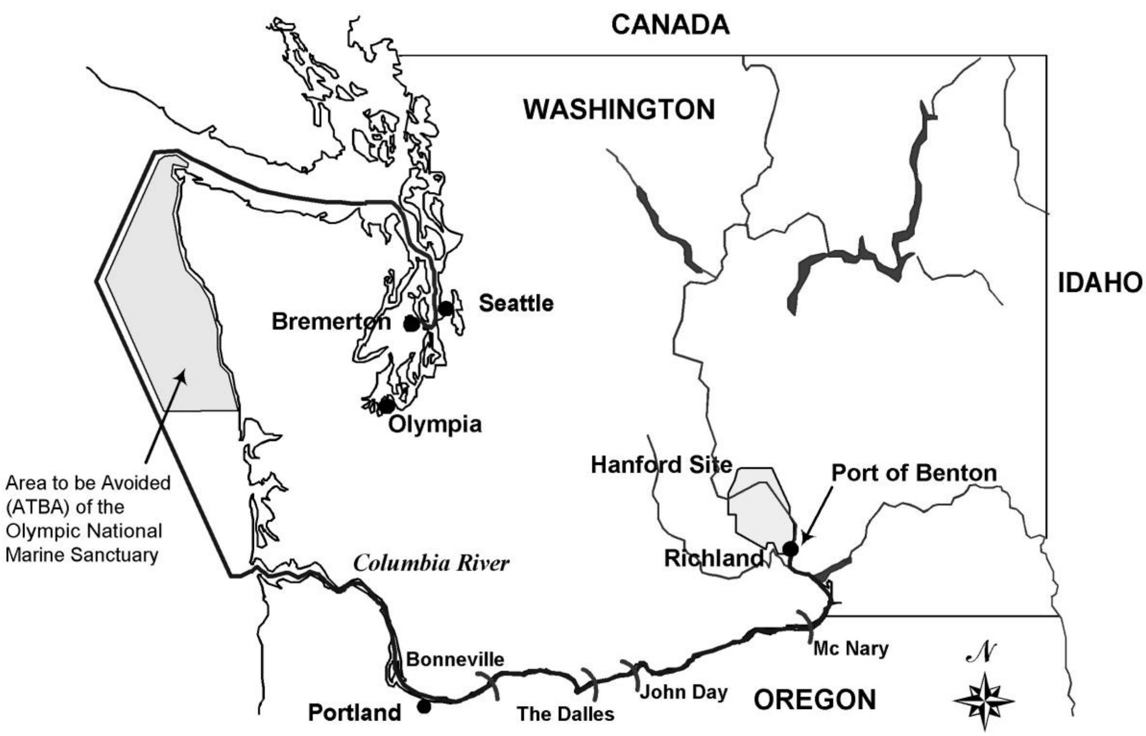
APPENDIX A REACTOR COMPARTMENT TRANSPORTATION

This appendix addresses the shipment of reactor compartments from Puget Sound Naval Shipyard to the DOE's Hanford Site in eastern Washington State for land disposal. The following are actions taken by the Navy to ensure safe shipments.

Barge Shipment

The Navy reactor compartment shipments meet all Department of Transportation requirements for transportation of low level radioactive material. Beyond these requirements, the Navy employs additional conservative precautions designed to ensure safe shipment of the reactor compartments.

The barge is towed from the Shipyard using a large commercial American Bureau of Shipping certified ocean tug. The tow is accompanied by a second, similar backup tug and a security escort vessel. The route follows the normal shipping lanes from the Shipyard through Rich Passage, past Restoration Point, and northerly through Puget Sound. The route is then westerly through the Strait of Juan de Fuca (staying in U.S. waters), past Cape Flattery, and southerly down the Washington coast, staying outside the Area to be Avoided (ATBA) of the Olympic Coast National Marine Sanctuary, to the mouth of the Columbia River. Shipment departure times from the Shipyard are calculated to allow passage across the bar at the mouth of the Columbia River on the incoming tide. The route is then up the Columbia River, following the Army Corps of Engineers' maintained shipping channel used for the regular transport of commercial cargo. The ocean tugs turn the barge over to river tugs on the lower Columbia River. The river route passes through the navigation locks at the Bonneville, Dalles, John Day, and McNary dams, and finally to the Port of Benton located at Richland, Washington.

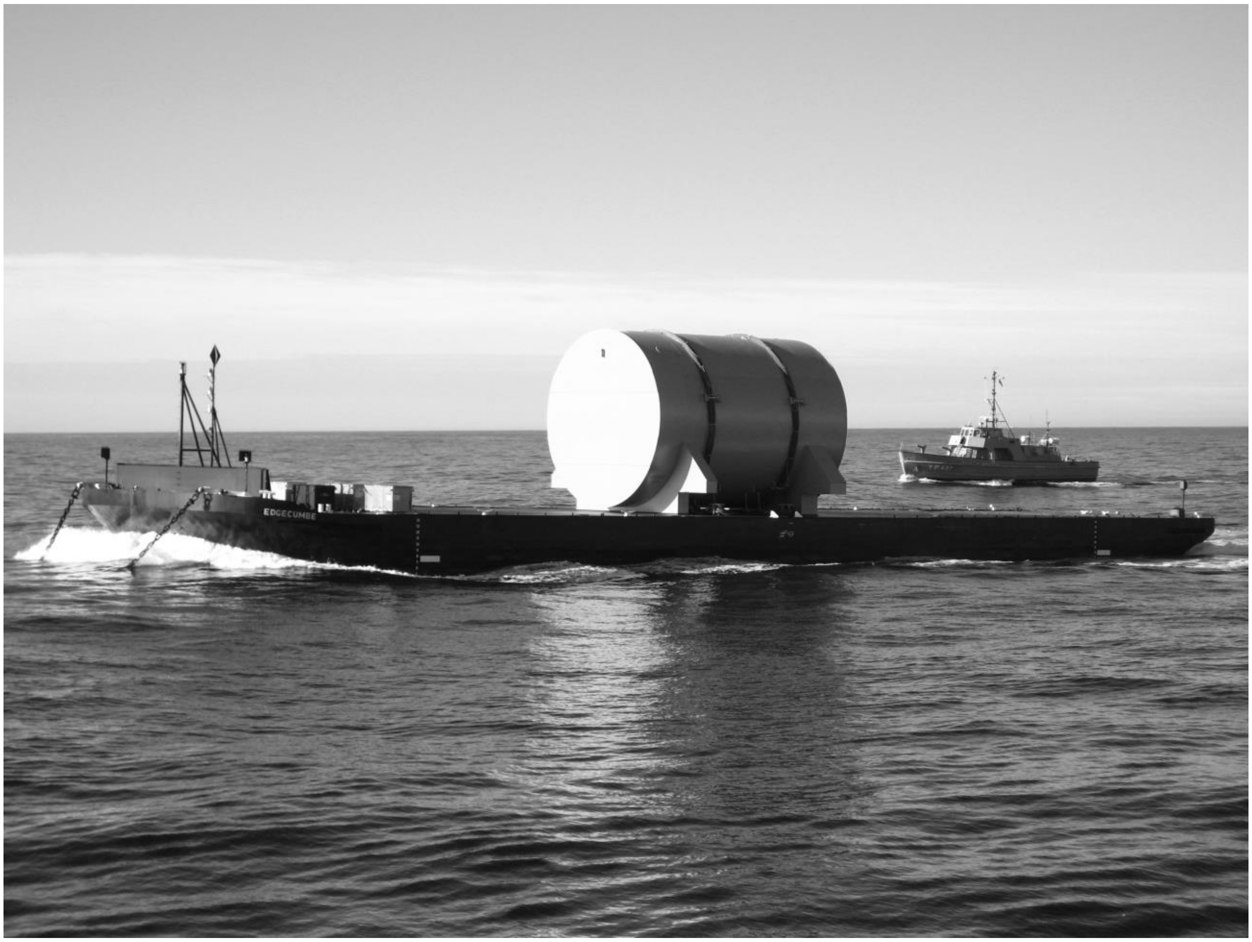


Tow Route

In addition to meeting Department of Transportation and U.S. Coast Guard requirements, the Navy takes extensive additional precautions to ensure the tow is safe and uneventful. Even though a barge accident is highly unlikely, credible scenarios have been analyzed (ref a and c). These analyses show that should an accident occur, there would be no significant risk to the public or the environment.

