Naval Reactors

Program Mission

Naval Reactors has complete responsibility for Naval nuclear propulsion work, beginning with technology development and continuing through reactor operation and, ultimately, ensuring appropriate and responsible reactor plant disposal. The Program's efforts have ensured, and continue to ensure, the safe operation of the many reactor plants in operating nuclear powered submarines and surface ships -- comprising over 40% of the Navy's major combatants, the successful deployment of the advanced fleet reactor for the SEAWOLF class, and the on schedule development of the reactor plant for the VIRGINIA class. Most recently, Naval Reactors is beginning design work on a reactor plant for a new class of aircraft carriers being planned by the Navy. Naval Reactors is principally a technology program in the business of power generation for military application. The Program's far-sighted development work ensures nuclear propulsion technology provides options to maintain and upgrade current capabilities, as well as meet future threats. Work is integrated as advances in various functional disciplines coalesce into the technology applicable to a Naval nuclear plant. The presence of radiation dictates a careful, measured approach to developing nuclear technology, evolving needed components and systems, and implementing them into existing or future plant designs. Intricate engineering challenges and long lead time to fabricate the massive, complex components require many years before introduction into the fleet.

Program Goal

Facilitate U.S. national security through the application of nuclear energy for propulsion of warships.

Program Objective

Meet requirements for nuclear propulsion by providing the Navy with long-lived, militarily effective reactor plants and ensuring their continued safe and viable operation.

Performance Measures

The following high-level performance measures represent the principal outcomes of Naval Reactors' work. Due to the integrated nature of research and development for nuclear propulsion work, effort overlaps between the measures. For example, the first two performance measures on meeting Navy goals for extended warship operation and ensuring the safety and reliability of reactor plants in Navy warships are closely related. Efforts within each performance measure can impact safety as well as endurance. In a similar manner, work on the new concept steam generator is aimed at improving safety and performance, but also benefits the endurance and acoustic goals. Despite the cross benefits, separate measures are appropriate since they reflect major, important goals of Naval Reactors' work. In the cases where effort overlaps multiple performance measures, the work is identified under the performance measure which represents the work's principal benefit.

The performance measures are integrated into the detailed program justifications within the budget. Thus, within each of the Detailed Program Justifications, Naval Reactors identifies the relevant performance measures from the list below, the principal activity areas necessary to ensure the performance measure outcome (summarized below), and verifiable supporting activities for each area. Decades will pass before overall success can be assessed, due to the inherent intervals between the time a technology is conceived, developed, applied in the fleet and proven over the operating life of the ship.

Conduct planned development, testing, examination and evaluation of nuclear fuel systems, materials, and manufacturing and inspection methods to ensure Naval nuclear reactors are able to meet Navy goals for extended warship operation.

As the Navy downsizes the fleet, demands on remaining ships increase. Each ship must carry more of the burden, be available for missions more of the time, and stay in service longer. To support these operational demands, materials, components and systems must be operationally reliable for longer periods than ever before. For example, plants originally designed for a twenty-year service life are now being called upon to serve up to about fifty years. Exhaustive testing, performance enhancements and development efforts are needed to ensure that component and system endurance -- despite potential corrosion, cracking, mechanical strain, and irradiation -- can be assured throughout extended lifetime. Development efforts to date have yielded significant advantages. Enhanced component reliability and improved predictive techniques have allowed the Navy to extend the intervals between major maintenance periods, increasing ship on-line time and, thus, the Navy's war fighting capability, while reducing cost. However, these advancements also generate new development and analysis challenges. For example, the longer intervals between maintenance periods reduce opportunities to examine and/or replace aging components and systems. Thus, more extensive analytical and testing efforts are required to verify materials and component performance. In a similar vein, development of a life-of-the-ship core offers major advantages in terms of ship availability, as well as reducing cost, radiation exposure and waste generation; but a life-of-the-ship core also reduces mid-life opportunities to examine components and help ensure integrity. Testing and verification, therefore, is of paramount importance. These efforts are especially challenging given the demanding nature of nuclear propulsion technology. Components and materials must perform reliably within the harsh environment of a reactor plant. Comprehensive and rigorous analyses are needed to ensure the ability to withstand the deleterious effects of irradiation, corrosion, high temperature and pressure over a lifetime measured in decades. In addition, Naval reactor plants must be rugged enough to accommodate ships' pitching and rolling; have the resilience to respond to rapidly-changing demands for power; be robust enough to withstand the rigors of battle; and be safe and easily maintainable for the sailors who live next to them.

The following activity areas are necessary to ensure the outcome of this performance measure:

- Improve nuclear heat source (core) design and analysis methods and develop improved designs to satisfy service life requirements.
- Evaluate and test improved core manufacturing processes and inspection techniques to support extended life reactors.
- Examine removed fuel cells at end-of-life and perform non-destructive examinations of irradiated test specimens to confirm predicted performance and validate design methods.
- Develop improved nuclear fuel, core and reactor structural materials which extend core

- lifetimes up to the life of the ship, and evaluate irradiation tests of new and existing materials to verify acceptable lifetime performance and to improve predictive capabilities.
- Test and evaluate plant materials to characterize the long term effects of the harsh operating environment and qualify improved materials and processes to ensure endurance requirements will be met.
- Conduct irradiations testing and perform detailed examinations to provide data for material performance characterization and prediction.

Complete scheduled design, analysis, and testing of reactor plant components, systems, and performance to ensure the operational safety and reliability of reactor plants for use in Navy nuclear powered warships so they can fulfill their national defense mission.

Naval Reactors expects to be responsible for the operation of on average over 100 reactors powering 40% of the Navy's major combatants. This is equal to the entire U.S. commercial nuclear power generating industry and nearly as many reactors as the next two largest nuclear power generating nations combined (France and Japan). These plants operate over lifetimes of up to five decades. Challenges to the reliability and integrity of the plants change and grow over the long life. Continuous monitoring and analyses are thus vital to ensure they continue to perform safely and reliably. Also, new knowledge gained during the years of operation must be assessed against the operating plants.

Since nuclear powered warships account for such a large portion of the Navy's combatant fleet, the successful operation of the reactor plants is a key factor in the Navy's ability to perform its national defense role. To date, nuclear powered ships have steamed more than 115 million miles without a reactor accident or a significant release of radioactivity to the environment. The continued ability of the Navy to benefit from nuclear propulsion is dependent on continuance of this record.

The following activity areas are necessary to ensure the outcome of this performance measure:

- Design and test improved reactor equipment including advanced control rod drive mechanisms.
- Perform physics testing and analysis to confirm expected fuel system and core performance and develop improved analysis methods for predicting core performance that reduce design approximations, uncertainties, and associated conservatism.
- Conduct reactor safety and shielding analyses for nuclear reactor plants to ensure containment of radiation and proper protection of personnel.
- Ensure satisfactory reactor plant operation throughout life and improve steam generator, energy conversion, and steam generator chemistry technologies to enhance performance and reduce maintenance costs.
- Develop instrumentation and control equipment to replace obsolete equipment and improve reliability and performance.
- Develop and test reactor plant components and applicable technologies which address known limitations and improve performance and reliability of components.
- Perform reactor plant analyses to assure safe operation and improve reactor plant chemistry controls to reduce corrosion and plant radiation levels.

Accomplish planned core and reactor component/system design and technology development efforts to support the Navy's acoustic requirements.

One of the greatest advantages provided by submarines is stealth. Stealth allows submarines to operate undetected, conducting surveillance or performing offensive missions with minimal concern for defensive needs, providing, in effect, a tremendous force multiplier. This capability must be maintained in the face of ever improving means of detection. In order to do so, Naval Reactors must ensure the reactor components and systems used in submarines meet tightening Navy operating parameters for quieting.

The following activity area is necessary to ensure the outcome of this performance measure:

- Develop and qualify improved core and reactor component thermal and hydraulic designs.

Maintain a utilization factor of at least 90% for prototype plants to ensure their availability for scheduled testing, training, and servicing needs, and provide for development of servicing equipment and testing of plant components, materials and procedures.

Naval Reactors has two operating land based prototype Naval nuclear propulsion plants at the Kesselring site in New York and also is the principal customer of the Advanced Test Reactor (ATR) located at the Idaho National Engineering and Environmental Laboratory.
The prototype plants in New York are an essential component in meeting Naval Reactors' mission of ensuring the safe and reliable operation of Naval reactor plants. Prototypes provide platforms for conducting testing under actual operating conditions, which can not be duplicated in the laboratory. This testing yields important technical data and experience, and allows potential problems to be identified and addressed before they occur in operating reactor plants. The prototypes are used to test new components and to verify reactor performance predictions by depleting the core faster than would be done in an operating shipboard plant. For example, the advanced fleet reactor, now used in the SEAWOLF Class attack submarine, has accumulated the equivalent of 15 years of fleet operation. The prototypes also are used to train Navy nuclear plant operators.

Operation of the ATR provides a unique capability to irradiate test specimens, which are then examined to provide data on the effects of radiation on materials. The ATR's arrangement permits varying conditions within the reactor test loops allowing accelerated life testing of materials, a major benefit.

The goal for operating the prototypes and the ATR is a 90% utilization factor. Utilization factor is a measure of prototype and ATR availability for planned testing, training, or maintenance. To meet this goal, Naval Reactors must be forward thinking in identifying potential problems before they occur.

At the end of life, servicing organizations must remove the core from a reactor plant. This is an extremely critical operation given the radioactivity inherent in the spent fuel.   If the reactor plant is to remain in service a new core must be installed at this point. Fuel transfer equipment is designed for safe operation under all possible normal and abnormal conditions, and thorough evaluations are made of the design and fabrication processes. Engineering models are tested to demonstrate proper operation and detailed procedures are prepared to cover use of the equipment.

The following activity areas are necessary to ensure the outcome of this performance measure:

- Operate land-based test reactor plants to provide for prototypical testing, core depletion analysis, and reactor plant operator training.
- Service land-based test reactor plants to ensure they continue to operate safely and efficiently, and develop equipment and procedures to provide for safe and efficient servicing of nuclear reactor plants.
- Operate and service the ATR to provide for materials irradiations testing.

Meet cost and schedule goals to safely and responsibly inactivate shutdown land-based reactor plants in support of the Department's environmental clean-up goals.

