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Report to the Chairmen, Subcommittees on Defense, Senate and House Committees on Appropriations

July 1992

NUCLEAR-POWERED SHIPS

Accounting for Shipyard Costs and Nuclear Waste Disposal Plans

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National Security and
International Affairs Division

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July 1, 1992

The Honorable Daniel K. Inouye
Chairman, Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable John P. Murtha
Chairman, Subcommittee on Defense
Committee on Appropriations
House of Representatives

In response to section 8130 of the Fiscal Year 1992 Department of Defense Appropriations Act (P.L. 102-172), we are reporting to you on the Navy's accounting practices at its nuclear shipyards. We used the Puget Sound Naval Shipyard as the basis for our review of these practices and determined the work load and costs for both nuclear and nonnuclear work in fiscal year 1991. Also included, as appendix III, is a report prepared by the Navy on its current plan for the handling and disposal of nuclear materials and radioactively contaminated materials of nuclear-powered ships, including cost projections for the next 20 years.

Background

The Navy has had nuclear-powered ships since the USS Nautilus was commissioned in 1954. As of June 1992, the Congress had authorized a total of 210 nuclear-powered submarines and surface ships. About two-thirds of those are now in operation, 23 are under construction or scheduled for construction, and over 40 have been decommissioned.

According to Navy officials, the Navy builds and maintains nuclear-powered ships to take advantage of the substantial military capabilities afforded by nuclear propulsion. Specifically, nuclear propulsion provides submarines true stealth and operational independence by enabling sustained, high-speed, submerged operation anywhere in the world's oceans, including under the polar ice. Nuclear propulsion also enhances the capability of surface ships by providing virtually unlimited high-speed endurance, without dependence on tankers and their escorts, while allowing for increased storage capacity for weapons and aircraft fuel in the space that is used for propulsion fuel in conventionally powered ships.

The Navy has six nuclear-capable shipyards that it uses to accomplish several types of projects on nuclear-powered ships. These projects include refuelings to provide an additional 15 to 20 years of nuclear propulsion capacity; reactor plant alterations, repairs, and maintenance as necessary to ensure the continued safe and reliable operation; and defueling, inactivating, and disposing of nuclear-powered ships at the end of their operational life. Nuclear-capable shipyards also conduct repairs and alterations to nonnuclear systems on both nuclear-powered and conventionally powered ships.

Although they differ in their specific capabilities, these six nuclear-capable shipyards have the facilities, equipment, support services, and trained personnel to work on nuclear propulsion systems. Two of the shipyards—Norfolk and Puget Sound—work on a full range of nuclear-powered and conventionally powered ships, ranging from submarines to aircraft carriers. Two other shipyards—Mare Island and Portsmouth—work primarily on nuclear-powered submarines, although Mare Island also works on nuclear-powered surface ships. The Charleston shipyard works on nuclear-powered submarines and conventionally powered surface ships. The Pearl Harbor shipyard works primarily on nuclear-powered submarines and conventionally powered surface ships homeported in the area.

The Navy Industrial Fund was established to finance operations of naval activities, including the naval shipyards. The fund covers the cost of work until the shipyard receives payment from its customers, typically Naval Sea Systems Command (NAVSEA) and fleet commanders.

Results in Brief

The Puget Sound Naval Shipyard captures and accumulates direct and overhead costs using the Standard Naval Shipyard Management Information System. Direct costs include labor and material costs for a project, for example, the inactivation of a nuclear-powered submarine. Overhead costs are costs that cannot be easily traced to a specific project because the benefits apply to more than one project, for example, the public works department. Overhead costs are applied to each hour of direct labor charged to a project based on rates that are established and periodically reviewed and adjusted by the shipyard Comptroller to ensure they accurately reflect the overhead costs being incurred.

Puget Sound's Management Information System also captures the cost of nuclear or nonnuclear work but is not designed to accumulate or report total costs by these categories on a fiscal year basis. Both NAVSEA and Puget Sound officials stated that the lack of such a cost breakdown is not a problem, since shipyard work is managed on a project and departmental basis. The Naval Sea Systems Command defines work as nuclear if it involves reactor plant systems and secondary plant (steam plant) systems under the technical cognizance of the Naval Nuclear Propulsion Program and components, equipment, parts, and materials for use in these systems. All other work on the ship is defined as nonnuclear and, according to NAVSEA officials, includes a wide range of work varying in complexity from installation, modification, and maintenance of sophisticated weapons systems, to simple hull preservation and painting. (App. I provides additional information on Puget Sound's cost accounting practices.)

In fiscal year 1991, Puget Sound worked on 24 nuclear-powered and 3 conventionally powered ships. The shipyard's total costs were about $784.9 million, of which about $736.4 million was charged to shipyard projects through job orders.[1] For fiscal year 1991, about 31 percent of the workdays and 35 percent of total costs charged to job orders at Puget Sound were for nuclear work. The average cost per workday for nuclear labor ($213) was 25 percent higher than for nonnuclear labor ($170). The average cost per workday for overhead applied to nuclear work ($303) was 60 percent higher than that applied to nonnuclear work ($189). This difference was due to the complex nature of nuclear work, which requires a greater level of services, and the higher cost of specially trained and skilled workers and specialized shipyard departments that support nuclear work, such as radiological control, nuclear engineering, nuclear planning, and nuclear quality assurance. In addition, nuclear work requires extensive training and supervision. (App. II provides additional information on the costs incurred in fiscal year 1991 at Puget Sound for both nuclear and nonnuclear work.)

As agreed with the Senate Subcommittee staff, we did not obtain written comments on this report from the Department of Defense. However, we discussed a draft of this report with officials of Naval Sea Systems Command (in the Industrial and Facility Management Directorate, the Comptroller Directorate, and the Nuclear Propulsion Directorate) and the Puget Sound Naval Shipyard and have incorporated their comments as appropriate. We are sending copies of this report to the Chairmen of the Senate and House Committees on Armed Services and Committees on Appropriations, the Secretaries of Defense and the Navy, the Director of

[1]Job orders are used to collect and identify direct costs and to apply overhead to customer orders.

the Office of Management and Budget, and other interested parties. We will make copies available to others on request.

Our objectives, scope, and methodology are included as appendix IV. To develop information on the cost accounting practices of Puget Sound, we interviewed shipyard officials and reviewed representative cost accounting records. We did not conduct any independent testing of the shipyard's cost accounting records. We also reviewed applicable Department of Defense and Navy regulations and guidance related to the operation of the Navy Industrial Fund and cost accounting practices at naval shipyards. In addition, we reviewed the Navy's evaluation of the Industrial Fund accounting systems, which included an assessment of their compliance with the Comptroller General's accounting principles, standards, and related requirements.

The shipyard's financial data is recorded and maintained using the Standard Navy Shipyard Management Information System. To assess the reliability of data in the system, we reviewed the Navy's Federal Managers' Financial Integrity Act assessments related to the Navy's Industrial Fund accounting system. This assessment reported that the Navy Industrial Fund accounting system in place at the shipyards has several material weaknesses and is not fully in compliance with the Comptroller General's accounting principles, standards, and related requirements. In addition, we reviewed the work of other audit organizations that rely on the data in this system and concluded that the cost data accumulated and reported by the system is essentially reliable for the purposes of our review.

Please call me on (202) 275-6504 if you have any questions about this report. Major contributors to this report are listed in appendix V.

Martin M Ferber
Director, Navy Issues

Contents

Tables

Figures

Abbreviations

NAVSEA Naval Sea Systems Command

The Cost Accounting System of the Puget Sound Naval Shipyard

Puget Sound is one of six nuclear-capable naval shipyards the Navy uses when nuclear-powered ships need shipyard services. The shipyard, which was established in 1891, has six dry docks and the associated facilities to service a full range of Navy vessels, from nuclear-powered attack submarines to nuclear-powered aircraft carriers. Over 12,000 civilian employees and over 300 military personnel support shipyard operations at Puget Sound.

The Puget Sound Naval Shipyard's primary projects include ship inactivations, refuelings, overhauls, repairs, recycling, and alterations. Although the shipyard generally services nuclear-powered ships, most of the shipyard's work is nonnuclear. NAVSEA defines work as nuclear if it involves reactor plant systems and secondary plant (steam plant) systems under the technical cognizance of the Naval Nuclear Propulsion Program and components, equipment, parts, and materials for use in these systems. The designation of a task—for example, welding or pipe fitting—as either nuclear or nonnuclear depends on whether the task performed is related to a nuclear or nonnuclear defined system.