Submarine Reactor Compartment Disposal Packages Ready for Shipment

The equipment and the transportation procedures are designed to minimize the potential for transportation accidents, to mitigate the consequences of an accident in the unlikely event one should occur, and to facilitate recovery if necessary. Care is taken to make barge accidents highly unlikely. For example, only experienced commercial towing contractors are used, with the advantage of employing people experienced in the work and the route, using regularly operated and maintained equipment. Two tugs are used, one for the tow and one traveling along as a backup to take over in case of a problem with the primary tug. Fully crewed, American Bureau of Shipping certified, commercial ocean tugs are specified for the tow from the Shipyard to the Columbia River. These vessels have more power than would be normally employed for a barge of the size and load-line rating used for reactor compartment disposal. A large pusher-type river tug and backup, both having reserve engine capacity, are used on the Columbia River.



Barge and Escort Vessel During Ocean Tow

All towing operations, including the route to be followed, operating procedures, and casualty procedures, are planned by the towing contractor and approved by the Navy. Normal shipping lanes are used through Puget Sound to minimize the potential for collision or inadvertent grounding. The barge is equipped with flooding alarms. A backup towing bridle and tow line are installed on the barge with a trailing line behind the barge for bringing backup towing gear aboard the tug if the primary towing gear fails. Shipments are not made in the winter or when inclement weather is predicted. Shipments are also planned to avoid interfering with scheduled recreational events, such as boat races, on the tow route.

Licensed ship pilots are used in Puget Sound, on the Columbia River, and for crossing the Columbia River Bar. Shipyard personnel familiar with the towing procedures and the characteristics of the reactor compartment accompany each shipment to monitor the operations and provide advice to the tug captain if needed. Coast Guard or Navy personnel are also stationed aboard the escort vessel. With the above precautions, the potential for a towing accident involving the barge is much lower than the already small probability of accidents during routine barge traffic throughout the United States.

Each of the barges used is highly compartmented and is designed to maintain its upright stability with any two compartments flooded. The welds attaching the reactor compartment to the barge are designed to withstand the maximum forces associated with wind loading, list, trim, pitch, roll, yaw, and any credible accident. Because the reactor compartment sits well back from the sides of the barge and because the extremely strong exterior of the package can withstand severe accidents, breach of the reactor compartment due to collision is not considered a credible event.

Damage due to fire is also extremely unlikely. The transport barge carries no combustible fluids to support a fire. The thick steel packaging of the reactor compartment has a high capacity for absorbing heat and would not be damaged significantly if exposed to fire. In addition, the waterborne shipment environment would provide easy access to firefighting water to put any fire out.

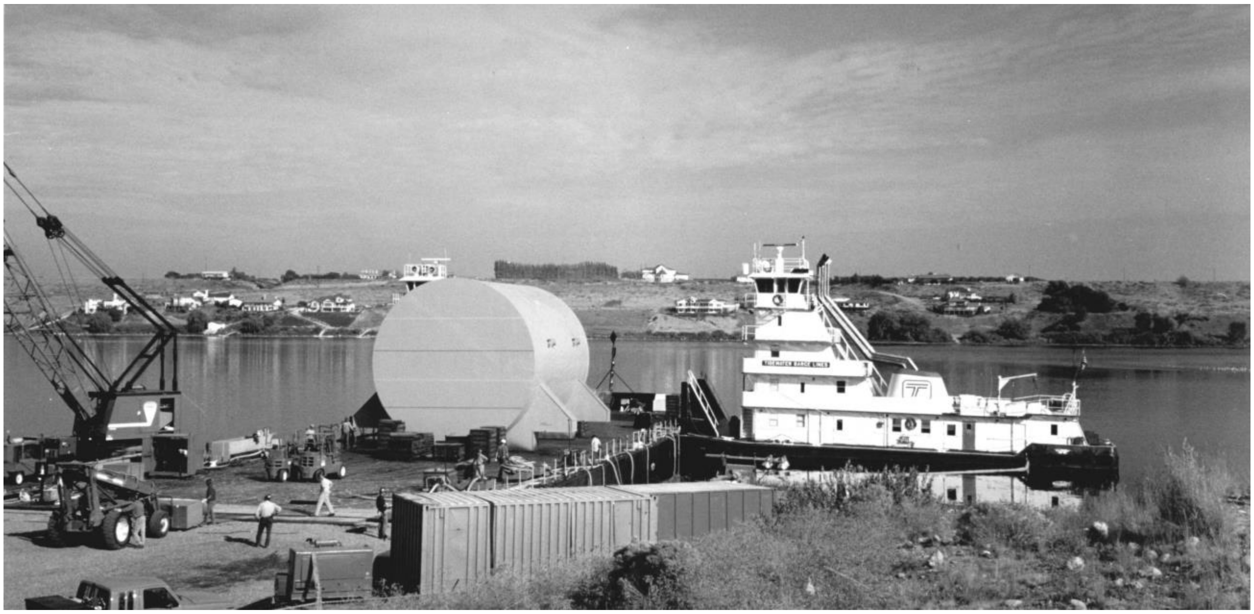
There are no other credible accidents related to water transportation that could cause a breach of the package and release of radioactivity.

Barge on Columbia River

In the highly unlikely event it became necessary, the Navy has incorporated in the barge and package a number of engineered features to facilitate location and salvage. A buoy is attached to the barge and would float to the surface to mark its location. An emergency position indicating radio beacon (EPIRB) would also float to the surface and transmit a locating signal on a frequency monitored by the U.S. Coast Guard-SAR Rescue Coordination Center. In addition, an emergency transponder is mounted to the package which uses underwater sonic signaling to locate its position. Salvage capability is provided for the package to allow the attachment of salvage gear to raise the sunken reactor compartment package using commercial or Navy owned heavy lift ships if refloating the barge is not possible. The barge and package could be raised as a unit, or separated by divers for separate recovery, without any impact on the environment.

Offloading and Land Transportation

Offloading is accomplished at the Port of Benton at Richland, Washington. Facilities at the Port consist of a barge offloading slip constructed of sheet-piling cofferdams and rip-rap earthen bulkheads. The slip is periodically inspected both above and below water to ensure it is in good condition. Maintenance work is controlled under the provisions of an Army Corps of Engineers permit as well as state and local permits and authorizations which are designed to protect river quality.



Offloading at the Port of Benton

Before the barge is docked, divers inspect the slip to ensure the gravel bottom is free of obstructions. The barge is placed in the slip and water is added to the barge compartments in a controlled sequence to ground the barge firmly on the gravel bottom of the slip, with the deck of the barge against and level with the top of the sill at the landward end of the slip.

The welds holding the reactor compartment package to the barge are cut, and the compartment is jacked up and placed on four steel columns. A crane is not required for this work. As is done during drydock lifts, jacking is in small increments with support blocks and shims temporarily placed under the load to support the compartment if hydraulic jack pressure is lost. A transport vehicle is then moved onto the barge and under the package. The transport vehicle is commercially operated under contract. To date, these have all been multiple wheel high capacity trailers specially designed for heavy loads.

The package is attached to the transport vehicle using welded attachments, and raised off the support columns using jacking features built into the transport vehicle. The transporter is then driven off the barge, and the package transported approximately 26 miles to a burial trench at the Hanford Site's 218-E-12B burial ground in the 200 East Area. At the trench, the package and transporter are maneuvered into a large off-loading dock area, the welded attachments to the transporter are cut free, and the reactor compartment package is removed from the transporter using a system of high capacity tracks and rollers. The package is moved into its final disposal position and lowered onto the concrete rail.

Reactor Compartment Package enroute to the Disposal Trench

The time from shipyard departure to placing the package in the trench is about six days, of which three days involve the barge transit.