Naval Reactors has shutdown six prototype plants no longer required for testing. These six plants are located at three sites. Based on the projected future use of each one of those sites by Naval Reactors, different degrees of inactivation appropriately were chosen as the goals for the various facilities at the start of this effort. With the shutdown of the S1C plant, there is no future need for the Windsor Site.   As such, Naval Reactors is demolishing all structures, remediating the area, recycling/disposing of waste material, and releasing the site for unrestricted use. While the S3G and D1G prototype plants at the Kesselring Site in New York are shutdown, Naval Reactors is still operating two prototype plants at that site. Thus, Naval Reactors intent has been to remove the reactor plants and engine room components from the shutdown plants, but leave the supporting buildings for potential future uses. At the NRF site in Idaho, Naval Reactors has shutdown all three plants -- S5G, S1W, and A1W; however, Naval Reactors will continue to operate the Expended Core Facility at that site for the long term. As a result, and in recognition of the other shutdown reactor plants on the INEEL site, the inactivation plan for NRF included defueling the shutdown plants, placing them in an environmentally benign lay-up condition, and remediating various facilities and supporting systems.

Naval Reactors original intent was to complete the noted inactivation effort by 2002. To date, Naval Reactors has made good progress -- defueled six of the seven reactors (one plant has two reactors) with defueling work underway on the remaining reactor and, as noted below, work is well underway on other aspects of the inactivation. However, the need to fund other priorities within Naval Reactors Development precludes accomplishing the original schedule. Public opinion, publicized in numerous newspaper articles published during and after the Environmental Impact Statements public comment period for the New York and Connecticut prototype plants, support prompt inactivation. Prompt dismantlement is also consistent with the Department's environmental clean-up goals, and is the most efficient and cost effective approach to this work.

The following activity areas are necessary to ensure the outcome of this performance measure:

- Continue inactivation efforts at the Windsor site in Connecticut to eliminate surplus facilities, remediate and dismantle plant facilities and release applicable areas.
- Continue inactivation efforts at the Kesselring Site in New York to eliminate surplus facilities, remediate and dismantle plant facilities and release applicable areas.
- Continue inactivation efforts at the Naval Reactors Facility in Idaho to eliminate surplus facilities, remediate and dismantle plant facilities and release applicable areas.

\# **Ensure no personnel exceed Federal limits for radiation exposure and no significant findings result from environmental inspections by state and federal regulators.**

Over time, the harmful effects of materials previously thought safe such as asbestos and PCBs have become known. In addition, sensitivity has increased concerning the environmental quality of ground water and air. These trends have resulted in stricter government regulations on environmental quality. Despite these stricter government regulations, Naval Reactors continues to have an outstanding environmental performance record. Since 1967, the Naval Reactors Program has voluntarily utilized a limit of five rem per year, and no Program personnel have received greater than five rem in a year since then. Additionally, we have had an aggressive program to minimize exposure to as low as reasonably achievable such that since 1980, no Program personnel have received over two rem in any one year. During 1997, average occupational radiation exposure for Program personnel was again a small fraction of the 300 millirem of radiation exposure received by an average American in one year due to radiation naturally present in the environment. When properly and diligently dealt with, nuclear propulsion is a safe, efficient power source, and is environmentally less damaging than other sources. Naval Reactors cleans up after itself in a rigorous, environmentally safe, and correct manner - including properly maintaining our facilities.

The following activity areas are necessary to ensure the outcome of this performance measure:

- Conduct radiological control, environmental, and safety operations necessary to protect laboratory employees, minimize release of hazardous effluents to the environment, and comply with all applicable regulations.
- Conduct ongoing clean up of test facilities to reduce hazards to personnel, and reduce potential liabilities due to changing conditions or accidental releases.

Complete 90% of VIRGINIA class plant development and testing work by the end of FY 2000.

The VIRGINIA class will provide needed capability for the Navy at an affordable price. Naval Reactors is well along on the reactor plant intended for this ship. This plant encompasses Naval Reactors most advanced component and system technology, with a life-of-the-ship reactor core, a simplified plant arrangement and fewer components compared to previous designs.

Complete initial development efforts on a reactor plant for a new aircraft carrier.

On October 5, 1998, the Navy decided on nuclear propulsion for use in a future aircraft carrier class, designated CVNX. Since developing the reactor plant for the NIMITZ Class in the 1960's, we have designed and built three generations of new submarine reactor plants. Applying these developments to a reactor plant for CVNX will allow incorporation of significant design improvements for simplicity, maintainability, and reliability.

Performance Measure Funding Matrix
FY 2000

Performance Measures	Reactor Technology & Analysis	Plant Technology	Materials Development & Verification	Evaluation and Servicing
	Budget Categories (dollars in thousands)			
Meet Navy goals for extended warship operation, through:				
Nuclear heat source design and analysis methods	50,000			
Core manufacturing processes and inspection techniques	18,000			
Removed fuel cell and irradiated test specimen examination				18,000
Fuel, core and reactor structural material development & testing			43,800	
Plant materials development and testing			38,000	
Irradiations testing and examination			43,000	
Ensure safety and reliability of reactor plants, through:				
Reactor equipment design & testing	44,000			
Physics testing and analysis	20,000			
Safety and shielding analyses	13,000			
Steam generator, energy conversion, and chemistry technologies improvements		23,000		
Instrumentation and control equipment development		45,000		
Reactor plant components development & testing		35,200		
Reactor plant performance analyses and chemistry control		8,000		
Support Navy's acoustic requirements, through:				
Core and reactor component thermal and hydraulic design	16,000			
Ensure prototype plant availability, through:				
Operation of land-based test reactor plants				32,000
Servicing of land-based test reactor plants				14,000
Operation and servicing of the advanced test reactor				18,000
Inactivate shutdown prototype plants, through:				
Inactivation efforts in Connecticut				7,000
Inactivation efforts in New York				19,400
Inactivation efforts in Idaho				17,000
Maintain outstanding environmental performance, through:				
Radiological, environmental and safety operations	35,000			
Cleanup of test facilities				25,000

The funding profiles for the following performance measures are included as subsets of the above funding matrix, since the data was extracted without consideration to the broader applicability and benefit of the work to other reactor plant types. Much of Naval Reactors' technology is generic in nature as all Naval reactor plant types are based on pressurized water reactor technology. As such, demarcating work between plant types and between operating plant and new plant development efforts is arbitrary, and not properly reflective of the way work is actually accomplished. However, this table does give insight into the effort benefitting the next generation and new aircraft carrier reactor plant developments.

(dollars in thousands)

	FY 1998	FY 1999	FY 2000
Next Generation Reactor plant development and testing	80,000	50,000	40,000
Development of new reactor plant for a future aircraft carrier	35,000	60,000	80,000

Significant Accomplishments and Program Shifts

- With the declining number of ships, the Navy's dependence on each ship grows as they are called upon to rapidly respond to crises world-wide. Nuclear-powered warships, which will continue to comprise 40% of the Navy's major combatants, offer significant advantages in dealing with widely dispersed crises and threats with fewer ships -- their stealth, firepower, versatility, virtually unlimited high-speed endurance, and independence from logistics support make these ships especially well-suited to the future missions of the Navy. Nuclear powered submarines are typically the first U.S. forces to arrive on scene. They reconnoiter and secure the area for following forces. For example, in 1996, submarines were an essential component of the Navy force deployed to the Taiwan strait, chosen for their surveillance capabilities and specialized, hard-to-detect weaponry. Aircraft carriers provide our most visible forward presence. The nuclear carrier can sprint from one theater to another without stopping to refuel and can remain on station a higher percentage of the time than conventional carriers. These advantages were demonstrated recently by the USS NIMITZ's 7000 mile high speed transit from the South China Sea to the Arabian Gulf and by the transit of the USS GEORGE WASHINGTON from the Mediterranean Sea to the Arabian Gulf.
- Naval Reactors' careful engineering and approach to safety ensured the Program has never had a Naval nuclear accident or significant release of radioactivity to the environment. This environmental and safety record has endured almost 50 years and has been essential to nuclear-powered warships safely steaming over 115 million miles. This accomplishment is the result of thorough development, testing, and analysis of cores, components, and systems; stringent quality standards and rigorous training; and detailed analysis of operating components/plants to verify expected performance. The former Soviet Navy's nuclear propulsion safety record offers a stark contrast — they suffered casualties because of risks and inadequacies the U.S. would not tolerate.
- As the operating lives of Naval nuclear plants are extended beyond their original design lifetimes, Naval Reactors' efforts are intended to ensure these plants continue to perform safely and reliably. Careful, detailed validation and improvement efforts are necessary to support the Navy's decision to keep ships in service for up to 40-50 years vice original expectations.
- Continuing development efforts are yielding greater capabilities. Ongoing efforts in metallurgy, thermal hydraulics, instrumentation and control, structural mechanics, manufacturing processes, physics, and nuclear design/analysis methods provide the base for future propulsion plant development and improvements to existing ones. Naval Reactors is investigating new structural materials, coolant chemistries, reactor plant arrangements, core configurations, manufacturing

techniques, plant and facility monitoring equipment, and heat exchange methods. Features sought are enhanced power density, longer life, increased resilience, reduced corrosion, ease of operation, and affordability. Major efforts for the near future include upgrades to existing components and equipment to help extend operating ship lifetimes and improve overall reactor plant performance, development/testing of the next generation reactor components and systems for the Navy's VIRGINIA class -- including the first true life-of-the-ship core, which will obviate the need for expensive refuelings, and the new concept steam generator, which should greatly reduce corrosion concerns and improve acoustic performance -- and initial development of a reactor plant for a new aircraft carrier.

The Program's cost-saving initiatives have led to shutting down six of eight land-based prototype plants. Naval Reactors is inactivating and laying up the shutdown plants to place them in an environmentally benign state pending full dismantlement at some future date. Efforts to reduce costs continue, but are not as dramatic.

