FISCAL YEAR 1979 DEPARTMENT OF ENERGY AUTHORIZATION FOR ATOMIC ENERGY DEFENSE ACTIVITIES

HEARING

BEFORE THE

COMMITTEE ON ARMED SERVICES
UNITED STATES SENATE

NINETY-FIFTH CONGRESS
SECOND SESSION
ON

S. 2693

A BILL TO AUTHORIZE APPROPRIATIONS FOR THE DEPARTMENT OF ENERGY FOR NATIONAL SECURITY PROGRAMS FOR FISCAL YEAR 1979, AND FOR OTHER PURPOSES

APRIL 24, 1978

Printed for the use of the Committee on Armed Services

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FISCAL YEAR 1979 DEPARTMENT OF ENERGY AUTHORIZATION FOR ATOMIC ENERGY DEFENSE ACTIVITIES

MONDAY, APRIL 24, 1978

U.S. Senate,
Subcommittee on Arms Control
of the Committee on Armed Services,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:05 a.m., in room 212, Russell Senate Office Building, Senator Henry M. Jackson (chairman) presiding.

Present: Senators Jackson and Thurmond.

Also present: Francis J. Sullivan, staff director; John T. Ticer, chief clerk; Donald R. Cotter, professional staff member; Rhett B. Dawson, counsel; Kenneth W. Fish, Edward B. Kenney, James C. Smith, professional staff members; Maria Fabrizio Dickinson, clerical assistant; and Ron Lehman, assistant to Senator Bartlett.

DEPARTMENT OF ENERGY

Senator Jackson. The meeting will come to order.

We meet today to consider the almost $3 billion request by the Department of Energy for their defense activities.

[The bill S. 2693 follows:]

[S. 2693 95th Cong. 2d sess.]

A BILL To authorize appropriations for the Department of Energy for national security programs for fiscal year 1979, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1979".

TITLE I—NATIONAL SECURITY PROGRAMS

OPERATING EXPENSES

Sec. 101. Funds are hereby authorized to be appropriated to the Department of Energy (hereinafter in this Act referred to as the "Department") for fiscal year 1979 for operating expenses incurred in carrying out national security programs, including scientific research and development in support of the armed services, strategic and critical materials necessary for the common defense, and military applications of nuclear energy as follows:

(1) For Weapons Activities, $1,232,694,000;

(2) For Defense Intelligence and Arms Controls, $28,400,000;

(3) For Special Materials Production, $501,500,000; and

(4) For Program Direction and Management Support Related to National Security Programs, $47,151,000.

PLANT AND CAPITAL EQUIPMENT

Sec. 102. Funds are hereby authorized to be appropriated to the Department for fiscal year 1979, for plant and capital equipment, including planning, construction, acquisition, or modification of facilities (including land acquisition), and for acquisition and fabrication of capital equipment not related to construction, necessary for national security programs, as follows:

(1) For weapons activities:

Project 79–7–a Tonopah Test Range upgrade, Phase II, Sandia Laboratories, Albuquerque, New Mexico, $4,000,000.

Project 79–7–b, fire protection improvements, Los Alamos Scientific Laboratory, Los Alamos, New Mexico (A–E and long lead procurement only), $2,000,000.

Project 79–7–c, proton storage ring, Los Alamos Scientific Laboratory, Los Alamos, New Mexico, $16,700,000.

Project 79–7–d, water cooling station upgrade, Lawrence Livermore Laboratory, Livermore, California, $2,300,000.

Project 79–7–e, production and assembly facilities, Pantex Plant, Amarillo, Texas, $10,000,000.

Project 79–7–f, stockpile quality evaluation facility, Y–12 Plant, Oak Ridge, Tennessee, $2,300,000.

Project 79–7–g, facilities for B43 modernization, various locations, $18,000,000.

(2) For special materials production:

Project 79–7–h, utilities replacement and expansion, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory, Idaho Falls, Idaho, $10,500,000.

Project 79–7–i, transmission and distribution systems upgrading, Richland, Washington, $14,000,000.

Project 79–7–j, pollutant discharge elimination, Savannah River, South Carolina, $9,000,000.

(3) For defense waste management:

Project 79–7–k, waste management facilities, Savannah River, South Carolina, $75,000,000.

(4) For project 79–6, general plant projects—

(A) for weapons activities, $21,400,000;
(B) for special materials production, $10,250,000; and
(C) for waste management, $5,950,000.

(5) For project 79–8, plant engineering and design—

(A) for special materials production, $12,000,000;
(B) for defense waste management, $1,500,000; and
(C) for military application, $10,000,000.

(6) For capital equipment not related to construction—

(A) for weapons activities, $86,400,000;
(B) for special materials production, $32,000,000;
(C) for waste management, $8,000,000; and
(D) for program direction and management support, $300,000.

ADDITIONAL AUTHORIZATIONS FOR PREVIOUSLY AUTHORIZED PROJECTS

Sec. 103. Funds are hereby authorized to be appropriated to the Department for fiscal year 1979, for national security projects previously authorized by law, as follows:

(1) For project 74–1–b, replacement ventilation air filter, F Chemical Separations Area, Savannah River, South Carolina, $2,100,000; for a total authorization of $7,300,000.

(2) For project 75–7–c, intermediate-level waste management facilities, Oak Ridge National Laboratory, Oak Ridge, Tennessee, $1,000,000; for a total authorization of $11,500,000.

(3) For project 77–13–a, fluorinel dissolution process and fuel receiving improvements, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory, Idaho Falls, Idaho, $100,400,000; for a total authorization of $115,400,000.

(4) For project 77–13–f, waste isolation pilot plant, Delaware Basin, southeast New Mexico, $40,000,000; for a total authorization of $68,000,000.

(5) For project 78–16–d, weapons safeguards, various locations, $11,000,000; for a total authorization of $28,000,000.

(6) For project 78–16–g, radioactive liquid waste improvement, Los Alamos Scientific Laboratory, Los Alamos, New Mexico, $11,900,000; for a total authorization of $12,500,000.

(7) For project 78–16–i, laboratory support complex, Los Alamos Scientific Laboratory, Los Alamos, New Mexico, $14,000,000; for a total authorization of $16,000,000.

(8) For project 78–17–a, production component warehouse, Pantex Plant, Amarillo, Texas, $2,550,000; for a total authorization of $2,800,000.

(9) For project 78–17–c, core facilities office building, utilities and roads, Lawrence Livermore Laboratory, Livermore, California, $11,000,000; for a total authorization of $12,300,000.

(10) For project 78–17–d, steam plant improvements, Y–12 Plant, Oak Ridge, Tennessee, $7,000,000; for a total authorization of $10,000,000.

(11) For project 78–18–a, high level waste storage and waste management facilities, Richland, Washington, $9,000,000; for a total authorization of $27,000,000.

(12) For project 78–18–e, environmental, safety and security improvements to waste management and materials processing facilities, Richland, Washington, $24,500,000; for a total authorization of $40,000,000.

TITLE II—DEFENSE PROGRAMS WITH POTENTIAL CIVILIAN APPLICATION

OPERATING EXPENSES

Sec. 201. Funds are hereby authorized to be appropriated to the Department of Energy (hereinafter in this Act referred to as the "Department") for fiscal year 1979 for operating expenses incurred in carrying out national security programs including scientific research and development in support of the armed services, strategic and critical materials necessary for the common defense, and military applications of nuclear energy, as follows:

(1) For Inertial Confinement Fusion, $91,800,000.

(2) For Naval Reactor Development, $265,600,000.

(3) For Nuclear Materials Security and Safeguards, $40,089,000.

PLANT AND CAPITAL EQUIPMENT

Sec. 202. Funds are hereby authorized to be appropriated to the Department for fiscal year 1979 for plant and capital equipment, including planning, construction, acquisition, or modification of facilities (including land acquisition), and for acquisition and fabrication of capital equipment not related to construction, necessary for national security programs, as follows:

(1) For project 79–6, general plant projects, for naval reactor development, $3,000,000.

(2) For capital equipment not related to construction—

(A) for laser fusion, $8,200,000;

(B) for naval reactor development, $22,000,000;

(C) for nuclear materials security and safeguards, $3,000,000.

ADDITIONAL AUTHORIZATIONS FOR PREVIOUSLY AUTHORIZED PROJECTS

Sec. 203. Funds are hereby authorized to be appropriated to the Department for fiscal year 1979 for projects previously authorized by law, as follows:

(1) For project 77–13–g, safeguards and security upgrading, production facilities, multiple sites, $3,800,000; for a total authorization of $20,200,000.

(2) For project 78–4–a, high energy laser facility (NOVA), Lawrence Livermore Laboratory, Livermore, California, $187,000,000; for a total authorization of $195,000,000.

TITLE III—GENERAL PROVISIONS

REPROGRAMING

Sec. 301. Except as otherwise provided in this Act—

(1) no amount appropriated pursuant to this Act may be used for any program in excess of (A) 120 per centum of the amount authorized for that program by this Act, or (B) $5,000,000 more than the amount authorized for that program by this Act, whichever is the lesser, and

(2) no amount appropriated pursuant to this Act may be used for any program which has not been presented to, or requested of, the Congress, unless a period of thirty calendar days (not including any day in which either House of Congress is not in session because of adjournment of more than three calendar days to a day certain) has passed after receipt by the appropriate committees of the House of Representatives and the Senate of notice given by the Secretary of Energy containing a full and complete statement of the action proposed to be taken and the facts and circumstances relied upon in support of such proposed action, or unless each such committee, before the expiration of such period, has transmitted to the Secretary written notice waiving the remainder of such thirty-day notice period.

PROJECT COST VARIATION PROVISIONS

SEC. 302. The Department is authorized to start construction of any construction project for which funds are authorized to be appropriated by this Act only if the currently estimated cost of that project does not exceed by more than 25 per centum the estimated cost set forth for the project. Further, the total cost of any project undertaken shall not exceed the estimated cost set forth for that project by more than 25 per centum unless and until additional appropriations are authorized. This section shall not apply to any project with an estimated cost of less than $5,000,000.

LIMITS ON GENERAL PLANT PROJECTS

SEC. 303. The Secretary of Energy is authorized to start a project set forth under section 102(4) of this Act only if—

(1) the then maximum currently estimated cost of the project does not exceed $750,000 and the then maximum currently estimated cost of any building included in the project does not exceed $300,000 (except that the building cost limitation may be exceeded if the Secretary determines that it is necessary to do so in the interest of efficiency and economy); and

(2) the then maximum currently estimated total cost of all projects undertaken under such section does not exceed the total amount authorized by such section for such projects by more than 25 per centum.

AVAILABILITY OF FUNDS

SEC. 304. Subject to the provisions of appropriations Acts, amounts appropriated pursuant to sections 101 and 102 of this Act for policy and management activities, for general plant projects, and for plant engineering and design are available for use, when necessary, in connection with all national security programs of the Department.

AUTHORIZATION TO PERFORM CONSTRUCTION DESIGN SERVICES

SEC. 305. In addition to construction design services performed with funds authorized under section 102(5) for plant engineering and design, the Secretary of Energy is authorized to perform construction design services for any national security construction project of the Department (in amounts not in excess of the amounts specified in such section) whenever (1) such construction project has been included in a proposed authorization bill transmitted to the Congress by the Secretary of Energy, and (2) the Secretary determines that the project is of such urgency in order to meet the needs of national defense or protection of life and property or health and safety that construction of the project should be initiated promptly upon enactment of legislation appropriating funds for its construction.

ADJUSTMENTS FOR PAY INCREASES

SEC. 306. Appropriations authorized by this Act for salary, pay, retirement, or other benefits for Federal employees may be increased by such amounts as may be necessary for increases in such benefits authorized by law.

NATIONAL SECURITY PROGRAMS

Senator JACKSON. The bulk of the request covers the overall nuclear weapons program, naval propulsion, production and control of special nuclear materials and the confinement fusion programs.

We recognize that this is a substantial amount of money and reflects about a 12-percent increase over last year's authority, but we must remember the importance of these defense activities. These activities:

Underwrite, with advanced weapon and propulsion technology, our strategic deterrent forces and our theater forces;

Maintain the safety, security and reliability of the components and weapons making up these forces; and

Contribute to an intelligence and technology base for verification in support of arms control proposals.

We will hear this morning from a number of witnesses from the Department of Energy: Dr. Kerr, Acting Assistant Secretary of Energy for Defense Programs; Dr. Cunningham, Director, Office of Nuclear Energy Programs; and Admiral Rickover, Director, Naval Nuclear Propulsion Program.

Dr. Kerr will cover the nuclear weapons program, the intelligence and verification technology program, the nuclear materials security and safeguards program, and the inertial confinement fusion program. Dr. Cunningham will cover the operations relating to production of special nuclear material and the various waste disposal programs involved with the materials cycle. Admiral Rickover will cover the naval nuclear propulsion program in support of surface ships and submarines. He will appear about 11 o'clock.

While recognizing the importance of these programs, we must also be aware of the possible impact of arms control proposals which have been made with respect to terminating or further restricting nuclear testing. Other items which may affect this or later funding requirements include the President's decision on the so-called "neutron bomb," the curtailment of the modern B77 strategic bomb, and proposals to terminate special nuclear material production. We will ask these witnesses to discuss the possible programmatic effects of these matters after they present their formal statements.

We will proceed first with Dr. Kerr. You may wish, Dr. Kerr, to introduce the Department of Energy team who may supply testimony or be asked to respond to questions.

We are also glad to have the laboratory directors here today. We understand they do not have formal statements to make, but we want them to have an opportunity to briefly comment on the status of the laboratories—accomplishments and problems they see. We also have some questions on which we would like their views.

You may proceed, Dr. Kerr.

STATEMENT OF DR. DONALD M. KERR, ACTING ASSISTANT SECRETARY FOR DEFENSE PROGRAMS (DP); ACCOMPANIED BY DR. GEORGE W. CUNNINGHAM, ACTING PROGRAM DIRECTOR FOR NUCLEAR ENERGY (ET); DR. ROBERT D. THORN, LOS ALAMOS SCIENTIFIC LABORATORY; DR. ROGER BATZEL, LAWRENCE LIVERMORE LABORATORY; DR. MORGAN SPARKS, SANDIA LABORATORIES; MAJ. GEN. JOSEPH K. BRATTON, DIRECTOR, MILITARY APPLICATION, DP; DR. RICHARD L. SCHRIEVER, DEPUTY DIRECTOR, LASER FUSION, DP; HARVEY E. LYON, DIRECTOR, SAFEGUARDS AND SECURITY, DP; RAY E. CHAPMAN, DIRECTOR, INTERNATIONAL SECURITY AFFAIRS, DP; JOHN A. GRIFFIN, DIRECTOR, CLASSIFICATION, DP; HERMAN ROSER, MANAGER, ALBUQUERQUE OPERATIONS OFFICE; MAHLON E. GATES, MANAGER, NEVADA OPERATIONS OFFICE; AND MAJ. GEN. MILTON E. (GENE) KEY, DEPARTMENT OF DEFENSE

FISCAL YEAR 1979 BUDGET

Dr. KERR. Thank you, Mr. Chairman.

It is a pleasure to appear before you on behalf of the Department of Energy's fiscal year 1979 budget request.

I am joined by Maj. Gen. Joseph Bratton to my right, Director of Military Application for the Department of Energy, and to my left Maj. Gen. Gene Key of the Department of Defense, representing the Office of the Assistant Secretary for Atomic Energy. They are prepared to assist me in answering particularly those questions associated with the weapons program.

Today I will cover the four major programs within the Department's Atomic Energy Defense Activity mission which fall under the responsibility of the Assistant Secretary for Defense Programs. These are the nuclear weapons program, the intelligence and verification technology program, the nuclear materials security and safeguards program, and the inertial confinement fusion program. I shall also briefly describe the activities of the Office of Classification.

Dr. George Cunningham, representing the Assistant Secretary for Energy Technology, will follow me and will present a short overview of the special materials production program. After Dr. Cunningham, representatives of the weapons laboratories will speak: Dr. Robert Thorn of the Los Alamos Scientific Laboratory (LASL), Dr. Roger Batzel of the Lawrence Livermore Laboratory (LLL), and Dr. Morgan Sparks of the Sandia Laboratories (SL).

ATOMIC ENERGY DEFENSE ACTIVITIES

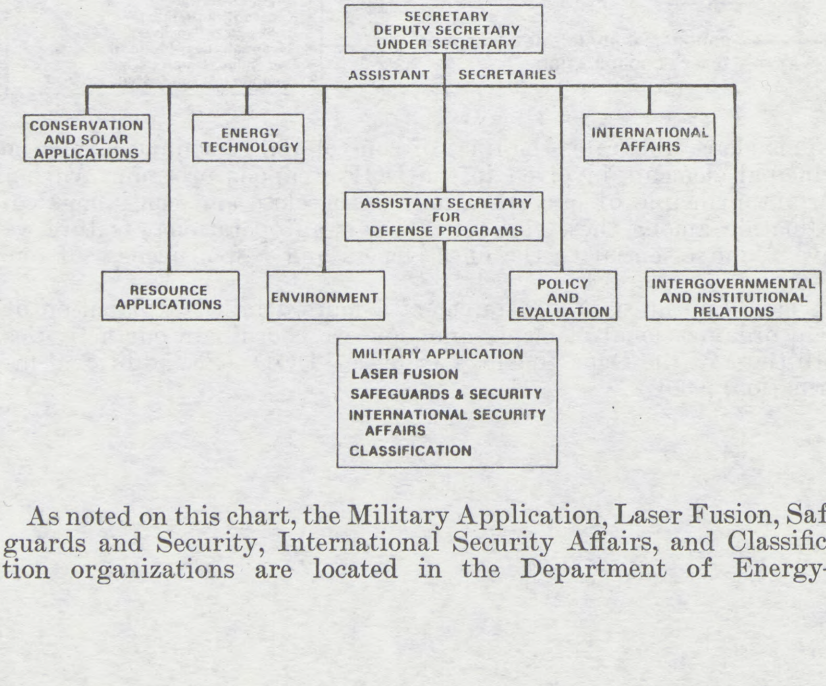
FY 1979 BUDGET REQUEST
($ MILLIONS)

	FY 1978		FY 1979	
	B/A	B/O	B/A	B/O
NUCLEAR WEAPONS ACTIVITIES	1,395	1,271	1,461	1,387
INTELLIGENCE & VERIFICATION TECHNOLOGY	25	23	28	27
NUCLEAR MATERIALS SECURITY & SAFEGUARDS	41	37	43	38
INERTIAL CONFINEMENT FUSION	130	122	126	122

Our fiscal year 1979 request of $1,658 million for the portion of the Atomic Energy Defense Activities listed in this chart represents an increase of $67 million over our fiscal year 1978 budget authority. The fiscal year 1979 request consists of: $1,461 million for the nuclear weapons activities of research and development, testing, and production; $28 million for our intelligence and verification technology activities; $43 million for security and safeguards for nuclear materials and facilities; and $126 million for inertial confinement fusion activities.

I should like to proceed through the four programs shown on the chart in the order in which they are listed.

DEPARTMENT OF ENERGY

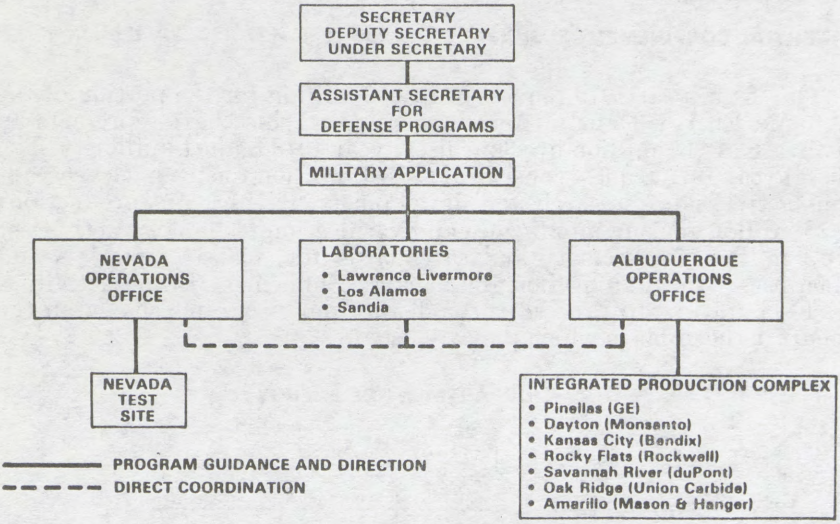


As noted on this chart, the Military Application, Laser Fusion, Safeguards and Security, International Security Affairs, and Classification organizations are located in the Department of Energy—

DOE—within the Office of the Assistant Secretary for Defense Programs, one of the eight Assistant Secretaries in the Department.

NUCLEAR WEAPONS PROGRAM

Today I will first address the responsibilities of the Director of Military Application, General Bratton, which consist of the research, development, testing, and production of nuclear weapons as well as the lifetime surveillance of the weapons stockpile. DOE continues to execute these responsibilities under authorization originally given to the Atomic Energy Commission by the Atomic Energy Act of 1946 and transferred to the DOE by the Department of Energy Organization Act of 1977.



DEPARTMENT OF ENERGY - WEAPONS ORGANIZATION

This chart illustrates the lines of control and coordination for the principal elements involved in the DOE weapons program. An important principle of our operations is the close and continuous coordination among these elements. This is an operational feature we have found essential to the effectiveness and responsiveness of our system.

I have appended to my statement a more detailed explanation of these organizational elements and how we coordinate our activities with those of the Department of Defense—DOD. (See additional information, p. 26.)

FY 1979 WEAPONS BUDGET

FUNDING REQUEST

($ Millions)

	BUDGET AUTHORITY	BUDGET OUTLAYS
OPERATING		
RESEARCH & DEVELOPMENT	$ 375	$ 370
TESTING OF ATOMIC WEAPONS	210	214
PRODUCTION & SURVEILLANCE	648	612
TOTAL OPERATING	1,233	1,196
EQUIPMENT	86	70
CONSTRUCTION	142	121
GRAND TOTAL	$1,461	$1,387

FISCAL YEAR 1979 WEAPONS BUDGET REQUEST

The fiscal year 1979 authorization request for the weapons program totals $1,461 million in new obligational authority. As in the budget before you, I show here the budget authority (B/A) and budget outlays (B/O) for the program. In subsequent sections, I will address the operating categories in terms of outlays, or costs, because we manage our subactivities on a cost performance basis.

WEAPONS-OPERATING

The proposed level for the weapons operating program includes $370 million for research and development, $214 million for testing of atomic weapons, and $612 million for the production of new weapons approved by the President and surveillance and maintenance of the stockpile of existing weapons to assure their readiness as required for our national security. I shall comment on each of these three areas.