Potential offloading and land transportation accidents would all involve dropping or toppling the package, or collision with another vehicle. Because of the package design, none of these accidents has the potential to release radioactivity.

The potential for mishandling the package is minimized in a variety of ways. Offloading and land transportation is accomplished under a Navy contract by commercial contractors experienced in handling heavy loads. Conservative engineering designs, load testing of equipment, the use of Navy approved written procedures, and independent monitoring of the work all minimize the potential for a problem. The transport vehicles that are used are designed to transport heavy loads and are very stable. The overland transit is coordinated by Hanford Site transportation personnel. Escort vehicles ensure a clear roadway for the transporter, minimizing the potential for collision with other vehicles.

Preparing to move a Reactor Compartment Package into place on the Rail Delivery System in the Disposal Trench at Hanford

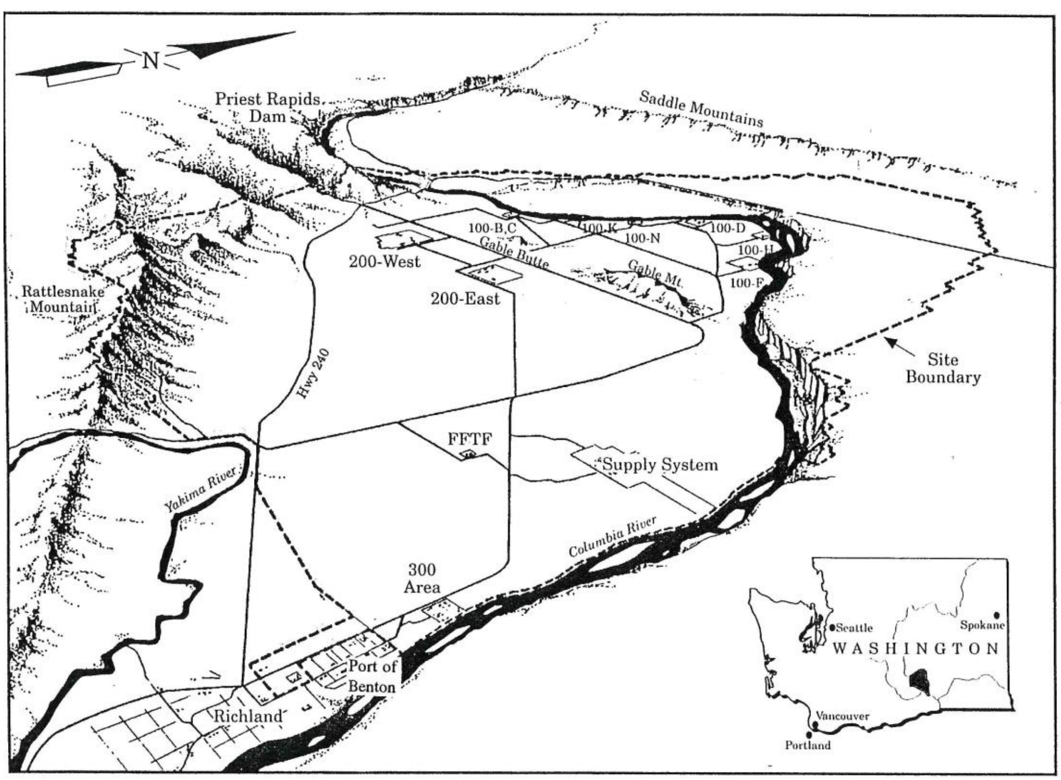
APPENDIX B REACTOR COMPARTMENT DISPOSAL AT HANFORD

This appendix addresses the disposal site at the 218-E-12B Burial Ground at the DOE's Hanford Site in eastern Washington State.

The Hanford Site encompasses approximately 581 square miles (1505 square kilometers) of mostly undisturbed relatively flat desert. The site is located in south-central Washington State within the semi-arid Pasco Basin of the Columbia Plateau. The Columbia River flows through the northern part of the site and forms part of the eastern site boundary. The land provides a buffer for areas once used for nuclear materials production, waste storage, and waste disposal (ref m). The Tri-Cities of Richland, Kennewick, and Pasco to the southeast is the nearest population center. About 587,000 people live within an 80 kilometer radius of the center of the Site according to the 2010 census (ref n).

From 1943 until the late 1980's, Hanford was the location of DOE's reactor and chemical separation facilities for the production of plutonium for use in nuclear weapons. The work at Hanford is now primarily directed toward decommissioning the production facilities, disposal of the wastes, and remediation of contamination that resulted from past operations.

The active Hanford Low Level Burial Grounds consist of eight burial ground sites that cover a total area of approximately 518 acres in the Site's 200 East and 200 West areas. The 200 East Area is located near the center of the Hanford Site on a plateau about 700 feet above sea level, and contains reactor fuel chemical separation processing facilities as well as various waste management facilities. The reactor compartments are placed in the 218-E-12B Burial Ground, one of two active burial grounds in the 200 East Area. This burial ground is an active landfill which began receiving waste in 1967.

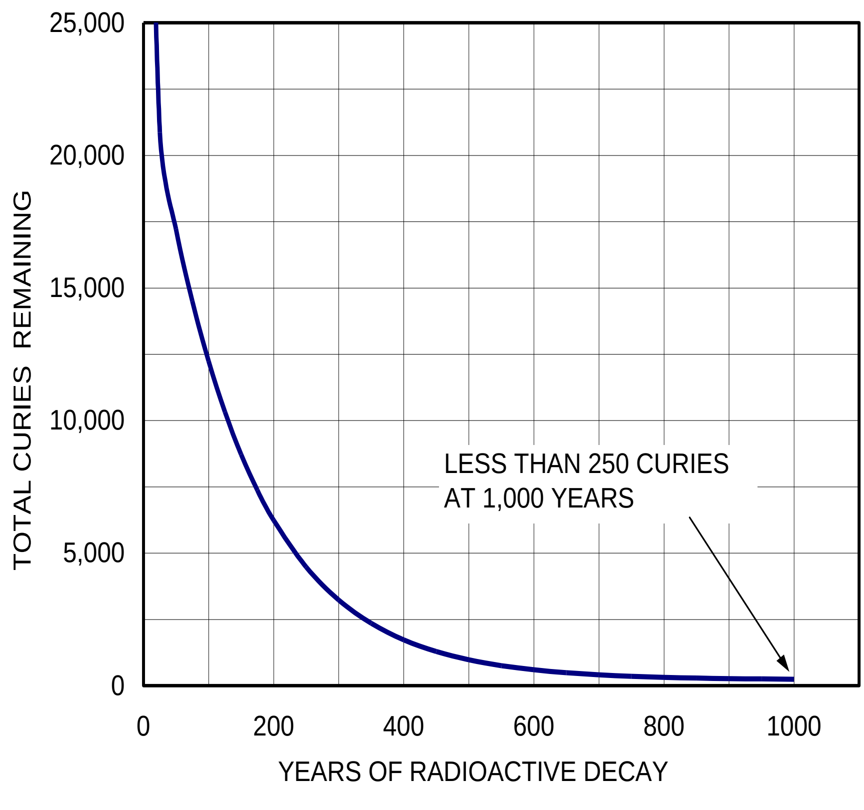


Department of Energy's Hanford Site

The concentrations of radionuclides in waste shipped to the Hanford Site are within limits established by the DOE for disposal of low level radioactive waste. The integrity of the reactor compartment packages exceeds Hanford radioactive waste packaging criteria and NRC criteria for high integrity containers (HICs). For example, the reactor compartment package's design life in Hanford soils will be more than twice the required HIC design life of 300 years, and the reactor compartment package, with its 30 foot drop capability, greatly exceeds the one foot drop capability required for HICs.

After burial, direct radiation at the land surface will be insignificant (i.e. below detectable levels) due to the low contact radiation fields on the package and the shielding effect of the soil cover. For most of the next millennium the reactor compartment package will effectively isolate the radioactivity and other materials, including lead shielding and PCBs, from the environment.