The shipyard has production shops that work on projects, shops or departments that provide support to the production shops, and departments that provide general support for all shipyard work. Puget Sound has separate production shops that do sheetmetal work, welding, electrical work, painting, and machining. Shops or departments that support the work of the production shops offer services such as planning, engineering, inspection, and quality assurance. Depending upon the nature of the work performed, a shop or department in this category may support only nuclear work, only nonnuclear work, or both nuclear and nonnuclear work. Shipyard departments that provide general support for all work (nuclear and nonnuclear) include the shipyard Commander, the shipyard Comptroller, public works, and security.

Puget Sound Is a Navy Industrial Fund Activity

Like other naval shipyards, Puget Sound is a Navy Industrial Fund[1] activity. As a fund activity, Puget Sound uses the capital resources of the fund to finance the initial costs of projects until it receives payments from its customers. When a customer—usually the Naval Sea Systems Command or a fleet commander—requests work, Puget Sound defines the work for the project and provides the customer an estimate. In accordance with NAVSEA

[1] In fiscal year 1992, the Navy Industrial Fund was incorporated with other Defense industrial and stock funds into the Defense Business Operations Fund.

policy, when fixed price conditions are present, the customer and Puget Sound commence negotiations for a fixed price before the project is 50 percent complete.

The fund uses the accrual method of accounting for costs[2] and operates under guidance developed to effectively control and account for the cost of work performed. How well Puget Sound estimates costs, negotiates prices, and performs the work affects whether it makes or loses money on a project. To meet the fund's goal of breaking even over the long term, Puget Sound must be able to accurately track the costs it incurs. To this end, Puget Sound, like all other naval shipyards, accumulates and reports costs and workdays by job order numbers using the cost accounting application of the Standard Naval Shipyard Management Information System. This system captures the cost of work defined as nuclear or nonnuclear by project but is not designed to report these costs on a fiscal year basis. Both NAVSEA and Puget Sound officials stated that the lack of such a cost breakdown is not a problem, since shipyard work is managed on a project and departmental basis.

Guidance and standards governing the administration of Navy Industrial Fund activities are set forth in the Department of Defense Accounting Manual 7220.9-M, the Naval Comptroller Manual (Volume 5), and the Navy Industrial Fund Financial Management Systems and Procedures Manual (NAVSEA Instruction 7670.1). As an executive branch agency within the Department of Defense, the Navy is also required to adhere to the standards and procedures established by the Cost Accounting Standards Board in its reporting and recording of cost information.

Although the Navy has noted some weaknesses in Navy Industrial Fund accounting systems, and Puget Sound has noted some deficiencies in the system as used at Puget Sound, the Naval Audit Service has found the cost accounting information at the naval shipyards to be essentially reliable. Because the Department of Defense is currently evaluating how to standardize its accounting policy and systems used by fund activities, the Navy plans to make no substantive improvements until these studies are complete.

[2]Under the accrual method of accounting, revenues are accounted for when earned, costs are accounted for in the fiscal period during which the benefits are received, and expenditures are recorded when goods or services are received, irrespective of when payment is accomplished.

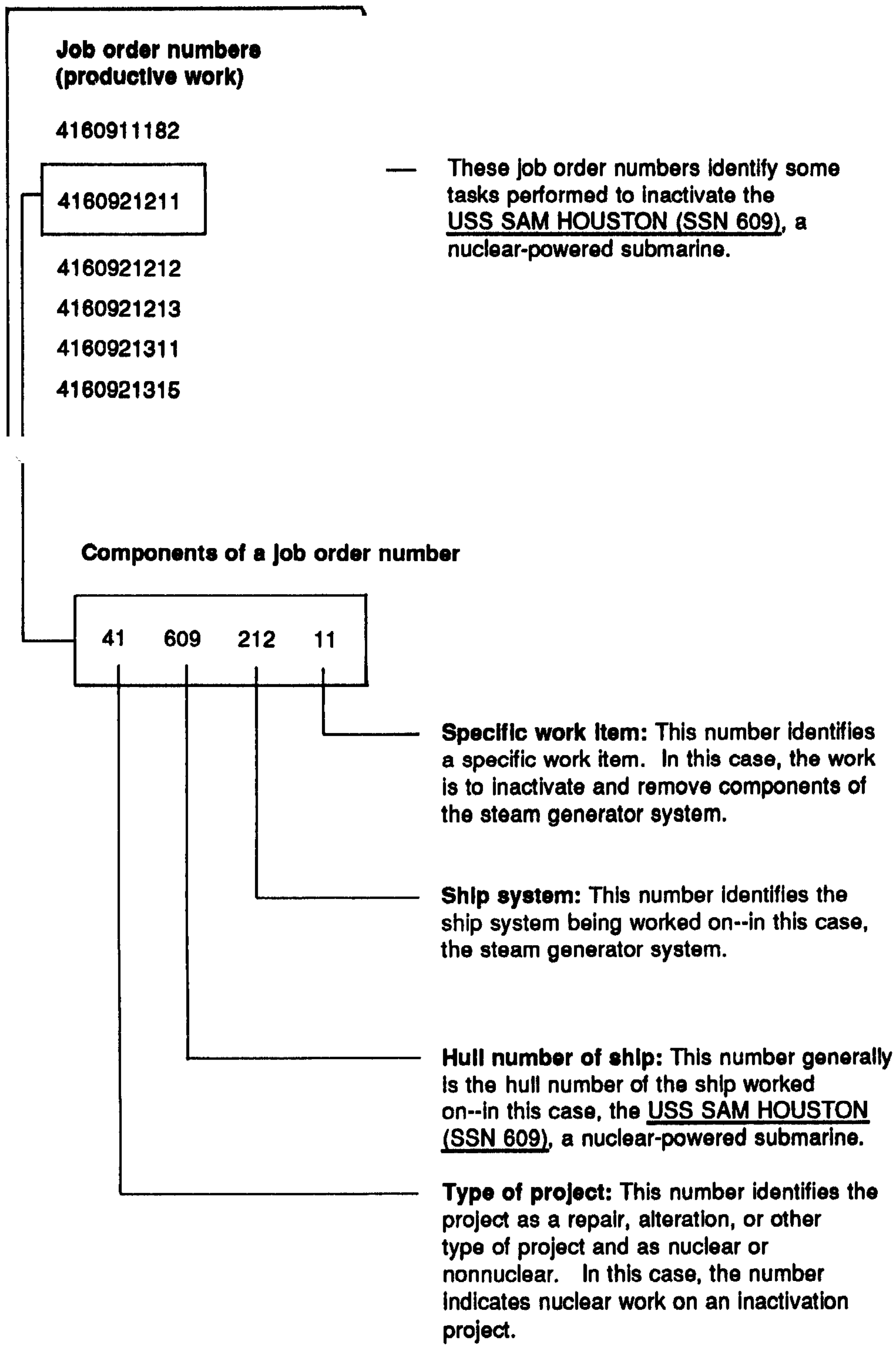
Costs Are Accumulated by Job Order Numbers

When a customer requests shipyard work, the shipyard Comptroller establishes and approves a customer order that (1) authorizes the issuance of job orders to accomplish work requested by the customer and (2) establishes accounting records required to accumulate costs.

Each project is broken down into many tasks, each of which is assigned a job order number. As shown in figure I.1, each job order number has 10 digits that identify productive work by

- the type of project to be performed, including whether the related work is nuclear or nonnuclear;
- the hull number of the vessel being worked on;
- the ship system that is being worked on; and
- the specific work item.

Figure I.1: Job Order Numbers and Their Components



Cost Accounting System Records Direct and Overhead Costs

Puget Sound's cost accounting system captures and accumulates direct costs. Direct costs include the costs of labor, material, and certain other costs that are identifiable without undue effort to a specific project. The system captures labor costs through its timekeeping and payroll system and material costs through its material management system. These costs are accumulated and summarized by job order number on periodic, system-generated reports. Direct costs that cannot be classified as labor or material—such as tuition and transportation—are recognized as "other direct costs" by the cost accounting system. These costs are also captured, accumulated, and summarized by job order number.

The cost accounting system also accumulates overhead costs. Overhead costs include costs that cannot be easily traced because the benefits apply to more than one project. Overhead costs include the cost of clerical and administrative support for each production shop and the cost of the shipyard Commander's office and the public works department, which support all shipyard activities. When a shop charges direct labor hours to a job order number, overhead costs are applied to that job order number according to the overhead rate of that particular shop.