Funding Profile

(dollars in thousands)

	FY 1998 Comparable Appropriation	FY 1999 Original Appropriation	FY 1999 Adjust-ments	FY 1999 Current Appropriation	FY 2000 Request
Naval Reactors Development					
Plant Technology	112,900	111,100	0	111,100	111,200
Reactor Technology & Analysis	192,000	192,000	0	192,000	196,000
Materials Development & Verification	115,000	119,500	0	119,500	124,800
Evaluation & Servicing	166,020	163,589	0	163,589	149,400
Facility Operations	50,000	51,100	0	51,100	48,000
Program Direction	20,080	20,100	0	20,100	20,600
Subtotal, Naval Reactors Development	656,000	657,389	0	657,389	650,000
Construction	14,500	12,800	0	12,800	15,000
Subtotal, Naval Reactors Development	670,500	670,189	0	670,189	665,000
Use of prior year balances	-148	-4,049	0	-4,049	0
Total, Naval Reactors Development	670,352	666,140	0	666,140	665,000

Public Law Authorization:
Public Law 83-703, "Atomic Energy Act of 1954"
Executive Order 12344 (42 U.S.C. 7158), "Naval Nuclear Propulsion Program"

Funding by Site

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
Bettis Atomic Power Laboratory	324,300	326,489	326,600	111	0.0%
Idaho National Engineering & Environmental Laboratory	50,100	48,200	49,650	1,450	3.0%
Idaho Operations Office	900	925	940	15	1.6%
Knolls Atomic Power Laboratory	273,500	272,875	266,610	-6,265	-2.3%
Pittsburgh Naval Reactors Office	5,800	5,800	5,900	100	1.7%
Schenectady Naval Reactors Office	4,900	5,200	5,300	100	1.9%
All Other Sites	11,000	10,700	10,000	-700	-6.5%
Subtotal, Naval Reactors Development	670,500	670,189	665,000	-5,189	-0.1%
Use of prior year balances	-148	-4,049	0	+4,049	0%
Total, Naval Reactors Development	670,352	670,189	665,000	-1,140	-0.1%

Site Description

Bettis Atomic Power Laboratory

The Bettis Atomic Power Laboratory is a government-owned, contractor-operated laboratory solely dedicated to Naval nuclear propulsion work. Bettis' mission is directed toward ensuring the continued safe and reliable operation of nuclear reactor propulsion plants for Naval surface ships and submarines through design, development, testing and operational follow. Bettis has a specialized testing facility for full scale steam generator testing, a control drive mechanism test facility and the expended core facility in Idaho for examination of spent nuclear fuel.

Idaho National Engineering & Environmental Laboratory

The Idaho National Engineering and Environmental Laboratory (INEEL) is a multi-disciplinary laboratory that applies its engineering and scientific capabilities to key national security areas such as reactor safety and improvement, waste removal and advanced energy production. Naval Reactors funding at the INEEL is for activities conducted at the site's Advanced Test Reactor (ATR). The ATR is the only facility in the Nation capable of performing material irradiation testing. The facility is Naval Reactors' main source of data on the performance of reactor fuel, poison, and structural materials under irradiated conditions.

Idaho Operations Office

The Idaho Operations Office provides review and approval of technical safety requirements, criticality safety activities, restart authorizations and oversight of the Idaho National Engineering & Environmental Laboratory to verify safety and administrative compliance.

Knolls Atomic Power Laboratory

The Knolls Atomic Power Laboratory is also a government-owned, contractor-operated laboratory solely dedicated to Naval nuclear propulsion work. KAPL's mission also is directed toward ensuring the continued safe and reliable operation of nuclear reactor propulsion plants for Naval surface ships and submarines through design, development, testing and operational follow. KAPL has fuel manufacturing development capabilities, unique thermal-hydraulic test capabilities, and two prototype nuclear propulsion plants at the Kesselring Site for operational testing of new technologies under typical operating conditions prior to fleet introduction.

Pittsburgh Naval Reactors Office

The Pittsburgh Naval Reactors Office maintains oversight of the Bettis Atomic Power Laboratory.

Schenectady Naval Reactors Office

The Schenectady Naval Reactors Office maintains oversight of the Knolls Atomic Power Laboratory.

All Other Sites

Naval Reactors Headquarters administers the Naval Nuclear Propulsion Program. The Lawrence Livermore National Laboratory Atmospheric Release Advisory Capability provides the emergency response and management efforts related to real-time consequence assessment of atmospheric release of radioactive and toxic chemical material. The Oak Ridge National Laboratory Radiation Shielding Information Center performs collection evaluation and dissemination of information related to nuclear radiation transport.

Reactor Technology & Analysis

Mission Supporting Goals and Objectives

The work in this category ensures the continued safe operation of existing reactors, and develops new reactors with improved power capabilities, endurance, reliability and efficiency, and greater simplification. Reactor Technology and Analysis efforts support the performance measures of meeting Navy goals for extended warship operation, ensuring the operational safety and reliability of reactor plants for Navy warships, supporting Navy acoustic requirements, and ensuring continued excellence in radiological and environmental control.

Improved nuclear heat source design and analysis methods are needed to satisfy service life requirements. Limitations in these analytical techniques necessitate design conservatism, which must be reduced to increase the operating margin for reactors. Emphasis in this area is on thermal-hydraulics, structural and fluid mechanics, vibration analyses and nuclear core design and analysis work to more accurately predict reactor performance and reduce design conservatism. Improved core manufacturing processes and inspection techniques also are being pursued to support extended life requirements.

Effort also is underway to improve analysis tools and understanding of basic nuclear data. This will aid in improving Naval Reactors ability to predict performance over the longer lifetimes. Other efforts in this area are dedicated to designing and testing simpler, more reliable reactor equipment; performing analyses to ensure reactor safety; and developing improved shield designs to reduce cost and radiation levels.

Development and qualification of core and reactor component thermal and hydraulic designs is aimed at improvements in power and flow which facilitate improved acoustic performance. Radiological and environmental monitoring and controls ensure operations are conducted without adverse impact on employees or the environment

Funding Schedule

	FY 1998	FY 1999	FY 2000	$ Change	% Change
Reactor Technology and Analysis	192,000	192,000	196,000	+4,000	0.021
Total, Reactor Technology and Analysis	192,000	192,000	196,000	+4,000	+2.1%

Detailed Program Justification

(dollars in thousands)

	FY 1998	FY 1999	FY 2000
I. Conduct planned development, testing, examination and evaluation of nuclear fuel systems, materials, and manufacturing and inspection methods to ensure Naval nuclear reactors are able to meet Navy goals for extended warship operation.			

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
A. Improve nuclear heat source (core) design and analysis methods and develop improved designs to satisfy service life requirements.			
The reactor design codes used in support of current designs were necessarily constrained in their modeling capability due to computational limitations and limited test data. As a result of the limitations in design codes, conservative procedures and designs are necessary to ensure safety and acceptability.			
However, supporting extended service life requirements necessitates reducing this design conservatism to extend the operating margin for current reactors. Reducing this conservatism safely requires extensive testing to provide data for the qualification of new analytical models and to aid in establishing new, or revising existing, core performance criteria. Engineering analyses and testing in the areas of nuclear analysis, thermal-hydraulics, structural mechanics, fluid mechanics, dynamic structural load tests and vibration are needed to confirm the acceptability and performance of the core and reactor components.			
Extended service life requirements are also being met through development of improved designs, such as the next generation reactor for the Navy's VIRGINIA class and in the future an improved reactor for future aircraft carriers. The core for the VIRGINIA class will be the first designed from inception to last the life of the ship. Development effort for new core designs entails validating key structural, thermal-hydraulic, and nuclear calculations to provide design assurance. Key components and design features are tested under prototypic operating conditions to demonstrate the mechanical, thermal-hydraulic and flow-induced vibration acceptability of the design and manufacturing processes	61,000	52,000	50,000

Verifiable Supporting Activities:

FY 1998 Conduct shock and vibration testing of the next generation reactor mechanical test cell and commence analysis of results.

Develop detailed design of test program to qualify fluid mechanics and thermohydraulic models.

(dollars in thousands)		
FY 1998	FY 1999	FY 2000

FY 1999 Assess and resolve implications of reactor test program on design margin and design bases for next generation reactor.

Assess feasibility and potential benefits of high temperature reactor concepts.

Initiate qualification of improved reactor code and design procedures using thermal-hydraulic data.

Initiate conceptual design of an advanced core for use in a reactor plant intended for a new aircraft carrier.

FY 2000 Incorporate experimental results to update analysis methods for the next generation reactor. Review engineering designs, analyses and test work to assure next generation reactor will perform as expected.

Evaluate technical requirements for reactors with high temperature capability.

Develop and qualify code and design procedure using test data.

Initiate reference design for an advanced core for use in a reactor plant intended for a new aircraft carrier.

	(dollars in thousands)	
FY 1998	FY 1999	FY 2000

B. Evaluate and test improved core manufacturing processes and inspection techniques to support extended life reactors.

Earlier Naval core designs result in hot spots in the fuel during operation, and margins are built into the fuel designs and operating limits to compensate. The current fuel manufacturing process, the Modified Fuel Process (MFP), reduces hot spots and allows cores to operate with higher energy density needed for longer endurance. However, this process is expensive and technically challenging. Continuing effort is aimed at improving fuel manufacturing to develop a process which can deliver a high power core at lower cost.

Naval Reactors needs manufacturing process improvements to support new core design features, discussed above, and must develop new processing methods to manufacture cores with improved capabilities to meet design requirements and objectives. In addition, the experience gained by doing manufacturing and inspection process development can be applied in ensuring manufacturability of new core designs and preparing manufacturing contract specifications.

The intent of manufacturing and inspection development efforts also is to reduce cost compared to current processes. Other efforts include developing more cost-effective processes for fuel elements, fuel assemblies, and core structural components. Test specimens are manufactured for in-reactor tests to qualify design and process changes for ultimate application in core design and manufacturing. . . . .

FY 1998	FY 1999	FY 2000
20,000	15,000	18,000

Verifiable Supporting Activities:

FY 1998 Establish manufacturing capability to pilot advanced fuel process concepts.

Develop advanced systems with reduced cost.

FY 1999 Conduct initial demonstration of the new fuel system manufacturing process.

Continue development of advanced fuel systems.

Investigate new manufacturing and inspection technologies to reduce core cost and improve core operation.

	(dollars in thousands)	
FY 1998	FY 1999	FY 2000

FY 2000 Model key manufacturing processes and demonstrate advanced processing technologies on mockups.

Begin qualification of advanced fuels and processing techniques.

Develop new and emergent manufacturing and inspection technologies to improve core operation, solve technical problems and reduce core cost.