During this time the majority of the radioactivity will have naturally decayed to stable atoms. The remaining small amount of radioactivity is in structural metal alloys that are highly corrosion resistant in Hanford soil conditions. These alloys, which maintain a passive outer protective layer in the Hanford environment, will provide additional millennia of radioactive decay before radioactivity can migrate to the environment.



Radioactivity in a Reactor Plant vs. Time After Final Operation
(This graph applies to submarine and cruiser class reactor plants)

Reactor Compartment Disposal Trench, Fall 2017

The chemically hazardous constituents of waste are also required to be characterized and must meet applicable Resource Conservation and Recovery Act (RCRA) and Toxic Substances Control Act (TSCA) requirements for land disposal. Federal and state regulations have been established for landfills to prevent significant impact to the environment or human health from the migration of waste to groundwater or surface water. Only lead shielding and PCBs cause the reactor compartment to fall under these regulations.

The reactor compartments contain a significant amount of solid lead used as shielding, requiring them to be regulated under Washington State Dangerous Waste Regulations. A study prepared for the Washington State Department of Ecology (ref g) shows it is not practical to remove this lead shielding in view of the increased personnel radiation exposure that would be involved.

The reactor compartments contain PCBs tightly bound in the composition of solid materials such as thermal insulation, electrical cable coverings, paints, and rubber items manufactured and used before PCBs were banned in the 1970s. The PCBs are present in concentrations above 50 parts per million but are considered non-leachable, bulk product waste under TSCA, suitable for disposal at solid waste landfills. The disposal of such PCBs in radioactive waste is not regulated under TSCA.

Reactor compartments constructed before the mid-1970s also contain asbestos in insulation on pipes and other components. This asbestos is fully contained within the reactor compartments, which complies with the Federal Clean Air Act.

The release of lead and PCBs will occur only after the steel of the outer package has corroded away to allow corrosion of interior components, which will be a very slow process in the desert climate. At a minimum, the first potential generation of contaminated leachate as a result of general corrosion and soil pressure would not occur for about 600 years (ref c). Containment of the radioactivity and nearly all of the lead and PCBs will be far longer. The radioactive metal alloys are highly corrosion resistant in the Hanford soil. The soil chemistry will tend to resist the formation of transportable corrosion products. The solid PCBs are bound in long lasting materials.

The lead corrosion products generated would be retained in the soil by strong anion-cation adsorption mechanisms, and there would be very little migration. For example, the earliest estimated time lead could reach the groundwater is 240,000 years. To help put this time in perspective, the recorded history of human civilization is less than 10,000 years, and the predicted timeframe for return of an ice age in the Hanford area is on the order of 40,000 to 50,000 years. Even when these constituents eventually reach the groundwater, the concentrations will be too low to be of concern. Thus, burial of the reactor compartments at Hanford poses insignificant risk to the environment.

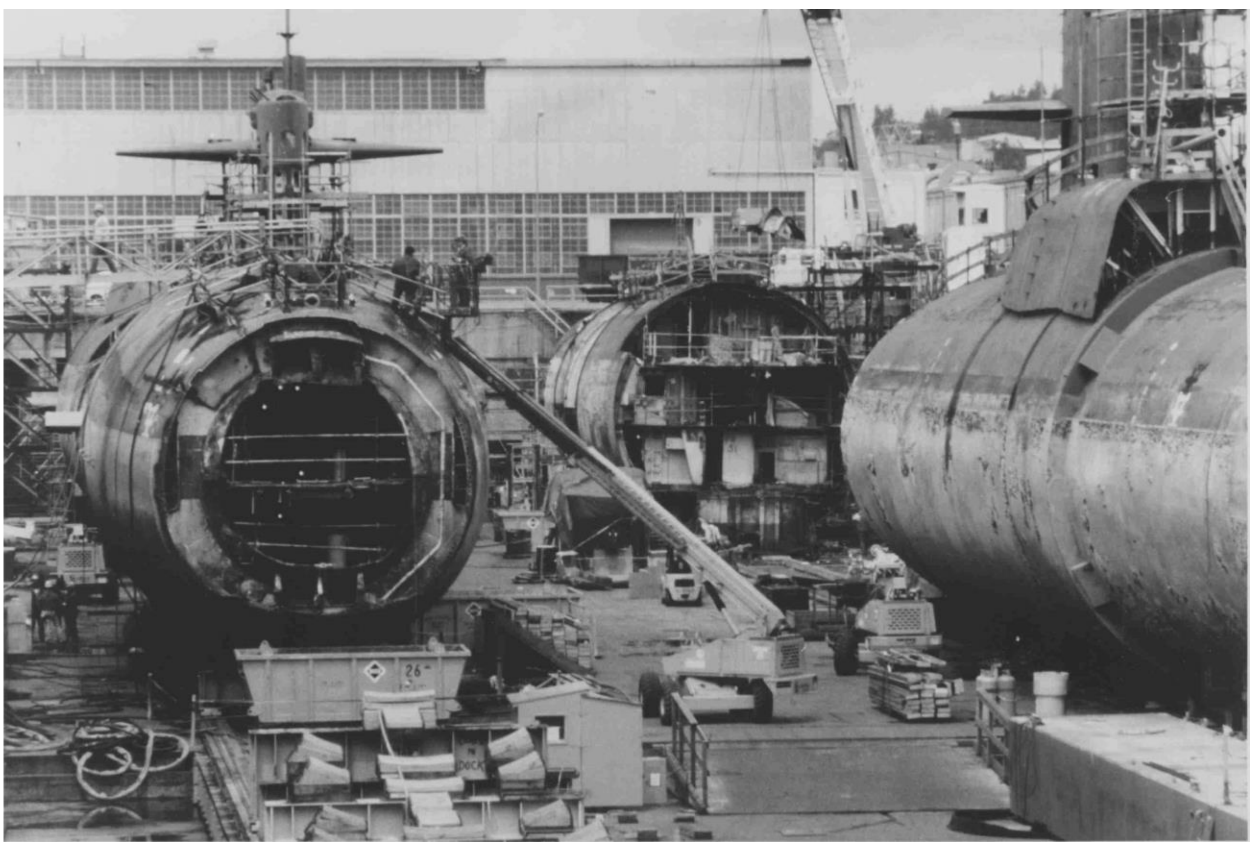
APPENDIX C   SHIP RECYCLING PROCESSES

Purpose

This appendix describes the approach, processes, and equipment involved in recycling ships at Puget Sound Naval Shipyard. The following descriptions of recycling work assume the reactor has been defueled, the reactor compartment has been removed, and the remaining ship's systems are inactivated, deenergized, and drained.