A production shop's hourly overhead rate is the sum of (1) the hourly overhead rate of the shop itself (productive overhead), which differs by shop, and (2) the shipyard's hourly general overhead rate, which is applied equally to all shops. Each shop's overhead rate is applied equally to nuclear and nonnuclear work based on the number of direct nuclear or nonnuclear labor hours charged. Puget Sound's overhead rates are established by the shipyard Comptroller, who periodically reviews and adjusts them to ensure that they accurately approximate current actual overhead costs.

Fiscal Year 1991 Work Load and Costs at Puget Sound Naval Shipyard

In fiscal year 1991, Puget Sound spent about 1.5 million workdays primarily on 24 nuclear-powered vessels and 3 nonnuclear vessels as detailed below:

- inactivation, including reactor compartment disposal and recycling, of four nuclear-powered submarines;
- inactivation, including reactor compartment disposal, of two nuclear-powered submarines;
- reactor compartment disposal, including recycling, of three nuclear-powered submarines;
- reactor compartment disposals on five previously inactivated nuclear-powered submarines;
- recycling of two previously inactivated nuclear-powered submarines that had also previously undergone reactor compartment disposal;
- refueling overhauls of two ships (one nuclear-powered cruiser and one nuclear-powered submarine);
- non-refueling overhauls of two ships (one nuclear-powered aircraft carrier and one nuclear-powered submarine);
- upkeep on one nuclear-powered aircraft carrier;
- selected restricted projects on three ships (two nuclear-powered submarines and one nuclear-powered cruiser); and
- projects on three nonnuclear ships.

The total cost of nuclear and nonnuclear work done at Puget Sound in fiscal year 1991 was $784.9 million. Of this amount, $736.4 million was for direct labor, direct material, direct other, and overhead costs applied to project job orders—35 percent for nuclear work and 65 percent for nonnuclear work (see table II.1 for a breakdown of these costs). The remaining $48.5 million was neither charged to project job order numbers nor allocated between nuclear and nonnuclear work.

Table II.1: Costs Incurred at Puget Sound Naval Shipyard in Fiscal Year 1991

Cost category	Nuclear	Nonnuclear	Total
Direct			
Labor	$97,640,177	$177,037,935	**$274,678,112**
Material	10,459,684	53,610,920	**64,070,604**
Other	9,593,887	52,218,074	**61,811,961**
Total direct	**$117,693,748**	**$282,866,929**	**$400,560,677**
Applied overhead	138,850,035	197,008,559	**335,858,594**
Total charged to job orders	**$256,543,783**	**$479,875,488**	**$736,419,271**
Other			**48,473,349**
Total			**$784,892,620**

Although Puget Sound worked almost exclusively on nuclear-powered vessels in fiscal year 1991, only 31 percent of the workdays (about 459,000 of a total of about 1.5 million workdays) was spent on nuclear work.

As shown in table II.1, the average cost per workday for nuclear work is higher than the average for nonnuclear work. For labor costs, the average cost per workday for nuclear work ($213) was 25 percent higher than the cost per workday for nonnuclear work ($170). For applied overhead, the average cost applied per workday of nuclear work ($303) was 60 percent higher than the cost applied per workday for nonnuclear work ($189). According to NAVSEA and Puget Sound officials, this difference is due to the complex nature of nuclear work and the standards by which it must be performed. Nuclear work requires more extensive engineering, tighter quality controls, more detailed planning, and radiological controls not associated with nonnuclear work. These services, which are largely technical in nature, are provided by specialized shipyard departments that incur both direct and overhead costs and that must be staffed by nuclear engineers. NAVSEA and shipyard officials also explained that nuclear work requires more extensive training, supervision, and internal quality assessment than nonnuclear work to ensure that the work is done properly and to necessary standards.

In addition, NAVSEA officials stated that with the implementation of some accounting changes that will transfer some labor costs from overhead to direct, they expect the proportion of nuclear costs to increase. They explained that through fiscal year 1991, labor costs for first-line supervisors, planners, schedulers, and project managers for both nuclear and nonnuclear work were charged to overhead accounts. Beginning in fiscal year 1992, these same shipyard workers have charged their time as a direct cost. Because more of these workers' services are required for nuclear work, NAVSEA officials expect the number of direct labor hours charged to nuclear work will increase and, as a result, increase the proportion of total overhead costs applied to nuclear work.

The $48.5 million in costs that were not charged to job orders included the following:

- Overhead costs of $12.7 million because the shipyard's estimated overhead rates were too low to cover the actual overhead costs incurred in fiscal year 1991.
- A depreciation expense of $15.9 million for buildings, structures, and equipment that the shipyard did not charge to its customers during fiscal year 1991. With the transition to the Defense Business Operations Fund, officials from NAVSEA expect the Navy Comptroller to direct the shipyards to charge depreciation costs to their customers. These funds will then be used for capital investment projects.
- Expenses of $6.9 million for leave and benefit costs for military personnel assigned to the shipyard. Although the shipyard paid the labor costs, military personnel appropriations funded leave costs, and other appropriations funded costs such as medical, commissary, and subsistence benefits.
- A write-off of $13 million in excess material. This fiscal year 1991 write-off of excess material was required by the Navy Comptroller for all naval shipyards.

Disposal of Nuclear Materials and Radioactively Contaminated Materials of Nuclear-Powered Ships

UNCLASSIFIED

DISPOSAL OF NUCLEAR MATERIALS

AND

RADIOACTIVELY CONTAMINATED MATERIALS

OF

NUCLEAR-POWERED SHIPS

JUNE 1992

Prepared by

The Director, Naval Nuclear Propulsion

Office of the

Chief of Naval Operations

Department of the Navy

UNCLASSIFIED

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, DC 20350-2000

IN REPLY REFER TO

19 June 1992

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and International
Affairs Division
U.S. General Accounting Office
Washington, DC 20528

Dear Mr. Conahan:

The Fiscal Year 1992 Department of Defense Appropriations Act, Section 8130 of Senate Bill HR 2521 (PL 102-172) requires that "The Comptroller General of the United States, in conjunction with the Department of the Navy, shall issue a report no later than July 1, 1992 on the Navy's accounting practices at its nuclear shipyards. The report shall include a detailed review of the Navy's current plan for the handling and disposal of all nuclear and radioactively contaminated materials of nuclear powered vessels. The report shall include cost evaluations and projections for the next twenty years based on the current Navy plan."

During meetings between representatives of the General Accounting Office (GAO), the Navy, and the Office of the Secretary of Defense, the GAO determined that two reports, one by the Navy (Naval Sea Systems Command Nuclear Propulsion Directorate) and one by the GAO, should be provided (under GAO signature) to the Senate and House Appropriations Committees. Specifically, the Navy report would cover the nuclear and radioactive materials aspects and the GAO report would cover the shipyard accounting aspects.

Enclosed is the Navy report entitled "Disposal of Nuclear Materials and Radioactively Contaminated Materials of Nuclear-Powered Ships".

Sincerely,

B. DeMARS
Admiral, U.S. Navy
Director, Naval Nuclear Propulsion

Encl:
(1) Disposal of Nuclear Materials and Radioactively Contaminated Materials of Nuclear-Powered Ships

Copy to:
ASSTSECDEF (AE)
ASSTSECNAV (I&E)
OP-08
Chief, OLA
COMNAVSEASYSCOM

Contents

Executive Summary

PURPOSE

The Fiscal Year 1992 Defense Appropriations Act (Section 8130 of Senate Bill HR 2521 (PL 102-172)) states: "The Comptroller General of the United States, in conjunction with the Department of the Navy, shall issue a report no later than July 1, 1992 on the Navy's accounting practices at its nuclear shipyards. The report shall include a detailed review of the Navy's current plan for the handling and disposal of all nuclear materials and radioactively contaminated materials of nuclear-powered vessels. The report shall include cost evaluations and projections for the next twenty years based on the current Navy plan."

This report addresses the handling and disposal of nuclear materials and radioactively contaminated materials.