FY 1979 WEAPONS BUDGET

RESEARCH AND DEVELOPMENT

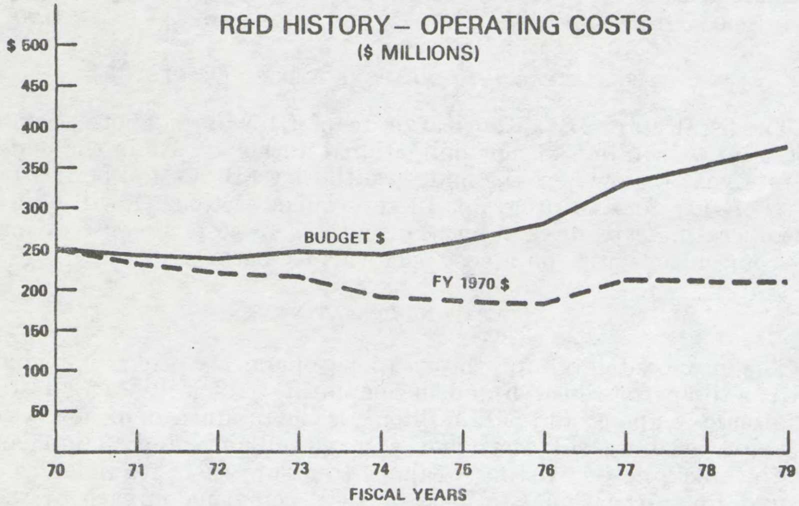
($ Millions)

	FY 1977	FY 1978	FY 1979
CURRENT WEAPONS	$150	$168	$169
ADVANCED DEVELOPMENT	60	59	74
DEVELOPMENT CAPABILITY	101	102	106
SPECIAL PROJECTS	18	22	21
TOTAL	$329	$351	$370

RESEARCH AND DEVELOPMENT

The budget request of $370 million for research and development proposes an increase of $19 million, or about 5 percent, over fiscal year 1978. This level supports 7,675 man-years of effort.

The requested level provides the resources—manpower, materials, and services—needed to support the efforts of DOE's weapons laboratories in [the] research, development, and engineering of nuclear weapons. These efforts include current weaponization of DOD-required nuclear weapons for stockpile; advanced development for future weapons applications; and maintenance of a development capability base in those scientific and engineering areas necessary to both current and future weapons development. This activity is conducted principally at the three DOE weapons laboratories.



This chart shows, both in actual year dollars and fiscal year 1970 dollars, the funding trend for our research and development activities since 1970.

FY 1979 WEAPONS BUDGET

RESEARCH AND DEVELOPMENT WORKLOAD

CURRENT WEAPONS

- B43 BOMB MODERNIZATION (ALTERNATIVE TO B77 BOMB)
- W78 MINUTEMAN III WARHEAD
- W79 8-INCH ARTILLERY PROJECTILE
- W80 CRUISE MISSILE WARHEAD
- W81 STANDARD MISSILE (SM-2) WARHEAD
- W82 155mm ARTILLERY PROJECTILE

POSSIBLE CANDIDATES

- GROUND LAUNCHED CRUISE MISSILE WARHEAD
- PERSHING II SURFACE-TO-SURFACE MISSILE WARHEAD
- M-X ICBM WARHEAD
- TRIDENT II WARHEAD

Current weapons development, or weaponization, is the focal point of the weapons research and development effort. It is guided by current national needs for providing new strategic weapons; for modernizing tactical nuclear weapons; and for monitoring and maintaining the reliability of weapons now in stockpile. Needs for 1979 are shown.

FY 1979 WEAPONS BUDGET

RESEARCH AND DEVELOPMENT

(Manyears)

	FY 1977	FY 1978	FY 1979
CURRENT WEAPONS	2,984	3,144	3,235
ADVANCED DEVELOPMENT	1,607	1,516	1,405
DEVELOPMENT CAPABILITY	2,639	2,728	2,637
SPECIAL PROJECTS	485	424	398
TOTAL	7,715	7,812	7,675

Advanced development is the essential source of new concepts needed to maintain the quality of our nuclear weapons deterrent and to meet future DOD requirements for new nuclear systems. Historically, it has provided the United States a means of attaining and maintaining our superior nuclear technology base. The current weapons activities described above derive from the advanced development activities of years past. Advanced development activities being conducted today are required to extend our nuclear capabilities so that evolving system requirements can be met effectively and efficiently. Manpower directed to this area will decrease by about seven percent from fiscal year 1978 because of the number and complexity of current weapons programs.

FY 1979 WEAPONS BUDGET

TESTING

($ Millions)

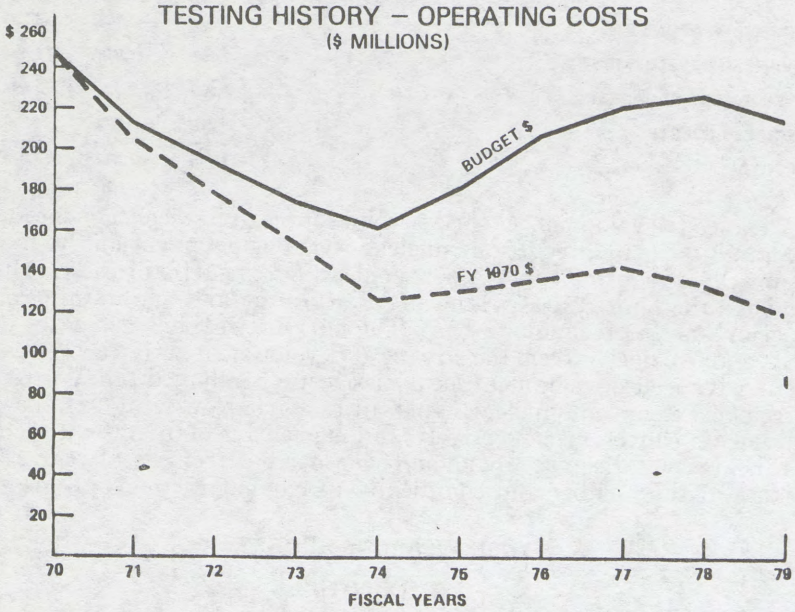
	FY 1977	FY 1978	FY 1979
TESTS	$158	$155	$152
LABORATORY PARTICIPATION - COMMON	$62	70	62
TOTAL	$220	$225	$214

TESTING

The DOE budget request for fiscal year 1979 for testing is $214 million, a decrease of $11 million, or about 5 percent, below fiscal year 1978. Our testing program, as shown on the chart, covers the funding for the Nevada Test Site operations and fabrication of test devices; the second line supports the laboratory personnel who are involved in the testing program.

The DOE nuclear weapons underground test program is structured by DOE, approved by the President, and accomplished at the Nevada Test Site under the operational management of the Nevada Operations Office. Technical direction for each individual test and testing operation is provided by the sponsoring weapons design laboratory.

Underground nuclear testing is a key element in our weapons research and development effort. Maintenance of an adequate level of testing is essential to new or improved nuclear designs. It is important to the general advancement of nuclear weapon technology, to assurance of maintaining a capable technology base, and to high confidence over the long-term in a reliable nuclear weapons stockpile.



This chart shows, in the same manner as applied earlier to research and development, the budget trend for testing of weapons during the decade of the seventies.

These tests will be in support of ongoing current and advanced development programs. The fiscal year 1979 budget for testing will provide for a program [deleted]. I should emphasize that the fiscal year 1979 budget as structured does not assume a cessation of testing prior to or during fiscal year 1979.

FY 1979 WEAPONS BUDGET

PRODUCTION AND SURVEILLANCE

($ Millions)

	FY 1977	FY 1978	FY 1979
WAR RESERVE NEW PRODUCTION	$202	$280	$343
STOCKPILE MAINTENANCE	52	57	74
STOCKPILE RELIABILITY	56	59	70
PROCESS DEVELOPMENT	37	42	47
OTHER COSTS	51	66	78
TOTAL	$398	$504	$612

PRODUCTION AND SURVEILLANCE

Our largest operating category is for production of nuclear weapons as approved by the President and lifetime surveillance and maintenance of the weapons stockpile to assure its readiness and reliability. Production of nuclear weapons is conducted at our integrated complex of seven production plants to which I referred earlier.

The request for fiscal year 1979 is $612 million. The increase of $108 million, or about 21 percent, over fiscal year 1978 is primarily to provide for production of new war reserve weapons, as indicated on the first line of the chart.

War reserve new production, which accounts for about 56 percent of the weapons production category, is for procurement, fabrication, and assembly of material, piece parts, and components needed to manufacture weapons to be delivered to the DOD for the nuclear weapons stockpile.

FY 1979 WEAPONS BUDGET

WAR RESERVE NEW PRODUCTION

($ MILLIONS)

	FY 1977	FY 1978	FY 1979	IOC
B61–2 BOMB				
B61–3 BOMB				
B61–4 BOMB				
B61–5 BOMB				
W70–2 LANCE				
W70–3 LANCE				
W76 TRIDENT				
B77 BOMB				
W78 MINUTEMAN III				
W79 8-INCH ARTILLERY				
W80 CRUISE MISSILE				
MOD 0 (SLCM)				
MOD 1 (ALCM)				
TOTAL				

This chart shows new production funding for the period fiscal year 1977 to fiscal year 1979 by specific bomb and warhead, and indicates in the right-hand column the date of initial operational capability. This chart is consistent with the data contained in the President's budget for production of enhanced radiation warheads and does not reflect the hold on production activities for those weapons in fiscal 1978 pending Presidential certification mandated by the Byrd-Baker amendment to the fiscal year 1978 Appropriation Act.

The President has decided to defer production of weapons with enhanced radiation effects. As directed by the President, we are working with Defense to proceed with the modernization of the Lance and the 8-inch artillery projectile, leaving open the option of installing the enhanced radiation elements.

[Chart deleted.]

The planned production of new bombs and warheads is summarized here for the period fiscal year 1977 through fiscal year 1982 and reflects the latest stockpile approved by the President.

[Chart deleted.]

This chart is a graphical display of production data carrying the Presidentially approved projections for weapons in engineering development or later phases through fiscal year 1985 and differentiating between full production authority through fiscal 1980, long lead procurement only for fiscal 1981 and 1982, and planning authority only for fiscal 1983 through 1985. The tactical systems are in red and the strategic systems are in the blue part [deleted].

You will note, in particular, [deleted].

With respect to the stockpile, [deleted].

FY 1979 WEAPONS BUDGET

EQUIPMENT

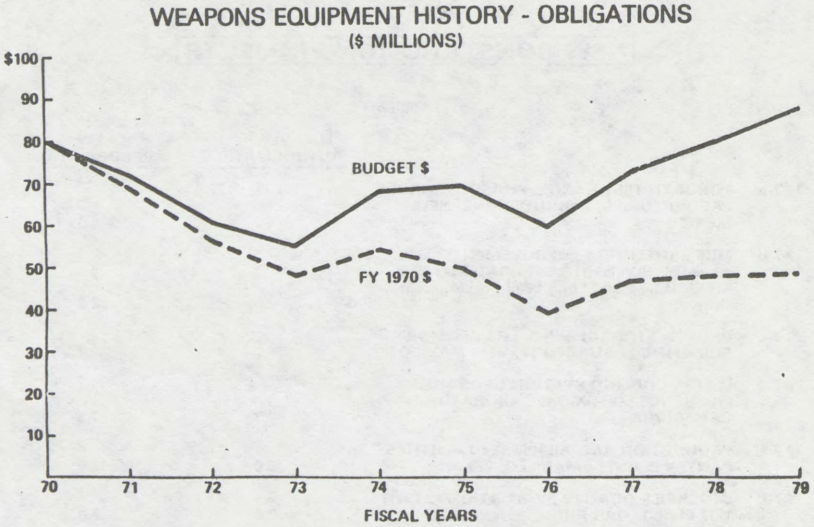
(B/A $ Millions)

	FY 1977	FY 1978	FY 1979
RESEARCH AND DEVELOPMENT	$26	$35	$36
TESTING	13	17	18
PRODUCTION AND SURVEILLANCE	25	18	24
OTHER CAPITAL EQUIPMENT	6	9	8
TOTAL	$70	$79	$86
COMPUTERS (Included Above) 1/	$ 8	$ 9	$ 6

1/ EXCLUDES LEASED COMPUTERS

WEAPONS-CAPITAL EQUIPMENT

The fiscal year 1979 budget authority requested for capital equipment not related to construction totals $86 million, an increase of $7 million, or about 9 percent, over fiscal year 1978. Included are $80 million for basic equipment and $6 million for major computer acquisitions. The trend lines for purchase of capital equipment are shown here in the same format used for the operating accounts.



This year's request is one of our highest priorities. For future years, it will be essential to establish a plan to assure that the equipment status of our facilities is at the level of efficiency and effectiveness normally regarded as necessary to a modern plant and laboratory complex. We intend to continue to assign a high priority to this effort.

FY 1979 WEAPONS BUDGET

CONSTRUCTION

($ Millions)

	NEW AUTHORIZATION	NEW OBLIGATIONAL AUTHORITY
NEW PROJECTS (7)	$ 55.3	$ 55.3
CONTINUING PROJECTS (7)	57.4	54.8
GENERAL PLANT PROJECTS	21.4	21.4
PLANT ENGINEERING AND DESIGN	10.0	10.0
TOTAL	$144.1	$141.5

WEAPONS-CONSTRUCTION

Our last budget category is for construction. The amount requested for fiscal year 1979 for authorization is $144.1 million, while associated appropriations total $141.5 million. This is down from our fiscal year 1978 levels of $194.8 million and $177 million, respectively. The requested authorization includes $55.3 million for seven new construction projects.

FY 1979 WEAPONS BUDGET

NEW CONSTRUCTION PROJECTS

($ Millions)

		NEW AUTHORIZATION	NEW APPROPRIATION
79-7-a	TONOPAH TEST RANGE, PHASE II, SANDIA LABORATORIES, ALBUQUERQUE, NEW MEXICO	$ 4.0	$ 4.0
79-7-b	FIRE PROTECTION IMPROVEMENTS, LOS ALAMOS SCIENTIFIC LABORATORY, NEW MEXICO (A-E and Long Lead Procurement Only)	2.0	2.0
79-7-c	PROTON STORAGE RING, LOS ALAMOS SCIENTIFIC LABORATORY, NEW MEXICO	16.7	16.7
79-7-d	WATER COOLING STATION UPGRADE, LAWRENCE LIVERMORE LABORATORY, CALIFORNIA	2.3	2.3
79-7-e	PRODUCTION AND ASSEMBLY FACILITIES, PANTEX PLANT, AMARILLO, TEXAS	10.0	10.0
79-7-f	STOCKPILE QUALITY EVALUATION FACILITY, Y-12 PLANT, OAK RIDGE, TENNESSEE	2.3	2.3
79-7-g	FACILITIES FOR B43 MODERNIZATION, VARIOUS LOCATIONS	18.0	18.0
	TOTAL	$55.3	$55.3

In response to the fiscal year 1978 authorization action to include an fiscal year 1979 line item for capital planning and design, we have requested $10 million in our fiscal year 1979 budget for use in preparing definitive designs for fiscal year 1981 projects. In our fiscal year 1981 budget request, we plan to have cost estimates for most projects based upon more definitive engineering design.

Before leaving this area, some comments pertaining to the overall condition of our physical plants—the laboratories as well as the production facilities—might be useful. In general, the plants and utilities of our complex are aging and are in need of selective refurbishment, restoration, and modernization. The problem exists in varying degrees at our several installations. We are surveying our entire system to identify a phased program of orderly restoration and improvements geared to our estimates for future requirements and workload.

INTELLIGENCE AND VERIFICATION

I will next discuss DOE's intelligence and verification technology program. This program has a separate budget this year, but this does not imply new areas of activity. Funds for this work were formerly included in the weapons research and development budget. However, due to the importance of these efforts to national intelligence and verification capabilities, we believe that separate identification is appropriate.

INTELLIGENCE AND VERIFICATION TECHNOLOGY

FY 1979 BUDGET REQUEST
($ MILLIONS)

	FY 1978		FY 1979	
	B/A	B/O	B/A	B/O
OPERATING EXPENSE				
INTELLIGENCE	DELETED		DELETED	
VERIFICATION TECHNOLOGY	DELETED		DELETED	
TOTAL OPERATING	24.7	23.3	28.4	27.4

The total request for this program of $28.4 million is divided into two broad categories: Nuclear test verification [deleted] and intelligence [deleted].

VERIFICATION TECHNOLOGY

These expenditures are for verification and monitoring activities in connection with the Threshold Test Ban Treaty, the Peaceful Nuclear Explosives Treaty and the Comprehensive Test Ban Treaty—CTBT—under negotiation. A significant portion is design of an in-country monitoring capability that may become part of a negotiated test ban.

This funding also supports seismic research efforts emphasizing explosive yield measurement and includes maintenance of a regional seismic network at the Nevada Test Site and research activities to maintain and enhance U.S. underground detection capabilities. This is particularly important to CTBT objectives.

Work is also done on reviewing nuclear technology transfers and maintaining appropriate export controls.

INTELLIGENCE

Provided for with this funding are the continued development, procurement, packaging, testing, and the analysis of spaceborne radiation detector subsystems used for monitoring of the Limited Test Ban Treaty.

DOE has special responsibilities regarding the effects of technology export on foreign nuclear weapons prospects and/or capabilities as they relate to U.S. nonproliferation policies which are provided for by this request. Important contributions are made to the analysis and interpretation of intelligence information bearing on proliferation as well as other areas in which DOE has particular expertise. Examples are foreign energy assessments and nuclear weapons and production system analysis, particularly relative to a possible test ban.

A review of our technology exports from a nonproliferation standpoint and some environmental sample analysis work are also accomplished with these funds.

NUCLEAR MATERIALS SECURITY AND SAFEGUARDS

Next, I will discuss the objectives and planned accomplishments of the DOE's nuclear materials security and safeguards program.

The objectives of this program are to:

Develop safeguard concepts and the basic safeguards technology;

Evaluate prototype equipment and modules;

Assess safeguards effectiveness at Government facilities;

Transfer to Government and industry information on effective equipment and technology available to be utilized in implementing safeguards and security systems;

Finally, assist the International Atomic Energy Agency (IAEA) in solving international safeguards equipment and measurement problems, including the training of their inspectors.

EXPECTED MAJOR ACCOMPLISHMENTS PLANNED FOR FY 1979
SECURITY AND SAFEGUARDS

- GENERALLY COMPLETE SAFEGUARDS SYSTEMS UPGRADING AT DOE FACILITIES
- DEVELOP, TEST, AND EVALUATE EQUIPMENT FOR:
    - ENRICHMENT PLANTS
    - SPENT FUEL STORAGE
- CONDUCT PHYSICAL PROTECTION TRAINING FOR OTHER NATIONS
- COMPLETE OPERATIONAL EVALUATION REAL-TIME MATERIAL ACCOUNTABILITY

The major accomplishments planned for fiscal year 1979 are shown on this chart.

Safeguards and security systems for special nuclear materials are in place at DOE facilities using combinations of physical protection, access controls, surveillance, containment, and accountability elements.

NONPROLIFERATION OBJECTIVES

The safeguards and security program also provides for inputs into the U.S. nuclear weapons nonproliferation initiatives, including development of effective safeguards concepts, and necessary technology and equipment for proliferation resistant nuclear fuel cycles. These safeguards efforts are closely coordinated and support the nuclear energy technology studies within DOE and the U.S. nonproliferation policies as developed within Congress and the administration.

IAEA ASSISTANCE

Our effort to transfer safeguards technology to the IAEA is closely coordinated with the Department of State, the Arms Control and Disarmament Agency (ACDA), and the Nuclear Regulatory Commission (NRC). Our objective is to aid the IAEA by transferring DOE-developed safeguards technology to IAEA to aid in increasing its safeguard effectiveness.

DOE–WIDE SAFEGUARDS FUNDING ESTIMATES FOR FY 1979
($ MILLIONS)

	FY 1978		FY 1979	
	B/A	B/O	B/A	B/O
OPERATING	$134	$128	$147	$140
EQUIPMENT	13	16	18	16
CONSTRUCTION	51	38	20	31
TOTAL	$198	$182	$185	$187

DOE-WIDE SAFEGUARDS

This chart shows the funding for safeguards efforts by all Department of Energy programs. On a DOE-wide basis, the President's fiscal year 1979 budget requests $185 million for operating, maintaining, and largely completing the implementation of such improved safeguards at DOE facilities. This is slightly down from fiscal year 1978 as the effort to improve safeguards at facilities having significant quantities of special nuclear material against terrorist attacks nears completion.

INERTIAL CONFINEMENT FUSION

The next program I shall talk about is the inertial confinement fusion program.

INERTIAL CONFINEMENT FUSION BUDGET REQUEST
($ in Thousands)

	FY 1978		FY 1979	
	B/A	**B/O**	**B/A**	**B/O**
Operating Expenses	$104,000	$ 96,300	$ 91,800	$ 92,800
Capital Acquisition				
Equipment	13,200	10,400	8,200	9,600
Construction				
NOVA	3,000	2,500	20,000	7,500
ANTARES	5,000	7,500	6,000	8,100
EBFA	4,400	4,700	0	4,000
Prior Projects	0	793	0	0
Subtotal	12,400	15,493	26,000	19,600
Subtotal Capital Acquisition	25,600	25,893	34,200	29,200
Total Program	$129,600	$122,193	$126,000	$122,000

FISCAL YEAR 1979 BUDGET REQUEST

Our budget request for fiscal year 1979 totals $126 million. The operating funds of $91.8 million would support the efforts of the DOE laboratories and some 75 contractors. We are requesting $34.2 million in capital acquisition funding. This includes $8.2 million for equipment and construction funding of $6 million to continue the construction of the High Energy Laser Facility at the Los Alamos Scientific Laboratory which will house the Antares laser, and $20 million to begin the Nova upgrade of the Shiva laser at the Lawrence Livermore Laboratory. Recent research results lead us to believe that we may need to make an adjustment between construction and operating funds during 1979.

The inertial confinement fusion program is conducted primarily at our three weapons laboratories—LASL, LLL, and Sandia. Each laboratory is conducting research into the use of different promising drivers to accomplish inertial confinement fusion. Other major participants in the program include the University of Rochester and KMS Fusion, Inc.