General Approach to Recycling

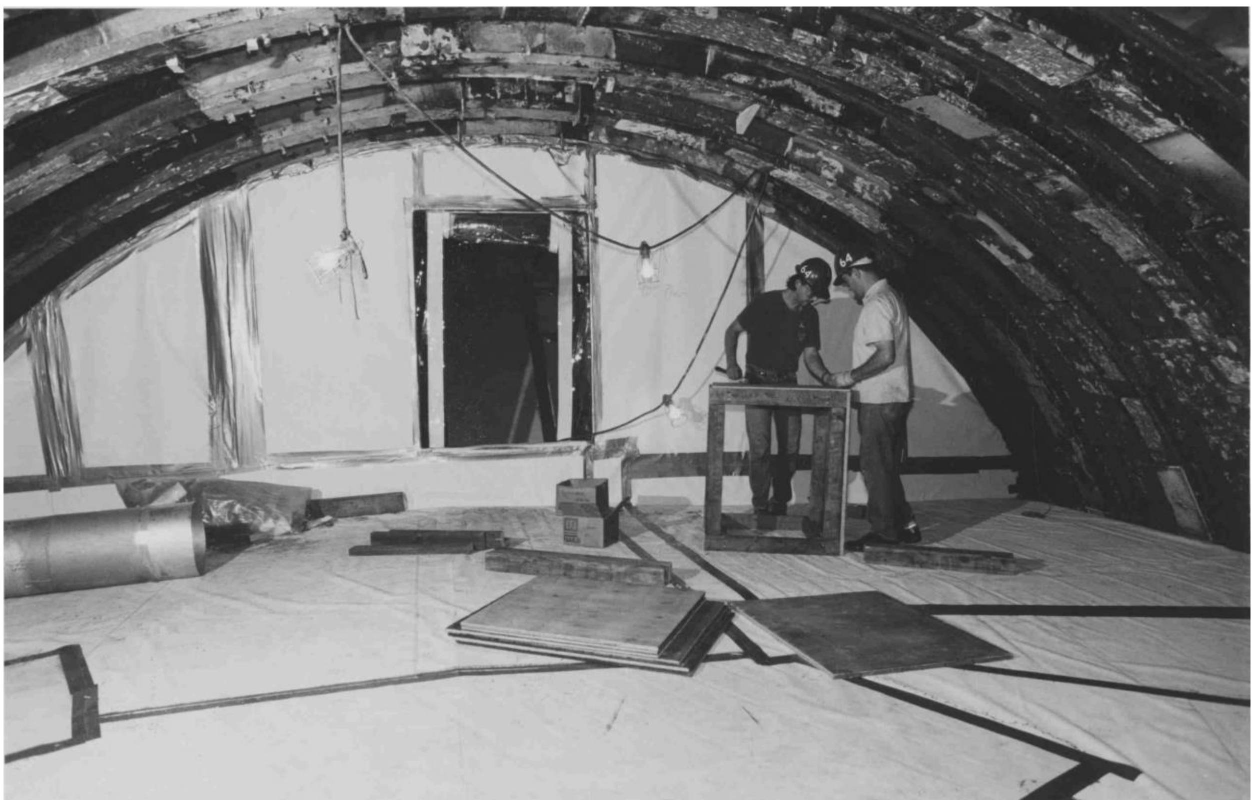
The Shipyard continues to explore ways to optimize in-dock ship dismantlement. There have been two basic methods used to date. The first method is to remove large sections of the ship's hull with most of the adjacent structure piping, cabling, and equipment still attached. The removal is accomplished in a planned and controlled dismantlement sequence involving about 350 major individual sections of hull and structure (for a typical LOS ANGELES Class submarine). The ship's internals are stripped only to the extent necessary to allow hull sections and deck sections to be cut free. The removed sections are placed on a land transporter (usually a railcar or flatbed truck) and moved to a shipyard facility where they pass through a number of workstations to be processed into segregated recyclable materials and waste.



Submarine Undergoing Recycling in Drydock

The second method that evolved is to strip the interior of the ship, including the removal of all accessible hazardous materials. The hull is then cut into sections as is done in the first method. One advantage of this approach is that portions of the ship's interior can be stripped pierside prior to docking, shortening the in-dock time. This is an important factor, as the number of ships being recycled can be limited by the drydocks available for hull cutup and reactor compartment preparation work. The other advantage is that the intact hull provides a good environmental containment for hazardous material removal operations inside the ship, including abrasive blasting.

The recycling process currently being used is a combination of the two approaches. Normally work pierside is done in preparation for making access cuts through the hull once the ship is in drydock. This includes removing interferences such as electrical cable, hull insulation, piping systems, and other items not critical to maintaining hull integrity. Sections of the ship that can be easily stripped pierside are being stripped. Sections that have substantial interferences or other features that make shipboard stripping difficult are cut out for disassembly and processing at the separate processing facility.

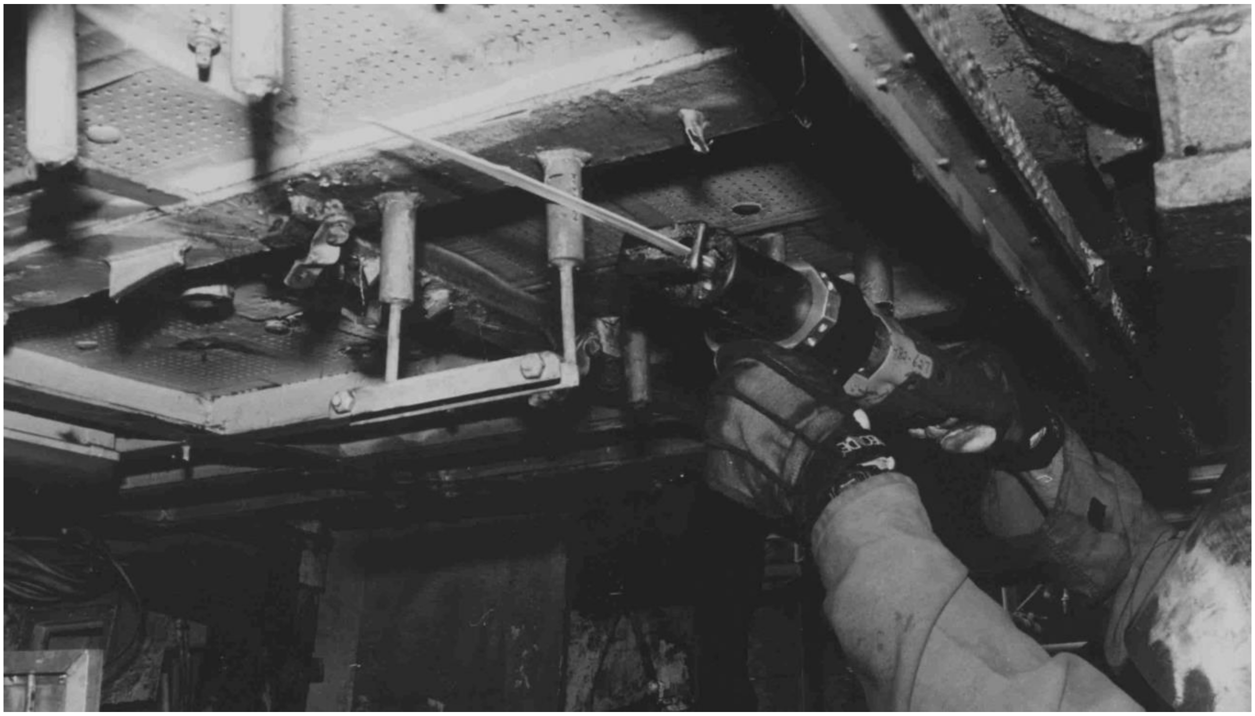


Interior of Submarine with Equipment Removed

Crane Positioning for Lift of Material from Submarine Undergoing Recycling

Puget Sound Naval Shipyard can use any available drydock for ship recycling, while only select drydocks can be used for reactor defueling. Docking multiple ships in a single drydock enables the Shipyard to work on more than one ship at a time, allowing better utilization of services such as portal cranes, abrasive blast equipment, and rolling stock.

The Shipyard uses permanent separate processing facilities augmented by temporary dockside facilities located near the recycling drydocks to process the removed materials and for downsizing the sections of the ship.



Cutting Lightweight Metal

Shipboard Dismantlement

There are a number of hazardous materials present in older ships that need special controls for health, safety, and environmental protection (ref k, o, and p). However, most of these are present in relatively small quantities in discrete locations. The exceptions are asbestos, PCBs, and metallic lead, which are present in significant quantities. Thus, one of the first actions when a ship begins the recycling process is to identify and tag equipment and structure that contain these materials. This includes shipboard sampling to identify insulating materials (both on piping systems and on ship's structure), paint, and other products that may contain asbestos or PCBs. This identification program allows the proper personnel safety and environmental controls to be established for shipboard dismantlement and in the subsequent handling, processing, and disposition of the removed materials.

In dismantling the ship, care is taken to unbolt and remove equipment that will be refurbished and reused. However, the remaining non-reusable equipment, wiring, piping, and non-structural material is most efficiently removed by destructive processes. It is cut free using reciprocating saws, hand held shears, plasma torches, and oxy-fuel cutting torches. The lighter materials are cut into pieces that can be manually loaded into large material handling containers.