II. Complete scheduled design, analysis, and testing of reactor plant components, systems, and performance to ensure the operational safety and reliability of reactor plants for use in Navy nuclear powered warships so they can fulfill their national defense mission.

A. Design and test improved reactor equipment including advanced control rod drive mechanisms.

The control rods directly control reactivity in the reactor. Regulation of the reactivity, and reactor safety and reliability, demand the mechanisms which drive the control rods perform without incident.

Current mechanism designs are based on 1960s technology. Development efforts are focussed on incorporating a new design which would virtually eliminate inadvertent scrams and improve reliability of performance. Other planned improvements include: a simpler design, improved lifetime features, and additional operating flexibility.

	FY 1998	FY 1999	FY 2000
New reactor heavy equipment, including reactor vessel, closure head, closure studs, and a core basket, also must be developed and qualified to accommodate new core designs. Effort during the budget period is focussed on the equipment for the next generation reactor and for a reactor for a new aircraft carrier. Detailed three-dimensional structural analyses are performed to ensure these important components are not over stressed	29,000	39,000	44,000

(dollars in thousands)		
FY 1998	FY 1999	FY 2000

Verifiable Supporting Activities:

FY 1998 Test and resolve design issues for extended life of control rod drive mechanisms.

Perform testing of control drive mechanism lead units, including life, thermal, and shock and vibration testing.

Carry out design/structural analysis validation and continue fit up and alignment studies of reactor equipment for the next generation reactor.

Conduct analysis of stress-strain relationships and cyclic loading.

FY 1999 Conduct control drive mechanism lead unit life testing and examinations.

Begin life testing of prototypical production unit control drive mechanisms.

Evaluate concepts for control drive mechanisms for a new aircraft carrier.

Assess sizing of reactor equipment for a new aircraft carrier based on analytical and experimental methods.

FY 2000 Complete remaining control drive mechanism lead unit testing, examination and reports.

Perform any needed testing and resolve design issues arising from receipt inspection or power unit assembly for the next generation reactor.

Initiate reference designs for reactor equipment and an improved control drive mechanism for use on a new aircraft carrier.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
B. Perform physics testing and analysis to confirm expected fuel system and core performance and develop improved analysis methods for predicting core performance that reduce design approximations, uncertainties, and associated conservatism.			
The first cores Naval Reactors developed had expected service lives of two years. Subsequent development efforts have allowed extending this service life to over twenty years, and development is underway to deliver a life-of-the-ship core which will last over thirty years. While yielding significant advantages in terms of reduced radiation exposure, reduced cost, and increased ship availability, the longer core life is pushing nuclear analysis tools beyond proven experience. These tools are limited in their ability to accurately predict core physics performance at later phases of life. Naval Reactors is developing improved methods and tools to provide continued assurance of safe and reliable operation at stages in life which extend well beyond current operating experience.			
In addition, current physics methods use approximations which limit design precision and require allowances be built into the design. Naval Reactors is improving design methods and software to reduce the degree of conservatism. For example, advancements in computer capability are being exploited to provide more precise calculations of core performance over lifetime. This will allow a reduction in uncertainties and biases currently applied to core reactivity predictions. These reductions can lead to reduced costs and improved reactor performance through more accurate predictions of power levels in the various regions of a core under transient and steady-state conditions.			
Qualification of these improved analytical and design methods requires extensive testing; comparison of calculations to experimental results and operating experience; and validation of predictions against prototype core measurements. Differences between calculations and experimental results are resolved and the results factored into improved methods and computer programs. Efforts also are focussed on improving measurements of basic nuclear data and determining experimental programs required to improve the data. This includes measurement of nuclear cross sections which underlie all reactor physics calculations	21,000	20,000	20,000

Verifiable Supporting Activities:

FY 1998 Analyze physics results from middle-of-life operation of the advanced fleet reactor prototype core.

Correlate advanced fleet reactor physics data to expand model qualification base.

Achieve improvement in speed for deterministic solution of neutron transport equation.

Establish core concepts to support design basis decisions for a reactor for a new aircraft carrier.

Conduct physics analysis of expended fuel data from the S8G prototype core to confirm predictions and methods.

FY 1999 Evaluate advanced fleet reactor prototype physics data for the most reactive time in life.

Develop a parallelized version of the Monte Carlo program to achieve a large reduction in time for solving the neutron transport equation.

Develop affordable core design concepts to support design basis for a reactor for a new aircraft carrier.

Analyze physics data from the D2W prototype expended core examination.

FY 2000 Evaluate physics data from late-in-life operation of the advanced fleet reactor and qualify model predictions against the measured data.

Incorporate improvements to major nuclear design programs.

Start reference design effort for more affordable core design for an advanced aircraft carrier.

Apply improved physics methods, modeling procedures and cross section data to reduce reactivity bias.

Analyze physics data from the NIMITZ prototype expended core examination to validate physics predictions and methods.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
C. Conduct reactor safety and shielding analyses for nuclear reactor plants to ensure containment of radiation and proper protection of personnel.			
Naval Reactors conducts reactor safety analyses of all plants and new core designs to confirm the adequacy of the design and assure public health and safety. Safety assessments are conducted for specific reactor plant designs to identify any potential safety vulnerabilities and to assess the likelihood of a core damaging casualty. Severe accident assessments are conducted for specific reactor plant designs to evaluate containment integrity for postulated accident scenarios.			
In addition, shielding analyses are conducted to ensure containment of radiation and continued safe operation. New shield materials are sought to improve shield effectiveness, while eliminating the use of hazardous materials such as lead. Shielding methods improvements more accurately predict the effectiveness of the radiation shielding and the extent of radiation reactor components and materials receive. This allows shielding to be better optimized to reduce radiation exposure to personnel and equipment during reactor plant and servicing operations and during the handling and shipment of spent nuclear and other highly radioactive materials	11,000	13,000	13,000

Verifiable Supporting Activities:

FY 1998 Improve analysis methods.

Continue no-lead shield design with evaluation of alternatives for eliminating lead from shielding.

FY 1999 Further develop analysis methods.

Complete the CVN 77 shield design.

Develop and qualify improved shield design methods.

FY 2000 Develop and qualify improved shield design methods.

Establish initial design methods for a reactor intended for a new aircraft carrier.

	(dollars in thousands)	
FY 1998	FY 1999	FY 2000

III. Accomplish planned core and reactor component/system design and technology development efforts to support the Navy's acoustic requirements.

A. Develop and qualify improved core and reactor component thermal and hydraulic designs.

	FY 1998	FY 1999	FY 2000
Work in this area is focused on improving thermal hydraulic analytical models and codes. Improved tools will enable a more accurate determination of flow requirements, increasing the margin between operating conditions and performance limits.			
For additional explanation, please refer to classified addendum. .	18,000	19,000	16,000

Verifiable Supporting Activities:

FY 1998 Initiate model and code development and fundamental testing to extend the advanced computational fluid dynamics code.

Evaluate application of modified hydraulic design to future core designs.

FY 1999 Develop models and perform fundamental testing for the application of the advanced computational fluid dynamics code to additional areas.

Develop models and conduct testing to extend the qualified range of the thermal and hydraulic design procedures.

Develop models and conduct testing for extension of modified hydraulic design code to future core designs.

FY 2000 Validate and qualify advanced computational fluid dynamics code for additional application.

Validate the advanced code for use in modified hydraulic design analysis.

Develop and qualify improved shield design methods.

Establish initial design methods for a reactor intended for a new aircraft carrier.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
IV. Ensure no personnel exceed Federal limits for radiation exposure and no significant findings result from environmental inspections by state and federal regulators.			
A. Conduct radiological control, environmental, and safety operations necessary to protect laboratory employees, minimize release of hazardous effluents to the environment, and comply with all applicable regulations.			
Radiological materials must be properly controlled to protect the health and safety of workers, the public and the environment. Naval Reactors has developed and enforces strict compliance with requirements for safe handling and disposal of radiological material. Additional procedures are in place to ensure environmental compliance. The principal focus of these environmental efforts is to prevent the generation of environmental hazards, by reducing wastes and preventing pollution.			
Training is conducted to ensure radiological, safety and environmental requirements are understood. In addition, personnel and affected work areas receive routine radiological monitoring to ensure exposure is within minimal limits. Environmental monitoring confirms operations do not impact the surrounding community, and emergency response capabilities are in place to control or mitigate any problems.	32,000	34,000	35,000

Verifiable Supporting Activities:

All Years Survey and document radiological conditions; train personnel for all phases of radiological work and environmental work.

Minimize the production and safely dispose of all waste in accordance with applicable regulations.

Audit compliance to all regulations to ensure effectiveness of controls

	FY 1998	FY 1999	FY 2000
Total, Reactor Technology & Analysis	192,000	192,000	196,000

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
#I.A. Decrease in nuclear heat source design reflects progress on development of next generation reactor	- 2,000
#I.B Increases to reflect development of reactor for a new aircraft carrier	+3,000
#II.A Increase in reactor equipment and control drive mechanism development reflects initiating concepts work for a reactor plant intended for a new aircraft carrier	+ 5,000
#III.A New computer codes with improved predictive capabilities result in streamlined processes used to qualify analytical design methods	- 3,000
#IV.A Increase in radiological and environmental controls reflects inflation and increased effort to ensure compliance with all	+ 1,000
Total Funding Change, Reactor Technology & Analysis	+ 4,000

Plant Technology

Mission Supporting Goals and Objectives

Plant Technology encompasses development, testing and analysis of components and systems which transfer, convert, control and measure power created by the reactor. Components sustain wear through operation that threatens reactor plant integrity, and new components and systems are needed to support new applications either in existing or new reactor plants. Thus, the principal thrust is to develop and apply predictive, analytic, and testing tools to find potential problems to enable corrective actions and the continued safety of operating plants. This, or changing performance requirements, may lead to the need to develop new or modified components and systems. The advances achieved in the various applicable technologies such as manufacturing/welding processes, fluid dynamics, models and analysis methods and thermal-hydraulics have enhanced operating plant performance and allowed major improvements in performance for new reactor plants. For example, the reactor plant now under development for the VIRGINIA class will be simpler, hence more reliable, and more power dense than previous plants because of the continuing advances. These advances and the results of continuing technological progress are being assessed for possible use in a reactor plant for a new aircraft carrier with development expected in future years.