CONCLUSION

The Naval Nuclear Propulsion Program generates a small part of the Nation's radioactive waste requiring disposal, and the cost to manage this aspect of the Program has been relatively low. Although future projections are somewhat uncertain, it is expected that disposal costs will continue to be modest. Over the next twenty years, low-level radioactive waste disposal costs are expected to average about $90 to $95 million annually. While nuclear-powered warships represent about forty percent of the Navy's major combatants, the handling and disposal costs of the resultant radioactive waste is only about one tenth of one percent of the total 1992 Navy budget. Experience has demonstrated that this waste can be dealt with safely and at a cost which is reasonable considering the substantial military benefit nuclear-powered warships represent to the national defense.

SUMMARY

Nuclear materials and radioactively contaminated materials removed from nuclear-powered ships include Naval reactor fuel plus waste in the form of low-level radioactive waste, mixed low-level radioactive and hazardous waste and defueled reactor compartments. The costs to handle and dispose of this material (summarized below) are minor in light of the importance and size of the Nuclear Fleet and the military advantages of nuclear propulsion.

ii

Low-level Radioactive Waste. As in the private sector, the Navy's unclassified low-level radioactive waste is disposed of at commercial burial grounds licensed by the Nuclear Regulatory Commission (NRC) or a state per NRC agreement. Current shipping and burial costs are about $5 million per year but are expected to increase somewhat due to new taxes and fees in accordance with Federal Law. Although future costs are very uncertain, given the evolving nature of regulations and the unknown costs of future disposal sites, the Navy anticipates unclassified low-level radioactive waste shipment and burial costs of about $15 million annually over the next twenty years. (All cost figures in this report are in current dollars.)

Department of Energy (DOE)-classified low-level radioactive waste from nuclear-powered ships is buried in Government burial grounds. The shipping and disposal cost was about $4 million in 1991. Using the same basis for calculating future rates for this classified waste as used for disposal of unclassified low-level radioactive waste (and including the cost of disposal containers), the Navy anticipates disposal costs of about $5 million annually over the next twenty years.

Shipyard costs for preparation for disposal and handling of both unclassified and DOE-classified low-level radioactive waste were about $5.5 million in 1991 and are anticipated to be $5.5 million annually over the next twenty years.

Mixed Low-Level Radioactive and Chemically Hazardous Waste. The Navy avoids generation of mixed waste whenever possible, and where feasible, separates radioactivity from hazardous material. Pending development of DOE and commercial treatment capacity, Naval shipyards are storing the small amounts of mixed waste generated. Given small volumes, disposal costs for mixed waste from Naval nuclear work should be much lower than for low-level radioactive waste (though more expensive per cubic foot). Since there is no current capacity for mixed waste disposal, there is little basis for accurately projecting future disposal costs. However, using cost estimates cited in a recent GAO report on mixed waste disposal and anticipated volumes of mixed waste to be generated, annual disposal costs would range from $60,500 to a possible (but improbable) $7.5 million over the next twenty years.

A unique category of mixed waste not included above is radioactively contaminated lead shielded equipment and containers. Over the next twenty years, the Navy expects to generate an average of 425 cubic feet of contaminated lead annually. Based on a recent commercial activity bid for disposal of this type of material, an annual average cost of about $4 million is projected for processing and disposal of this material.

Defueled Reactor Compartments. Defueled reactor compartments are removed from ships at Puget Sound Naval Shipyard and shipped to the DOE Hanford Site (24 as of June 1992) for disposal. A 1991

iii

GAO survey of this process was closed out "with no external reporting." During their exit conference, GAO stated that "the RC [Reactor Compartment] disposal program is being managed well." Submarine reactor compartment disposals currently cost about $7.5 million each. Based on current ship retirement plans, the average annual cost to dispose of reactor compartments from nuclear-powered ships over the next twenty years is expected to be about $60 million. Department of Defense force level decisions may alter the pace (and therefore the annual cost) of reactor compartment disposals.

Naval Reactor Fuel. Naval reactor fuel removed from ships constitutes less than one percent of the volume of spent fuel produced annually in the U.S. and poses no environmental problem since the fuel is designed to stringent military standards. In fact, analysis indicates that Naval fuel can be stored in excess of one million years before the protective cladding loses its integrity.

Fuel removed from ships is transferred to DOE custody and sent to the Expended Core Facility (ECF) in Idaho for inspection and examination prior to transfer to the DOE's Idaho Chemical Processing Plant (ICPP). Over the next twenty years, shipping costs will average about $1.3 million annually.

The fuel, even after use in shipboard reactors, contains substantial amounts of enriched uranium, which can be recovered in the future as circumstances warrant. Until recently, the DOE reprocessed the fuel to reclaim the remaining enriched uranium. Plans for the future entail storing the fuel for potential reprocessing or placing it in a geologic repository. Whether Naval reactor fuel will be reprocessed or placed in a repository is uncertain at this time; however, if DOE decides to use a repository, such disposal will not occur until more than twenty years hence.

Chapter 1

INTRODUCTION

The commercial nuclear power industry, hospitals and medical research centers, industrial users of radionuclides, and Government activities are the primary generators of nuclear and radioactively contaminated materials. Within the Federal Government, the largest generator is the Department of Energy's nuclear weapons complex and nuclear energy research and development facilities. The Naval Nuclear Propulsion Program is a relatively small generator.

Nuclear and radioactively contaminated materials fall into several commonly used categories. These include reactor fuel removed from reactors, plus high-level, transuranic, low-level, and mill tailing waste. Of these categories, the Navy generates only reactor fuel removed from ships and low-level waste from reactor plant servicing work on nuclear-powered ships.

Chapter 2

LOW-LEVEL RADIOACTIVE WASTE

Low-level radioactive waste is a general term for a wide variety of materials which are radioactively contaminated. This waste can be in many different physical forms such as used protective clothing, metal components, plastic, or any other material which has come into contact with radionuclides or had radioactivity induced by exposure to neutron radiation.

The concentration of radioactivity in low-level waste can vary greatly. The Nuclear Regulatory Commission has established concentration categories for low-level waste (10CFR61). These classifications, from the lowest concentration to the highest, are Class-A, Class-B, Class-C, and Greater-Than-Class-C. NRC regulations require that these wastes be segregated for disposal. Class-A waste has radioactivity of low concentration or short half-life so that its hazard is essentially eliminated within 100 years. Class-B and Class-C waste can remain hazardous for 300 to 500 years and, therefore, require greater care in burial and protection from intruders. Greater-Than-Class-C waste may not be disposed of by shallow land burial.

Low-level Radioactive Waste Policy Amendments Act of 1985

The Low-level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA) establishes the division of responsibility for disposal of low-level waste. Under the LLRWPAA, the states are responsible for providing for the disposal of low-level radioactive waste except for Department of Energy (DOE) waste, waste from decommissioning Navy ships, and nuclear weapons waste. The latter categories and Greater-Than-Class-C waste are identified as Federal responsibilities which are managed by DOE. The LLRWPAA established a series of milestones for states, or compacts of several states, to develop low-level waste disposal sites. The act provides a series of escalating penalties for states which do not provide for low-level waste disposal. Starting in 1993, compacts with disposal sites may bar entry of waste from outside the compact.

2

Radioactive Waste Disposal

The Navy publishes an annual report ("Environmental Monitoring and Disposal of Radioactive Wastes from U.S. Naval Nuclear-powered Ships and Their Support Facilities") which describes the types of low-level radioactive waste and discusses the amounts of low-level radioactive waste generated at shipyards. This annual report is widely distributed and provided to Congress. The following is an excerpt dealing with low-level radioactive waste from the report for 1991:

SOLID RADIOACTIVE WASTE DISPOSAL

During maintenance and overhaul operations, solid low-level radioactive wastes consisting of contaminated rags, plastic bags, paper, filters, ion exchange resin and scrap materials are collected from nuclear-powered ships and their support facilities. These low-level radioactive materials are required to be strictly controlled to prevent loss. These controls include Naval accountability procedures which require serialized tagging and marking and signatures by radiologically trained personnel.

Solid radioactive waste materials are packaged in strong tight containers, shielded as necessary, and shipped to burial sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission. Solid radioactive materials from Naval nuclear-powered ships have not been dumped at sea since 1970 when the Navy issued procedures prohibiting sea disposal of solid radioactive materials. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites.

Table 3 summarizes the total radioactivity and volumes of radioactive solid waste disposed of during the last five years. Table 3 includes all waste generated by U.S. Naval nuclear-powered ships and the listed support facilities since all radioactive solid waste generated by U.S. nuclear-powered ships is transferred to the listed facilities. The quantity of solid radioactive waste in any one year from a particular facility depends on the amount and type of support work performed that year. Table 3 does not include fuel or other classified radioactive components shipped to Department of Energy facilities for processing and for disposal.