The machinery in the engine room of the ship requires considerably more work to remove than the lighter equipment and materials in the other areas of the ship. Much of this heavy equipment must be crane lifted, even when cut into pieces. Large holes are cut in the top and sides of the ship’s structure to facilitate removal of material during the early phases of dismantlement. Material handling containers are either lowered into the ship or placed alongside where material can be placed into them. Larger equipment is moved under a hull access cut where a crane can lift it out of the ship.

Electrical cables are cut using both hydraulic and manually operated cable cutters. Larger diameter piping is cut with pneumatic reciprocating saws. Smaller diameter piping can be cut using electric reciprocating saws. Light metal items such as partitions and ventilation ducts are also easily cut using electrical reciprocating saws. All removed materials are cut into sizes that can be manually placed into the material handling containers.

Asbestos Insulation Being Removed from Piping

Asbestos insulation is removed by personnel specially trained in asbestos work under stringent work controls. Every effort is made to protect the environment and the worker. Asbestos removal uses work procedures which employ the use of containments, HEPA filtered vacuum cleaners, and wetting agents. The work areas are monitored to ensure the air quality remains within prescribed limits. After the asbestos insulation is removed it is carefully packaged in waste bags, labeled with appropriate asbestos warning labels and shipped to an approved land fill for disposal in accordance with all established requirements (ref q, r, and s).

Shipboard Removal of Cover Plates to Allow Access to Remove
PCB Felt Sound Damping Material

PCBs are encountered in significant concentrations, primarily in wool felt sound damping material used to insulate the hull of submarines. This damping material is installed under bolted metal plates against hull or machinery foundation structures. During the time period when early submarines were constructed, PCBs were commonly used for their fire retardant properties. The covering plates and the impregnated wool felt are manually removed and disposed of as PCB waste. The work is done by trained personnel under work controls which prevent the spread of PCB contamination. Where entire interior areas of the hull require cleaning, high capacity steel abrasive blasting equipment is used to remove the PCB residue. The areas to be abrasive blasted are isolated from the rest of the ship and provided with controlled and filtered ventilation. Personnel wear protective clothing and are supplied with breathing air. The steel abrasive is recovered and reused. The PCB waste is packaged for disposal in accordance with applicable requirements (ref j).

Sections of the hull that are not planned to be completely cleaned of PCBs while shipboard require the PCB felt and PCB residue to be removed from the area where the hull will be cut. The hull sections are removed from the drydock and special off-hull abrasive blasting facilities are used or the residue is removed by hand scraping and wire brushing, followed by wiping with chemical and detergent rinses.

For submarines, lead ballast in the way of hull sectioning work is manually removed. The individual pieces generally weigh about 60 to 100 pounds. Two different lead removal methods are employed in ship recycling. One method is the removal of individual pieces which are packaged in bags for transport. The other method involves cutting the ship's structure and removing the entire lead ballast intact. The configuration of the individual lead ballast determines the method used.

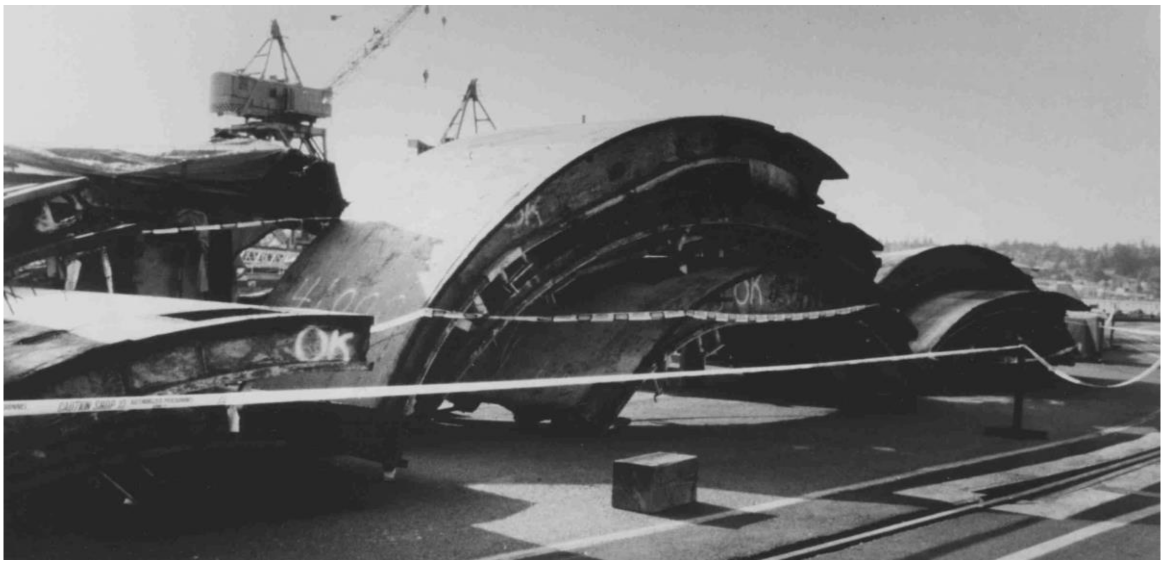
Lead Ballast Removal

The heavy steel hull and structural materials are cut with hand held torches capable of cutting hull material at speeds up to 18 inches per minute. Extremely thick components such as shafts are cut using heavy duty oxy-fuel torches. Although care is taken to prevent inadvertently starting fires, fire watches with CO_2 bottles and fire hoses are stationed near the cutting operations. The slag and debris produced by the burning process is controlled to prevent it from entering the environment by way of the drydock drainage system.

The majority of the hull sections cut from the ship are under 10 tons in weight, allowing them to be handled by a variety of shipyard cranes and heavy duty fork lifts. However, because of restricted access, it is not practical to cut some sections of the ship into such small pieces in drydock (e.g. the missile compartment crown sections). Thus, some sections weigh nearly 50 tons, a weight which can be handled by a number of the Shipyard's portal cranes. These larger sections are transported to an off-hull facility for processing.

Processing Facilities

The major hull and deck sections, and other removed components, are processed in separate processing facilities. Some sections come from the ship already stripped and cleaned. Based on their size, these may be placed directly into a gondola railcar or may require additional cutting to allow for more efficient loading. Other sections require further dismantlement and processing to remove hazardous materials, including asbestos, PCBs, and any remaining metallic lead. Components and equipment which exhibit sensitive or classified design information require demilitarization to remove this information. The following paragraphs discuss the processing facility operations.



Staged Submarine Hull Sections

Where required, hull and deck sections are further dismantled and stripped of attached materials. Non-hazardous materials are stripped first. Light structure, piping, electrical wiring, and other attachments are cut away using hand held grinders, saws, and torches.

Metal materials (removed shipboard or from hull and deck sections at the processing facility) are segregated, and placed in appropriate containers for recycling. Non-recyclable materials such as insulating materials are disposed of as waste.

Equipment which contains sensitive information is demilitarized in accordance with approved guidelines. Some equipment requires total destruction. This is accomplished by cutting and melting. About 80,000 pounds of equipment is melted from each submarine. Other forms of demilitarization include dismantlement and segregation of alloys as scrap metal.

Processing Facility Dismantlement of Hull Sections

Just as for shipboard work, facility processing of hull sections and other components containing hazardous materials such as lead, PCBs, and asbestos, requires special controls to protect personnel and the environment during stripping and cleaning operations. After hull sections have been cleaned, workers cut them into smaller sections for final shipment as shown above. Personnel protection is also maintained for cutting operations, work involving high temperatures, and other such operations common to heavy industry.

Asbestos removal is accomplished in isolated areas with controlled and filtered ventilation. Asbestos work controls similar to those described for shipboard work, are employed for asbestos removal at the separate processing facility.

Lead removal is usually a manual process to remove remaining ballast lead and miscellaneous lead components. This work is accomplished by specifically trained personnel wearing protective clothing and breathing equipment. The removed lead is shipped from the Shipyard for recycling.