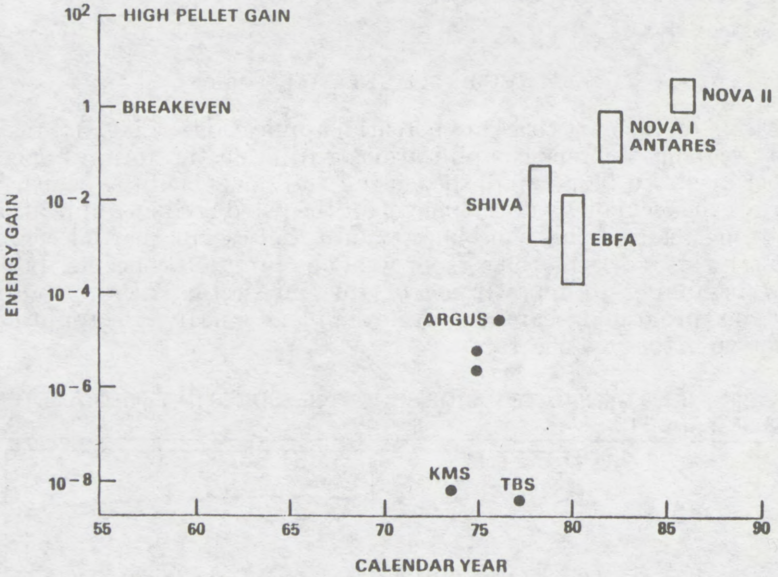
INERTIAL CONFINEMENT FUSION PROGRAM GOAL

TO DEVELOP THE TECHNOLOGY OF INERTIAL CONFINEMENT FUSION FOR THE

- **NEAR TERM APPLICATIONS TO NUCLEAR WEAPONS DEVELOPMENT AND TESTING AND**
- **LONGER TERM APPLICATIONS AS AN INEXHAUSTIBLE ENERGY SOURCE**

As you may recall, in the ICF program we are seeking to demonstrate the feasibility of large releases of energy from very small amounts of deuterium fuel and apply this technology in the near term to weapons technology applications, and in the longer term as a potentially inexhaustible source of energy.

ACCOMPLISHED & EXPECTED FUTURE GAIN FROM VARIOUS DRIVERS



By irradiating small pellets filled with deuterium and tritium, the heavy isotopes of hydrogen, we have produced fusion energy on the order of one ten-thousandth of input laser beam energy. In the current year with Shiva we may raise the raw energy gain to one-thousandth of breakeven. Breakeven is the point at which we produce fusion energy equal to the energy in the incident laser beam. In fiscal year 1979, we hope to reach at least 1 percent of breakeven, and in the early 1980's, breakeven. We believe that the course we are now pursuing utilizing the Nova laser could bring us, by the mid-1980's, to the point at which we can produce substantially more energy than we use to irradiate a single target, thereby demonstrating the scientific feasibility of inertial confinement fusion.

APPLICATIONS TO

WEAPONS

- NUCLEAR WEAPON PHYSICS
  - — MEASUREMENTS OF EQUATIONS OF STATE
  - — MEASUREMENTS OF OPACITY
  - — SHOCK WAVES/IMPLOSION PHYSICS
  - — CONTRIBUTIONS TO WEAPON CODE DEVELOPMENT
  - — CONDITIONS OF THERMONUCLEAR BURN
- WEAPON EFFECTS

ENERGY

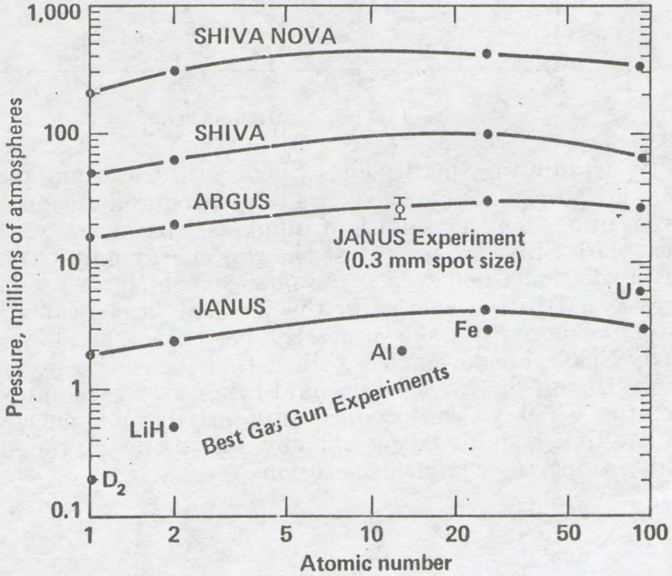
- ELECTRICAL POWER
- PRODUCTION OF FISSILE MATERIAL
- PRODUCTION OF HYDROGEN
- PROCESS HEAT

APPLICATION OF INERTIAL FUSION

Listed on the next chart are potential applications of inertial fusion. The weapons technology applications will be in the form of specific experiments to be accomplished using the same facilities which are part of the technology development for the listed civilian applications.

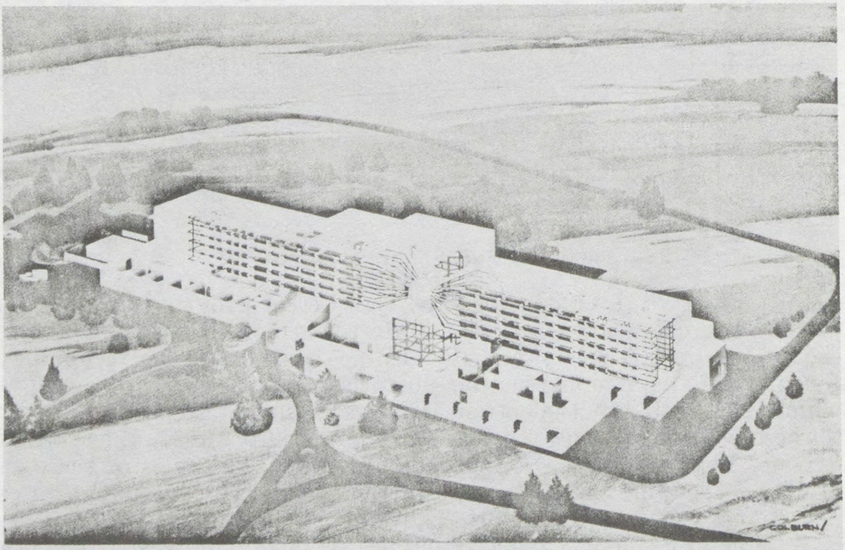
As members of this subcommittee are well aware, inertial confinement fusion's origins come from weapons program concepts. ICF is now beginning to repay some of this intellectual debt by aiding weapons program researchers. An example of a near-term application is shown in the next chart.

LASERS CAN GENERATE LARGE SHOCK PRESSURES IN 1 mm DIAMETER DISK TARGETS



Using high power lasers, we can determine properties of materials used in weapons at various pressures. Other techniques for making such measurements are limited to about 2 megabars whereas lasers should enable us to achieve pressures of up to 200 megabars.

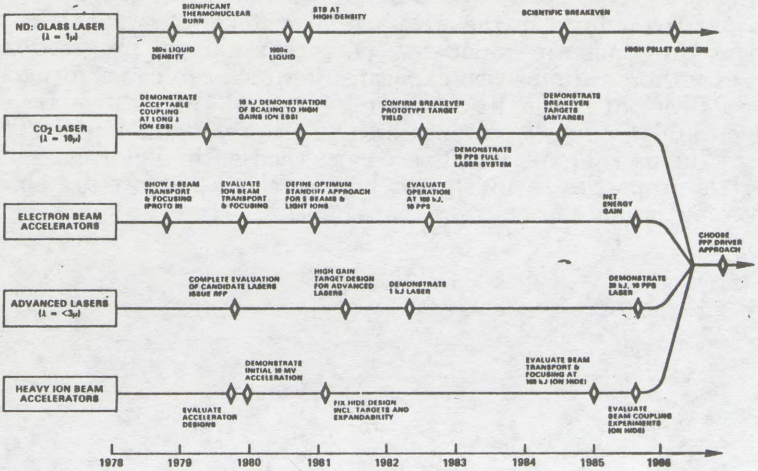
Cooperative efforts in the weapons laboratories between ICF and weapons programs are underway. There is a natural progression of types of military application experiments which can be performed on ICF facilities of gradually increasing sizes. At present, we are still limited to relatively low power lasers and electron beam drivers. Thus, most of the useful experiments are concerned with exploring critical materials properties as illustrated by this chart, and we are able to study some limited aspects of weapons physics.



SHIVA NOVA LABORATORY FACILITY

Our ability to investigate the conditions of thermonuclear burn will be significantly increased when we bring into operation the Nova I and Antares lasers. An artist's conception of the Nova facility is shown here. Finally, we will be able to do studies of nuclear weapons effects and radiation vulnerability only with very high power drivers and high gain pellet burns. Although we foresee these applications, I should emphasize that ICF can never be a total substitute for underground nuclear testing.

NEAR-TERM PROGRAM MILESTONES



PROGRAM ROLES AND MILESTONES

In summary, this chart illustrates the current program and the two major program goals—to demonstrate scientific feasibility, which is the top line on this chart, and to determine the most suitable technology for driving the fusion reaction potentially at high repetition rates which is indicated by the bottom four lines. The milestones on the way to these goals, as we now see them, are shown according to the types of drivers. The chart can also be used to illustrate the roles of the program participants: LLL is leading the glass laser technology; Los Alamos the CO_2 gas laser effort. The electron and light ion beam effort is centered at Sandia. Advanced and heavy ion efforts are located both in DOE laboratories and in several university and industrial laboratories.

FY 1979 PLANS

- SIGNIFICANT THERMONUCLEAR BURN EXPERIMENTS WITH SHIVA
- BEGIN NOVA AND NOVA PELLET DESIGNS
- CONTINUE CONSTRUCTION OF OMEGA X; BEGIN USER PHASE AT ROCHESTER
- CONTINUE CONSTRUCTION OF ANTARES
- DETERMINE RELATIVE EFFECTIVENESS OF 10μm RADIATION WITH EBS
- BEGIN CONSTRUCTION OF 1000 JOULE, VISIBLE WAVELENGTH LASER
- COMPLETE EVALUATION OF ION AND ELECTRON FOCUSING AND TRANSPORT ON PROTO II; COMPLETE EBFA
- DEVELOP ONE DESIGN FOR HEAVY ION DEMONSTRATION EXPERIMENT (HIDE)
- PERFORM WEAPON-RELATED PHYSICS STUDIES (ALL LABS)
- DEVELOP DATA BASE FOR USE IN ESTIMATING CAPITAL AND ELECTRICITY COSTS

FISCAL YEAR 1979 PLANS

This chart depicts our overall planned fiscal year 1979 activities. In essence, if we succeed, we should have an important advance in our understanding of several key issues; namely, the effectiveness of CO_2 laser radiation relative to glass laser radiation and our ability to achieve significant thermonuclear burn.

OFFICE OF CLASSIFICATION

LEGAL BASIS

— **Atomic Energy Act and E.O. 11652**

RESPONSIBILITIES

— **DOE classification and declassification program**

— **Prepares classification guides**

— **Point of contact for classification matters**

— **Represent DOE on Interagency Classification Review Committee**

— **Classification Guide for Nuclear Proliferation**

CLASSIFICATION PROGRAM

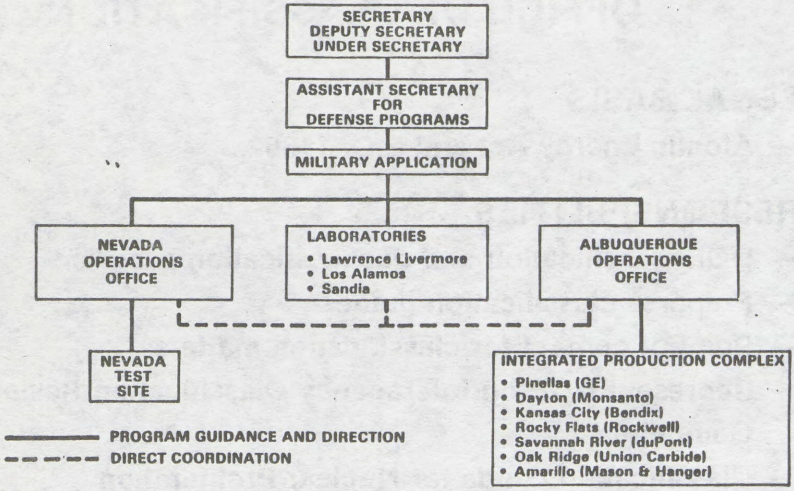
Lastly, I will briefly summarize our classification program. The Department of Energy has a special responsibility for the classification and declassification of restricted data and formerly restricted data information under the provisions of the Atomic Energy Act. The Office of Classification carries out this responsibility for the Department not only for restricted data but also for other classified information covered by Executive Order 11652. In carrying out this responsibility, the Office develops and recommends the policies, standards, and procedures for the Department's classification and declassification program and prepares guides that are used not only within the Department but also by other Government agencies dealing with restricted data information. The Office serves as the point of contact within the Department for classification matters involving other Government agencies and other governments and represents the Department on the Interagency Classification Review Committee.

As you know, there is a great emphasis at the present time on the matter of nuclear proliferation. The Office of Classification has recently developed a guide that will provide classification guidance for information relating to proliferation. This guide has been coordinated with other concerned Government agencies and will provide guidance for programs and studies related to the proliferation of special nuclear material and weapons. It will be especially useful in classification determinations for nonproliferation alternative systems assessment program (NASAP) and international nuclear fuel cycle evaluation (INFCE) studies that are presently underway within the executive branch.

Mr. Chairman, that concludes my overview statement and I shall be pleased to answer any questions you may have at this time.

[The appended data referenced on page 8 follows:]

DEPARTMENT OF ENERGY - WEAPONS ORGANIZATION



WEAPONS ORGANIZATION/OPERATION

Weapons research and development is conducted primarily at DOE's three government-owned, contractor-operated nuclear weapon design laboratories: the Lawrence Livermore Laboratory (LLL), which is located in Livermore, California, about 40 miles east of San Francisco; the Los Alamos Scientific Laboratory (LASL). Los Alamos, New Mexico and the Sandia Laboratories (SL) with facilities in Albuquerque, New Mexico (SLA), and in Livermore, California (SLL).

These laboratories employ over 20,000 people, with about one-half of them being funded by the weapons program. The other half is engaged in nuclear and nonnuclear energy research and development, biomedical research and development, and related work for other agencies. The primary task of the laboratories is to pursue supporting research and exploratory development of new or improved nuclear weapon concepts, to develop and test selected weapons designs in response to national security objectives, to monitor production of nuclear weapons, and to assure stockpile quality and reliability. However, all are broad-based, multiprogram laboratories. At LLL and LASL the physical sciences are dominant, while at SL the emphasis is on engineering.

LLL and LASL are the nuclear design laboratories. LASL was established under the Manhattan Project during World War II. It is responsible for the nuclear-device aspects of weapons research and development. LLL was established in 1952, has similar responsibilities, and, like LASL, is operated under contract with the University of California.

Sandia Laboratories were established in 1949 and are responsible for the nonnuclear aspects of weapons. The operating contract is with the Western Electric Company.

The Nevada Test Site, involving over 5,000 contractor personnel—about two-thirds of whom are associated with weapons efforts—is an extension of the three weapons laboratories and is currently this country's only active test area for underground nuclear experiments. Of the remaining one-third, a large number are involved in other national security-related missions under reimbursable work arrangements such as the DOD test activities. The remaining personnel perform energy-related work such as basic geological experiments and exploratory efforts for long-term radioactive waste storage. The Nevada Test Site is managed by the DOE Nevada Operations Office.

Weapons production is conducted at seven government-owned, contractor-operated plants. These specialized installations, for which the Albuquerque Operations Office is responsible, employ approximately 20,000 people, about 16,000 of whom are involved in weapons-related activities. These "integrated contractors" are:

Bendix Corporation, which operates the Kansas City Plant, Kansas City, Missouri; this is our largest plant, and it is engaged in work on electrical, mechanical, and plastic components.

E. I. du Pont de Nemours and Company, Savannah River Plant, South Carolina; this facility performs loading, unloading, and reclamation of tritium.

General Electric Corporation, Pinellas Plant, Clearwater, Florida; this plant produces neutron generators and other small components.

Monsanto Research Corporation, Mound Facility, Dayton, Ohio; we produce detonators and other small components here.

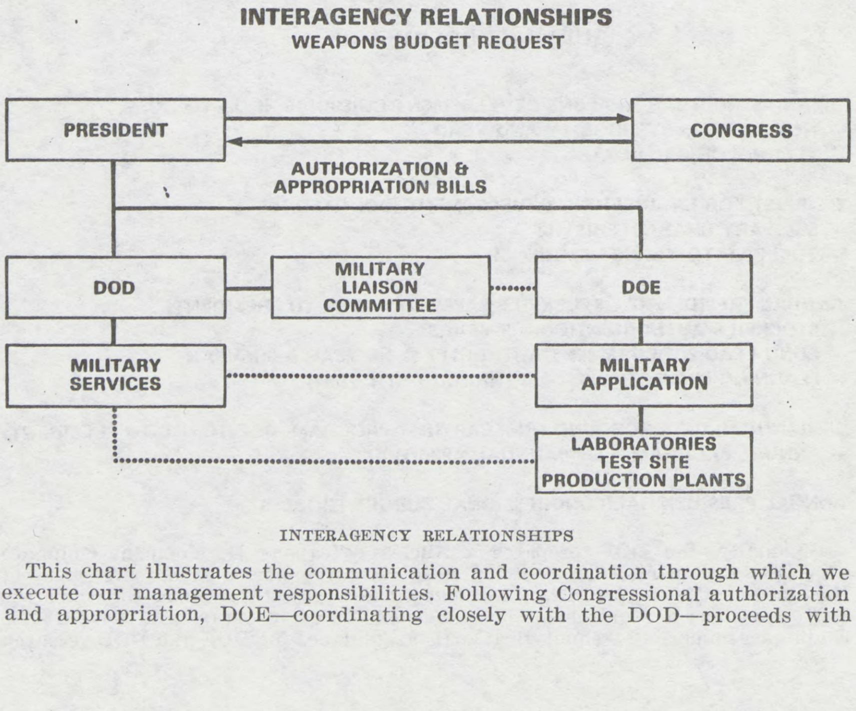
Rockwell International, Rocky Flats Plant, Golden, Colorado; here we have the facilities for plutonium recovery and fabrication.

Union Carbide Corporation, Y–12 Plant, Oak Ridge, Tennessee; where our uranium fabrication and other work is carried out.

Mason and Hanger-Silas Mason, Pantex Plant, Amarillo, Texas; this is our final assembly plant for all weapons.

The production plants have a wide range of manufacturing skills and special capabilities needed to manufacture nuclear weapons, including the ability to produce components from uranium, plutonium, and rare elements and their compounds. The attained levels of precision, quality, reliability, and process control are, for the most part, not found in private industry.

Design groups from the laboratories work closely with the production plants on technologies that may be required for future weapon applications. This interaction begins essentially when the design team is formed and continues throughout the weapon development and production cycle.



INTERAGENCY RELATIONSHIPS

This chart illustrates the communication and coordination through which we execute our management responsibilities. Following Congressional authorization and appropriation, DOE—coordinating closely with the DOD—proceeds with the implementation of its weapons program. The dotted lines indicate the continuous coordination between DOE and the DOD. A major forum for this communication is the Military Liaison Committee (MLC). By use of the MLC forum, we are responsive to the needs and requirements of the Military Services and the Joint Chiefs of Staff. Through such working level agencies as Joint Project Officers Groups dedicated to specific programs, the Military Application staff as well as the staffs of the DOE weapons laboratories and production complex interface at the individual program level with the various military development agencies.

MILITARY APPLICATION RESPONSIBILITIES

- ALLOCATION OF NUCLEAR WEAPONS PROGRAM RESOURCES
- DIRECTION OF WEAPONS RESEARCH, DEVELOPMENT, TESTING, AND PRODUCTION
- STOCKPILE MAINTENANCE AND SURVEILLANCE
- WEAPON SAFETY AND SECURITY
- ADMINISTRATION OF COOPERATION WITH UNITED KINGDOM
- RECOMMENDATION (With DOD) OF STOCKPILE COMPOSITION

This chart briefly summarizes Military Application responsibilities. We carry out these responsibilities in close coordination and in cooperation with other organizations, both within and outside of the Department of Energy. For example, such matters as the allocation of special nuclear material resources mandate close and continuous coordination with the DOE Assistant Secretary for Energy Technology, as well as continuous contact with the DOD, in order to be aware constantly of Defense programs impacting our weapons program.

The DOD also provides guidance regarding the objectives of our weapons development programs. To illustrate the basic guidance and requirements considered in accomplishment of these responsibilities, the most essential documentation is listed on this chart.

GUIDANCE DOCUMENTS

BIENNIAL NUCLEAR WEAPONS DEVELOPMENT GUIDANCE (DOD TO DOE)
- NEW SYSTEMS BY PRIORITY AND YEAR
- TECHNOLOGICAL GOALS

REQUEST FOR ENGINEERING DEVELOPMENT (DOD TO DOE)
- MILITARY CHARACTERISTICS
- STOCKPILE-TO-TARGET SEQUENCE

ANNUAL PRESIDENTIAL STOCKPILE PAPER (DOD/DOE TO PRESIDENT)
- STOCKPILE AUTHORIZATION – 3 YEARS
- LONG LEAD PROCUREMENT AUTHORITY – 4th YEAR & 5th YEAR
- PLANNING PROJECTIONS – 4th THROUGH 8TH YEAR

SEMIANNUAL UNDERGROUND NUCLEAR TEST PROGRAM (DOE TO NSC TO PRESIDENT)
- ANNUAL PROGRAM – SEMIANNUAL APPROVAL

ANNUAL PRESIDENTIAL/CONGRESSIONAL BUDGET PROCESS

Biennially, the DOD prepares a Nuclear Weapons Development Guidance (NWDG) document. DOE contributes to its development. A major element of this document is the prioritized identification of projected systems for which the DOD envisions a requirement over the next 10 to 15 years. The NWDG also contains a number of technological goals as guidance for DOE and DOD research and development efforts. While these technological goals are not identified with any particular military system, they typically include such technology challenges as increasing yield-to-weight ratio of a weapon; decreasing use of special nuclear material; achieving tailored effects such as enhanced or reduced radiation; or developing better command control and disable techniques for protection against possible terrorist threats.

The second document provides us with specific guidance relative to the engineering development of a particular warhead design for a DOD system application. The military characteristics define the various warhead parameters to be met, and the stockpile-to-target sequence specifies the various environments which the warhead shall be expected to survive over its stockpile lifetime. The engineering development request is the culmination of a cycle during which the warhead/system concept is first examined, followed by further studies and tests which determine the feasibility of the warhead for the system application. The DOD's engineering development request and DOE's acceptance of it constitutes, in effect, our contract to develop and prepare for production of a particular warhead. Production and stockpiling the warhead is subject to Presidential approval and leads me to the next document.

The third document which provides us formal guidance is the annual Presidential Stockpile Paper. This paper, which is jointly prepared by the DOD and DOE and presented to the President for approval and modification, contains three major parts upon which we base our planning to achieve and maintain the United States stockpile of nuclear weapons. The first part is a stockpile authorization for the current year and the next two years. We are authorized to procure the hardware and produce the precise numbers and types of weapons specified during this three-year period.

The second part is an authorization by the President to make plans and commit to long-lead procurements for the number and types of those weapons specified for delivery in the fourth and fifth years. The third major part is the planned weapon stockpile for the fourth through eighth years, to be noted by the President and updated to reflect policy and programming decisions as they occur.