Figure 2 shows that the total annual volume of solid low-level radioactive waste was substantially reduced in the 1970's, despite increasing numbers of ships. This reduction was accomplished simultaneously with reduction in personnel radiation exposure, as described in reference 23. This reduction was accomplished by several techniques including a total containment concept for radiological work which minimizes the spread of radioactivity to non-radioactive materials, use of preplanning and mockups to minimize rework, reusing rather than disposing of tools and equipment, use of radioactive liquid processing procedures which minimize depletion of processing media, use of compaction equipment and efficient packaging to fully use space in disposal containers, and separating solid waste that requires special disposal owing to its radioactive content from that which does not. The latter is achieved by work site controls and by use of sensitive detection equipment to detect radioactivity only slightly greater in

3

concentration than that found in natural materials such as soil, rocks, water, and biological matter (see reference 22) thus requiring the material to be handled as radioactive for waste disposal purposes. Material which passes the screening provided by this sensitive detection equipment can be disposed of as ordinary waste. Challenging goals are set by each shipyard to ensure continuing management attention to minimizing generation of waste in radiological work.

The annual volume of solid low-level radioactive waste disposed of in 1991 by the entire Naval Nuclear Propulsion Program, as shown in Table 3, could be contained in a cube measuring about fifteen yards on a side. The total annual volume is approximately thirteen percent of the solid low-level radioactive waste generated annually by all nuclear electric power reactors and approximately seven percent of the total volume of solid low-level radioactive waste buried in all U.S. commercial burial grounds each year (reference 24). The amount of solid low-level radioactive waste shipped for disposal during 1991 was higher than in recent years. In view of the tripling of waste disposal surcharges scheduled to take effect in many states in 1992 and the potential for closure of some sites at the end of 1992, a concerted effort was made to reevaluate radioactive equipment which was in storage for potential future use and to dispose of that equipment for which no specific future need was identified. Some of this equipment was no longer needed due to the declining fleet size.

Deactivation of Ingalls Shipbuilding Radiological Facilities

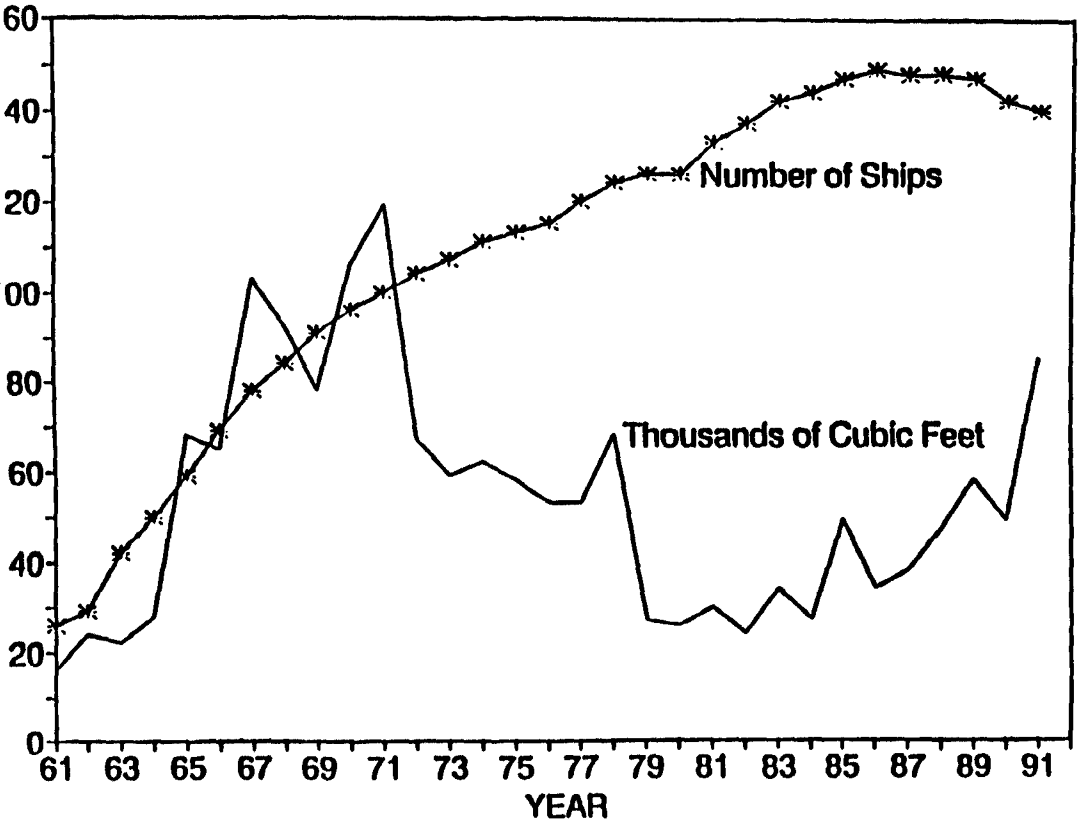
From 1958 to 1980, Ingalls Shipbuilding was engaged in the construction and overhaul of Naval nuclear-powered ships in Pascagoula, Mississippi. The shipyard radiological facilities which supported this work were deactivated between 1980 and 1982 by removing and disposing of all radioactive material associated with Naval nuclear propulsion plants. Useful items, such as tools and equipment that were radioactively contaminated, were transferred to other organizations in the Naval Nuclear Propulsion Program. The remaining radioactive material was disposed of as solid waste.

Extensive radiological decommissioning surveys were performed to verify the removal of this radioactive material. Direct radiological surveys were performed on over 274,000 square feet of building and facility surfaces. Over 11,000 samples of these surfaces as well as soil, ground cover and concrete were taken from all areas where radioactive work was previously performed. These samples were analyzed using sensitive laboratory equipment. In addition, both the State of Mississippi and the Environmental Protection Agency (reference 25) performed overcheck surveys of the deactivated facilities. After these surveys were completed, the Ingalls facilities were released for unrestricted use. Personnel who subsequently occupy these facilities will not receive measurable radiation exposure above natural background levels that exist in areas not affected by Naval nuclear propulsion plant work. Reference 25 is the report of the survey of the Ingalls facilities by the Environmental Protection Agency.

4

FIGURE 2

RADIOACTIVE SOLID WASTE DISPOSAL VOLUMES
IN THE NAVAL NUCLEAR PROPULSION PROGRAM, 1961-1991



5

TABLE 3 RADIOACTIVE SOLID WASTE FROM U.S. NAVAL NUCLEAR POWERED SHIPS AND THEIR SUPPORT FACILITIES FOR 1987 THROUGH 1991

FACILITY	1987 THOUSAND CUBIC FEET	1987 CURIES	1988 THOUSAND CUBIC FEET	1988 CURIES	1989 THOUSAND CUBIC FEET	1989 CURIES	1990 THOUSAND CUBIC FEET	1990 CURIES	1991 THOUSAND CUBIC FEET	1991 CURIES
Kittery, Maine Portsmouth Naval Shipyard	1	<1	1	2	9	3	1	<1	4	9
Groton, New London, Conn. Electric Boat Division, State Pier and Sub Base	2	<1	2	<1	1	1	2	1	2	<1
Newport News, Virginia Newport News Shipbuilding	3	3	7	<1	15	<1	8	52	15	3
Norfolk, Virginia Naval Shipyard and Tenders	6	1	11	1	5	<1	12	1	17	<1
Charleston, South Carolina Naval Shipyard, Tenders, and Naval Nuclear Power Training Unit	7	4	8	51	10	11	8	138	13	122
Vallejo, California Mare Island Naval Shipyard	10	2	6	4	5	3	5	1	5	1
Bremerton, Washington Puget Sound Naval Shipyard	6	1	8	62	7	1	8	92	26	<1
Pearl Harbor, Hawaii Naval Shipyard and Sub Base	3	7	4	5	6	1	5	1	3	6
TOTAL	38	20	47	127	58	22	49	287	85	144

NOTES:
(1) This table includes all radioactive waste from tenders and nuclear-powered ships. This radioactivity is primarily cobalt 60. This radioactive waste is shipped to burial facilities licensed by the U.S. Nuclear Regulatory Commission or a State.
(2) Volumes less than 500 cubic feet are reported as 1 thousand cubic feet and activities less than 0.5 curie are reported as <1 curie.
(3) The Naval Nuclear Power Training Unit is the site of the moored training ship.