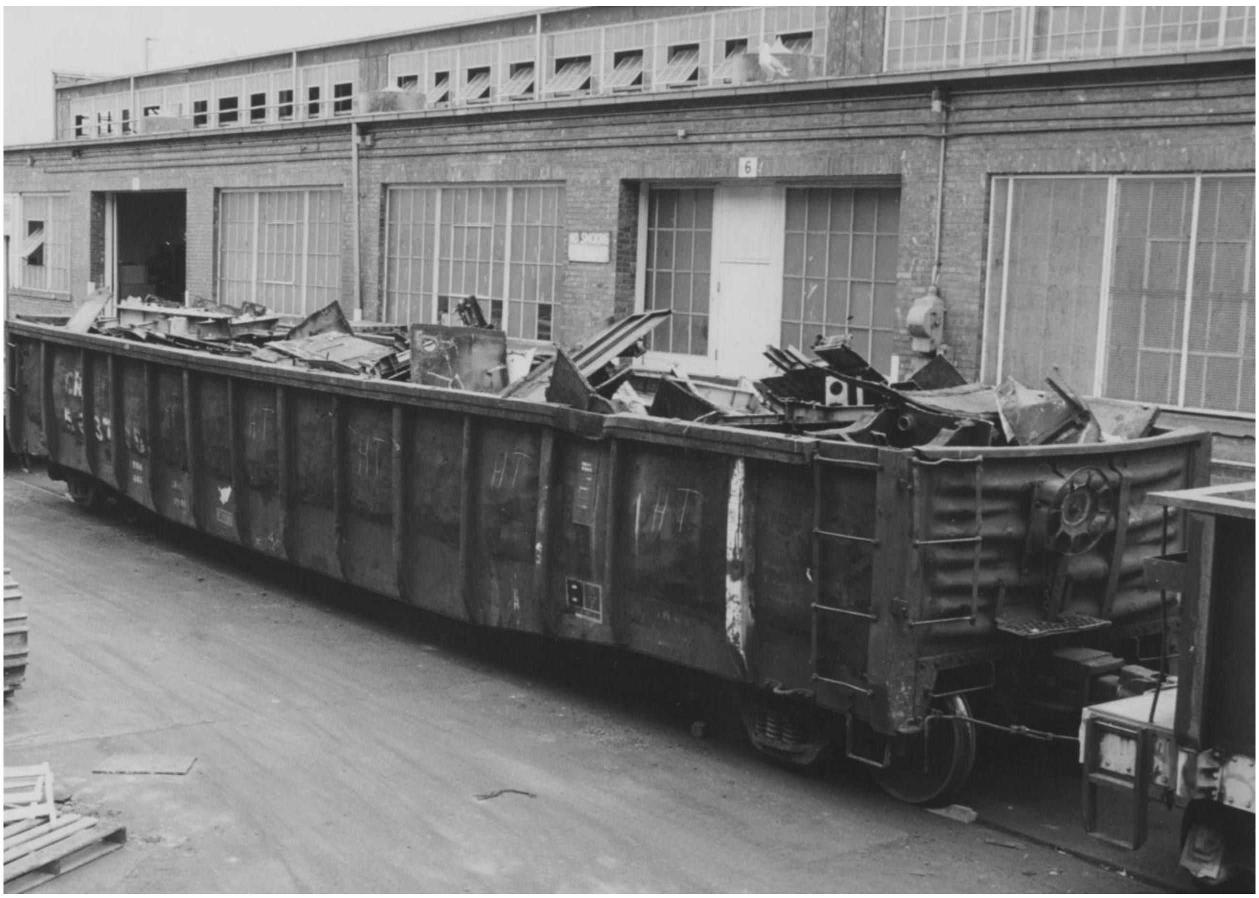
PCB work is also performed in controlled areas by trained personnel wearing protective equipment. The PCB-bearing wool felt and its cover plates are manually removed (if still attached to structure) and disposed of as PCB waste. The PCB residue on the metal surfaces is then removed. Steel abrasive blasting using high capacity blasting equipment, has proven to be the most efficient removal process. Blasting is conducted inside containments having controlled and filtered ventilation by personnel wearing full body protective clothing and supplied with breathing air. The steel abrasive is recovered and reused.

Some electrical cable contains asbestos and PCBs. Electrical cable is cut with hydraulic or manual cable cutters and shipped to a recycling contractor.

Scrap metals are sold for recycling through a mixed metals contract managed by the Defense Logistics Agency (DLA). Reusable equipment not needed by the Navy or Defense Department is sold to private bidders through the DLA Disposition Services Office at Joint Base Lewis-McChord, Washington.

A typical LOS ANGELES Class submarine recycling generates approximately 2,000,000 pounds of HY-80 steel, 4,000,000 pounds of other steel, 600,000 pounds of lead and 1,000,000 pounds of other mixed metals such as aluminum, copper, brass and monel.

A typical cruiser recycling generated about 11,000,000 pounds of hull steel and furnishings, and about 1,000,000 pounds of aluminum superstructure.



Recyclable Material Ready for Shipment

APPENDIX D COMPLETED REACTOR COMPARTMENT DISPOSAL AND SHIP RECYCLING PROJECTS

REACTOR COMPARTMENT SHIPMENT No.	HULL NUMBER		NAME	YEAR RC DISPOSAL WAS COMPLETED	YEAR SHIP RECYCLE WAS COMPLETED*
1	SSBN	599	Ex-Patrick Henry	1986	1997
2	SSN	592	Ex-Snook	1987	1997
3	SSBN	598	Ex-George Washington	1988	1998
4	SSN	588	Ex-Scamp	1988	1991
5	SSBN	601	Ex-Robert E. Lee	1989	1991
6	SSBN	618	Ex-Thomas Jefferson	1989	1998
7	SSBN	600	Ex-Theodore Roosevelt	1989	1995
8	SSN	607	Ex-Dace	1989	1997
9	SSBN	620	Ex-John Adams	1990	1996
10	SSBN	602	Ex-Abraham Lincoln	1990	1994
11	SSN	596	Ex-Barb	1990	1996
12	SSBN	608	Ex-Ethan Allen	1990	1999
13	SSBN	610	Ex-Thomas A. Edison	1990	1997
14	SSN	603	Ex-Pollack	1990	1995
15	SSN	685	Ex-Glenard P. Lipscomb	1991	1997
16	SSBN	622	Ex-James Monroe	1991	1995
17	SSN	585	Ex-Skipjack	1991	1998
18	SSBN	623	Ex-Nathan Hale	1991	1994
19	SSN	595	Ex-Plunger	1991	1996
20	SSN	591	Ex-Shark	1991	1996
21	SSBN	616	Ex-Lafayette	1992	1992
22	SSBN	609	Ex-Sam Houston	1992	1992
23	SSN	605	Ex-Jack	1992	1992
24	SSN	604	Ex-Haddo	1992	1992
25	SSN	606	Ex-Tinosa	1992	1992
26	SSN	612	Ex-Guardfish	1992	1992
27	SSN	594	Ex-Permit	1992	1993
28	SSN	651	Ex-Queenfish	1992	1993
29	SSBN	631	Ex-Ulysses S. Grant	1993	1993
30	SSBN	611	Ex-John Marshall	1993	1993
31	SSBN	654	Ex-George C. Marshall	1993	1994
32	SSN	613	Ex-Flasher	1993	1994
33	SSN	665	Ex-Guitarro	1993	1994
34	SSBN	617	Ex-Alexander Hamilton	1993	1994
35	SSBN	656	Ex-George W. Carver	1993	1994
36	SSBN	628	Ex-Tecumseh	1994	1994
37	SSN	587	Ex-Halibut	1994	1994
38	SSBN	659	Ex-Will Rogers	1994	1994

* Reactor compartment removal and ship recycling were conducted in separate dockings from 1986 through 1991. Beginning in 1991, ships were recycled during reactor compartment disposal.