The fourth major documented guidance which we are provided is the Underground Nuclear Test Program Direction from the President. Each year we prepare a test program which supports the technological goals and projected nuclear weapon systems which were provided to us in the NWDG, in the feasibility examinations, and in engineering development programs, as well as other DOE development goals. In addition, it provides for weaponization testing of those systems authorized in the Presidential Stockpile Paper. General Presidential approval is sought for each fiscal year's program, and twice a year the President is asked for specific permission to conduct those tests planned for the next six-month period.

Finally, the last major source of guidance illustrated on this chart is the Budget Review Process.

INERTIAL CONFINEMENT FUSION

Senator JACKSON. Thank you, Dr. Kerr.

Let me just ask one question at the outset on the fusion program. Where do we stand currently vis-a-vis the Russians?

Dr. KERR. At the present time both we and the Russians appear to be pursuing the development of large glass laser systems, CO_2 laser systems and electron beam systems. With regard to who is ahead, which I would guess to be the thrust of your question, I would like to defer to Dr. Richard Schriever, the Deputy Director of the Office of Laser Fusion, who is more experienced than I. Perhaps he could add to my comments. From my perceptions we are doing about the same things. I would like him to comment on the question of who's ahead.

Senator JACKSON. Doctor, come on up.

Dr. SCHRIEVER. We don't have the complete kind of interaction with the Russian program that we have with Western countries which would allow us to carefully measure and evaluate what they are doing. Not all of their program is visible to us.

Senator **Jackson**. We have had some exchanges?

Dr. **Schriever**. Yes; but these are certainly informal exchanges. One scientist visits a laboratory there, a scientist visits a laboratory here. A number of these take place each year. The Soviet program seems at this time to put relatively larger emphasis on electron beam driven fusion. We think that their technology is at a par or perhaps a little better in this field. We are sure that we cannot see all of the work they are doing with electron beam technology [deleted].

In the glass laser area where we are emphasizing our research effort at this time we seem to be a bit ahead because of the optical technology which exists in this country making the technology more readily available to us as it is needed for our research. They seem to have on the whole a program which is approximately the same size. This is difficult to measure because their system of suppliers, producers, and vendors works differently from ours. They perhaps have more people supported directly by their program but we have more people participating in our industrial base.

Senator **Jackson**. Do you think we are on the right track now?

Dr. **Schriever**. Yes, sir.

Senator **Jackson**. I know these are difficult questions. I watched the beginning of this program Project Sherwood, I believe, starting in 1950 up at where Johnny Wheeler was involved at Princeton and I have asked the questions over the years. We were going to have a favorable result by the end of that decade about 1960. I wear the other hat over in the Energy and Natural Resources Committee and we are putting a lot of money into this program. The question, I guess, is whether you have greater confidence now on the approach you are making—that is, the laser approach—than you had, say, 10 years ago.

Dr. **Kerr**. I think there is one point, which of course you know very well [deleted].

Senator **Jackson**. The laser input, of course, came much later.

Dr. **Kerr**. That is right.

Senator **Jackson**. And opened up a whole new opportunity, is that correct?

Dr. **Kerr**. What I was trying to do was make the point [deleted]. I think informed opinion at this point is that the laser fusion program has at least the same chance of success that the magnetic fusion program does [deleted].

Senator **Jackson**. What was the test the other day at Los Alamos? There was something in the newspaper about it.

Dr. **Kerr**. I was there, and it was the startup of what they called their eight beam CO_2 laser system. It delivers a total power, if I am not mistaken, of 17 terrawatts. Last week it was a demonstration of the most powerful laser in the world, we believe. This week I am going to join my colleagues from Livermore for the dedication of their Shiva laser, a glass laser system, and if all the beams are on target that may become the most powerful laser in the world. The point is that at the present time we have two new facilities, a glass laser and a CO_2 system, that are to be the experimental facilities for the next steps in this program.

Senator **Jackson**. You have confirmed the good judgment of the Atomic Energy Committee back in 1949 of having two labs. They had a great debate here in the Senate and many wanted only one, but I think the competition between Livermore and Los Alamos has been useful. Would you agree?

Dr. KERR. I am an absolute believer as an alumnus of one of them and Dr. Schriever is an alumnus from another. I think another point is that the two labs' existence permits us to have a very much smaller Federal work force involved with the program. They tend to be a check and a balance on themselves rather than requiring a large technical staff of Government employees to try and manage in detail the programs they carry out.

Senator JACKSON. Thank you, Doctor. I appreciate that.

[Additional questions, with answers supplied, submitted for the hearing record follow:]

Senator JACKSON. Does the $10.0 million line item for fiscal year 1979 Capital Planning and Design include any laser fusion projects and, if so, what are they?

Dr. KERR. The $10.0 million line item does not include any laser fusion projects. However, we currently do see a requirement for fiscal year 1979 planning and design funds for the Electron Beam Fusion Accelerator II (EBFA II) at Sandia.

The Office of Laser Fusion supports a request from Sandia Laboratories, Albuquerque (SLA) to upgrade the Electron Beam Fusion Accelerator (EBFA) from EBFA I to EBFA II. For this to occur in a timely fashion, with initial construction to begin in fiscal year 1981, it will be necessary to obtain Plant Engineering and Design (PE&D) support at the $1,000,000 level in fiscal year 1979 and at the $1,500,000 level in fiscal year 1980.

Electron and light ion beam fusion research at SLA has made good progress over the past several years. We would describe its present status as being a relatively sophisticated and comprehensive program involving unique target design, innovative beam propagation techniques, and clearly defined roles for their inventory of high power generators. The overall promise of electron/light ion fusion has moved ahead strongly with the advent of plasma channel experimentation, magnetically insulated targets, and the development of new high-voltage pulse transmission methods. While many details need to be worked out, the SLA scientists have now converged on a comprehensive conceptual design which offers the good possibility of achieving breakeven or net energy gain in the 1984–85 time frame. The backbone of any such program is the high power generator. EBFA II represents the continuation of the series of generators designed and built at SLA. It will provide the nominal power, 60 TW, and energy 2 MJ, that we believe to be required for net energy gain with electrons or light ions. It is an upgrade of EBFA I, the latter having been designed with the necessary space for an upgrade in mind. A minimum of additional building space will be required, since the main building is being provided for EBFA I. The nominal upgrade is a factor of 2, from 36 modules to 72. This would lead to roughly an order of magnitude increase in pellet yield, all other conditions being equal. However, it is expected that the design of EBFA II, particularly the "front end," will be influenced by experiments on EBFA I, so that the effective yield of EBFA II should thereby be significantly enhanced over that based on simply doubling the EBFA I design. In fact, SLA projects a yield increase of 100 over that expected for EBFA I.

The stated SLA objective for EBFA II is net energy gain. Net energy gain is the energy produced in thermonuclear fusion which exceeds the wall plug energy supplied to the driver.

The result would amount to a major milestone in the entire ICF program. We regard the overall risk for achieving breakeven or NEG as higher than the main line glass laser program, but the far lower cost and the rich technical option more than justifies an aggressive program to confirm the usefulness of electrons and light ions at the breakeven energy and power level. Furthermore, ICF applications of military interest would benefit from the timely availability of a pulsed power source of the size of EBFA II. Specifically, EBFA II would directly provide an intense source of Bremsstrahlung radiation for nuclear weapon effects simulation. This is in addition to EBFA II being a source for simulation and basic weapon physics studies through actual pellet fusion. In the Bremsstrahlung mode, which does not depend on any pellet burn or thermonuclear reactions, EBFA II would provide a unique capability for testing critical electronic subsystems up to threat levels. Finally, because of the modular nature of EBFA II, it can be used for synergistic effects testing.

In summary, we believe the availability of an EBFA II facility by July of 1983 will be of benefit to both the civilian and military aspects of our program.

Senator JACKSON. Page 13 of your statement says recent research results lead you to believe you may have to make an adjustment between construction and operating funds. What research results are you speaking of and what changes in your budget request are you considering?

Dr. KERR. With respect to operating funds, several factors influenced this decision. First, progress in fusion experiments is being limited by underfunding of critical program elements such as target fabrication. While the slower progress we are referring to was at LLL, the LASL target fabrication budget is much lower than at LLL. Thus, if we do not significantly increase LASL's budget in this area, the major progress we expect in the LASL target experiment program in fiscal year 1979 might not materialize. A second factor reflects our concern that we need to keep a strong target design and experimental capability at LASL to provide the balance to and peer review of LLL in their lead role in high gain target design. A final factor is, since Sandia's progress in the area of electron beam development has been excellent in a very important portion of their program, we have decided to accelerate the pace of the work on electron beam development. In summary, to obtain a continuation of the excellent progress and momentum developed at LASL and SLA over the past year and achieve the important successes we expect during fiscal year 1979 from LASL and SLA, we feel they simply need to continue at the higher levels of operating funds.

With respect to construction funds, the funding shift from Nova to Antares is proposed to better equalize the two laser completion dates in the early 1980's. For the President's budget case, Antares would not be completed until sometime in 1984. By the addition of $4 million, that time can be moved back to September 1983, the time at which we plan to complete Nova I even with a $10 million reduction in construction funds. We believe the locking together of the completion of these 100 KJ facilities (Nova II will boost the energy from the 100 KJ of Nova I to a total of 300 KJ: Antares is to produce 100 KJ, the same as Nova I) to be very important to the program as the LASL group could offer balance, peer review, and strong alternatives to the approaches being pursued at LLL. Finally, it will be extremely difficult if not impossible to recover the time gained by this fiscal year 1979 reallocation of funds to Antares through requesting a larger appropriation in fiscal year 1980. Thus, the requested shift must be made for fiscal year 1979 funding if the time is to be recovered.

Briefly, as shown below, we request a transfer of $6 million of obligational authority out of construction funds. This would be obtained by reducing our obligational authority for Nova by $10 million and increasing obligational authority by $4 million for Antares for a net reduction of obligational authority for construction of $6 million. This corresponds to a budget outlay of $3.6 million which we would apply to increasing our operating budgets at LASL and SLA. By diverting an additional $1.8 million of outlays from other parts of our operating budget, we would actually increase LASL's operating budget by $4.3 million to $24.6 million and SLA's operating budget by $1.1 million to $10.8 million. These changes will provide needed increases for fusion theory and experiment efforts at each of these locations. We would also increase our capital equipment obligational authority by $1.2 million to a total of $9.4 million, bringing it up to a level comparable to fiscal year 1978.

NEUTRON BOMB

Senator JACKSON. Dr. Kerr, what specific impact has the President's decision on deferring production of the neutron bomb had on funding levels you are currently requesting?

Dr. KERR. General Bratton is well prepared to answer you. He testified concerning this on the House side last week, and we have charts that will show you in detail what we are trying to do in that area.

General BRATTON. I will elaborate on that a little if I may, sir, while Dr. Gilbert pulls out an appropriate chart or two to show you.

FY 1978 AND FY 1979 FUNDING IMPACT OF PRODUCTION HOLD ON ENHANCED RADIATION WARHEADS

(B/O $ IN MILLIONS)

	FY 1978	FY 1979
W70-3 LANCE WARHEAD	DELETED	DELETED
W79 8-INCH AFAP	DELETED	DELETED

This chart shows, specifically in response to your question, what has happened to our funding and the President's budget for fiscal year 1978 and the budget request for fiscal year 1979 because of the halt in the commitment of production funds during fiscal 1978. In terms of direct cost, budget outlays in millions of dollars, you can see there what we have not spent and that we have a decrease in this requirement of [deleted] in fiscal 1978 and a projected decrease of [deleted] in operating costs in fiscal year 1979.

I would like to qualify this chart though by saying that it is based on [deleted] which would be done in accordance with the President's decision that he announced on April 7; that is, the modernization of the Lance and 8-inch weapons leaving out the features that would provide enhanced radiation but allowing for subsequent addition of those features if a decision is ever made to do so.

Senator Jackson. I know the modifications have to be made on the delivery system [deleted].

General Bratton. [Deleted.]

Senator Jackson. The question in my mind that we want to look at seriously [deleted]. I understand that the President is simply going forward with the modifications of the Lance and the 8-inch. Isn't that essentially the basis of his decision?

General Bratton. Yes, sir.

Senator Jackson. [Deleted.]

General Bratton. Right. [Deleted.]

Senator Jackson. [Deleted.]

General Bratton. Yes, sir.

Senator Jackson. So that we could move rapidly, if that were to be the decision. Congress can't do anything about the deployment of forces, but we can, of course, authorize, direct, and appropriate the funds to have the weapon systems in being [deleted]. That is what I am addressing. The President, as Commander in Chief, of course, has the authority, and the exclusive authority, to deploy the Armed Forces of the United States. [Deleted.]

General **Bratton**. Yes, sir.

Dr. **Kerr**. Senator Jackson, we have been preparing that option as a part of our support to Defense and getting them ready to request what they will of us in this area. [Deleted.]

NON-ER WEAPONS

Senator **Jackson**. If we develop both Lance and the 8-inch enhanced radiation weapons, but without the enhanced radiation features, what will be the military utility of each, as contrasted to the original expectations for these new weapons? In particular, will the 8-inch artillery shell have acceptable military value against armored targets? Should we have the capability to convert to a new "conventional" nuclear shell, if you want to put it that way?

General **Bratton**. I will perhaps ask General Key to add to what I say in response to your question, sir.

Senator **Jackson**. All right.

General **Bratton**. Basically, everything we wanted to achieve originally with our 8-inch [deleted].

I believe though that the advantages of the new shell greatly outweigh these considerations. As far as targeting is concerned in a practical situation, I think the new shell will be a distinct improvement over the old [deleted].

I don't know whether General Key wants to add to that.

General **Key**. Mr. Chairman, I can give you the comparable radius of damage for the two. [Deleted.]

Senator **Jackson**. [Deleted.]

General **Key**. [Deleted.] I agree with General Bratton [deleted].

Senator **Jackson**. Well, that is all right.

General **Key**. [Deleted.]

Senator **Jackson**. [Deleted.]

General **Key**. Yes, sir.

Senator **Jackson**. [Deleted.]

General **Bratton**. [Deleted.]

Senator **Jackson**. [Deleted.]

General **Bratton**. That is correct, sir. [Deleted.]

Senator **Jackson**. [Deleted.]

General **Bratton**. Yes. [Deleted.]

Mr. **Cotter**. Could I ask General Key a question?

Senator **Jackson**. Yes.

Mr. **Cotter**. [Deleted.] Is that an acceptable situation for the Army?

General **Key**. We think that it is acceptable. [Deleted.]

Mr. **Cotter**. Has the production level yet been set for the number of rounds?

General **Key**. Right now the production level that we are using for the 8-inch is [deleted].

Mr. **Cotter**. [Deleted] how many nuclear 8-inch shells now available?

General **Key**. The total now—I will probably have to supply it for the record unless we have it in the book. [Deleted.]

Mr. **Cotter**. [Deleted.]

General **Key**. That is correct, sir.

Mr. COTTER. Could you provide those additional charts for the record, please?

General BRATTON. Yes, sir.

[The charts follow:]

ENHANCED RADIATION WARHEADS

- CHRONOLOGY HIGHLIGHTS
- PROGRAM FUNDING AND PRODUCTION SCHEDULES
- IMPLEMENTATION OF THE PRESIDENTIAL GUIDANCE

ENHANCED RADIATION (ER) WARHEADS—CHRONOLOGY

JAN 1975	ENGINEERING DEVELOPMENT OF W79 BEGAN.
JUL 1976	ENGINEERING DEVELOPMENT OF W70-3 BEGAN.
NOV 1976	PRESIDENT FORD APPROVED NUCLEAR WEAPONS STOCKPILE PAPER FOR FY 77–79, INCLUDING THE W70 AND W79. (W79 WAS SPECIFICALLY SHOWN AS ER; W70 WAS NOT.)
JAN 1977	PRESIDENT FORD'S BUDGET FOR FY 78 SENT TO CONGRESS; INCLUDED FUNDS IN ERDA WEAPONS PROGRAM FOR W70-3 AND W79, BOTH IDENTIFIED AS ER.
FEB 1977	CARTER ADMINISTRATION REVIEWED FORD BUDGET; MADE NO CHANGES IN ERDA WEAPONS PORTION.
FEB-MAR 1977	ERDA TESTIMONY TO CONGRESS (HASC, SASC, HAC, SAC) ON FY 78 WEAPONS BUDGET; NO APPARENT CONTROVERSY OVER W70-3 OR W79 PROGRAMS.
JUN-JUL 1977	JOINT ERDA-DOD BRIEFINGS ON ER WEAPONS GIVEN TO VARIOUS MEMBERS OF CONGRESS.
JUL 11, 1977	PRESIDENT'S LETTER TO SENATOR STENNIS FAVORING ER.
JUL 13, 1977	PRESIDENT SENT TO CONGRESS AN ARMS CONTROL IMPACT STATEMENT ON ER WARHEADS FAVORING PRODUCTION AND DENYING THAT DEPLOYMENT WOULD LOWER NUCLEAR THRESHOLD.
JUL 13, 1977	SENATE PASSED FY 78 ERDA APPROPRIATIONS BILL WITH BYRD-BAKER AMENDMENT.
JUL 21, 1977	PRESIDENT'S LETTER TO CHAIRMAN PRICE THANKING HIM FOR ER SUPPORT.

BYRD–BAKER AMENDMENT

"... PROVIDED FURTHER, THAT NONE OF THE FUNDS APPROPRIATED IN THIS ACT SHALL BE USED FOR PRODUCTION OF ENHANCED RADIATION WEAPONS UNTIL THE PRESIDENT CERTIFIES TO CONGRESS THAT PRODUCTION OF THESE WEAPONS IS IN THE NATIONAL INTEREST; PROVIDED FURTHER, HOWEVER, THAT AFTER SUCH CERTIFICATION IS RECEIVED, PRODUCTION MAY PROCEED, UNLESS WITHIN 45 DAYS CONGRESS BY CONCURRENT RESOLUTION DISAPPROVES SUCH PRODUCTION ..."

ENHANCED RADIATION (ER) WARHEADS–CHRONOLOGY

AUG 1977	AT PRESIDENT'S REQUEST, SECDEF PREPARED AN ANALYSIS OF TACTICAL NUCLEAR WEAPONS. SECDEF FAVORED ER WARHEADS, BUT RECOMMENDED NATO CONSULTATIONS.
SEP 1977	CONGRESS APPROVED ERDA FY 78 FUNDS FOR ER WEAPONS.
OCT 1, 1977	DOE HALTED ALL RESOURCE COMMITMENTS TO ER PRODUCTION.
JAN 1978	PRESIDENT CARTER'S BUDGET FOR FY 79 SENT TO CONGRESS; INCLUDED FUNDS FOR PRODUCTION OF W70-3 AND W79 WARHEADS.
FEB-MAR 1978	DOE TESTIMONY TO HASC, HAC, AND SAC ON FY 79 DOE WEAPONS BUDGET REQUEST.

FY 1978 WEAPONS BUDGET

FUNDS & DELIVERY SCHEDULE FOR ENHANCED RADIATION (ER) WARHEADS

(B/O $ IN MILLIONS)

FUNDS	W70-3 LANCE	W79 8-INCH ARTY
RESEARCH, DEVELOPMENT, & TESTING	DELETED	DELETED
PRODUCTION & SURVEILLANCE		
DIRECT (NON-ADD)		
INDIRECT (NON-ADD)		
SPECIAL NUCLEAR MATERIALS		
CAPITAL		
TOTAL		

DELIVERY SCHEDULE	DELETED
W70-3 LANCE	DELETED
W79 8-INCH	DELETED
PROJECTILE	DELETED

FY 1979 PRESIDENT'S REQUEST FOR WEAPONS BUDGET

FUNDS & DELIVERY SCHEDULE FOR ENHANCED RADIATION (ER) WARHEADS

(B/O $ IN MILLIONS)

FUNDS	W70-3 LANCE	W79 8-INCH ARTY
RESEARCH, DEVELOPMENT & TESTING	DELETED	DELETED
PRODUCTION & SURVEILLANCE		
DIRECT (NON-ADD)		
INDIRECT (NON-ADD)		
SPECIAL NUCLEAR MATERIALS		
CAPITAL		
TOTAL		

DELIVERY SCHEDULE	DELETED
W70-3 LANCE	DELETED
	DELETED
W79 8-INCH PROJECTILE	DELETED

PRESIDENTIAL STATEMENT ON ENHANCED RADIATION WARHEADS

APRIL 7, 1978

"I HAVE DECIDED TO DEFER THE PRODUCTION OF NUCLEAR WEAPONS WITH ENHANCED RADIATION EFFECTS. THE ULTIMATE DECISION REGARDING THE INCORPORATION OF ENHANCED RADIATION FEATURES INTO OUR MODERNIZED BATTLEFIELD WEAPONS WILL BE MADE LATER . . .

"ACCORDINGLY, I HAVE ORDERED THE DEFENSE DEPARTMENT TO PROCEED WITH THE MODERNIZATION OF THE LANCE MISSILE NUCLEAR WARHEAD AND THE 8-INCH WEAPON SYSTEM, LEAVING OPEN THE OPTION OF INSTALLING THE ENHANCED RADIATION ELEMENTS . . ."

IMPLEMENTATION OF PRESIDENTIAL DECISION

LANCE WARHEAD

DELETED

DELETED

- PROVIDES FOR LATER CONVERSION TO ER
- MEETS PRESIDENTIAL DECISION
- INITIAL DELIVERY TO DOD DELETED

DELETED

IMPLEMENTATION OF PRESIDENTIAL DECISION

8-INCH NUCLEAR PROJECTILE

OPTION 1: DELETED

DELETED

- PROVIDES FOR LATER CONVERSION TO ER

DELETED

- MEETS PRESIDENTIAL DECISION
- INITIAL DELIVERY TO DOD

DELETED

IMPLEMENTATION OF PRESIDENTIAL DECISION

8-INCH NUCLEAR PROJECTILE

OPTION 2: DELETED

DELETED

- DEVELOPMENT PROGRAM OF APPROXIMATELY YEARS

DELETED NUCLEAR TESTS REQUIRED

- DOES NOT FULLY MEET PRESIDENTIAL DECISION

DELETED

- PRODUCTION COULD BEGIN DELETED

FY 1978 AND FY 1979 REQUIREMENTS TO IMPLEMENT PRESIDENT'S DECISION
($ IN MILLIONS)

W70-3 LANCE	FY 1978	FY 1979
DELETED	DELETED	DELETED
W79 AFAP (8")		
DELETED	DELETED	DELETED

DELIVERY SCHEDULES	
	DELETED
W70-3 LANCE	
W79 8-INCH	

FY 1978 WEAPONS BUDGET
PRODUCTION FUNDS FOR ENHANCED RADIATION (ER) WARHEADS
(DIRECT $ MILLIONS B/O)

FY 1978 APPROPRIATIONS FOR PRODUCTION OR ER WARHEADS [1]		FY 1978 PLANNED COMMITMENTS
W70-3 LANCE	DELETED	DELETED
W79 8-INCH PROJECTILE	DELETED	
TOTAL	DELETED	

[1] INCLUDES WAR RESERVE NEW PRODUCTION AND STOCKPILE MAINTENANCE AND SURVEILLANCE.