6

Mixed Radioactive and Hazardous Waste

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act and the Resource Conservation and Recovery Act (RCRA) as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid commingling radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are radiologically processed in accordance with long-standing Program requirements. Such radiological processing includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

Disposal of Decommissioned, Defueled Naval Submarine Reactor Plants

During the 1980s, the nuclear-powered submarines constructed in the 1950s and 1960s began to reach the end of their service life. In 1982, the Navy, with the Department of Energy as a cooperating agency, published a Draft Environmental Impact Statement (EIS) on the disposal of decommissioned, defueled Naval submarine reactor plants. The Draft EIS was widely distributed to individuals, environmental organizations, state and local officials, and other Federal agencies. All substantive comments were analyzed and addressed in the Final EIS which was issued in 1984 (reference 22). Although the Navy had considered the alternative of disposing of the defueled ships by sinking at sea, the preferred alternative identified in the Final EIS was to bury the defueled reactor plants at a Federal disposal facility already used for low-level radioactive waste disposal. In December 1984, the Secretary of the Navy issued a Record of Decision to proceed with land burial.

A submarine is constructed with the nuclear power plant inside a single section of the ship called the reactor compartment. Before the reactor compartment is disposed of, the nuclear fuel is removed and handled in the same manner as nuclear fuel removed during refueling of nuclear-powered ships. The defueled reactor compartments are removed from decommissioned submarines in drydocks at the Puget Sound Naval Shipyard in Bremerton, Washington. After removal from a submarine, the reactor compartment is sealed and loaded onto a barge for transport to the Port of Benton on the Columbia River near the Department of Energy Hanford Site. At the Port of Benton, the reactor compartment is transferred to a land transporter which carries the reactor compartment to the burial trench of the Hanford Site. Further information on this process is contained in the Final EIS (reference 22). The first defueled reactor compartment was shipped to Hanford in 1986. Six defueled reactor compartments were shipped in 1991, which brought the total number shipped to 20.

(End of excerpt)

7

Unclassified Radioactive Waste Disposal Cost

The annual volume of unclassified low-level waste disposed of in 1991 by nuclear capable shipyards was approximately 88,500 cubic feet. This is about seven percent of the total volume of low-level waste shipped to the commercial sites. Furthermore, almost all low-level waste from shipyards is in the low concentration, Class-A category.

The following table lists the volumes and costs of unclassified low-level waste generated from servicing nuclear-powered ships. This waste was sent from shipyards to the commercial disposal sites.

1991 Shipping and Disposal Costs for Unclassified Low-Level Radioactive Waste

Shipyard	Volume (Cu.Ft.)	Cost per Cu.Ft.	Total Cost
Puget Sound	26,733	$36.28	$969,976
Pearl Harbor	2,792	$47.38	$132,307
Norfolk	16,956	$68.52	$1,161,900
Portsmouth	5,840	$90.44	$528,171
Charleston	12,689	$82.69	$1,049,295
Mare Island	5,104	$76.65	$391,252
Newport News	18,269	$68.67	$1,254,567
Electric Boat	139	$105.56	$14,673
Total	88,522	$62.16	$5,502,141

NOTE: Cost per cubic feet is calculated to the nearest cent.

These costs include both burial fees and transportation costs. The cost per cubic foot varies considerably among the shipyards. The disposal sites have different base fees. Some shipyards pay out-of-compact surcharges while others do not. Some shipyards have higher transportation costs due to their distance from the disposal site.

Shipyards have an extensive radiological controls program to support nuclear work. The Navy publishes an annual report ("Occupational Radiation Exposure from U.S. Naval Nuclear Propulsion Plants and Their Support Facilities"), which describes the Navy's radiological controls program in detail. This program is broad in scope and includes aspects such as dosimetry, control of radioactivity, strict accountability of radioactive material in transit within the shipyard, surveys for radiation and radioactivity, and work site radiological controls. Many of these activities support processing and handling of waste materials as well as other radioactive items which are reused. Naval Shipyards charge all of the costs associated with radiological controls to nuclear jobs (e.g., repair, alteration, refueling, or inactivation of Naval reactor plants) as part of maintenance availabilities for nuclear-powered ships. In 1991, Naval Shipyard costs to process and prepare low-level radioactive waste for shipment (including DOE-classified waste (discussed below)) totalled $5.5 million.

Classified Waste Shipped to DOE Sites

Some classified low-level waste is shipped from shipyards to DOE disposal sites. This waste consists of large DOE-classified reactor plant components removed from ships. These components cannot be shipped to the commercial sites because the technical information inherent in the component design is classified and must be Federally protected. The volume and curie content of these DOE-classified component shipments are included in the disposal site totals contained in the annual DOE report on radioactive waste inventories (DOE/RW-0006, Rev. 7, "Integrated Data Base for 1991: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics").

In 1991, the Naval Nuclear Propulsion Program disposed of 11,437 cubic feet of classified waste at a cost of approximately $4.1 million. The DOE sites' burial fees currently are lower than those for commercial sites. The total cost of classified component disposal is increased by the need to purchase heavily shielded disposal containers for some large, radioactive components. For these types of components, the cost of heavily shielded containers has ranged from $1 to $2 million per container in recent years. Two of these containers were used in 1991.

Reactor Compartment Disposal

In 1991, the GAO completed a survey of reactor compartment disposal which was closed out "with no external reporting." During the exit conference, GAO stated that "the RC [Reactor Compartment] disposal program is being managed well". Also, the GAO recently completed a review of nuclear submarine inactivations (GAO Report Code 394421, title not yet finalized). The GAO report describes the process of inactivating a nuclear-powered submarine, removing its reactor compartment for disposal, and recycling the remaining hull material. The GAO report includes no recommendations on reactor compartment disposal. Therefore, only the cost aspects of reactor compartment disposal are discussed further in this report. The cost of reactor compartment disposal varies depending upon whether reactor compartment removal is performed as part of a combined drydocking for defueling, inactivation, and ship recycling or whether only the reactor compartment removal is performed. The average reactor compartment disposal cost is approximately $7.5 million per reactor compartment. This includes costs incurred at the DOE Hanford Site, where defueled reactor compartments are shipped for burial. The eight reactor compartment disposals funded in Fiscal Year 1991 cost about $60 million total.

9

The cost of nuclear-powered ship reactor compartment disposal is much lower than for large civilian nuclear power plants. For comparison, disposal of the DOE Shippingport plant in the 1980s cost $91 million. The costs for disposal of large commercial nuclear power plants is expected to be much higher. The GAO conducted a review of the applicability of the Shippingport experience to decommissioning of the commercial Rancho Seco nuclear power plant (GAO/RCED-90-171, "Usefulness of Information From Shippingport Decommissioning For Rancho Seco"). The GAO noted that disposal of Rancho Seco would be much more expensive than Shippingport because the large reactor vessel would require remote cutting, there would be much more highly radioactive waste, and burial site charges had increased. The major reason for the lower cost of disposing of Navy reactor compartments is that the Navy reactor compartments do not require disassembly of the individual radioactive components.

Twenty Year Cost Projections for Low-Level Radioactive Waste Disposal

All of the cost projections in this section are in current year dollars.

There is much uncertainty in performing twenty year cost projections for disposal of any form of waste, given the evolving nature of regulations and the uncertain status of disposal sites. Such estimates are particularly difficult to make for low-level radioactive waste. The major reason is the uncertain status of commercial waste disposal sites. The GAO recently issued a report (GAO/RCED-92-21, "Slow Progress Developing Low-Level Radioactive Waste Disposal Facilities") which assessed the changes brought about by the LLRWPAA and the uncertainty of future disposal sites.

The GAO report also notes that it is unclear how many commercial disposal sites will be developed and how much they will charge in disposal fees. If a large number of disposal sites are developed and each one serves only a small number of states, the per unit disposal costs will be high. These high costs may encourage some site consolidation with resulting moderation in the disposal fee structure.

The LLRWPAA process is intended to result in dedicated regional sites for radioactive waste disposal. With regional sites, there will be little or no price competition. It is likely that the disposal fee structures will be regulated in a manner similar to utility companies. This already is happening with the Washington State disposal site. The Washington State Utilities and Transportation Commission has initiated a rate setting process. The site operator, US Ecology, filed a petition before the Commission (US Ecology, Petition for Determination of Initial Maximum Disposal Rate before the Washington Utilities and Transportation Commission, February 28, 1992).