A reactor plant provides a harsh environment for machinery. The constant exposure to water at high temperature and pressure is corrosive. Harmful corrosive environments exist in the steam generators due to the intense boiling environment inherent in the transfer of reactor heat to the turbines. Besides dealing with this continuing problem, Naval Reactors is pursuing technologies to greatly reduce corrosion through fundamental design changes. Also, machinery such as pumps with constantly rotating or operated parts wear and require lubrication. Obviously, to the extent this wear can be abated through the application of better materials and lubricants, as well as more resilient designs, the longer and more reliable the component and system. A constant concern is in improving or correcting one area, another will be made worse thus necessitating extensive and comprehensive testing.

Likewise, a continuing effort is devoted to applying the latest advances in electronics to instrumentation and control equipment and systems. Due to rapid degradation and obsolescence, this equipment must be replaced during the lifetime of an operating plant. While this presents a continuing challenge, there are advantages to this given the rapid technical advances. For example, the accuracy and reliability of the instrumentation can affect the useable power obtained from the reactor.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
Plant Technology	112,900	111,100	111,200	+100	0.1%
Total, Plant Technology	112,900	111,100	111,200	+100	0.1%

Detailed Program Justification

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
I. Complete scheduled design, analysis, and testing of reactor plant components, systems, and performance to ensure the operational safety and reliability of reactor plants for use in Navy nuclear powered warships so they can fulfill their national defense mission.			
A. Ensure satisfactory reactor plant operation throughout life and improve steam generator, energy conversion, and steam generator chemistry technologies to enhance performance and reduce maintenance costs.			
Steam generators must provide a safe interface between the reactor plant and the power turbines, transferring heat from the reactor plant to produce steam to run the power turbines. Hot water from the reactor flows through a bundle of thin-walled tubes within the steam generator. A shell containing the turbine water surrounds these tubes where it is boiled to steam. The integrity of steam generator components must be maintained in order to prevent radioactive contamination of the steam which is piped out of the steam generator to the power turbines. Maintaining steam generator integrity requires development of water chemistries and evaluation of corrosion effects. Trace impurities can become highly concentrated by the boiling process in areas of low flow and form deposits. The concentration of impurities in these deposits becomes corrosive and threatens the integrity of the unit. Development efforts are therefore required to evaluate potential corrosion mechanisms, devise methods to locate and remove deposits, minimize input of these impurities and continually test water chemistries and corrosion inhibitors for benefits and drawbacks to ensure they mitigate the consequences of these impurities. Development is also underway to test other ways to transfer energy. For example, the intent of the new concept steam generator is to minimize the propensity for concentration of impurities and eliminate low flow regions resulting in an inherently more corrosion resistant, reliable design. Efforts concentrate on building test units to demonstrate and qualify the process on a large scale. These test units will then be used to confirm the expected performance benefits.	35,000	25,000	23,000

(dollars in thousands)		
FY 1998	FY 1999	FY 2000

Verifiable Supporting Activities:

FY 1998 Examine steam generator sludge and corrosion samples to characterize thermal hydraulic, chemistry and corrosion behavior.

Perform testing of chemistry additives and corrosion inhibitors for eventual long term use.

Begin design of in-plant corrosion monitors for more detailed examination of chemistry and corrosion trends in several types of steam generators.

Continue fabrication of the new concept steam generator manufacturing demonstration unit full assembly and prepare for performance testing.

FY 1999 Evaluate steam generator sludge/corrosion samples and compare to test results to develop improved corrosion control and predictive tube corrosion models.

Continue testing necessary for long term use of potential new chemistry additives and corrosion inhibitors.

Continue design and begin testing in-plant corrosion monitors for several types of steam generators.

Initiate the manufacturing demonstration unit thermal and hydraulic testing.

FY 2000 Continue steam generator simulator testing and analysis for development of improved corrosion control and predictive models.

Continue testing of chemistry additives and corrosion inhibitors for long term use.

Accomplish additional testing of several types of steam generators with advanced in-plant corrosion monitors.

Identify and incorporate improvements to the new concept steam generator technology based on lessons learned from the manufacturing demonstration unit testing.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
B. Develop instrumentation and control equipment to replace obsolete equipment and improve reliability and performance.			
Naval reactor plants rely on instrumentation to monitor plant conditions, take corrective action and determine position and speed of the control rods used to regulate the reactor. Safe and reliable operation of the plant is dependent on the reliability and performance of this equipment. In addition, highly accurate and reliable equipment can increase actual usable power available from the reactor.			
Rapid technical advances in the electronics industry provide opportunities to improve equipment. The downside of these advances is rapid obsolescence because industry does not maintain the parts or capability to support older equipment. Due to its nature -- circuit cards and numerous interconnected small electrical components -- and obsolescence, lifetimes are much more limited than for heavy reactor equipment. As a consequence, this equipment must be replaced periodically over the life of a plant. Development concentrates on adapting equipment to reactor plant specifications that are more functionally integrated, less costly to support and more flexible to more easily incorporate future technological advances. The focus is on solid-state, microprocessor-based electronics technology which is simpler, more reliable and quieter.	45,900	41,000	45,000

Verifiable Supporting Activities:

FY 1998 Modify standardized instrumentation and control designs to incorporate lessons learned from testing and begin hardware qualification testing.

Develop engineering models of advanced pressure and flow sensors to be compatible with standardized instrumentation and control systems in various reactor plant types.

Complete compatibility testing of a new rod control system for the next generation reactor rod drive mechanisms.

(dollars in thousands)		
FY 1998	FY 1999	FY 2000

FY 1999 Continue qualification testing of standardized instrumentation and control hardware and continue design documentation of system software.

Continue engineering model development and testing of advanced pressure and flow sensors and prepare for qualification testing.

Examine potential instrumentation and control technologies for application in a reactor plant for a possible new aircraft carrier.

Begin development of instrumentation for OHIO and LOS ANGELES class submarine reactor plants using standardized building blocks.

FY 2000 Conduct testing of various standardized instrumentation applications, conduct qualification testing of software building blocks and modify as necessary.

Continue development of instrumentation for OHIO and LOS ANGELES Class submarine reactor plants using standardized building blocks.

Perform qualification testing of advanced pressure and flow sensors to ensure compatibility with standardized instrumentation and control.

Begin identification of functional requirements for a new aircraft carrier reactor plant instrumentation system.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
C. Develop and test reactor plant components and applicable technologies which address known limitations and improve performance and reliability of components.			
Naval Reactors evaluates current technologies and applies them to develop simpler components which maximize plant efficiency, reliability and safety. For example, the main coolant pump used in the NIMITZ Class carrier reactor plant, originally designed in the early 1960's, is being redesigned for backfit to incorporate current technologies which will address known problems and thus improve its performance and enhance reliability over the pump's operating life.			
Effort also is focused on optimizing reactor plant arrangement to achieve simplicity, resulting in fewer components. The fewer the number of components and systems, the less the maintenance, space and power needs. This results in cost savings, enhanced reliability, greater ease of operation and more power available for other uses in the ship. An important consideration is flow through each component and system in the reactor plant because the pressure drop associated with each component has an affect on flow through the core. Deviations from nominal flow can cause a heat level imbalance within the core, thus tight tolerances are necessary to ensure the entire plant operates safely and efficiently.	23,000	36,100	35,200

Verifiable Supporting Activities:

FY 1998 Perform next generation reactor coolant pump qualification testing.

Finalize redesign of the main coolant pump used in the NIMITZ Class carrier reactor plant and begin fabrication of the qualification unit.

Begin feasibility studies of components and systems for a reactor plant for a new aircraft carrier in support of the Navy's assessment of alternatives.

	(dollars in thousands)	
FY 1998	FY 1999	FY 2000

FY 1999 Develop the next generation reactor primary fluid system design and complete coolant pump qualification testing.

Complete qualification unit fabrication and initiate qualification testing of the redesigned NIMITZ Class carrier main coolant pump including flow testing.

Continue feasibility studies and initiate conceptual definitions of a reactor plant for a new aircraft carrier.

FY 2000 Complete test procedures associated with initial construction of the next generation reactor.

Continue qualification and flow testing of the redesigned NIMITZ Class carrier main coolant pump.

Initiate design of components, such as the main coolant pump and pressurizer, and arrangements for the reactor plant for a new aircraft carrier.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
D. Perform reactor plant analyses to assure safe operation and improve reactor plant chemistry controls to reduce corrosion and plant radiation levels.			
The reactor core heats water which flows through the steam generator. The steam generator transfers the heat to the turbine cycle water by producing steam for power . Any corrosion products present in the reactor water will be carried through the plant and irradiated in the core. Additionally, excessive build-up of corrosion products in the core acts as insulation and narrows water channels, reducing flow and heat transfer.			
Chemistry controls are aimed at reducing corrosion. Development effort aims at maintaining water chemistry within operating parameters to provide as benign an environment as possible, thus protecting the components and systems of the reactor plant. A key factor in the development process is a continuous flow of data from test facilities and operating plants.			
Detailed reactor system performance analyses are also performed to ensure naval reactor plants are safe during normal, transient and casualty conditions. The performance analyses establish operating limits and automatic protection systems set points which ensure the plant will operate safely and reliably during operation.			
Through continuous improvement in chemistry, reactor protection system analyses and advances in metallurgy discussed in the Materials Development and Verification category, Naval Reactors has been able to maintain consistently low radiation levels while enhancing reliability and correspondingly reducing maintenance costs.	9,000	9,000	8,000

Verifiable Supporting Activities:

FY 1998 Perform verification of the core performance model by comparing with expended core data.

Begin to evaluate an alternate chemistry for reactor water treatment in several types of reactor plants.

Begin the initial start-up reactor protection analysis for the next generation reactor.

Conduct channel closure/ end-of-life reactor systems performance analysis for the advanced fleet reactor.