[2] ASSUMES FUNDING COMMITMENTS BEGINNING DELETED

VERIFICATION

Senator JACKSON. The President's statement ought to be read here on enhanced radiation and it is as follows, and I am quoting:

> I have decided to defer the production of nuclear weapons with enhanced radiation effects. The ultimate decision regarding the incorporation of enhanced radiation features into our modernized battlefield weapons will be made later, and will

be influenced by the degree to which the Soviet Union shows restraint in its conventional and nuclear arms programs of force deployments affecting the security of the United States and Western Europe.

It is clear, according to this statement, we are tying the nonproduction and deployment of ER weapons to an arms control measure on the part of the Soviets. [Deleted.]

I would like to get a feel for how well we have thought this proposal through. We hold verification, as you know, to be a pivotal issue bearing on the acceptability of arms control agreements. Now we are discussing adding some classified features later. [Deleted.] Have we thought about that?

General BRATTON. [Deleted.]

Senator JACKSON. Of course we have to assume that they have an ER capability, too. It would not be very prudent at least not to assume that. [Deleted.]

General BRATTON. I think we have to credit them with the design capability to produce an enhanced radiation device. [Deleted.]

Senator JACKSON. [Deleted.]

General BRATTON. No, sir.

Senator JACKSON. All right.

B77 BOMB

I would like now, Dr. Kerr, to get into the circumstances of the B77 program and its cancellation. Originally the Defense Department must have justified the development and production of the B77. Arguments made by DOE indicated advances in reliability, deployment safety and security and survivability of the delivery aircraft because of the ability to deliver at extremely low altitudes.

The President's decision, as I understand it, was based on saving money and it seemed to be tied to the fact that the B–1 cancellation justified the cancellation of this bomb. The B43 was then suggested as an alternative. Now if I understand your testimony, you are saying that we are developing both the B77 and the B43, but only making production plans for the B43. This cancellation decision sounds a little bit like the neutron bomb decision. Why are we carrying out simultaneous development and testing for both? Is there enough money for both?

Dr. KERR. I will start the answer and be joined by my colleagues in completing it.

Our present status is following the President's acceptance of the OMB recommendation. We have stopped planning for production of the B77, but we are continuing the research and development that will complete the engineering development of that weapon. We had intended, as a result of the President's decision, to initiate preparation of production facilities, supported by some R. & D. for a modification of the B43. We have now stopped those B43-related actions in response to direction from the House Armed Services Committee that we not spend fiscal 1978 funds on a program that had not been authorized. So at the present time we have production plans for neither the B43 nor the B77.

With respect to some of the other points you have raised in your question, I would like to defer first to General Bratton and then possibly to General Block of the Air Staff who is here as well and may wish to comment on this matter.

General Bratton. I can say this on the bomb program to be very specific as to what it is we are doing. In fiscal 1978, we are spending a relatively small amount of money to continue the research and development [deleted] for the B77. We are spending no production money including capital and plant money on the B77 program in light of the President's decision in acting on our 1979 budget.

Regarding the B43 program, we are spending no money of any kind [deleted] because of the instructions given us by Chairman Price of the House Armed Services Committee. There is money in the fiscal 1979 budget to move ahead on the B43 program—the B43 modification. There is no money in the fiscal year 1979 budget for production of the B77 model.

COMPARISON OF B77 AND B43 BOMBS

Parameter	B77	Modified B43
Yield (KT)	DELETED	DELETED
Delivery	DELETED	DELETED
Fuzing	DELETED	Same as B77
High Explosive Safety	IHE	Same as B77
Nuclear Safety	Latest Technology Weak Link/Strong Link	Same as B77
Command and Control	CAT D PAL	Same as B77
Command Disable	Yes	Same as B77
Aircraft Compatibility	B-52, FB-111, F-4, F-16, F-111, A-4, A-6, A-7	Same as B77

Senator Jackson. Might I ask, were there any other Air Force or Navy aircraft involved as possible carriers of the B77 besides the B-1?

General Bratton. Yes, sir. The B77 bomb was designed to be carried by all of the aircraft in the Air Force and Navy inventories that have nuclear capability. We would plan the same for the modified B43. There is a list of the aircraft there on that chart.

Senator Jackson. Well, it is basically a laydown bomb, isn't it?

General Bratton. The B77 has full fuzing options, and it could be delivered in the laydown mode or in a retarded delivery ground burst or air burst. It gives you a delivery choice, [deleted].

The viewgraph that Dr. Gilbert is showing indicates the difference between the original B77 bomb and the modified B43 bomb. You will see that many of the elements are the same. The two essential differences are shown on the screen. The first item there is that the B77 [deleted].

The other difference is its capability for delivery at high speeds, at low altitudes against hard targets. The B77 was specifically designed to be delivered at a speed of [deleted] and to be effective against hard, irregular targets. The B43 will have design goals, as you can see there, to be delivered [deleted] with an objective of high probability of survival against the hard, irregular target. I don't know what that probability would turn out to be because the program has not proceeded that far. Those are the two essential differences as far as military effectiveness and capability.

Senator JACKSON. It is difficult for me to understand why especially the B77 is canceled, in light of the fact that it gives us a diversity of application against diverse targets. We do not have a comparable bomb [deleted] do we?

General BRATTON. This would be a unique capability of these B77's.

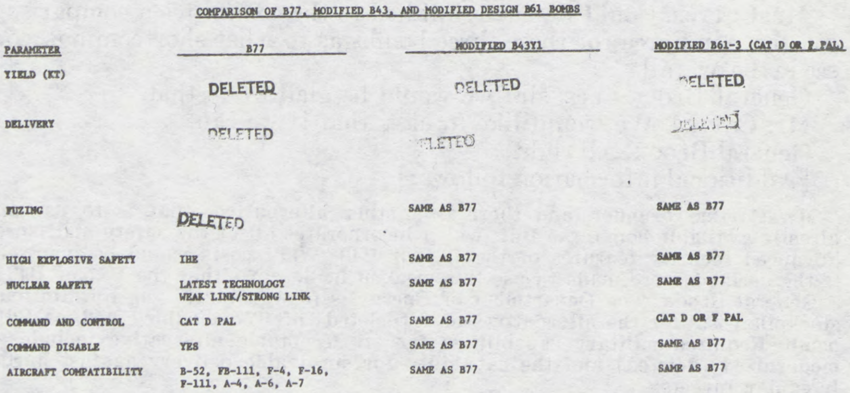
Senator JACKSON. What about the costs in terms of the other current systems?

General BRATTON. The B77 bomb, compared to current systems in the stockpile, is more expensive and, compared to the B43, it is more expensive. The President's decision, I believe, was made on economic grounds. These are some of the costs that I can show you. I have labeled these decision costs because these are direct costs that would be involved with the two programs—direct operating, direct capital, and cost of reactor products to build [deleted]. Down at the bottom there is some data on the amount of enriched uranium required for each of these programs.

B61 BOMB

Senator JACKSON. Now, the B61 which is another option, where does it fit in?

General BRATTON. The B61 is a very modern bomb which exists in several modifications. We are currently building modification 5. [Deleted.]



COMPARISON OF B77, MODIFIED B43, AND MODIFIED DESIGN B61 BOMBS

PARAMETER	B77	MODIFIED B43Y1	MODIFIED B61-3 (CAT D OR F PAL)
YIELD (KT)	DELETED	DELETED	DELETED
DELIVERY	DELETED	DELETED	DELETED
FUZING	DELETED	SAME AS B77	SAME AS B77
HIGH EXPLOSIVE SAFETY	IHE	SAME AS B77	SAME AS B77
NUCLEAR SAFETY	LATEST TECHNOLOGY WEAK LINK/STRONG LINK	SAME AS B77	SAME AS B77
COMMAND AND CONTROL	CAT D PAL	SAME AS B77	CAT D OR F PAL
COMMAND DISABLE	YES	SAME AS B77	SAME AS B77
AIRCRAFT COMPATIBILITY	B-52, FB-111, F-4, F-16, F-111, A-4, A-6, A-7	SAME AS B77	SAME AS B77

That Vugraph there shows on the right-hand column a modified B61–3. The B61–3 has the modern safety, security, and control provisions that would be possessed by the B77 or the modified B43. [Deleted.]

Our information from the Department of Defense has been that [deleted] the B61 do not meet [deleted] specifications for a new strategic bomb, which is why it has not been actively considered up to this time as a replacement for the B77. Otherwise, it is a very modern capable bomb.

Senator JACKSON. Will the added capability of cruise missiles for the B–52 reduce the requirements for the B77 or B43 or the [deleted] B61? Is that a factor in this?

General BRATTON. I have no specific data on how the numbers of the bombs may be affected by the advent of the cruise missile. I would like to defer here to the Department of Defense. I believe that they have some work ongoing which is addressing this issue.

General KEY. Mr. Chairman, if I might call on General Block from the Air Force to address this question.

Senator JACKSON. All right.

General, come on up.

Can you relate all this to what it does basically to the SAC mission? That is what we are talking about.

General BLOCK. Yes, sir, I think the basic point to be made here is that the continuing operational requirement for bomber force penetration dictates the continuing viability of the requirement for modernized effect [deleted].

Senator JACKSON. Which is the B77.

General BLOCK. That is one alternative, yes, sir.

Senator JACKSON. But you don't have another device that can give you [deleted].

General BLOCK. No, sir, we do not [deleted].

Senator JACKSON. And so from the targeting point of view—that is, carrying out SAC's mission—obviously, you want the widest range of application to meet the wide range of targets, is that right?

General BLOCK. It certainly enhances your operation.

Senator JACKSON. That is right.

Mr. Cotter, do you have any questions?

Mr. COTTER. Could we have supplied to the committee a comparison by the Air Force for these three bombs as to what shortcomings you see in the overall?

General BLOCK. Yes, sir: we would be glad to do that.

Mr. COTTER. We would like to have that if we can.

General BLOCK. All right.

[Additional information follows:]

Mr. COTTER. I understand there is another alternative—that is to use an already available bomb, the B61, which incorporates all of the safety and more advanced security features of the B77 or B43. What costs would be involved if the decision were made to use this weapon in lieu of either the B77 or B43?

General BLOCK. The Department of Energy is forwarding to you the lifetime stockpile costs for the alternatives of a [deleted] of B77, modified B43, or B61 bomb. Required military capabilities for an acceptable alternative include a modernized [deleted] and the capability for survivable delivery against hard, irregular targets.

Mr. **Cotter**. What targets, that are to be attacked by penetrating bomber, or the other aircraft [deleted].

General **Block**. The primary requirement [deleted] is for use against the increasing number of hardened, high-priority military targets such as: [Deleted.] Additionally, a [deleted] fuzing option flexibility would be effective against [deleted]. Effective targeting against such facilities requires that the weapon be capable of survivable laydown delivery against targets with hard, irregular surfaces.

Mr. **Cotter**. Will the added capability of cruise missiles for the B–52 reduce the requirement for the B77, B43, or [deleted] B61?

General **Block**. The Air Force believes there will be a continuing operational requirement for bomber force penetration. [Deleted.]

The addition of cruise missiles to the bomber force will affect the number of weapons required, but will not alter the operational requirement for a mix of weapon types and yields to optimize force application against a variety of targets.

Mr. **Cotter**. Would you provide to the Committee an analysis of the impact of SAC's mission if [deleted] (B61) were used? Also treat the limitations which the B43 modification would impose.

General **Block**. Currently stockpiled high-yield bombs were designed to achieve high probability of damage against [deleted] military targets. The increasing hardness of high-value military targets has decreased the effectiveness of older bombs. [Deleted.]

Additionally, aircraft altitude delivery restrictions of older weapons increase aircraft vulnerability to defenses at high-value targets.

Older weapons [deleted] limits operational flexibility in aircraft weapon loading and mission planning and drives the need for increased cross targeting to achieve the optimum weapon delivered against each Desired Ground Zero (DGZ). A mix of weapon types and yields must be maintained in the stockpile to support a spectrum of requirements when applying weapons against all DGZ's.

The following table provides a comparison of the characteristics of the B61, B43, and B77 alternatives against the mission requirements for bomb yield, fuzing, and delivery. Also compared are bomb capabilities to satisfy modern requirements for safety, security, and command and control features.

MODERNIZED BOMB REQUIREMENTS AND COMPARISON OF CHARACTERISTICS: B77, MODIFIED B43, AND B61

Capability	SAC ROC 6-69	B77 military characteristics	DOE plan for modified B43	B61-Mod 0 and/or B61-Mod 1	B61-Mod X
Yield	[Deleted.]				
Fuzing	Full-fuzing Options (FUFO): Freefall/retarded. airburst/groundburst.	Same as SAC ROC 6-76	To be determined	Same as SAC ROC 6-76	Same as SAC ROC 6-76.
Delivery	[Deleted.]				
Safety, security, and command and control.	Not specified	IHE, CAT D PAL, USG-driven switches. All modern safety electronics.	Same as B77	No IHE [deleted.] B61-0; CAT B PAL. B61-1: [Deleted.]	Same as B77.

[Deleted.]

The series of B61 bombs (Mods 0 through 5) appear to have considerable flexibility in their specified aircraft altitude and speed delivery envelope. [Deleted.]

The newer mods of the B61 offer enhancements in safety, security, and command and control. B61 Mod 2 incorporates Command Disable System (CDS) and CAT D PAL. The Mod 5 additionally includes weak link/strong link switches, driven by a Unique Signal Generator (USG). Mods 3 and 4 add the feature of an Insensitive High Explosive (IHE) [deleted].

The modified B43 appears to meet requirements for a modernized, high-yield nuclear bomb. The DOE plan to modify B43Y1 bombs includes installation of a new IHE [deleted].

The modified B43Y1 design will include improvements in tail/parachute and nose sections to achieve compatibility with SRAM-loaded B-52 aircraft and delivery capability from lower altitudes than currently stockpiled B43 bombs. Fuzing options are yet to be determined; however, the B43 modification is intended to provide a [deleted] laydown capability improved over that of currently stockpiled B43 bombs. The DOE plan also includes modernization of the B43Y1 safety, security, and command and control features to include USG-driven switches and CAT D PAL.

Senator **Jackson**. All right, gentlemen. I think we will conclude that part of the questioning.

Mr. **Cotter**. Excuse me.

COST COMPARISON

General Bratton, could you give us the overall cost of the B77? You just gave us a decision cost but there are now some sunk costs. What will be the total cost for the B77, the B43, and what would be the cost if it was decided that the B61 [deleted] were all of the new safety security? Give us those costs all together.

[Chart deleted.]

General **Bratton**. On this viewgraph, Mr. Cotter, are the total B77 costs, loaded figures, taking into account all direct and indirect costs, capital, and reactor products. The total system cost is shown down in the lower right hand column, [deleted].

Mr. **Cotter**. That is for [deleted].

General **Bratton**. Yes.

Mr. **Cotter**. So that is [deleted].

General **Bratton**. Those are the costs over the lifetime of the system taking into account stockpile maintenance, reliability, and surveillance of all kinds.

Mr. **Cotter**. So that is the total?

General **Bratton**. Yes, sir, that is correct.

Mr. **Cotter**. And the B43?

[Chart deleted.]

General **Bratton**. The next chart shows the B43 on the same basis. You can see the [deleted] amount in the lower right hand column.

Mr. **Cotter**. That is for [deleted].

General **Bratton**. Right.

Mr. **Cotter**. So that is [deleted]. What would be the B61 cost with all of the features [deleted].

General **Bratton**. Do we have a chart on that same basis?

Mr. **Gilbert**. We do not have a chart on the B61 modified, but it would be around [deleted].

Mr. **Cotter**. So it would be slightly less but it would have [deleted].

Mr. **Gilbert**. Yes; it would [deleted].

Mr. COTTER. Everything but the [deleted] and the low-altitude release capability.

Mr. GILBERT. It has the low-altitude release capability also.

Mr. COTTER. So it is [deleted] question between the B61 and the B77.

General BRATTON. The B61 would have all the other features.

Mr. COTTER. Presumably it would be available earlier?

General BRATTON. Our first deliveries of the B61, 3 and 4 are in [deleted].

Mr. COTTER. So with the B43 we have a more immediate capability [deleted].

General BRATTON. Yes.

Mr. COTTER. I think the committee will be very interested in the very serious attention being paid to the B61 option, General Block.

Senator JACKSON. We ought to have all of those options before us so that we can make a judgment on the authorization.

COMPREHENSIVE TEST BAN

All right. I would like to turn now, if I might, to the comprehensive test ban. I think the fundamental question here, Dr. Kerr, is the impact on the reliability of our nuclear weapons, if a complete ban on testing were to occur.

Dr. KERR. We are well prepared to answer that, having studied this question for some months now.

Senator JACKSON. Well, it really goes back to 1963.

Dr. KERR. That is right. We have taken advantage of that study as well, sir.

I think in summary I can tell you this, and the lab directors can add comments if they choose.

Our weapons designers believe that the current and planned U.S. nuclear weapons cannot be indefinitely maintained or remanufactured without nuclear tests. In the absence of testing, confidence in the stockpile will degrade as the result of two things. The first is the diminished ability to identify and correct deficiencies discovered during stockpile surveillance. This will occur with the loss of experienced personnel which will become significant [deleted].

The combination of these two things, we feel, would begin rendering the stockpile less reliable than it is presently under a CTB.

Senator JACKSON. Let me ask you about the problem on verification. In the event that we agreed to test only at a certain level—[deleted]—what effect might this have on the processes you have described?

Dr. KERR. With respect to the current stockpile, both of the weapon design laboratories have indicated that [deleted].

Senator JACKSON. [Deleted.]

Dr. KERR. That is correct. That is specifically the answer to the question. What is the minimum yield at which one might recertify a current weapon system?

Senator JACKSON. What would it have to be if you were desirous of testing a new system?

Dr. KERR. I will offer my first——

Senator JACKSON. I mean what is the minimum?

Dr. KERR. [Deleted.]

Senator JACKSON. Of course we have been testing underground. [Deleted.]

Dr. **Kerr.** All the weapons that have entered stockpile since the termination of atmosphere testing had been either tested in the atmosphere or underground until March 31, 1976.

Dr. **Batzel.** I don't think that is quite right.

Senator **Jackson.** Would you stand up and be identified.

Dr. **Kerr.** Dr. Batzel, director of Livermore.

Dr. **Batzel.** Roger Batzel, director of the Lawrence Livermore Laboratory.

The Spartan weapon was tested at Amchitka underground [deleted].

Mr. **Cotter.** What was that yield?

Dr. **Batzel.** The test yield was [deleted].

Senator **Jackson.** Well, while you are on your feet, and we will ask the other acting director, what will be the impact on the labs in terms of people if we have a comprehensive test ban treaty that simply cuts it all off?

Dr. **Batzel.** The simple answer is that over a period of time, [deleted]. I think we will have difficulty holding together a viable weapons capability for the country. I think by working as best we can to provide experimental capabilities and flexibilities for the people we have at the laboratory—there are nonnuclear experiments which can be done and related experiments which have to be done—then I think [deleted] is certainly a reasonable estimate. I think we might even be able to stretch it out to as long [deleted]. After that length of time, I think we have severe problems with respect to maintaining a real weapons capability at the laboratory.

Senator **Jackson.** I might ask Dr. Thorn the same question.

Dr. **Thorn.** I agree largely with what Dr. Batzel said. I think we can look back at the moratorium in 1958 to 1961 and you can see a steady erosion starts to occur. I think our hope is that we can have other programs that can substitute for the weapons testing that are closely akin to the weapons program such as laser fusion and contained hydrodynamics explosions that might keep the interest of the engineers, and the physicists who are responsible for the weapons designed.

B77 BOMB

Mr. **Dawson.** Dr. Kerr, on the B77 gravity bomb, what documents do you have to show the President's decision?

General **Bratton.** The decision was relayed to us in the normal course of the President's response to our proposals for the fiscal 1979 budget through the Office of Management and Budget just as it was relayed to Defense in that fashion. Unless I can be corrected by General Key, I don't know of any other documentation that the White House or Defense would have on that either.

General **Key.** I know of none.

Mr. **Dawson.** To your knowledge has the President submitted to the Congress a letter of rescission on the B77 production?

General **Bratton.** Has the President sent to Congress——

Mr. **Dawson.** A letter of rescission.

General **Bratton** [continuing]. A letter of rescission.

Dr. **Kerr.** I think I can help with that. Thus far; no. We did prepare a deferral schedule identifying $23.5 million of B77 production facilities and indicating that this amount would be used to reduce the fiscal 1979 appropriation request. This was sent to OMB on

March 8 and again on March 20 because they stated that they had not received the first letter. It is an OMB function to notify Congress of such deferrals, and thus far they have not done so.

Mr. Dawson. What is the specific reason as to why the administration does not see it necessary in the case of the B77 to send a letter of rescission to the Congress?

Dr. Kerr. I can't answer your question directly. I think the point is that we have provided the information to OMB and I don't know why they are slow in getting it out.

Mr. Dawson. When was the decision made by OMB?

General Bratton. The President's decision was made during the week of December 17, 1977, so that is some 4 or 5 months.

Mr. Dawson. And you have anticipated the approval of a nonexisting letter of rescission by stopping the B77 production funds, is that correct?

General Bratton. Yes. When the President's decision became known, action had to be taken with respect to the 1978 budget. It made no sense to have a decision that would not include the production of the B77 in the 1979 budget while proceeding to spend money for that production in the 1978 budget.

Mr. Dawson. Have you studied the opinion on the Minuteman production decision by the Comptroller General of the United States which raises some questions as to the compliance with the spirit of the Budget Impoundment Control Act by the Department's anticipation of a congressional approval of a letter of rescission?

General Bratton. Not specifically.

Mr. Dawson. Could you provide for the record, please, the legal basis upon which you proceeded without the letter of rescission? Or if you cannot do that, would you direct the subcommittee to the proper department officials within the administration?

General Bratton. We will do our best to do that, yes, sir.

[The information follows:]

The Department of Energy has taken all required steps to insure that our actions concerning construction project 78–16–b, Full-fuzing option bomb production facilities, are in compliance with applicable legal requirements including title X of the Congressional Budget and Impoundment Act of 1974, 31 U.S.C. section 1400 et seq. Specifically, in March 1978, DOE provided OMB with all information which might be necessary for preparation of an appropriate message to Congress under title X. We understand that OMB has prepared a proposed "special message" under 31 U.S.C. section 1403 which contains the statutorily required information concerning project 78–16–b. We have contacted OMB regarding the status of this matter and are advised that it has been transmitted to the White House.

We believe that a reduction of spending during the period in which a Presidential deferral message is being prepared is appropriate. A contrary conclusion could complete the wasteful expenditure of funds for programs which are ultimately deferred.

Mr. Dawson. I have one more question, Mr. Chairman. I appreciate the time.

Senator Jackson. Yes, sir.