REACTOR COMPARTMENT SHIPMENT No.	HULL NUMBER		NAME	YEAR RC DISPOSAL WAS COMPLETED	YEAR SHIP RECYCLE WAS COMPLETED
39	SSBN	655	Ex-Henry L. Stimson	1994	1994
40	SSBN	629	Ex-Daniel Boone	1994	1994
41	SSN	614	Ex-Greenling	1994	1994
42	SSBN	630	Ex-John C. Calhoun	1994	1994
43	SSBN	633	Ex-Casimir Pulaski	1994	1994
44	SSN	578	Ex-Skate	1995	1995
45	SSN	583	Ex-Sargo	1995	1995
46	SSBN	657	Ex-Francis Scott Key	1995	1995
47	SSN	637	Ex-Sturgeon	1995	1995
48	SSBN	640	Ex-Benjamin Franklin	1995	1995
49	SSN	579	Ex-Swordfish	1995	1995
50	SSN	584	Ex-Seadragon	1995	1995
51	SSBN	634	Ex-Stonewall Jackson	1995	1995
52	SSBN	641	Ex-Simon Bolivar	1995	1995
53	SSN	663	Ex-Hammerhead	1995	1995
54	SSBN	658	Ex-Mariano G. Vallejo	1995	1995
55	SSN	597	Ex-Tullibee	1996	1996
56	SSBN	644	Ex-Lewis and Clark	1996	1996
57	SSN	650	Ex-Pargo	1996	1996
58	SSN	669	Ex-Seahorse	1996	1996
59	SSN	662	Ex-Gurnard	1996	1996
60	SSN	673	Ex-Flyingfish	1996	1996
61	SSN	615	Ex-Gato	1996	1996
62	SSN	652	Ex-Puffer	1997	1997
63	SSN	575	Ex-Seawolf	1997	1997
64	SSN	689	Ex-Baton Rouge	1997	1997
65	SSN	667	Ex-Bergall	1997	1997
66	SSN	638	Ex-Whale	1997	1997
67	SSBN	625	Ex-Henry Clay	1997	1997
68	SSBN	627	Ex-James Madison	1997	1997
69	SSN	670	Ex-Finback	1997	1997
70	SSN	668	Ex-Spadefish	1997	1997
71	SSN	649	Ex-Sunfish	1997	1997
72	SSBN	643	Ex-George Bancroft	1998	1998
73	SSN	646	Ex-Grayling	1998	1998
74	SSN	672	Ex-Pintado	1998	1998
75	SSN	682	Ex-Tunny	1998	1998
76	SSN	678	Ex-Archerfish	1998	1998
77	SSBN	624	Ex-Woodrow Wilson	1998	1998
78	CGN	35	Ex-Truxtun, Plant #1	1999	1999
79	CGN	35	Ex-Truxtun, Plant #2	1999	1999
80	SSN	660	Ex-Sand Lance	1999	1999
81	SSBN	619	Ex-Andrew Jackson	1999	1999
82	SSN	664	Ex-Sea Devil	1999	1999
83	CGN	41	Ex-Arkansas, Plant #1	1999	1999
84	CGN	25	Ex-Bainbridge, Plant #2	1999	1999

REACTOR COMPARTMENT SHIPMENT No.	HULL NUMBER		NAME	YEAR RC DISPOSAL WAS COMPLETED	YEAR SHIP RECYCLE WAS COMPLETED
85	CGN	25	Ex-Bainbridge, Plant #1	1999	1999
86	CGN	41	Ex-Arkansas, Plant #2	1999	1999
87	SSN	674	Ex-Trepang	2000	2000
88	SSN	647	Ex-Pogy	2000	2000
89	SSN	676	Ex-Billfish	2000	2000
90	SSBN	645	Ex-James K. Polk	2000	2000
91	SSBN	636	Ex-Nathanael Greene	2000	2000
92	SSN	684	Ex-Cavalla	2000	2000
93	SSN	666	Ex-Hawkbill	2000	2000
94	SSN	648	Ex-Aspro	2000	2000
95	CGN	36	Ex-California, Plant #2	2001	2001
96	CGN	36	Ex-California, Plant #1	2001	2001
97	SSN	679	Ex-Silversides	2001	2001
98	SSN	621	Ex-Haddock	2001	2001
99	SSN	590	Ex-Sculpin	2001	2001
100	SSBN	632	Ex-Von Steuben	2001	2001
101	CGN	39	Ex-Texas, Plant #2	2001	2001
102	CGN	39	Ex-Texas, Plant #1	2001	2001
103	SSN	686	Ex-L. Mendel Rivers	2002	2002
104	SSN	680	Ex-William H. Bates	2002	2002
105	CGN	38	Ex-Virginia, Plant #2	2002	2002
106	CGN	38	Ex-Virginia, Plant #1	2002	2002
107	SSN	703	Ex-Boston	2002	2002
108	SSN	642	Ex-Kamehameha	2002	2002
109	SSN	681	Ex-Batfish	2002	2002
110	SSN	687	Ex-Richard B. Russell	2002	2002
111	SSN	653	Ex-Ray	2003	2003
112	SSN	675	Ex-Bluefish	2003	2003
113	SSN	661	Ex-Lapon	2004	2004
114	SSN	639	Ex-Tautog	2004	2004
115	SSN	683	Ex-Parche	2006	2006
116	CGN	40	Ex-Mississippi, Plant #2	2007	2007
117	CGN	40	Ex-Mississippi, Plant #1	2007	2007
118	SSN	718	Ex-Honolulu	2008	2008
119	SSN	586	Ex-Triton, Plant #1	2009	2009
120	SSN	586	Ex-Triton, Plant #2	2009	2009
121	CGN	37	Ex-South Carolina, Plant #2	2010	2010
122	CGN	37	Ex-South Carolina, Plant #1	2010	2010
123	SSN	677	Ex-Drum	2011	2011
124	SSN	688	Ex-Los Angeles	2012	2012
125	SSN	692	Ex-Omaha	2012	2012
126	SSN	696	Ex-New York City	2014	2014
127	SSN	693	Ex-Cincinnati	2014	2014
128	SSN	695	Ex-Birmingham	2016	2016
129	SSN	694	Ex-Groton	2016	2016
130	SSN	704	Ex-Baltimore	2017	2017

REACTOR COMPARTMENT SHIPMENT No.	HULL NUMBER		NAME	YEAR RC DISPOSAL WAS COMPLETED	YEAR SHIP RECYCLE WAS COMPLETED
131	SSN	702	Ex-Phoenix	2017	2017
132	SSN	697	Ex-Indianapolis	2018	2018
133	SSN	712	Ex-Atlanta	2018	2018

APPENDIX E ORGANIZATIONS INVOLVED IN SUBMARINE INACTIVATION, DISPOSAL, AND RECYCLING

This appendix lists key government, commercial, and private organizations involved in planning for and implementation of submarine inactivation, disposal, and recycling.

FEDERAL AGENCIES

U.S. Department of Energy, Richland Field Office (DOE-RL)

U.S. Environmental Protection Agency, Region 10 (EPA)

U. S. Department of Labor, Occupational Safety and Health Administration (OSHA)

U.S. Navy, Commander, THIRD Fleet

U.S. Navy, Commander, Navy Region Northwest

U.S. Coast Guard, Marine Safety Center, Washington D.C.

U.S. Coast Guard, Commander, 13th Coast Guard District

U.S. Navy, Naval Criminal Investigative Service (NCIS)

U.S. Navy, Naval Undersea Warfare Center (NUWC), Division Keyport, Washington

U.S. Army Corps of Engineers, Northwestern Division

U.S. Fish and Wildlife Service

National Oceanic and Atmospheric Administration (NOAA), Fisheries

STATE AND LOCAL AGENCIES

Washington State Department of Ecology

Washington State Department of Health, Division of Environmental Health, Office of Radiation Protection

Washington Department of Fish and Wildlife

Oregon State Department of Energy

Oregon State Health Division, Radiation Control Section

Grant County Public Utility District

Port of Benton, Richland, WA

Puget Sound Clean Air Agency

City of Richland, WA

NATIVE AMERICAN TRIBES AND NATIONS

Confederated Tribes and Bands of the Yakama Nation

Confederated Tribes of the Umatilla Indian Reservation

Nez Perce Tribe

PRIVATE INDUSTRY

American Bureau of Shipping (ABS)

Columbia River Bar Pilots Association

Columbia River Pilots Association

Towing and Landhaul Contractors

Hanford Site Contractors