10

This rate setting petition provides insight into the future direction of disposal fees. US Ecology requested an increase in the base charge (including taxes and in-compact surcharges) from $36 to approximately $50 per cubic foot. The US Ecology petition also provides information on expected costs at other regional disposal facilities. This information was gathered by the Low-level Radioactive Waste Forum in July 1991. Compact officials estimated the disposal fees at future disposal sites. The responses are listed below for states or compacts that are applicable to Navy radioactive waste. Texas is listed because Maine is negotiating with Texas to accept future Maine waste, including that from Portsmouth Naval Shipyard.

Projected Future Radioactive Waste Disposal Fees

State	Fee per Cubic Foot
California	$320
Texas	$246
Connecticut	$300-$800
Maine	Not Estimated
North Carolina	Not Estimated
Washington	$50

The above table illustrates the uncertainty of future Navy costs for radioactive waste disposal. Fees for Navy radioactive waste originating within the Northwest Compact (Puget Sound and Pearl Harbor Naval Shipyards) will continue to remain relatively low while fees for other Navy waste will be higher. For the purposes of making a projection, the California fee of $320 per cubic foot will be used for all Navy waste originating outside the Northwest Compact. This is considered to be a reasonable method for estimating since the California site is closer to licensing than any other new site, and there are no estimates available for the Southeast Compact or Maine.

From 1987 through 1991, the Naval Nuclear Propulsion Program has shipped an average of 55,000 cubic feet of low-level radioactive waste to the commercial disposal sites. Of this, approximately 15,000 cubic feet originated within the Northwest Compact. Applying the $50 per cubic foot Washington charge to 15,000 cubic feet and $320 to the remaining 40,000 cubic feet would result in an average disposal cost of $246 per cubic foot. An additional $20 per cubic foot has been added to cover transportation costs and miscellaneous disposal site fees for an average annual disposal cost of $266[1] per cubic foot and an annual disposal cost of $14.6 million for the Navy.

[1] During final preparation of this report, the South Carolina Legislature passed legislation that would keep the Barnwell low-level radioactive waste disposal site open through the end of 1996. Waste originating from outside the Southeast Compact would be subject to a surcharge of $120 per cubic foot in addition to the normal disposal fees. However, waste from outside the Southeast Compact may be excluded after July 1, 1992. Even with the $120 per cubic foot surcharge for some shipyards, the average Navy disposal cost will be less than the $266 per cubic foot cost estimate while Barnwell remains open. However, for the purposes of making a twenty year cost projection, the estimated average cost of $266 per cubic foot has been retained.

11

For classified components disposed of at DOE sites, cost projections are also uncertain. DOE has embarked on a multi-year Programmatic Environmental Impact Statement on its environmental restoration and waste disposal programs. It is unclear what the outcome will be in terms of DOE disposal operations. For the purpose of this report, the cost will be assumed to be $266 per cubic foot, the same as the above calculated average for the commercial sites. This should be a conservatively high estimate since (1) DOE burial charges are currently lower than commercial charges; (2) $266 per cubic foot is more than four times higher than current commercial charges; and (3) the DOE burial charges are not subject to compact surcharges, which make up a major fraction of commercial site charges.

Over the next twenty years, the volume of DOE-classified components is estimated to average 6600 cubic feet per year. At $266 per cubic foot, this will result in disposal fees of $1.8 million per year. In addition, the average annual cost of disposal containers for these components is estimated to be $2.8 million. Thus, the total classified component cost is expected to be approximately $4.6 million annually over the next twenty years.

Naval Shipyard costs to process and prepare low-level radioactive waste are not expected to change significantly on a constant dollar basis. Since the annual volume of unclassified and DOE-classified waste projected for the next twenty years is less than that shipped in 1991, the annual cost to process and prepare the waste is conservatively projected to remain $5.5 million, the cost for 1991.

The reactor compartment disposal costs at Hanford do not have the same fee structure as other low-level waste disposed of at DOE sites. Since the reactor compartments are disposed of in a separate trench, all associated DOE costs are segregated and reimbursed by the Navy. These DOE costs are included in the overall cost of reactor compartment disposal. The $7.5 million unit cost (in constant dollars) of submarine reactor compartment disposal is expected to remain steady in future years. The only uncertainty in this projection is whether future regulatory requirements could increase the cost of disposal at Hanford. Based on current planning for ship force levels and inactivations, the average annual cost (in current dollars) for reactor compartment disposal over the next twenty years will be about $60 million. Department of Defense force level decisions may alter the pace of inactivations and the resulting annual cost of reactor compartment disposals.

Projecting the cost of mixed waste disposal is less certain than for any of the categories of low-level waste. Since there is presently no capacity for commercial mixed waste disposal, there is little basis for accurately projecting the future cost. GAO report GAO/RECD-92-61 discusses this uncertainty. Estimates cited in this report ranged from $121 to a possible (but

12

improbable) $15,000 per cubic foot. Even if the cost is at the higher end of these projections, the total cost incurred by the shipyards for mixed waste disposal should be less than for unclassified low-level waste since the amount of mixed waste generated annually is very small. As noted earlier, the Naval Shipyards generate only a few hundred cubic feet per year, and this amount is decreasing due to vigorous efforts to avoid generation of mixed waste. At a 500 cubic foot per year generation rate and $15,000 per cubic foot disposal cost (which is a higher cost than expected) the annual cost of mixed waste disposal would be $7.5 million per year. Assuming $121 per cubic foot, the annual cost would be only $60,500 per year.

Since mixed waste is being stored until treatment or disposal capacity is developed, the actual disposal costs will not be stable from year to year. No treatment or disposal costs will be incurred until the capacity is available. When capacity is available, the initial costs will be higher as the backlog of mixed waste is worked off. Afterward, the annual cost should reach a stable rate. Predicting how high the initial surge of costs will be is highly uncertain because it is not known when this capacity will become available. Also, such capacity is unlikely to become available at the same time for mixed waste with varying chemical characteristics or for all regions of the country. It would not be unreasonable to expect the initial short term annual cost to be five times the long term average annual costs projected above.

Another unique category of mixed waste (not included in the above projections) is radioactively contaminated lead shielded equipment and containers. Little of this material is considered to be a waste today because it is still being used for shielding purposes. However, over the next twenty years, an average of 425 cubic feet of contaminated lead per year is expected to be generated. (Very little of this waste will be generated in the next ten years because the equipment will still be in use.) Since solid lead has been regulated as a hazardous waste only in the past few years, commercial capacity for decontaminating, treatment by encapsulation, or recycling contaminated lead equipment is relatively new. One shipyard has received a bid from a commercial company for decontamination of lead equipment at a cost of $12 per pound of lead. Although the types of radioactively contaminated lead equipment will vary, this price is considered representative of what treatment and disposal of lead shielded equipment will cost in the future. Applying the $12 per pound cost to the 425 cubic feet (which is approximately 0.3 million pounds) per year generation rate results in an annual average projected cost of $3.6 million.

13

The above twenty year disposal forecasts for low-level radioactive waste disposal are summarized as follows:

Summary of Twenty Year Forecasts for Low-Level Radioactive Waste Disposal

Type of Waste	Projected Annual Cost
Unclassified Low-level Waste Transportation and Burial	$14.6 million
Classified Low-level Waste Transportation and Burial	$4.6 million
Shipyard Processing and Preparation of Low-level Waste	$5.5 million
Mixed Waste	$0.06 to $7.5 million
Reactor Compartments	$60.0 million
Lead Shielding and Containers	$3.6 million
Total	$88.4 to $95.8 million

14

Chapter 3

NAVAL REACTOR FUEL

Description of Naval Reactor Fuel

Naval reactor fuel fully meets military standards which require high structural integrity, compactness, the ability to withstand rapid changes in power level, and the ability to sustain combat shock. For example, Naval reactor fuel is designed to withstand shock loads in excess of ten times greater than those for which commercial nuclear fuel is designed. Further, all fission products produced in the fuel during reactor operation remain in the fuel. This is of overriding importance in ensuring that shipboard personnel, who live and work in proximity to nuclear propulsion plants receive virtually no occupational radiation exposure. (In contrast, in commercial reactors, it is not unusual for small amounts of fission products to be released by the fuel to the reactor coolant as a consequence of normal operation.)