Mr. Dawson. Has anyone in the Air Force, General Block, taken the position that the B61 is an attractive alternative to producing either the B77 or the B43?

General Block. Not to my knowledge.

Mr. Dawson. Has SAC studied the B61 as an alternative?

General Block. Yes, sir. They have looked at it.

Mr. Dawson What was their decision?

General Block. It needs [deleted].

Mr. Dawson. They have [deleted].

General Block. Yes, sir; [deleted].

Mr. Dawson. Thank you, General Block.

Thank you, Dr. Kerr.

Senator Jackson. Before we turn to Dr. Cunningham and the production program, I wonder if I might go back to Dr. Sparks, Dr. Batzel, and Dr. Thorn and ask if they have any comments they wish to make at this time regarding the work of their respective laboratories, matters that are relevant to the committee. We would be delighted to hear from you gentlemen.

SANDIA LABORATORIES

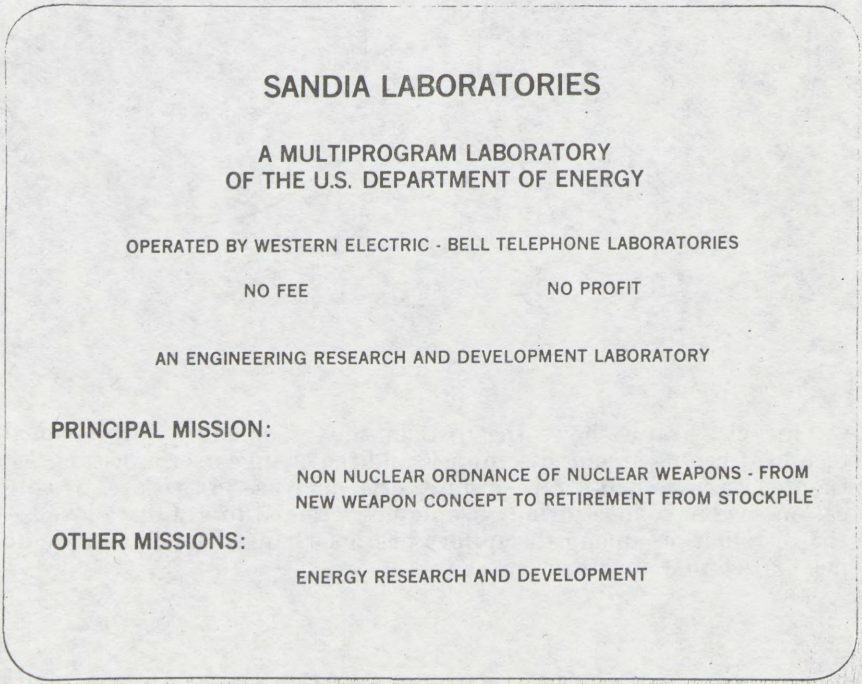
Dr. Sparks. I am not sure, Mr. Chairman, if you had a specific question or did you want——

Senator Jackson. No, just a short comment from you about anything that is on your mind. The laboratories are very important in my view.

Dr. Sparks. Thank you very much. I appreciate it.

Senator Jackson. I just want to know where we are, very briefly.

Dr. Sparks. Maybe I can make up a little time. I had intended to utilize today as a get acquainted opportunity with this committee but I know that you personally, Senator Jackson, with your background from Atomic Energy Committee days, are pretty well familiar with what we do. So I will just take a very few minutes and then make a



SANDIA LABORATORIES

A MULTIPROGRAM LABORATORY
OF THE U.S. DEPARTMENT OF ENERGY

OPERATED BY WESTERN ELECTRIC - BELL TELEPHONE LABORATORIES

NO FEE NO PROFIT

AN ENGINEERING RESEARCH AND DEVELOPMENT LABORATORY

PRINCIPAL MISSION:

NON NUCLEAR ORDNANCE OF NUCLEAR WEAPONS - FROM NEW WEAPON CONCEPT TO RETIREMENT FROM STOCKPILE

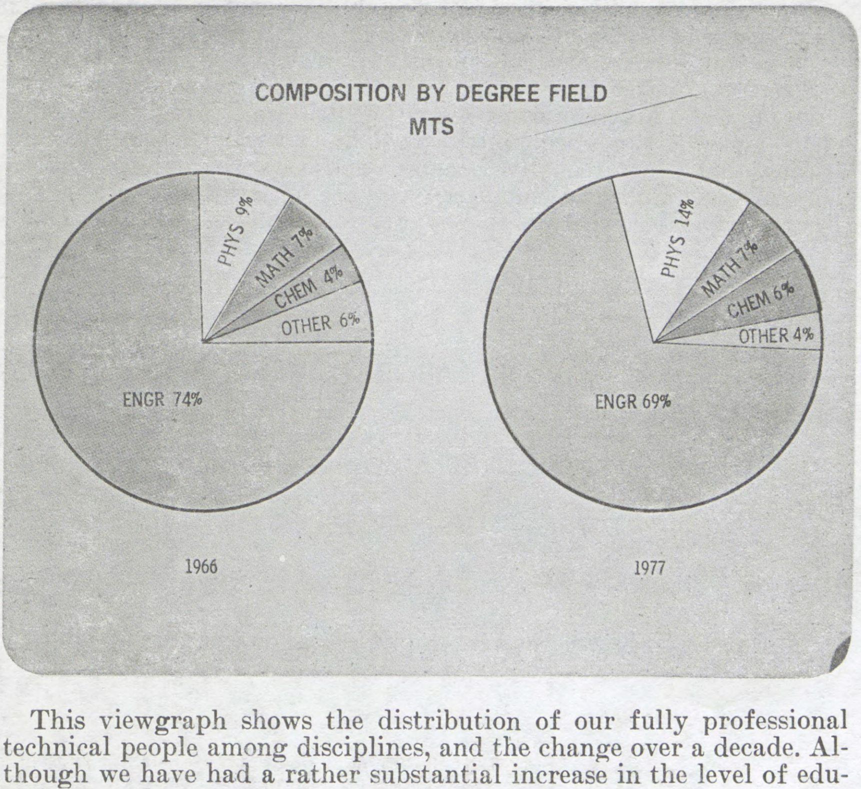
OTHER MISSIONS:

ENERGY RESEARCH AND DEVELOPMENT

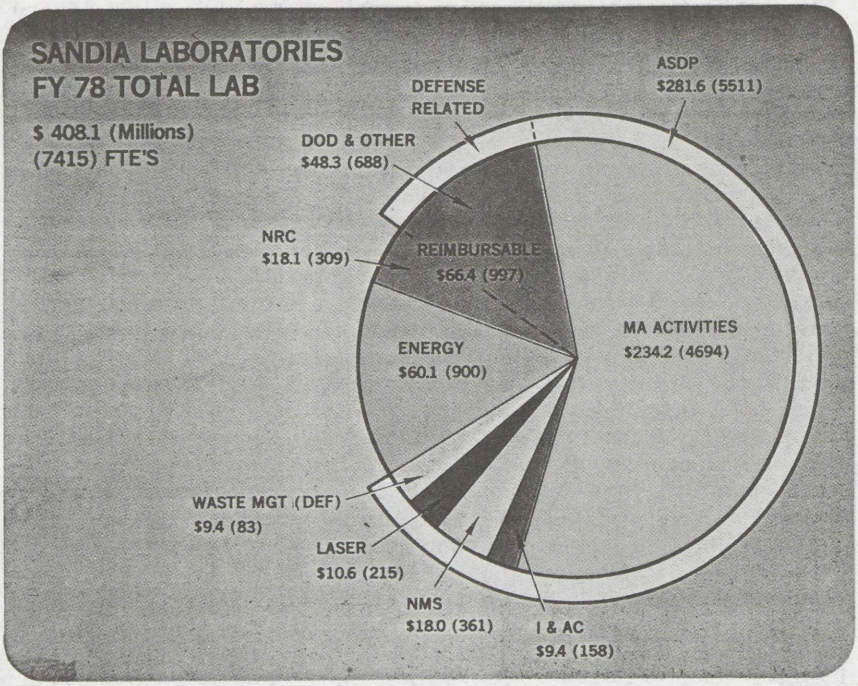
If you will put on that first viewgraph. This will remind you that Sandia is one of the three weapons laboratories. We are an engineering laboratory. I will talk a little bit about the difference between Sandia on the one hand and Los Alamos and Lawrence Livermore on the other hand. As you know, they both have an identical charter and are responsible for the nuclear explosive package. We work in a complementary way with each of those Laboratories, and our responsibilities tend to be the other things that are required to take a nuclear explosive package and turn it into a weapon.

Senator JACKSON. You are more on the engineering end of it?

Dr. SPARKS. We also have a great deal of theoretical work. All three laboratories are multidiscipline as well as multiprogram, and in addition to engineers, we have a large number of scientists. So it is a quantitative comparison, but emphasis at Sandia is on engineering as opposed to scientific things. The name that is often used to describe this nonnuclear part of the weapon is nuclear ordnance.


COMPOSITION BY DEGREE FIELD
MTS

This viewgraph shows the distribution of our fully professional technical people among disciplines, and the change over a decade. Although we have had a rather substantial increase in the level of education—we have most of our people now trained to graduate levels—the distribution among disciplines has not changed much and we do not expect that it will.



The next viewgraph shows the breakdown in a pie chart form of our 1978 budget, and the expected breakdown in 1979 is essentially the same. The activities shown around the edge of the chart in this ring shown in white indicate what we are calling Defense-related, and that includes, of course, all of the things that you heard about from General Bratton and Dr. Kerr today. But, in addition, it includes some work that we do directly for the Department of Defense. Principally, this is an extended responsibility for some of the work in the weapons program that we are already involved in. It includes some of the things that have grown out of work that we have done for the Office of Military Application—such as inertial confinement and our safeguards work and the laser fusion work which in our case involves the e-beam technology. The part in orange is the energy-related work that we do for the Department of Energy. So about three-quarters of all our activities are directly concerned with defense.

I think I will skip the rest of those and make a few general comments about the state of health of the Laboratory. We are in pretty good shape these days. We had some traumatic periods for a while during the late sixties and early seventies when we had layoffs, the staff was decreased by about 20 percent. We are stabilized now, and I think the composition of our staff, its capability, and its morale are very good.

Programmatically, as shown in this chart, we are well supported, and I think our programs are in good shape. The main concern we have right now is for our physical facilities. We, like the other laboratories, are more than 30 years old and much of what we have is wearing out. Many of our people are located in World War II temporary buildings. It is very inefficient to use buildings that are scattered around, and in recent years there is the added difficulty of trying to heat and cool these poorly constructed and separated buildings. We very badly need what we call the systems development laboratory which is currently in H.R. 11686 for $1 million in fiscal 1979. That would get us started on this building, the total estimated cost of which is $13 million. It would go a very long way toward alleviating our space problems.

The big uncertainty that hangs over all of us I think is the CTB. It would not affect Sandia's activities directly or immediately nearly so much as I am sure you will hear from the other two lab directors because the treaty presumably will not affect the continued testing of the kinds of components that we are responsible for. But, of course, the whole reason for nuclear weapons has to do with the nuclear explosive package and so the fate of that element will determine ultimately the activities in the entire weapons complex.

In the case of a test ban, one of the things that I assume and would urge to continue would be the modernization of the existing stockpile in terms of its safety and security. I know you are all familiar with the evolution of the PAL system and some of the new kinds of safety features that are now designed into our most modern weapons. That modernization activity alone I think would consume [deleted] to be totally complete.

Senator Jackson. To finish it?

Dr. Sparks. To finish it, to take the entire stockpile and to bring it up to date with all the things we know how to do right now.

Senator Jackson. Thank you, Dr. Sparks. I appreciate having that report. Your role is a very important one. I appreciate it.

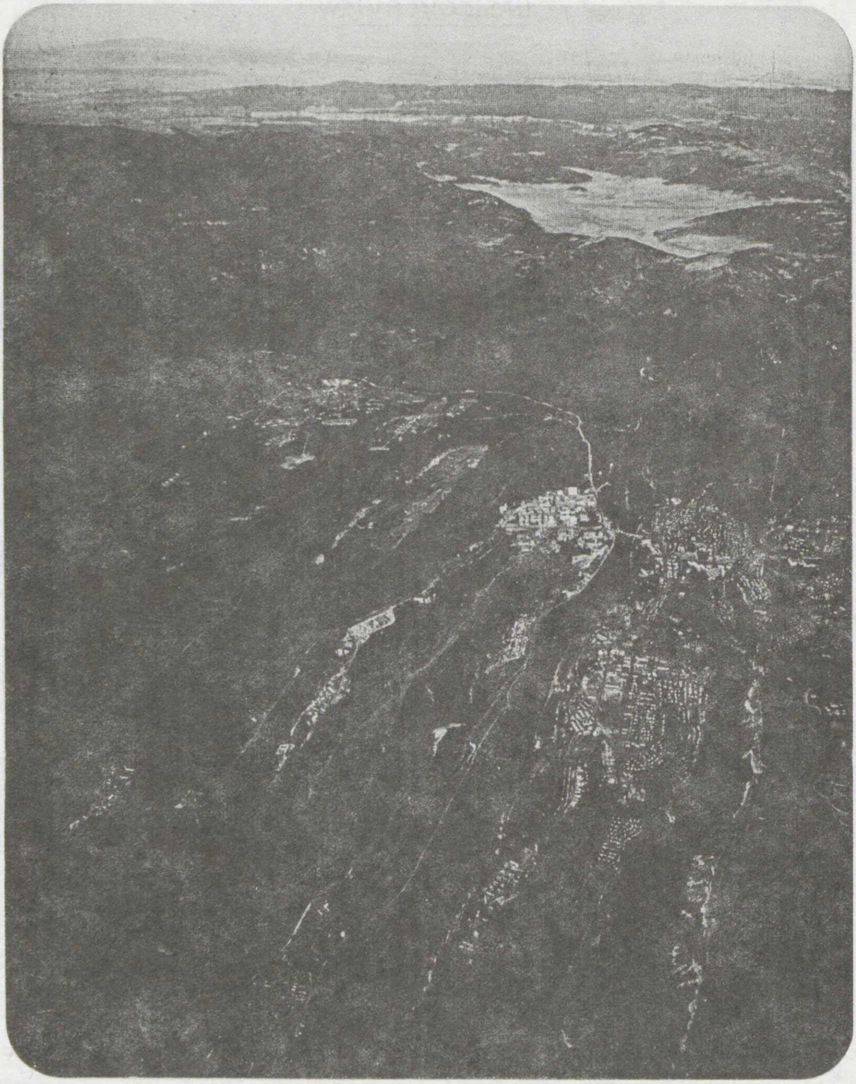
Dr. Sparks. Thank you.

Senator Jackson. We want to be kept advised of any problems that should arise at any time.

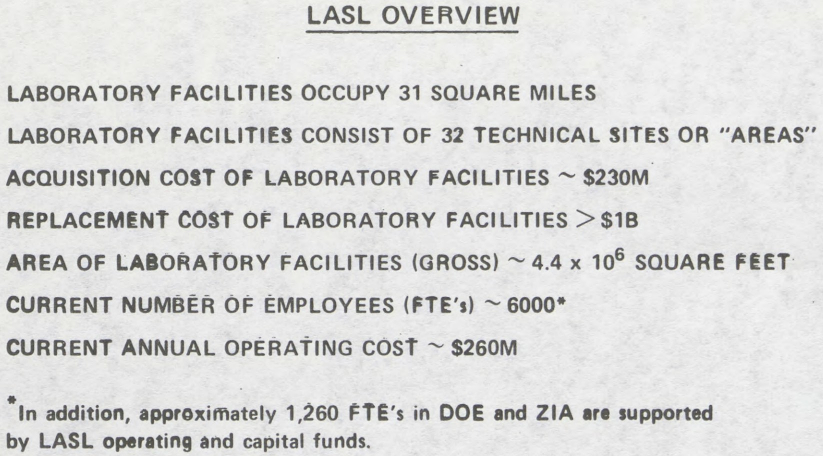
Dr. Sparks. Thank you.

LOS ALAMOS SCIENTIFIC LABORATORY

Senator Jackson. Now I ask Dr. Thorn if you would like to make any comments that might bear on concerns of the committee.



Dr. Thorn. I wish to tell you a little about the Los Alamos Scientific Laboratory and to review briefly our accomplishments in defense programs this past year. Los Alamos is situated in the mountains of northern New Mexico on many finger-like messas. You see the original townsite which was also the site of the original laboratory facilities that produced the first atomic bomb. In addition, many of our present technical facilities such as our old and new plutonium handling facilities, our high explosive machining and firing sites, and our computing and administrative sites are shown here.



LASL OVERVIEW

LABORATORY FACILITIES OCCUPY 31 SQUARE MILES

LABORATORY FACILITIES CONSIST OF 32 TECHNICAL SITES OR "AREAS"

ACQUISITION COST OF LABORATORY FACILITIES ~ $230M

REPLACEMENT COST OF LABORATORY FACILITIES > $1B

AREA OF LABORATORY FACILITIES (GROSS) ~ 4.4×10^6 SQUARE FEET

CURRENT NUMBER OF EMPLOYEES (FTE's) ~ 6000*

CURRENT ANNUAL OPERATING COST ~ $260M

*In addition, approximately 1,260 FTE's in DOE and ZIA are supported by LASL operating and capital funds.

The next viewgraph shows the statistical overview of the laboratory. As you can see, we are 6,000 employees of the University of California and 1,260 employees of Zia and DOE, working at 32 technical sites in an area of 31 square miles.

Senator JACKSON. How much of your budget is nonnuclear?

Dr. THORN. At the present time——

Senator JACKSON. I mean in terms of nonmilitary.

Dr. THORN. Forty-five percent is weapons, 55 percent is for the Assistant Secretary for Defense Programs, and the remainder is for other energy-related activities.

Senator JACKSON. OK.

LASL STAFF

FULL TIME, REGULAR EMPLOYEES

EFFECTIVE MARCH 24, 1978

	HIGHEST DEGREE			
SCIENCES	BS	MS	PhD	TOTAL
PHYSICS	81	122	591	794
CHEMISTRY	65	38	219	322
MATHEMATICS	65	54	33	152
STATISTICS	0	2	9	11
COMPUTER SCIENCE	11	14	12	37
ASTRONOMY AND ASTRO-PHYSICS	1	2	25	28
GEOLOGY AND GEOPHYSICS	12	6	24	42
METALLURGY AND CRYSTALLOGRAPHY	4	9	12	25
MD, DVM, BIOMED, BIOCHEM, BIOPHYSICS	0	9	29	38
OTHER LIFE SCIENCES	15	18	21	54
MISCELLANEOUS SCIENCE	8	1	7	16
TOTAL SCIENCES	262	275	982	1519
ENGINEERING				
MECHANICAL	145	71	43	259
CHEMICAL	40	14	15	69
ELECTRICAL, RADIO, AND ELECTRONIC	113	75	46	234
ENGINEERING PHYSICS AND NUCLEAR	9	39	73	121
CIVIL, MINING, AND ARCHITECTURAL	27	13	3	43
AERONAUTICAL	2	11	11	24
MATERIALS (CERAMICS, METALLURGY, ETC.)	12	21	13	46
OTHER (INDUST., HEALTH, MILITARY, ETC.,)	12	14	11	37
TOTAL ENGINEERING	360	258	215	833
MISC. NON-TECHNICAL STAFF MEMBERS	31	21	5	57
NON-DEGREED STAFF MEMBERS				57
TOTAL STAFF MEMBERS	653	554	1202	2466
TECHNICAL SUPPORT EMPLOYEES				2189
NON-TECHNICAL SUPPORT EMPLOYEES				1310
	TOTAL			5965

Dr. THORN. As shown here, we have a highly trained staff, educated primarily in the physical sciences, but also with a strong engineering component. We probably have more Ph.D.'s per capita than any other town in the United States.

LASL CURRENT WEAPONIZATION PROGRAMS

FY78 - FY80

- PHASE 3
  - B61-3 } AIRCRAFT-DELIVERED BOMBS
  - B61-4 }
  - W76 - Mk 4 RB, TRIDENT I SLBM
  - W78 - Mk 12A RV, MINUTEMAN III ICBM
  - W80 - AIR AND SEA LAUNCHED CRUISE MISSILES
  - W81 - STANDARD MISSILE - 2
  - B43M - AIRCRAFT-DELIVERED BOMB, REPLACE B77
- PRE-PHASE 3
  - PERSHING II
  - M-X
  - GLCM
  - Mk 500
  - HARPOON
  - TACTICAL BOMB
  - ASROC/B57
  - ASALM

Now for some of our weapon accomplishments. As you can see, we have a large number of weapon systems under engineering development. In addition we are actively working on many new systems which may soon go into the engineering development stage. We are working on the B61 Mod 3 and Mod 4. The main purpose is to retrofit this bomb with insensitive high explosive and to fit in a denial system based upon a CAT F PAL [deleted].

The insensitive HE will explode under any realistic scenario except by internationl detonation built into the system, thereby eliminating the Palomares-Thule type international incident [deleted].

[Additional information follows:]

Senator Jackson. If insensitive high explosive, IHE, is good, why not put it in all new systems—for example, the W81 and the artillery shells?

Dr. Kerr. IHE is being incorporated into most of the newer systems. Exceptions occur only in those cases where operational conditions make incorporation unnecessary [deleted].

Dr. Thorn. The Trident warhead development is essentially complete.

Senator JACKSON. Is that Trident I or Trident II?

Dr. THORN. Trident I. [Deleted.]

The Minuteman III and Mark 12–A warhead development is also nearly complete. [Deleted.]

We are also responsible for developing the cruise missile warhead, the W80. Originally intended for the SRAM as well as the ALCM and Tomahawk systems, this warhead had many compromises imposed upon it to meet the varied and often incompatible requirements of the three systems. Nevertheless we have been able to provide [deleted] satisfying low intrinsic radiation for personnel protection for use on submarines and still compatible for delivery from airplanes. [Deleted.] The Standard Missile W81 warhead [deleted]. This approach, while three inches longer than the Navy wished, results in about a $60 million savings [deleted].

Senator JACKSON. [Deleted] am I correct?

Dr. THORN. You are correct, sir.

[Deleted.]

Senator JACKSON. Right.

Dr. THORN. The B43M does not have a [deleted] of the B77 which it could replace. The modernization is intended to replace [deleted] with in insensitive HE [deleted] to update the electrical system to modern safety standards. [Deleted.] With a new parachute it can be delivered by the B–52 bomber with all options and it can be produced at a cheaper production cost. Our development of this bomb is held in abeyance now, awaiting further guidance.

Our preengineering development weapons are: Pershing II which could use the B61, or the W80, and the MK–500 which could use the Trident warhead. We also have attractive candidates for MX that have been fully tested and for the other system on the list.

Finally I would like to mention an accomplishment in the laser fusion area. About 12 days ago our eight-beam carbon dioxide laser system delivered 17 trillion watts of power in less than 1 billionth of a second in the first full power demonstration of the machine. We feel that the CO_2 laser, because of its efficiency and capabilities for repetitive operation, is a prime candidate for a fusion reactor driver.