	FY 1998	FY 1999	FY 2000
FY 1999 Continue analysis of core performance by isolating the effects of water acidity and temperature.			
Continue the alternate chemistry treatment test for possible future use in several plant types.			
Perform the protection analysis for the next generation reactor.			
Initiate analysis to extend advanced fleet reactor protection basis to end-of-life.			
FY 2000 Incorporate results of isolation tests in the core performance model.			
Conclude whether to implement alternate chemistry use for reactor water treatment on several plant types.			
Perform the initial start-up test protection analysis for the next generation reactor, and develop a design basis for the reactor protection analysis under abnormal operating conditions.			
Continue end-of-life advanced fleet reactor performance analysis.			
Total, Plant Technology	112,900	111,100	111,200

(dollars in thousands)

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
# I.A Decreases to reflect progress on new concept steam generator.	- 2,000
# I.B Increases to support Instrumentation and Control design and development for new aircraft carrier.	+4,000
# I.C. Decreases to reflect refinement in designs for an improved main coolant pump	-900
# I.D. Decrease reflects progress in performance analysis for next generation reactor.	- 1,000
Total Funding Change, Plant Technology	+ 100

Materials Development & Verification

Mission Supporting Goals and Objectives

Materials Development & Verification provides the high performance materials necessary for Naval reactor plant applications. This work principally supports the performance measure to ensure Naval nuclear reactor plants are able to meet Navy goals for extended warship operation. Ensuring materials will withstand the rigors of the harsh environment -- irradiation, high temperature, high pressure, and corrosion -- over a number of decades is a central element to providing longer lived reactor plants. This challenge is compounded by the inability to examine or replace materials in the reactor plant once assembled. Thus, candidate materials must be identified and developed, and these materials, plus materials currently in use, must be extensively and strenuously tested to assure they can meet demand. The materials are also continuously reassessed based on evolving knowledge, and analytical and testing techniques.

Developing and qualifying these high performance materials requires conducting tests of varying periods, up to many years; collecting test data from prototypical specimens and materials removed from service; and assembling that data into improved predictive models. The ability of these models to accurately predict material performance is vital to operating plant safety and to qualifying materials for longer lifetimes.

Work in this category is divided into three areas: core and reactor structural materials, plant materials, and irradiations testing. The first two areas concern the different challenges and demands placed on materials based on their location and function. For example, core materials are subject to more intense irradiation and higher heat levels, while plant materials are more susceptible to stress and cracking. Irradiation testing is used to support both core and plant material development, but is highlighted to reflect the fundamental impact of radiation on material performance.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
Materials Development & Verification	115,000	119,500	124,800	+5,300	4.4%
Total, Materials Development & Verification . .	115,000	119,500	124,800	+5,300	4.4%

Detailed Program Justification

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
I. Conduct planned development, testing, examination and evaluation of nuclear fuel systems, materials, and manufacturing and inspection methods to ensure Naval nuclear reactors are able to meet Navy goals for extended warship operation.			
A. Develop improved nuclear fuel, core and reactor structural materials which extend core lifetimes up to the life of the ship, and evaluate irradiation tests of new and existing materials to verify acceptable lifetime performance and to improve analytical capabilities.			
Materials used in a reactor core as fuel, poison, cladding, and structural pieces must be capable of maintaining their mechanical integrity in an operating reactor environment which subjects them to the harmful effects of irradiation, pressure, corrosion, and heat. This demand is further exacerbated by their need to endure this harsh environment over increasing time periods. In order to support core life expectations of more than 30 years, development and testing of economically attractive materials with improved physical or nuclear characteristics is being pursued. Improvements in material characteristics offer the potential for increased core lifetime, reductions in analytical conservatism and cost savings.			
The ability to qualify materials for specific applications is dependent upon fabrication process development, and through testing and development of predictive models to cover design applications. Materials used in long life core designs must be qualified in advance by collecting data on their performance during tests, examining their condition after testing and at end of use, and assembling the collected data into sound predictive models	37,000	40,500	43,800

Verifiable Supporting Activities:

Materials work supporting long life core concepts, by nature, involves extended testing conducted over many years. The verifiable supporting activities described below provide examples of materials data generated each year thus representing outcomes within the continuing general scope of work.

FY 1998 Develop an improved predictive model for corrosion performance.

Complete next phase of post irradiation crack growth rate testing of X750 and A625 materials.

Develop improved fuel material processing technique to reduce costs and environmental wastes.

Conduct initial evaluations of fuel specimens subjected to various conditions in support of improved performance limits.

FY 1999 Upgrade fuel performance modeling to support improved fuel performance analysis.

Complete post irradiation crack growth rate testing to determine whether the effect of radioactive fluence on stress corrosion cracking resistance of X750 and A625 can be reduced.

Evaluate acceptability of fuel manufactured with a new production process that reduces cost and utilizes environmentally friendly materials.

Conduct destructive evaluation of fuel specimens which underwent performance testing and assess changes to design bases.

FY 2000 Reevaluate model based on latest irradiated materials data.

Conduct testing of prototypic X750 fasteners to provide temperature dependencies for use in a predictive cracking model.

Complete interim evaluation of initial high temperature fuel material irradiations tests to assess performance.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
B. Test and evaluate plant materials to characterize the long term effects of the harsh operating environment and qualify improved materials and processes to ensure endurance requirements will be met.			
Materials used throughout the reactor plant are critical as degradation can lead to reduced performance, shorter lifetime, increased maintenance, or component failure. Consequently, Naval Reactors' efforts are focused on developing and qualifying materials to assure their endurance commensurate with the need to support increasingly longer lived nuclear cores. In dealing with material degradation, a leading concern is stress corrosion cracking, the damage potentially occurring to materials carrying high tensile loads exposed to fluids, radiation, or high temperatures. Other plant material concerns include embrittlement resulting from irradiation, and the use of cobalt in plant materials. Cobalt is used in certain alloys because of its contribution to strength and wear resistance, but has a propensity to remain irradiated longer than other materials, complicating servicing and inactivation. Development and qualification of low or non-cobalt materials is underway.			
Naval Reactors employs various methods to test, evaluate, and develop improved plant materials. For example, autoclave corrosion test facilities are used to create a hot, pressurized environment to recreate, under accelerated conditions, what the material would experience over a longer period of time in an operational reactor plant. Materials which have been in service are examined to provide critical operating data. In addition, destructive and non-destructive testing and examination provides valuable data on material performance and reliability. Non-destructive testing is generally less expensive and allows repeated examination of materials, as well as analysis of the material condition of components still in service, however, some key data on the strength and vulnerabilities of materials can only be obtained through destructive means. An example of destructive testing is measuring the onset of cracking in a material which is intentionally subjected to controlled destructive conditions of stress and corrosion.	40,000	39,000	38,000

	(dollars in thousands)	
FY 1998	FY 1999	FY 2000

Verifiable Supporting Activities:

Because understanding the long term behavior of materials and phenomenon such as stress corrosion cracking is an incremental learning process, the verifiable supporting activities described below represent accomplishments of milestones within the continuing overall effort.

FY 1998 Conduct destructive and non-destructive examinations of component samples removed from operating plants, including a post-service exam of an improved stress corrosion cracking resistant alloy.

Complete initial testing of new low-cobalt alloys and select candidates for continued development.

Conduct thermal embrittlement testing for pressure vessel materials made by the most current material fabrication process.

Complete testing to demonstrate adequacy of valve fasteners for an extended lifetime.

FY 1999 Continue stress corrosion cracking testing and evaluation and complete preliminary version of an advanced predictive model.

Conduct advanced testing of promising new low-cobalt alloys.

Complete first phase of program to evaluate effects of chemistry and material microstructure on irradiation damage in pressure vessel materials.

Improve testing capabilities by developing laser spectroscopy techniques to study low level contaminants in water and monitor stability of additives.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
FY 2000 Complete current phase of crack growth rate testing of corrosion resistant materials to support model refinements. Continue development of low cobalt alloys. Conduct testing to evaluate long term temperature and irradiation embrittlement behavior of a reactor vessel structural material. Perform testing to extend lifetime of high strength fasteners. Improve crack growth rate and corrosion fatigue testing capabilities by developing advanced non destructive testing methods and automated data acquisition techniques.			
C. Conduct irradiations testing and perform detailed examinations to provide data for material performance characterization and prediction.			
Irradiation is the most invasive factor to which reactor materials are exposed, compounding the demands caused by other environmental factors. The Advanced Test Reactor (ATR), located at the Idaho National Engineering and Environmental Laboratory, is Naval Reactors' main source of data on the performance of reactor fuel, poison, and structural materials under irradiated conditions. ATR's high operating flux characteristics allow approximations of lifetime effects from nuclear reactor operation to be obtained in a much shorter time. While operation of the facility is funded in the Evaluation and Servicing budget category, work here includes fabricating test specimens for insertion into the ATR, designing irradiation test trains to expose materials to selected reactor conditions, and conducting post-irradiation detailed examinations to analyze how the material stood up to reactor operating conditions. Test trains are specially engineered structures which hold material specimens in place during irradiation, and are periodically inserted and withdrawn allowing acquisition of data from a wide variety of materials and configurations. The test train's internal arrangement and location in the ATR determines the exposure to specific conditions.	38,000	40,000	43,000

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000

Verifiable Supporting Activities:

Testing and collection of data from these tests is an ongoing, often long term activity. The verifiable supporting activities indicate the start or completion of significant testing efforts. These activities should be viewed as a part of the overall continuing effort.

FY 1998 Commence irradiation testing of advanced fuel samples at various temperatures.

Irradiate samples to investigate fundamental corrosion processes.

FY 1999 Complete irradiation of pressure vessel fracture toughness specimens.

Complete irradiation of samples to investigate cracking phenomenon.

FY 2000 Initiate irradiation of advanced fuel samples using enhanced facilities for control of sample temperatures during irradiation.

Initiate irradiation of vendor fuel samples to demonstrate acceptability of newly established production process.

	FY 1998	FY 1999	FY 2000
Total, Materials Development & Verification	115,000	119,500	124,800

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
# I.A Increase in core and reactor structural materials reflects increased emphasis required to support resolution of emergent issues arising from recently identified performance findings, as well as increased testing to support qualification for extended lifetime . . .	+ 3,300
# I.B. Decrease reflects reduced efforts on destructive examination and testing of components removed from operating plants and reduced effort to develop lower cost manufacturing methods . . .	- 1,000
# I.C. Irradiations testing increases reflect development of improved testing capabilities needed to conduct on-line monitoring of radiation effects. This capability will facilitate improved material performance data and understanding of effects, and will permit faster access to data. Improved capability is necessary to support qualification and validation of material performance for longer life. Also reflects increased cost of irradiations testing in the Advanced Test Reactor . . .	+ 3,000
Total Funding Change, Materials Development & Verification . . .	+ 5,300

Evaluation & Servicing

Mission Supporting Goals and Objectives

Evaluation and Servicing work encompasses the operation, maintenance, and servicing of land-based prototype Naval nuclear propulsion plants and the Advanced Test Reactor, the examination of expended cores to validate end-of-life predictions, and the preservation of environmental quality at all Naval Reactors' sites.