The Naval Nuclear Propulsion Program has devoted substantial effort over the years to increase the lifetime of Naval reactor fuel. The first reactor core installed in USS NAUTILUS (the first nuclear-powered submarine) lasted two years. By the 1960s, core lifetimes had increased to over ten years. Current lifetimes are even longer (e.g., twenty plus years). By comparison, a typical commercial reactor is refueled every few years. Thus, the fact that today's U.S. nuclear-powered warships require only one refueling during their lifetime is an important element in reducing the amount of fuel which must be handled. This, coupled with the containment of fission products in Naval reactor fuel, greatly reduces the total effort and cost required to handle Naval reactor fuel when compared with commercial reactor fuel.

To achieve compact, long-life core designs, Naval reactor fuel employs highly enriched uranium. Since the reactor must be able to operate even at the end of core life with full fission product poisoning present, a critical mass of fuel must be present at end of life. Thus, a considerable amount of enriched uranium remains in the core when it is removed from the ship, representing an economic resource which can be recovered. (This is discussed further below.) In addition, because highly enriched uranium is used in Naval reactor fuel, as contrasted with the low enriched uranium used in commercial cores, very little plutonium is produced in the Naval fuel during reactor operation. This makes dealing with the removed Naval reactor fuel less complex.

15

Disposition of Naval Reactor Fuel Removed from Ships

Refueling of U.S. nuclear-powered warships has entailed the same basic process since the inception of the Naval Nuclear Propulsion Program over 40 years ago. The process involves removal of all reactor fuel from the ship, placement of the fuel into secure shielded containers, and shipment of these containers by rail to the Naval Nuclear Propulsion Program Expended Core Facility (ECF). ECF is located on the DOE's Idaho National Engineering Laboratory (INEL) Site in Eastern Idaho.

ECF examines reactor fuel removed from ships to confirm that it has performed as expected in service and subjects some fuel to more detailed examinations to provide valuable research and development information. After completing the examinations, ECF ships the fuel in shielded containers a short distance to the Idaho Chemical Processing Plant (ICPP), a separate facility also at INEL. A DOE organization other than the Naval Nuclear Propulsion Program is responsible for ICPP. Until recently, ICPP dissolved the fuel to recover the remaining enriched uranium, for use in other DOE programs.

Twenty Year Cost Projections

The changing world situation has substantially reduced the DOE's need for nuclear weapons material, including enriched uranium. The need for enriched uranium is more than met by the existing stockpile and from decommissioned weapons. The DOE therefore has recently announced that further reprocessing to recover uranium from Naval reactor fuel is unnecessary and will be discontinued.

The materials used in fabrication of Naval reactor fuel are highly corrosion resistant. Because of this high corrosion resistance, plus the high structural integrity of Naval reactor fuel, it is already in a form conducive to storage or burial without the need for further processing. Thus, Naval reactor fuel can be placed in a geologic repository or reprocessed should such reprocessing become desirable for material or economic reasons. Based on analysis, Naval reactor fuel ruggedness is such that the protective fuel cladding will not lose its integrity for in excess of one million years, thereby enabling potential recovery even if placed in a geologic repository. It is important to note that Naval reactor fuel would represent less than one percent of the volume of commercial fuel to be disposed of in geologic repositories.

Naval reactor fuel will continue to be shipped to ECF for examination, followed by transfer to ICPP for storage until final disposition. (The average annual shipping cost will be about

16

$1.3 million over the next twenty years). Because Naval reactor fuel is so compact, ICPP's present fuel storage capacity can handle receipts for the next 30 plus years.

The future storage cost to the Navy is uncertain since DOE is now revising its guidelines for billing the Navy based on the decision to stop reprocessing Naval reactor fuel. These guidelines are not expected until late 1992 and should result in costs to the Navy substantially lower than historic reprocessing costs. Whether Naval reactor fuel will be reprocessed or placed in a repository is uncertain at this time; however, if DOE decides to use a repository, such disposal probably will not occur until more than twenty years hence. Consequently, the cost of final disposition of Naval reactor fuel cannot be predicted at this time.

CONCLUSION

The Naval Nuclear Propulsion Program generates a small part of the Nation's radioactive waste requiring disposal, and the cost to manage this aspect of the Program has been relatively low. Although future projections are somewhat uncertain, it is expected that disposal costs will continue to be modest. Over the next twenty years, low-level radioactive waste disposal costs are expected to average about $90 to $95 million annually. While nuclear-powered warships represent about forty percent of the Navy's major combatants, the handling and disposal costs of the resultant radioactive waste is about one tenth of one percent of the total 1992 Navy budget. Experience has demonstrated that these wastes can be dealt with safely and at a cost which is reasonable considering the substantial military benefit nuclear-powered warships represent to the national defense.

RELATED REPORTS

U.S. General Accounting Office. Nuclear Waste: Slow Progress Developing Low-Level Radioactive Waste Disposal Facilities (GAO/RCED-92-61, January 1992)

U.S. General Accounting Office. Nuclear R&D: Usefulness of Information From Shippingport Decommissioning for Rancho Seco (GAO/RCED-90-171, June 1990)

U.S. Naval Nuclear Propulsion Program. Environmental Monitoring and Disposal of Radioactive Wastes From U.S. Naval Nuclear-Powered Ships and Their Support Facilities. (Report NT-92-1, February 1992)

U.S. Naval Nuclear Propulsion Program. Occupational Radiation Exposure from U.S. Naval Nuclear Propulsion Plants and Their Support Facilities. (Report NT-92-2, February, 1992)

U.S. Department of Energy. Integrated Data Base for 1991: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics. (DOE/RW-0006, Rev. 7)

U.S. General Accounting Office. Draft Report on Nuclear Submarine Inactivation Costs. (Report Code 394421)

US Ecology, Petition for Determination of Initial Maximum Disposal Rate before the Washington Utilities and Transportation Commission. February 28, 1992

19

Objectives, Scope, and Methodology

In response to section 8130 of the Fiscal Year 1992 Department of Defense Appropriations Act, we reviewed the Puget Sound Naval Shipyard's cost accounting practices. We concentrated our work on two objectives: (1) developing a description of the cost accounting system, and (2) determining the shipyard's fiscal year 1991 costs for nuclear and nonnuclear work. We conducted our work at the Puget Sound Naval Shipyard because our time was limited and because it is one of two nuclear-capable naval shipyards that works on a full range of nuclear-powered and conventionally powered ships from submarines to aircraft carriers. In addition, Puget Sound and all other naval shipyards are required to follow the same guidance and standards for cost accounting and use the same Standard Navy Shipyard Management Information System.

To develop information on the cost accounting practices of Puget Sound, we interviewed shipyard officials and reviewed representative cost accounting records. We did not conduct any independent testing of the shipyard's cost accounting records. We also reviewed applicable Department of Defense and Navy regulations and guidance related to the operation of the Navy Industrial Fund and cost accounting practices at naval shipyards. In addition, we reviewed the Navy's evaluation of the Industrial Fund accounting systems, which included an assessment of their compliance with the Comptroller General's accounting principles, standards, and related requirements.

To document fiscal year 1991 costs at Puget Sound, we obtained and reviewed the shipyard's fiscal year 1991 financial statements and other relevant and available cost information. Because the Shipyard Management Information System is not designed to accumulate and report total nuclear or nonnuclear costs charged to job order numbers on a fiscal year basis, we asked the shipyard's chief accountant to categorize the fiscal year 1991 cost data provided in the shipyard's financial statement by type of project as nuclear and nonnuclear. We did not independently verify the shipyard's categorization of costs.

The shipyard's financial data is recorded and maintained using the Standard Navy Shipyard Management Information System. To assess the reliability of data in the system, we reviewed the Navy's Federal Managers' Financial Integrity Act assessments related to the Navy's Industrial Fund accounting system. This assessment reported that the Navy Industrial Fund accounting system in place at the shipyards has several material weaknesses and is not fully in compliance with the Comptroller General's accounting principles, standards, and related requirements. In addition, we reviwed the work of other audit organizations that rely on the data in this system and concluded that the cost data accumulated and reported by the system is essentially reliable for the purposes of our review. We met with officials representing the Naval Sea Systems Command (in the Industrial and Facility Management Directorate, the Comptroller Directorate, and the Nuclear Propulsion Directorate) to obtain an overview of the procedures and practices used to account for costs at shipyards, to clarify cost accounting requirements, and to discuss the availability of data on nuclear costs.

We conducted this review from February to June 1992 in accordance with generally accepted government auditing standards.

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