Thank you.

Senator JACKSON. Thank you for a fine statement, Dr. Thorn Is Norris Bradbury still living in Los Alamos?

Dr. THORN. He certainly is.

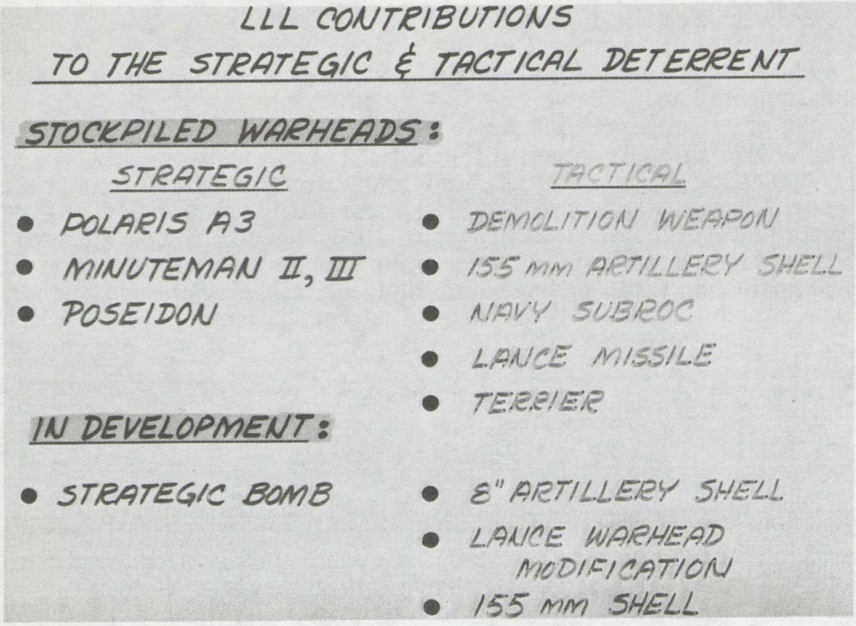
Senator JACKSON. Say hello to him.

Dr. THORN. And my boss, Dr. Agnew, is traveling in Egypt.

Senator JACKSON. Dr. Batzel would you like to comment?

LAWRENCE LIVERMORE LABORATORY

Dr. BATZEL. I know the chairman is fully familiar with the origin of the Lawrence Livermore Laboratory and so I will leave that and go on to just remind you about the laboratory's contribution to the stockpile at the present time. In the strategic area there is the Polaris A3, the Minuteman II and III, and Poseidon.



LLL CONTRIBUTIONS
TO THE STRATEGIC & TACTICAL DETERRENT

STOCKPILED WARHEADS:

STRATEGIC	TACTICAL
● POLARIS A3	● DEMOLITION WEAPON
● MINUTEMAN II, III	● 155 mm ARTILLERY SHELL
● POSEIDON	● NAVY SUBROC
	● LANCE MISSILE
	● TERRIER

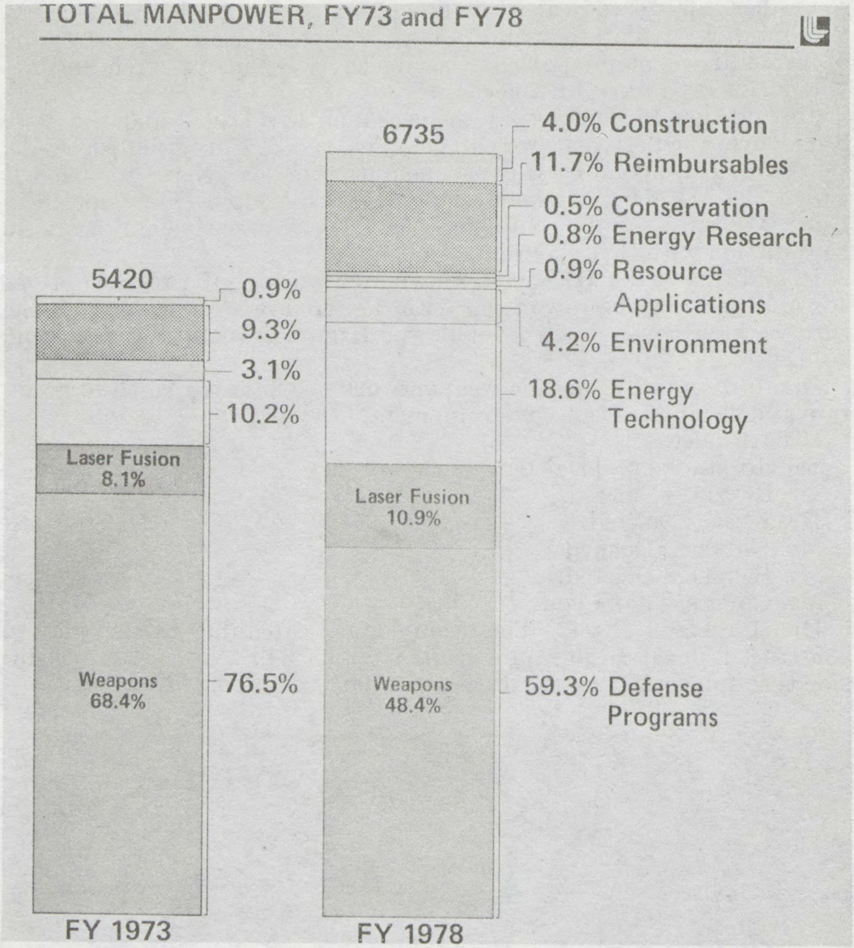
IN DEVELOPMENT:

● STRATEGIC BOMB	● 8" ARTILLERY SHELL
	● LANCE WARHEAD MODIFICATION
	● 155 mm SHELL

The laboratory has provided the strategic warheads for our strategic missile systems.

In development is the strategic bomb, B77, which we discussed in some detail this morning.

Also listed are the tactical systems. The current systems under developement again have been discussed—the Lance, W70 Mod 3, the W79 or 8-inch, and we just started work on the 155 which is a replacement for the existing artillery warhead.



If I may have the next viewgraph. This is a breakdown of our effort in the Laboratory. This shows the way the nuclear weapons effort has gone over the last 5 years. In 1973 our nuclear weapons effort was 68 percent of the Laboratory's total effort and laser fusion was 8 percent. The other programs listed made up the additional approximately 25 percent. Today the nuclear weapons part of our effort is 48 percent, defense programs total 59 percent. Thus about 40 percent of our current effort is nondefense.

Senator JACKSON. What is that percentage of nondefense?

Dr. BATZEL. It is 40 percent today.

In the last 5 years the Laboratory has grown, but as you can see the nuclear weapons effort has decreased significantly. In fact if one goes back to 1970, the nuclear weapons research and development effort in the Laboratory has decreased about 35 percent, which we found somewhat difficult to deal with. The influx of new programs, I think, stabilized the Laboratory and put us in a position to do a better job of providing a major part of the nuclear weapons research and development capability for the country.

In addition to completing the work on the Lance and the W79 8-inch over the past year, we will complete the B77 program [deleted].

We have also completed experimentation on a warhead for what is called the MK–500, a maneuvering RB. This meets Navy specifications. We successfully completed the nuclear experimental work in conjunction with that program.

In addition to the MK–500 we have been working to provide options for MX and have been working with the Air Force [deleted] to make sure we have covered a reasonable spectrum of capabilities for them.

[Deleted.]

In addition to the specific weapon work, we have managed to maintain a little bit of advanced development. [Deleted.]

[Chart deleted.]

Senator JACKSON. [Deleted.]

Dr. BATZEL. [Deleted.]

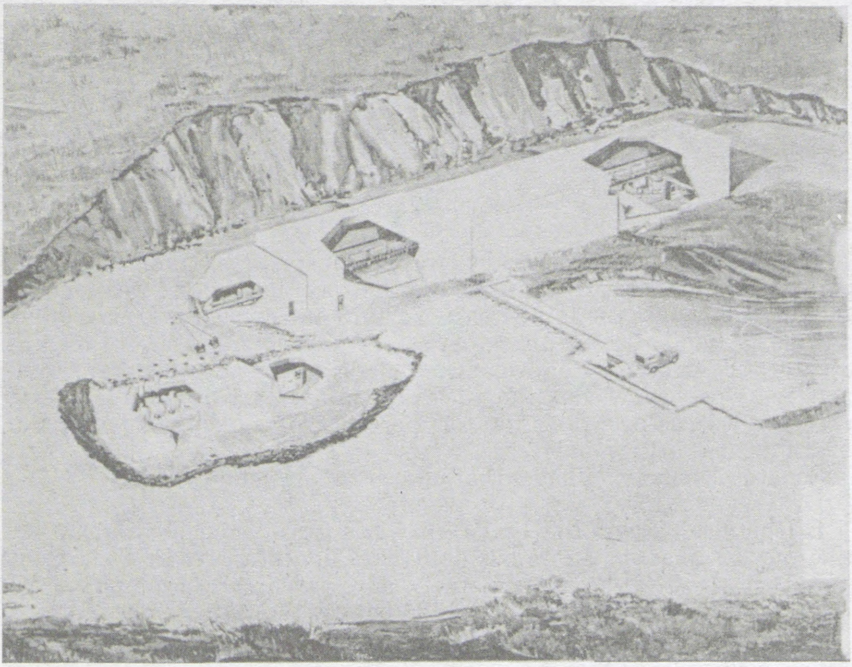
Dr. KERR. [Deleted.]

Mr. COTTER. [Deleted.]

Dr. BATZEL. [Deleted.]

Mr. COTTER. Thank you.

Dr. BATZEL. [Deleted.] The technological capability exists today to construct a flash radiography facility which will allow us to look inside that sphere and see the details of what is going on. [Deleted.]



We had included in fiscal 1978 the first step along the way toward construction of this particular facility [deleted]. Congress authorized $5 million and appropriated $3 million in fiscal 1978, the additional $7.9 million to complete the facility was not included by the OMB for fiscal 1979. I think it should have been included. I think it is important to have that kind of capability available to the weapons laboratories in order to elaborate this very important phenomena.

I make the general observation that we find it difficult to convince our people to work on the weapons program when they see a decreasing level of effort with time. We are looking forward in fiscal 1979 to an additional decrease in effort in the laboratory because of the cut in the research and development funds and test dollars.

With that I will close. Thank you.

Senator JACKSON. Thank you, Dr. Batzel. We appreciate having your statement.

I want to say to all three laboratory heads that Senator Stennis, the chairman of the full committee, has indicated his interest and that of other committee members that want to visit the laboratories and our nuclear complexes. So we will be in touch with you during the course of the year.

Thank you gentlemen very much.

SPECIAL NUCLEAR MATERIALS PRODUCTION

Now Dr. George Cunningham, if you will come forward. What I am going to do here is put your entire statement in the record, as if read, in the interest of time because we only have two or three questions and they relate also to Dr. Kerr. Your entire statement, with the charts, will go in the record.

[The prepared statement of Dr. Cunningham follows:]

PREPARED STATEMENT OF GEORGE W. CUNNINGHAM, ACTING PROGRAM DIRECTOR FOR NUCLEAR ENERGY

Mr. Chairman, members of the Subcommittee, I am pleased to appear before you to discuss the fiscal year 1979 budget for the Department of Energy's Special Nuclear Materials Production Program. The fiscal year 1979 budget request for this program is $903.9 million in budget authority, compared to $674.7 million in fiscal year 1978. There are two major subprograms under the Special Materials Production Program—the Production-Process Development activities and the Defense Waste Management activities.

PRODUCTION-PROCESS DEVELOPMENT

The objectives of the production-process development program are to:

Provide nuclear materials, except for enriched uranium, for national defense requirements;

Provide nuclear materials, except for enriched uranium, for DOE reactor systems development and research programs, as appropriate;

Receive and reprocess nonproduction fuels (Navy propulsion, research and test reactors, and others) for recovery of enriched uranium and plutonium, as appropriate;

Achieve and maintain technical capability to perform necessary process improvements and develop advanced technology to support production operations;

Allocate resources to operate and maintain facilities, consistent with production requirements, in an efficient, cost-effective, safe, secure, and environmentally-acceptable manner.

To accomplish these objectives, the program provides for the operation of three heavy water-moderated production reactors at Savannah River, South Carolina, the dual purpose (N) reactor at Richland, Washington, and related chemical processing and supporting facilities. Feed materials for the Savannah River reactors and the N-reactor at Richland are manufactured at the DOE facilities at Fernald and Ashtabula, Ohio. The Special Materials Production Program also includes receipt and reprocessing of nonproduction reactor fuels (Navy propulsion, research reactors and test reactors) at the Idaho Chemical Processing Plant at Idaho Falls, Idaho, for recovery and reuse of the remaining enriched uranium.

TABLE 1.—FISCAL YEAR 1979 OPERATING BUDGET—SPECIAL MATERIALS PRODUCTION, PRODUCTION-PROCESS DEVELOPMENT

[In thousands of dollars]

	Fiscal year 1978 estimate		Fiscal year 1979 estimate	
	Budget authority	Budget outlays	Budget authority	Budget outlays
Production [1]	284, 014	271, 629	324, 100	316, 200
Process development [2]	13, 605	12, 904	12, 400	11, 300
Total	297, 619	284, 533	336, 500	327, 500

[1] [Deleted.]

[2] Includes defense waste management.

Production, includes:

Fabrication of reactor fuel and target elements for insertion into reactors.

Operation of three heavy-water-moderated production reactors at Savannah River and the dual purpose (N) reactor at Richland.

Operation of chemical separation facilities at Savannah River and Richland to recover plutonium, tritium, and other isotopes from irradiated fuel elements.

Operation of the Idaho Chemical Processing Plant to recover enriched uranium from spent fuel elements from research, test, and Naval propulsion reactors.

Operation of plutonium conversion facilities at Richland and Savannah River.

Rework of enriched lithium compounds from retired weapons.

Preparation of deuterium and depleted uranium billets for the weapons program.

Process Development provides: research and development necessary to support production operations, including efforts on reactor safety, improved reactor fuels and processing, radiation exposure studies, environmental monitoring, scrap recovery, etc.

In regard to operating budget authority (Table 1) we are requesting an increase of $38.9 million which represents a 13.1 percent increase for the Production-Process Development Program over the fiscal year 1978 appropriations level. A significant portion of this increase is to cover inflation; the remaining increase reflects restoration of the three Savannah River reactors to full productivity with corresponding increases in fuel and target fabrication rates and critical maintenance, but decreases will be required in fuel reprocessing, scrap recovery and process development.

TABLE 2.—FISCAL YEAR 1979 BUDGET ESTIMATES—SPECIAL MATERIALS PRODUCTION, PRODUCTION-PROCESS DEVELOPMENT SUMMARY, PLANT AND CAPITAL EQUIPMENT

[In thousands of dollars]

	Project No.	Total estimated cost	Fiscal year 1979 budget authority
Plant—New budget authority for construction projects—New fiscal year 1979 line item projects:			
1. Utilities replacement and expansion, ID	79–7–h	10, 500	10, 500
2. Transmission and distribution system upgrading, RL	79–7–i	14, 000	14, 000
3. Pollutant discharge elimination, SR	79–7–j	9, 000	9, 000
4. General plant projects	79–6	16, 200	16, 200
5. Plant engineering and design, various locations	79–8	1, 500	1, 500
Total for new fiscal year 1979 line items			5i, 200
Capital equipment (total)			32, 000

The capital equipment budget increases $3.0 million or 10.3 percent over the fiscal year 1978 amount of $29.0 million. This level of effort provides for essential equipment replacement and is shown in Table 2. As you know, the largest proportion of the facilities was built and has been in service since the 1940's and 1950's. This being the case, maintenance costs and worn-out or obsolete equipment replacement costs continue to require increasing funding levels to maintain the standards of safety and health applied to these facilities and operations.

In recent years, the production program has remained relatively stable. However, new criteria and constraints have been introduced into this program which contribute substantially to increased annual funding levels. These activities include such items as occupational and public health and safety, environmental protection, housekeeping, and safeguards and security. While these activities have obvious benefits, the costs they represent do not contribute directly to special materials production. In addition, as the production facilities reach the end of their useful lives, there will be major costs associated with decommissioning and decontamination.

CONSTRUCTION PROJECTS

Turning now to construction projects, I would like to identify four projects which are of special importance to this program. These are 77–13–a, Fluorinel Dissolution Process and Fuel Receiving Improvements at Idaho Chemical Processing Plant; 79–7–j. Pollutant Discharge Elimination, Savannah River; 79–7–i. Transmission and Distribution System Upgrading at Richland; and, 79–7–h. Utilities Replacement and Expansion at Idaho. The Fluorinel project at Idaho will provide facilities to receive and process fuels from Naval and DOE sources. The purpose of the Pollutant Discharge Elimination project at South Carolina is to bring the Savannah River site into compliance with the Federal Water Pollution Control Act of 1972. The purpose of the Transmission and Distribution System Upgrading project is to upgrade or replace power lines which have been in service for more than 30 years. The purpose of the Utilities Replacement and Expansion project is to provide the necessary utilities for the Fluorinel project addition to the ICPP, as well as expansion of existing systems to meet projected plant requirements.

All these projects are required to provide needed production capability, assure safe and reliable operations or satisfy legislated requirements. Line item construction projects proposed for fiscal year 1979 are shown in Table 2. Table 3 details the funds required in fiscal year 1979 for phase-funded projects initiated in prior years.

TABLE 3.—FISCAL YEAR 1979 BUDGET ESTIMATES—SPECIAL MATERIALS PRODUCTION, PRODUCTION-PROCESS DEVELOPMENT PLANT

[In thousands of dollars]

	Project No.	Total estimated cost	Fiscal year 1979 budget authority
Additional fiscal year 1979 funding—Projects approved in prior years:			
1. Environmental, safety, and security improvements to waste management and materials processing facilities, Richland, Wash	78–18–e	40, 000	30, 000
2. Fluorinel dissolution process and fuel receiving improvements, Idaho Chemical Processing Plant, Idaho National Engineering Laboratory, Idaho	77–13–a	115, 400	100, 400
3. Safeguards and security upgrading, production facilities, multiple sites	77–13–g	20, 200	3, 800
Total fiscal year 1979 funding projects approved in prior years			134, 200

Now, I will describe in greater detail the production activities which are supported by this request.

PRODUCTION OPERATIONS

At Richland, the slightly-enriched uranium billets received from Ashtabula, Ohio, are processed into zirconium-clad fuel elements for the N-reactor. The N-reactor is planned to be operated to produce fuel-grade (12 percent Pu–240) plutonium and by-product steam. This plutonium product must be blended to a lower Pu–240 assay for weapons purposes. At present, the spent fuel is not reprocessed, but is stored at Richland for future use. The by-product steam is utilized by the Washington Public Power Supply System (WPPSS) in its power generating station located adjacent to the reactor. The present contract between DOE and WPPSS, renewed in fiscal year 1977, calls for DOE to provide WPPSS annually with steam availability equivalent to 4.5 billion kwhe for revenues of $205.5 million over five years, ending in June 1983. The annual steam revenues in fiscal year 1979 are expected to be about $34 million. These funds will be returned directly to the Treasury and are not included in our revenue estimates.

At Savannah River, depleted uranium fuel cores from the Fernald Materials Production Center are clad with aluminum and irradiated in the production reactors for plutonium production. Enriched uranium received from Oak Ridge is processed into aluminum-clad reactor fuel elements. Enriched lithium from Y–12 is processed into target elements for tritium production. Each Savannah River reactor has the capability to produce weapon-grade plutonium and tritium, as well as other useful isotopes for weapons research and development. The major proportion of the output of the Savannah River reactors is devoted to the production of plutonium and tritium for weapons. DOE collaborates with the DOD in arriving at projected nuclear weapon stockpiles and build programs approved by the President, and from which are derived special nuclear materials requirements. Other products, such as plutonium–238, uranium–233, and transplutonium isotopes (e.g., Cf.,–252), are also produced primarily for such nonweapons use as reactor development space applications, and in the field of medicine. In fiscal year 1979, plutonium oxide (PuO_2) fuel production and plutonium scrap recovery are to be minimized.

Consistent with projected requirements for fiscal year 1979, N-reactor operations at Richland are scheduled to continue at essentially the same level as in fiscal year 1978, but the three Savannah River reactors are scheduled to resume operation at full productivity with corresponding increases in fuel and target fabrication rates. The increase in funding requested for fiscal year 1979 reactor operations reflects this restored level of operation, as well as increases in the cost of labor, materials, and energy resources.

At the Fernald Materials Production Center, feed operations in support of the diffusion plant cascade were terminated in fiscal year 1977. As a result, the share of Fernald overhead, formerly funded by the enrichment program, is now totally funded by the Materials Production Program, resulting in a large cost increase for this program, without a significant increase in feed materials output to the production reactor sites.

The Purex fuel reprocessing plant at Richland was placed in standby during 1972 because of the limited availability of fuel to be processed. The Purex reprocessing facility and equipment will be brought to a state of ready-availability in fiscal year 1979, in which condition only the training of supplementary operating personnel is required to achieve operation. Maintenance and operability testing of key processing equipment and systems will be completed. However, training of personnel and startup testing may require an additional year before "hot" operation can be achieved. Installation will also be underway on a facility to convert liquid plutonium nitrate to oxide and to upgrade instrumentation and equipment to monitor effluents more effectively.

Operations for chemical reprocessing of irradiated fuel will be limited due to funding decreases in fiscal year 1979. The budget provides for limited operation and maintenance of two reprocessing plants at Savannah River and one at Idaho for separation, decontamination, and purification of nuclear materials. Reprocessing of Rover nuclear rocket fuel (2,800 kg) was delayed, due to construction difficulties in completing that facility at Idaho. Hot startup of the Rover reprocessing facility will begin in fiscal year 1980. Other irradiated reactor fuel elements not associated with production of nuclear materials are also processed to recover the residual uranium at the Idaho Chemical Processing Plant (ICPP). These fuels are from Naval propulsion reactors, research reactors, and test reactors. They contain uranium highly enriched in U–235. The recovered highly-enriched uranium is used as fuel in the Savannah River reactors.

DEFENSE WASTE MANAGEMENT

I would like to emphasize at the outset that DOE considers the development and demonstration of acceptable methods of waste disposal as a matter of highest priority. This priority applies equally to wastes generated as a result of our national security activities and to wastes which result from civilian nuclear energy. A Department of Energy task force has assessed all aspects of waste management and has formulated its recommendations. The Committee has been furnished copies of the report.

The Department of Energy Task Force Report is a first element in the considerations of a Presidential Interagency Task Force on Nuclear Waste Management chaired by Dr. James Schlesinger. The other agencies which are represented by policy level executives are: Department of State, Department of Interior, Department of Transportation, Council on Environmental Quality, Environmental Protection Agency, Office of Management and Budget, and the relevant offices of the White House. The Nuclear Regulatory Commission attends as a non-voting participant. The Task Force is to recommend an Administration policy to the President by October 1, 1978.