Evaluation and Servicing supports the performance measures for ensuring the availability of prototype plants for testing and training, safely and responsibly inactivating shutdown prototype plants, supporting Navy goals for extended warship operation, and maintaining excellence in radiological and environmental control.

Keeping the prototype plants and the Advanced Test Reactor running efficiently is essential, as information obtained from testing provides valuable feedback for designing new cores and supporting operating fleet reactor plants. Testing of materials, components, cores, and systems in these reactor plants provides important technical data and experience under actual operating conditions.

The accumulation of operational data from the prototype and fleet operating plants, expended core examinations, and increases in the capability of computer modeling have enabled Naval Reactors to shut down six of the Program's eight prototype plants resulting in substantial cost savings. Work is aimed at inactivating and laying up the shutdown plants to place them in an environmentally benign state.

End-of-life fuel cell examinations and non-destructive examinations of irradiated test specimens contribute to extended warship operation by validating design predictions and providing information which can be used to improve future designs.

The Evaluation and Servicing category also funds ongoing clean up of facilities at all Naval Reactors sites to reduce hazards to personnel, and reduce potential liabilities due to changing conditions or accidental releases.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
Evaluation & Servicing	166,020	163,589	149,400	-14,189	8.7%
Total, Evaluation & Servicing	166,020	163,589	149,400	-14,189	-8.7%

Detailed Program Justification

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
I. Maintain a utilization factor of at least 90% for prototype plants to ensure their availability for scheduled testing, training, and servicing needs, and provide for development of servicing equipment and testing of plant components, materials and procedures.			
A. Operate land-based test reactor plants to provide for prototypical testing, core depletion analysis, and reactor plant operator training.			
Naval Reactors operates the MARF and S8G prototypes on an around-the-clock basis to test and evaluate new/improved equipment, components, materials and operating procedures. Each prototype provides a unique testing environment. A major focus is to quickly deplete the advanced fleet reactor in S8G since the information gained will validate the predictions for the cores installed in SEAWOLF class submarines and provide data useful in the development of long lived cores. The MARF prototype is depleting the developmental materials core at varying power levels, and periodic physics tests are being performed to determine how the nuclear fuel reacts with an advanced poison material being tested in that core. These tests are conducted multiple times over the life of the core to verify predicted behaviors as the fuel depletes.			
Over the budget period, Naval Reactors will perform routine maintenance on MARF and S8G to ensure the plants remain in a safe condition and can carry out their testing mission. Other necessary work supporting safe, effective prototype operation includes: operating support systems essential for reactor plant operations; maintaining technical manuals to reflect changes in operating and test procedures; monitoring plant and equipment performance to ensure problems are promptly identified and resolved; performing routine radiological monitoring of plant operations and personnel radiation exposure; maintaining proper plant and support system chemistry control; and replacing plant components as they age to ensure continued, reliable plant operations.	31,000	31,000	32,000

(dollars in thousands)

FY 1998	FY 1999	FY 2000

Verifiable Supporting Activities:

FY 1998 Meet depletion objectives for MARF and S8G cores.

Conduct the fourth MARF high power physics test and issue report.

FY 1999 Meet depletion goals for MARF and S8G.

Conduct the fourth MARF low power physics test and issue report.

FY 2000 Deplete the MARF and S8G cores according to depletion objectives.

Conduct the fifth MARF high power physics test and issue report.

Inspect pressurizer heater wells in MARF.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
B. Service land-based test reactor plants to ensure they continue to operate safely and efficiently, and develop equipment and procedures to provide for safe and efficient servicing of nuclear reactor plants.			
Naval Reactors also performs major servicings on the prototypes to ensure continuing operability. Anticipated major servicings over FYs 98-00 focus on inspecting and cleaning the steam generators. This must be done periodically as solid particles settle out of the boilerwater in the low flow areas where steam generator tubes and support plates meet. These particles form a sludge, which, if not removed, could cause chemical corrosion in the metal tubes and supporting plates. Performing these inspections and cleanings on prototype plants not only keeps them operating efficiently and safely, but increases our knowledge of how fast sludge is accumulating and how corrosion is occurring in shipboard steam generators.			
Naval Reactors ensures the feasibility of defueling and refueling operations is taken into consideration as part of design and development of new reactor cores. Efforts in this area currently are focused on the next generation reactor and a future aircraft carrier plant. Specifically, Naval Reactors is evaluating the next generation reactor design to ensure provision for reactor maintenance and defueling capability. Included in this effort is the design of all power unit loading, maintenance, and defueling equipment, and preparation of planning documents and analyses required for shipment and installation of the next generation reactor power unit and shipment and disposal of recoverable irradiated fuel and irradiated core components. Naval Reactors also is looking into reactor servicing concepts for a new aircraft carrier.	5,000	14,000	14,000

Verifiable Supporting Activities:

FY 1999 Inspect the two MARF steam generators.

Perform qualification testing on next generation reactor control drive mechanism seal welding machines.

Complete development of next generation reactor defueling procedures.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
FY 2000 Inspect one steam generator and clean both steam generators in S8G. Perform scoping studies to evaluate preliminary core and reactor servicing equipment design concepts for a new aircraft carrier.			

C. Operate and service the Advanced Test Reactor to provide for materials irradiations testing.

As the principal customer of the Advanced Test Reactor (ATR), Naval Reactors funds operation and maintenance of the reactor to support material irradiation testing. This is the only facility in the Nation capable of performing these tests. The ATR provides the ability to irradiate five train-type experiments with various flux conditions in pressurized water loops at the same time. Actual testing is funded in the Materials Development and Verification category.

	FY 1998	FY 1999	FY 2000
The ATR is the main source of test data on the performance of reactor fuel, poison, and structural materials under irradiated conditions. The irradiation test program supports operating Naval reactor plants, supports material selections made for the VIRGINIA class reactor plant, and supports database development that positions Naval Reactors to better understand emergent problems with existing reactors and to make informed material selections for new reactor designs.	15,000	16,000	17,000

Verifiable Supporting Activities:

All Years Meet operating efficiency goals.

II. Meet cost and schedule goals to safely and responsibly inactivate shutdown land-based reactor plants in support of the Department's environmental clean-up goals.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
A. Continue inactivation efforts at the Windsor site in Connecticut to eliminate surplus facilities, remediate and dismantle plant facilities and release applicable areas.			
The S1C plant is defueled and significant progress has been made on dismantlement. In 1996 an Environmental Impact Statement and Record of Decision recommending prompt dismantlement of the S1C reactor compartment were issued. Work to date has resulted in approximately 26 buildings/structures being demolished and disposal of over 9,000 tons of construction debris, over 1,000 tons of recycled steel, over 6,000 tons of PCB and asbestos contaminated waste, and 1100 cubic yards of radiological waste. The major remaining work efforts at this site center around reactor compartment dismantlement.	25,020	22,000	7,000

Verifiable Supporting Activities

FY 1998 Separate the S1C reactor pressure vessel from its supporting structures and package for disposal.

Separate, package, and ship the steam generators and reactor coolant pumps.

FY 1999 Complete primary shield tank removal, package, and ship out for disposal.

Complete reactor compartment removal and disposal activities.

FY 2000 Complete building demolition.

	FY 1998	FY 1999	FY 2000
B. Continue inactivation efforts at the Kesselring site in New York to eliminate surplus facilities, remediate and dismantle plant facilities and release applicable areas.			
The S3G and D1G plants at the Kesselring site in New York are defueled. The S3G engine room has been completely dismantled. In 1997, an Environmental Impact Statement and Record of Decision recommending prompt dismantlement of the S3G and D1G reactor compartments were issued.	20,000	14,000	19,400

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000

Verifiable Supporting Activities:

FY 1998 Complete D1G reactor compartment asbestos removal.

Complete servicing equipment disposal from D1G defueling.

FY 1999 Continue dismantlement activities, including preparations for S3G pressure vessel removal.

FY 2000 Continue inactivation efforts, including completion of S3G pressure vessel removal.

C. Continue inactivation efforts in Idaho to eliminate surplus facilities, remediate and dismantle plant facilities and release applicable areas.

	FY 1998	FY 1999	FY 2000
Work continues on the S1W, A1W, and S5G plants at the NRF site in Idaho. Defueling of the S5G plant will complete in FY 1998. The A1W plant has two reactors, one of which is defueled. Preparatory work is underway on the other reactor with defueling scheduled in FY 1999. Naval Reactors also will perform minimal site environmental remediation to support the spent fuel agreement with the State of Idaho.	31,000	25,589	17,000

Verifiable Supporting Activities:

FY 1998 Complete S5G defueling.

Complete servicing equipment disposal from A1W-B defueling.

FY 1999 Complete servicing equipment disposal from S5G defueling.

Complete the lay-up work for the S5G plant.

Defuel the A1W-A plant.

Decontaminate the S1W retention basin

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
FY 2000 Complete servicing equipment disposal from A1W-A defueling.			
Complete the lay-up work for the A1W plant.			
Continue environmental remediation efforts stipulated in the spent fuel agreement with the State of Idaho.			

III. Ensure no personnel exceed Federal limits for radiation exposure and no significant findings result from environmental inspections by state and federal regulators.

A. Conduct ongoing clean up of test facilities to reduce hazards to personnel, and reduce potential liabilities due to changing conditions or accidental releases.

Operation of test, examination, and manufacturing facilities has involved the use of hazardous materials. Decontamination and remediation efforts limit the hazards to personnel, reduce the potential environmental liabilities due to changing conditions or accidental releases, and provide more usable space for future operations. These efforts reduce the current and future hazards from materials such as asbestos, heavy metals, chemicals, and radioactivity.

	FY 1998	FY 1999	FY 2000
The facilities are first characterized to determine the extent and nature of clean up needed. The results of these characterizations are analyzed and the efforts are prioritized based on regulatory requirements and resources available to perform the work. As such, the order in which the following verifiable supporting activities are performed is subject to change based on this prioritization process. The activities identified are, however, representative.	25,000	25,000	25,000

(dollars in thousands)		
FY 1998	FY 1999	FY 2000

Verifiable Supporting Activities:

FY 1998 Conduct asbestos abatement actions at the Naval Reactors Facility (NRF) site.

Renovate the radioactive materials laboratory at the Knolls site.

Release the NRF #2 Spray Pond for non-radiological demolition.

Decontaminate floor space in the N-building and various rooms in the CX building at the Bettis Pittsburgh site.

FY 1999 Process for disposal historical waste from the L-Building at the Bettis Pittsburgh site.

Remove asbestos from various buildings and laboratories at the Bettis Pittsburgh site.

Continue Knolls site remediation activities.

FY 2000 Initiate remediation of obsolete fuel processing facility at the Bettis Pittsburgh site.

Conduct remediation activities at Bettis Pittsburgh for disposition of historically contaminated facilities and equipment.

Continue the renovation of various areas at the Knolls site.

Continue remediation efforts at NRF in support of CERCLA and voluntary consent order requirements.

IV. Conduct planned development, testing, examination and evaluation of nuclear fuel systems, materials, and manufacturing and inspection methods to ensure Naval nuclear reactors are able to meet Navy goals for extended warship operation.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
A. Examine removed fuel cells at end-of-life and perform non-destructive examinations of irradiated test specimens to confirm predicted performance and validate design methods.			
Data obtained from the examinations of in-service components and specimens provides valuable information on material and component characteristics and performance in the harsh reactor environment. The results of examinations are used to reduce uncertainties in behavior of cores and components, to produce improvements in existing ship performance, and to extend reliable operational life. Predictive and analytical tools are updated based on differences between calculations and observed performance. . .	14,000	16,000	18,000

Verifiable Supporting Activities:

FY 1998 Prepare the necessary procedures and schedules for examinations, assembly, shipment, receipt, and disassembly of about fifteen irradiation tests each year.

Begin A4W prototype expended core component examinations.

Begin D2W prototype expended core component examinations.

FY 1999 Prepare the necessary procedures and schedules for examinations, assembly, shipment, receipt, and disassembly of about fifteen irradiation tests each year.

Complete data collection for highest priority A4W prototype expended core component examination.

Receive ASNPP fuel from the A1W prototype.

FY 2000 Prepare the necessary procedures and schedules for examinations, assembly, shipment, receipt, and disassembly of about fifteen irradiation tests each year.

Complete data collection for highest priority D2W prototype expended core component examinations.

	FY 1998	FY 1999	FY 2000
Total, Evaluation and Servicing	166,020	163,589	149,400

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
# I.A. Increases for inflation	+ 1,000
# I.C Increases for inflation.	+ 1,000
# II.A Inactivation decreases as Windsor site inactivation nears completion	- 15,000
# II.B Increase reflects effort at Kesselring site to remove S3G pressure vessel	+ 5,400
# II.C Decrease reflects constrained inactivation effort at Naval Reactors Facility	- 8,589
# IV.A Increases to reduce backlog of core exams and waste and container unloading	+ 2,000
Total Funding Change, Evaluation & Servicing	- 14,189

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
General Plant Projects	9,000	9,000	9,000	0	0.0%
Capital Equipment	41,000	42,100	39,000	-3,100	-7.4%
Total, Capital Operating Expense	50,000	51,100	48,000	-3,100	-6.1%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 1998	FY 1999	FY 2000	Unapprop-iated Balance
90-N-102 Expended Core Facility Dry Cell	86,846	47,146	3,100	5,800	12,000	18,800
95-D-200 Laboratory Systems and Hot Cell Upgrades	19,600	18,500	1,100	0	0	0
97-D-201 Secondary Coolant System Refurbishment	5,000	400	4,600	0	0	0
98-D-200 Site Laboratory/Facility Upgrade . .	15,700	0	5,700	7,000	3,000	0
Total, Construction		66,046	14,500	12,800	15,000	18,800

Major Items of Equipment (TEC $2 million or greater)

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 1998	FY 1999	FY 2000	Accept-ance Date
ATR-ECF Transfer Casks	9,100	7,000	1,100	1,000	0	FY 2000
Corrosion/Chemistry Test Equipment Upgrade	5,400	4,700	700	0	0	FY 1999
Thermal-Hydraulic Test Equipment	2,900	100	200	1,100	1,500	FY 2001
Component Performance Test Facility Upgrade	2,100	800	1,300	0	0	FY 1999
Test Facility Upgrades	5,700	0	5,000	700	0	FY 1999
Scalable Parallel Computers .	12,000	0	12,000	0	0	FY 1998
Local Area Network Replacement	4,900	0	500	1,000	900	FY 2002
Scalable Parallel Upgrade . . .	12,000	0	0	12,000	0	FY 1999
Metal Processing Equipment .	4,200	0	0	2,500	1,700	FY 2000
Post-Irradiations Evaluation Laboratory	7,400	1,400	3,000	3,000	0	FY 1999
Next Generation Scalable Computer	10,000	0	0	0	10,000	FY 2000
Total, Major Items of Equipment		14,000	23,800	21,300	14,100	

Program Direction

Mission Supporting Goals and Objectives

Due to the critical nature of nuclear reactor work, Naval Reactors is a centrally managed organization. This places a heavy burden on the Federal employees who oversee and set policies/procedures for developing new reactor plants, operating existing nuclear plants, facilities supporting these plants, contractors, and the Bettis and Knolls Atomic Power Laboratories. In addition these employees interface with other DOE offices and local, state, and Federal regulatory agencies. Ten FTE's at the Idaho Operations Office oversee operation of the advanced test reactor, which Naval Reactors uses for materials irradiation and testing. Program direction has been grouped into four categories:

Salaries and Benefits provides for Federal personnel compensation, including awards, lump sum leave payments, and employer contribution to employees' benefits.

Travel includes necessary trips to our various sites to carry out the mission of the Naval Reactors Program.

Support Services are not used by Naval Reactors.

Other Related Expenses include training, building occupancy, telecommunications, postage, payroll processing, ADP maintenance, and other miscellaneous expenses associated with the Working Capital Fund, and Program operation.

Funding Schedule

	(dollars in thousands, whole FTEs)				
	FY 1998	FY 1999	FY 2000	$ Change	% Change
Headquarters					
Salary and Benefits	7,375	7,010	7,180	+170	+2.4%
Travel	490	500	510	+10	+2.0%
Support Services	0	0	0	0	0%
Other Related Expenses	635	650	670	+20	+3.1%
Total, Headquarters	8,500	8,160	8,360	+200	+2.5%
Full Time Equivalents	55	57	57	0	0%
Pittsburgh Naval Reactors					
Salary and Benefits	5,075	5,160	5,280	+120	+2.3%
Travel	100	150	110	-40	-26.7%
Support Services	0	0	0	0	0%
Other Related Expenses	605	515	600	+85	+16.5%
Total, Pittsburgh Naval Reactors	5,780	5,825	5,990	+165	+2.8%
Full Time Equivalents	67	72	70	-2	-2.8%
Schenectady Naval Reactors					
Salary and Benefits	4,340	4,595	4,700	+105	+2.3%
Travel	80	85	90	+5	+5.9%
Support Services	0	0	0	0	0%
Other Related Expenses	480	510	520	+10	+2.0%
Total, Schenectady Naval Reactors	4,900	5,190	5,310	+120	$2.3%
Full Time Equivalents	64	65	64	-1	-1.5%
Idaho Operations Office					
Salary and Benefits	800	820	840	+20	+2.4%
Travel	30	30	30	0	0%
Support Services	0	0	0	0	0%
Other Related Expenses	70	75	70	-5	-6.7%
Total, Idaho Operations Office	900	925	940	+15	+1.6%
Full Time Equivalents	9	10	10	0	0%
Total Naval Reactors Program					
Salary and Benefits	17,590	17,585	18,000	+415	+2.4%
Travel	700	765	740	-25	-3.3%
Support Services	0	0	0	0	0%
Other Related Expenses	1,790	1,750	1,860	+110	+6.3%
Total, Program Direction	20,080	20,100	20,600	+500	+2.5%
Full Time Equivalents	195	204	201	-3	-1.5%

Detailed Program Justification

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
Salaries and Benefits			
Federal Staff continue to direct technical work, provide management/oversight of laboratories and facilities to ensure safe and reliable operation of Naval nuclear plants and the advanced test reactor. Staffing decreases are in accordance with Departmental staffing agreements	17,590	17,585	18,000
Travel			
FY 2000 funding supports trips required to provide management and oversight of the Naval Reactors Program	700	765	740
Support Services			
Naval Reactors does not utilize Support Services contracts	0	0	0
Other Related Expenses			
Include provision for Working Capital funds, which were predominantly budgeted for by the Office of Nuclear Energy in FY 1997. Funding also supports training, and ADP maintenance	1,790	1,750	1,860
Total, Program Direction	20,080	20,100	20,600

Explanation of Funding Changes FY 1999 to FY 2000

	FY00 vs. FY99 ($000)
Salaries and Benefits	
# Increase in salaries and benefits is due to salary adjustments in accordance with allowable inflation	+415
Travel	
# Decrease in travel is due to a reduction in Program travel requirements partially offset by allowable inflation.	-25
Other Related Expenses	
# Increase in other related expenses is primarily due to requirements for non-capital ADP procurements, projected Working Capital Fund estimates from Human resources and allowable inflation.	+110
Total Funding Change, Naval Reactors Program Direction	+500

Other Related Expenses

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
Training	115	115	116	+1	+0.9%
Working Capital Fund	502	511	542	+31	+6.1%
Printing and Reproduction	10	11	11	0	0%
Rental Space	0	0	0	0	0%
Software Procurement/Maintenance Activities/ Capital Acquisitions	393	382	458	+76	19.9%
Other	770	731	733	+2	0.3%
Subtotal, Other Related Expenses	1,790	1,750	1,860	+110	+6.3%
Use of Prior Year Balances	0	0	0	0	0%
Total, Budget Authority	1,790	1,750	1,860	+110	6.3%