There is, as you know, a major waste management task presented by the accumulated waste from the national defense program. The technology for waste management can be used for either defense or commercial waste, and therefore these programs are closely coordinated to assure cross fertilization and to eliminate duplication. My remarks today will concentrate on the status and plans for the management of defense waste.

The objectives of our defense waste management program are shown on Table 4.

TABLE 4.—OBJECTIVES OF DEFENSE WASTE MANAGEMENT

1. To provide for the confinement of radioactive wastes for the protection of public health and safety and to meet and maintain requirements of applicable laws and regulations;
2. To develop and demonstrate, at the earliest possible date, the technology for safe disposition of nuclear waste to assure public confidence; and
3. To provide at the earliest practical date, considering budgetary and technical constraints, long-term management practices for DOE radioactive waste inventories that places minimal reliance on surveillance and maintenance.

The total budget request for the Defense Waste Management program is $350.0 million in budget authority and $281.6 million in budget outlays. The budget authority request represents an increase of $62.3 million, or 22 percent over the fiscal year 1978 appropriation (Table 5).

TABLE 5.—DEFENSE WASTE MANAGEMENT BUDGET AUTHORITY

[In millions of dollars]

	Fiscal year—	
	1978	1979
Operating:		
Interim waste management		78.4
Defense radioactive waste R. & D.		41.4
Terminal storage		20.5
Storage operations and related activities		24.7
Total, operating	123.3	165.0
Capital equipment	7.0	8.0
Plant:		
79-7-d Waste management facilities SR	0	75.0
79-8 Plant engineering and design	0	12.0
78-18-a High-level waste storage and waste management facility, RL	18.0	9.0
78-18-b High-level waste storage facilities, SR	16.0	26.0
77-13-d High-level waste storage and waste management facility, SR	27.0	4.0
77-13-f Waste isolation pilot plant, MM	22.0	40.0
75-1-c New waste calcining facility, ID	18.5	10.0
75-7-c Intermediate-level waste management facility, ORNL	0	1.0
Total, plant		177.0
Total, defense waste management		350.0

INTERIM HIGH-LEVEL WASTE STORAGE

The interim high-level waste management program treats the radioactive waste generated in the chemical separations facilities at Richland, Savannah River, and Idaho. Although the programs at these sites differ in approach and waste characteristics, they provide safe interim storage of the waste in a way that is compatible with the alternatives under consideration for the long-term management of the waste and that minimizes the potential for release to the environment. The strategy to accomplish this is to (1) reduce the quantity of waste stored as liquid to the extent possible by evaporation at Richland and Savannah River and by calcination at Idaho, and (2) improve the waste containment facilities and limit, as much as possible, operationally required storage of liquid waste to high integrity tanks of advanced design.

The fiscal year 1979 budget provides for continuation of the efforts to reduce the waste volume and convert liquid waste to safer less mobile forms. The program to retire old waste storage and handling facilities from active service continued in fiscal year 1978. The goal of this program is to have all of the old single-shell waste tanks at Richland retired from active liquid service by 1981 and to complete the replacement of the old waste storage tanks at Savannah River by 1986. To support this effort the construction of improved interim waste storage and handling facilities including new double-shell tanks at Richland and Savannah River and new calcine storage bins at Idaho continued in fiscal year 1978.

The fiscal year 1979 budget will continue the program at Richland to retire old single-shell waste storage tanks from active liquid storage service. Operations will continue to move waste from the old waste storage tanks to new double-shell tanks at Savannah River. The program to calcine liquid waste will continue at Idaho. The New Waste Calcining Facility will start up in fiscal year 1980. At all sites the construction programs will be continued to improve the waste management systems including construction of new waste storage tanks and bins.

LONG-TERM HIGH-LEVEL DEFENSE WASTE DISPOSAL (R. & D.)

This program provides for required research, development, equipment tests, engineering evaluations, and conceptual designs for the long-term management of the inventories and currently generated radioactive wastes from defense-related programs.

During fiscal year 1977, Technical Alternative Documents (TAD) for the long-term management of defense-related high-level waste at Savannah River, Idaho, and Richland were published as a basis for preparing programmatic environmental impact statements (EIS) and to inform the public of the alternatives available at each site. Preparation of these programmatic EISs was initiated in fiscal year 1977 for Savannah River and in fiscal year 1978 for Idaho and Richland. These documents will be completed in draft in fiscal year 1978 (Savannah River) and fiscal year 1979 (Idaho and Richland). Final documents will be completed approximately one year later. During fiscal year 1978, the safety of continued interim storage of solidified high-level waste in Richland tanks will be reassessed and reported. In fiscal year 1979, a reference process will be selected from among the alternatives for the long-term management of Savannah River high-level radioactive waste.

The R & D program for transuranic-contaminated solid waste has the primary objective to develop and demonstrate by fiscal year 1981 solid waste treatment methods (incineration, immobilization, etc.) required to meet Federal repository acceptance criteria.

During fiscal year 1978, testing of three prototype-scale transuranium-contaminated solid waste treatment systems (Cyclone Drum Incinerator, Controlled Air Incinerator, Fluidized-Bed Incinerator, and Acid Digestion) will continue or be initiated, and radioactive tests begun if warranted. These tests will be completed and documented in fiscal year 1979. Emphasis will be placed on the immobilization of transuranium (TRU), other solids, and volatile wastes.

The airborne waste program is focused largely on removal and fixation of plutonium particulates and tritium from waste streams to assure DOE accommodation of new Environmental Protection Agency (EPA) emission regulations and to reduce the volume of waste going to storage. Work is also underway on processes to immobilize krypton-85, iodine-129, and carbon-14 for long-term storage.

Terminal Storage—Waste Isolation Pilot Plant (WIPP)

The Waste Isolation Pilot Plant (WIPP) project for which a site is being investigated near Carlsbad, New Mexico, will provide a respository in a deep salt formation for disposal of low-level defense wastes containing transuranium elements and as a facility for experiments with various high-level wastes forms in an actual repository environment. Completion on this facility is scheduled for 1984 (table 6).

Table 6

WASTE ISOLATION PILOT PLANT MAJOR MILESTONES

● CONFIRM SITE	FY 1978
● SUBMIT ER&PSAR IN SUPPORT OF NRC LICENSE APPLICATION	FY 1979
● COMPLETE ACQUISITION OF ALL GAS, OIL AND MINERAL LEASE RIGHTS ON WIPP SITE	FY 1980
● START FACILITY CONSTRUCTION	FY 1981
● COMPLETE FACILITY CONSTRUCTION	FY 1984
● START WIPP OPERATION	FY 1985

A major increase over fiscal year 1978 is in support of the terminal storage program. Operating costs are to increase by about $9 million in order to support the scheduled work on WIPP. A total of $40 million in construction funds is being requested for A–E work, long-lead time procurement and land acquisition for the WIPP.

We are planning to request Nuclear Regulatory Commission (NRC) licensing of the operation of WIPP. Activities will continue to support the preparation and issuance of a final environmental impact statement and preliminary safety analysis report for the WIPP. Such activities include rock properties and mechanics studies, thermal and structural analysis, system analysis, nuclide migration, and transport studies. In addition, environmental baseline monitoring and development of special equipment and preparation of waste form and acceptance criteria and operations criteria will continue to support the future operations of the WIPP. In conjunction with this project, we will continue to acquire the necessary land, oil, gas, and mineral rights to protect the proposed site from development activities which might jeopardize its suitability.

Senator Jackson. I want to ask both Dr. Cunningham and Dr. Kerr four questions.

I have a note from the press that the arms control community now is talking about possible cutoff of production of special nuclear material. I want to ask each of you what the effect of such a cutoff would be on our weapons program. I don't think it is going to happen right away, but I mean it has been discussed.

Dr. Kerr. Let me start by answering in terms of what the effect would be on the weapons program itself.

To start with, should we immediately cease production of fissionable material for weapons? [Deleted.]

If you ask what kind of stockpile would you have in the future if we were to face a production cutoff, my answer has to be there are hundreds of possibilities. [Deleted.]

The other concerns we have had with respect to this question in working with the interagency group now considering it have to do more with compliance. It is our position that one could not verify compliance with a cutoff of producing fissionable material of this sort unless one were to have access to every reactor facility in the Soviet Union.

Senator JACKSON. The verification problem would be nothing short of horrendous would it not?

Dr. KERR. Yes, sir, that is correct.

[Deleted.]

Senator JACKSON. [Deleted.]

Dr. KERR. [Deleted.]

Senator JACKSON. Is there any way to verify the compliance of such a cutoff?

Dr. KERR. No, sir.

Senator JACKSON. Dr. Cunningham, do you wish to comment?

Dr. CUNNINGHAM. Yes, sir, I might make one comment, Mr. Chairman.

[Chart deleted.]

The black line there is our actual supply of special weapons material, the dotted line is the demand. This is for the Presidentially-approved stockpile through 1985. [Deleted.]

Senator JACKSON. I wanted to ask each of you, was DOD or Department of Energy involved in any kind of an interagency study on this proposed cutoff?

Dr. KERR. We were not involved in the initial proposal. The New York Times article was correct in that. We are presently both involved in an interagency study due to be completed in the near future with regard to this initiative.

Senator JACKSON. Would you be able to supply that study or the result to this committee so we will have some idea of what the preliminary findings are?

Dr. KERR. We would certainly make every effort to do so. We can certainly provide our input to that study to you when it is completed.

Senator JACKSON. Well, we would like to have it. I think that will be useful.

Mr. Cotter.

DOE/WEAPONS MANAGEMENT

Mr. COTTER. Dr. Kerr, I would like to give you four or five more questions for the record on management aspects which you can provide later. These have to do with the points that were raised in last year's report on your financial plans as to programing and the point on getting the Congress into the decisionmaking process on the weapons that are about to go into advanced development. Do you recall the questions in the report?

If you can provide those for the record.

Dr. KERR. We will be pleased to do that.

[The questions with answers supplied follow:]

Question. In the fiscal year 1978 authorization report you were requested to submit an orderly financial plan on modernization of equipment and a management procedure which would insure that funds authorized for national defense programs be used for that purpose. Could you give us some detail on what you have done to meet this request?

Answer. An extensive review of the physical condition and technological status of capital equipment and utilities at the weapons production plants was completed in October 1977. The results of this review indicated a need for substantial additional funding to bring these plants to an acceptable level of physical condition and technological capability. A review of the weapons laboratories and the Nevada Test Site and associated facilities is currently underway and will be completed shortly. We are giving this problem priority consideration in developing our fiscal year 1980 budget request.

DOE-wide procedures are currently being developed to assure the use of defense funds as authorized by the Congress.

Question. Last year the Committee noted with some concern that coordination between DOD and ERDA, now DOE, was not as close as these important and costly programs would require. Could you give us a progress report on how you are dealing with this and what you have done to improve coordination?

Answer. The DOE weapons program budget submission is structured to be consistent with the annual Joint DOD/DOE Memorandum to the President for the Nuclear Weapons Stockpile. We are currently negotiating with the DOD on an agreement which would provide for recognition of changes in the DOD requirements which occur subsequent to the preparation of the Joint DOD/DOE Memorandum and those DOD program changes which occur late in the calendar year subsequent to submission of the DOE budget. Furthermore, procedures have been established to assure that the appropriate Congressional committees are advised of all significant changes that occur subsequent to submission of the DOE budget.

Question. We also noted last year that the construction programming did not appear to be on a sound basis. Could you tell us what you are doing to acknowledge initial architectural and engineering studies prior to full funding of construction projects?

Answer. We are requesting $10 million under Project 79–8, Plant Engineering and Design, Various Locations, to implement the new procedures for construction projects. These funds will be used for Titles I and II design of the highest priority projects to be considered for authorization in fiscal year 1981. This will permit us to fully implement the new procedures without an interruption since the fiscal year 1979 funding will not be available until after the Department's fiscal year 1980 budget has been submitted to the OMB.

Question. The Committee strongly proposed that the Congress be involved in decisions on committing weapons to full-scale development. I believe that if there was a more conscious joint decision on these aspects, some of the problems we have encountered on the neutron bomb and the B77 might have been avoided. What procedures have you and the Defense Department developed to get us into the decision process?

Answer. Each year in the budget submitted to Congress we identify those weapons that have gone into full-scale development during the year. We also provide information on those systems anticipated to be going into full-scale development during the budget year. In the future, we will formally advise the appropriate committees as soon as DOE and DOD have reached an agreement committing a weapon to full-scale development at the time that decision is made.

Question. Your request for engineering design funds is $10 million. Normally, architectural/engineering costs are about 6 percent of construction costs. With the sophistication of DOE facilities, shouldn't that percentage be higher? Say 8 to 10 percent?

Answer. The $10 million requested for engineering design under Project 79–8 represents about 8 percent of the total costs of the projects being designed. Subsequent to the fiscal year 1979 budget submittal, our field offices have had the opportunity to identify more fully these costs. Our current estimates are that approximately 10 percent of the total project costs will be required for Titles I and II design.

WAR RESERVE NEW PRODUCTION

Senator THURMOND. Dr. Kerr, we might save a few minutes here while Senator Jackson is out. Would you elaborate on the requirements for the increase in the operating category for the production of nuclear weapons as it applies to new war reserve weapons?

Dr. KERR. Yes, sir, I think if we go back to one of our earlier charts it might graphically indicate [deleted] deliveries that we expect to make in terms of new production.

[Deleted.]

Senator THURMOND. Thank you.

WEAPONS RETIREMENT

Dr. Kerr, how are retired weapons disposed of to insure complete safety?

Dr. KERR. Weapons are—I choose another word, sir. We retire them and we recycle them in effect. They are taken to our Pantex facility in Amarillo, Tex., where they are disassembled, and the fissionable material elements in particular are then reused in the production of new weapons. They are done within the same facilities where we construct our new production, and the operation is subject to the same safety and security requirements as our new war reserve production, including transportation.

CAPITAL EQUIPMENT

Senator THURMOND. Dr. Kerr, in what areas are your various needs for capital equipment not related to construction?

Dr. KERR. Our principal needs in capital equipment refer at the present time to machine tools and certain other elements required for new production. We also have some requirements for equipment at our weapons laboratories, in particular, facilities to do diagnostics of hydrodynamics experiments, for example.

Dr. CUNNINGHAM. I might also add that we need continued equipment funding for the production facilities. As you know, most of our production facilities have been in operation since the 1940's; and it is necesary to continue upgrading and maintaining those facilities.

Senator THURMOND. Thank you.

Have you established a plan for future years or is this plan to be developed soon?

Dr. KERR. We are developing a plan in response to the fiscal year 1978 authorization report. We are conducting an extensive review of the physical condition in technology status of capital equipment and utilities at the production plants. The first phase of that study was completed in October of 1977. We are now reviewing the weapons laboratories and the Nevada Test Site for their requirements and expect to complete that study at the end of this month. We should be able to provide the Congress the results of these studies by June of 1978.

We intend to request additional funds beginning with the fiscal 1980 budget for the purpose of upgrading these facilities.

INTELLIGENCE AND VERIFICATION TECHNOLOGY

Senator THURMOND. Dr. Kerr, I am glad to see that you have set up a separate budget for intelligence and verification of technology and thereby given new importance to this activity. Would SALT II possibly lead us into new areas of activity for this program?

Dr. KERR. Our intelligence and verification technology is directed more toward treaties like the Limited Test Ban Treaty, the Threshold Test Ban Treaty, and a prospective complete or comprehensive test ban treaty. We are not directly involved in SALT verification. Our activities involve, for example, the provision of instrumentation to satellites that are used for nuclear test detection. We are also investing in seismic detection instrumentation and analytic techniques, so the answer to your direct question is no, sir, and it is because we are not specifically involved in the SALT verification.

Senator THURMOND. Shall I continue?

Senator JACKSON. Whatever you wish. I think we have Admiral Rickover waiting, and I thought maybe—if you want to get into some new areas, because we have covered, I think, most of it, Senator.

Senator THURMOND. Do you want me to ask the questions now or later?

Senator JACKSON. I think we have finished this part. Admiral Rickover is next.

Senator THURMOND. Are these gentlemen going to wait?

Senator JACKSON. No; I thought we would excuse them.

Go ahead if you wish.

SAVANNAH RIVER REACTORS

Senator THURMOND. Dr. Cunningham, what is the schedule for the restoration of three Savannah River reactors to full productivity?

Dr. CUNNINGHAM. In the 1979 budget, we expect to operate all three reactors at full capacity.

Senator THURMOND. How much of the $38.9 million will go for this purpose?

Senator JACKSON. Off the record.

[Discussion off the record.]

Dr. CUNNINGHAM. It will require $6 million more to bring them up to full productivity in 1979.

Senator THURMOND. When do you feel the pollutant discharge elimination project at the South Carolina plant will bring the Savannah River site into compliance with the Water Pollution Control Act of 1972?

Dr. CUNNINGHAM. The pollutant discharge elimination project is scheduled to be completed by the summer of 1981.

Senator THURMOND. Thank you.

Dr. Cunningham, you stated in your prepared remarks that operations for chemical processing of irradiated fuel will be limited due to funding decreases in fiscal year 1979. How did these decreases come about?

Dr. CUNNINGHAM. Well, the decreases are with regard to the overall production capacity. We felt that it was more important to take the three reactors and bring them back to full production and thereby reduce the reprocessing capabilities at Savannah River.

Senator THURMOND. Now what would be the effect of the limited operation and maintenance of the reprocessing plants in Idaho and South Carolina for separation, decontamination, and purification of the nuclear materials?

Dr. CUNNINGHAM. We expect to maintain the capabilities in both places with regard to reprocessing. This involves both the maintenance and the upkeep of the equipment and the facilities as well to assure safe operations.

WASTE MANAGEMENT

Senator THURMOND. As you know, there is continuing concern relative to the Department's waste management program. What risks go with the increased emphasis on using evaporation to reduce liquid wastes?

Dr. CUNNINGHAM. Well, with regard to the risks, we believe that this is actually an improvement in the waste management techniques. It does concentrate the material somewhat, resulting in higher radioactivity. On the other hand, it reduces the volume, and thereby we believe makes our overall waste management problem more manageable.

Senator THURMOND. I believe you also plan to improve waste containment facilities?

Dr. CUNNINGHAM. Yes, sir.

Senator THURMOND. Is there any plan to transfer waste presently stored to better facilities, or is your plan limited to new waste?

Dr. CUNNINGHAM. No, sir, Senator. We are completing the construction of new double-walled containers for the high level liquid waste, and we are in the process of transferring materials to those new tanks as rapidly as possible. We are also reducing the use of the old tanks and moving that material into the new tanks very rapidly.

Senator THURMOND. When will the waste program documents for the Savannah River be made public?

Dr. CUNNINGHAM. I believe the Savannah River programmatic environmental impact statements will be available for the public by the end of the year.

Senator THURMOND. I thank both of the gentlemen.

Dr. CUNNINGHAM. Thank you.

Senator THURMOND. Thank you, Mr. Chairman.

Senator JACKSON. Thank you, Senator Thurmond.

Thank you, gentlemen. It has been very helpful this morning. We appreciate your responses to the questions. We will go through this matter very faithfully. Thank you again.

Dr. KERR. Thank you, sir.

Senator JACKSON. The Chair will declare a recess for 3 or 4 minutes.

[A brief recess was taken.]

STATEMENT OF ADM. H. G. RICKOVER, U.S. NAVY, DIRECTOR, NAVAL NUCLEAR PROPULSION PROGRAM, ACCOMPANIED BY W. WEGNER, T. L. FOSTER, AND D. T. LEIGHTON

PREPARED STATEMENT OF ADM. H. G. RICKOVER, DIRECTOR, DIVISION OF NAVAL REACTORS, DEPARTMENT OF ENERGY

Mr. Chairman, I deeply appreciate this opportunity to state my views concerning the Department of Energy Naval Reactors Development Program as it affects the Naval Nuclear Propulsion Program.

INTRODUCTION

The Naval Nuclear Propulsion Program is a joint program of the Department of Energy and the Department of the Navy. Consequently, in the Department of Energy I am Director of the Division of Naval Reactors, and in the Navy I am the Deputy Commander for Nuclear Propulsion, Naval Sea Systems Command. By combining the Navy and Department of Energy responsibilities for naval nuclear propulsion under one organization duplication of programs and resources is eliminated, and we are able to maintain close coordination of technical work.

The naval nuclear propulsion work funded by the Department of Energy provides for the research and development of nuclear reactors for warships. In this regard, the Division of Naval Reactors in the Department of Energy is responsible for reactor plant research, design, development and health and safety matters relating to naval nuclear propulsion plants including construction, testing and maintenance of land prototypes. Within the Department of Energy I am also responsible for the Water Cooled Breeder Reactor Program, a civilian reactor development program.

The Department of the Navy is responsible for the military application of nuclear propulsion including construction, operation and maintenance of nuclear powered ships, and for the development of the non-reactor portions of the ships' propulsion plants. Authorization for this Navy funded work is under the cognizance of other subcommittees of the Senate Armed Services Committee.

The joint Naval Nuclear Propulsion Program involves many activities, including two Department of Energy-owned laboratories where research and development work is performed, various land prototypes owned by the Department of Energy, reactor component manufacturing plants owned by the private sector, and shipyards, both private and Naval, where nuclear ships are designed, built, and overhauled.

Since its inception, the nuclear Navy has grown from the world's first nuclear powered ship, the submarine U.S.S. *Nautilus*, to the current fleet of 122 warships including 41 ballistic missile submarines, 71 attack submarines, 3 aircraft carriers, and 7 cruisers. These ships have steamed a total of more than 37 million miles. In addition to the ships in operation, 7 Trident ballistic missile submarines, 25 *Los Angeles* Class attack submarines, 1 *Nimitz* Class carrier, and 2 *Virginia* Class cruisers have been authorized for construction. The Navy also operates a deep submergence, nuclear powered research submarine, the NR–1.

The Naval Reactors program is responsible for more operating reactors than the combined total of all U.S. civilian power reactors. Altogether, there are 148 operating naval reactors, which have accumulated over 1600 reactor years of operating experience. In the twenty-five years since the *Nautilus* land-prototype first operated, there has never been an accident involving a naval reactor nor has there been any release of radioactivity from the Naval Reactors Program which has had a significant effect on the environment.

The goal of the Naval Nuclear Propulsion Program is the design, development, and support of nuclear propulsion plants and reactor cores over a wide range of configurations and power ratings to meet the Navy's various military requirements for the nation's defense.

Naval Reactors Development effort involves design and development of improved naval nuclear propulsion plants and reactor cores having high reliability, minimum complexity, and long fuel life. Particular emphasis is placed on obtaining advanced longer-lived cores necessary for increased ship performance and availability. By reducing the number of refuelings we are able to reduce costs, increase the availability of nuclear-powered warships and minimize radiation exposure and radio-active waste.

The FY 1979 Naval Reactors Development budget request is $290.6 million. This is an increase over the FY 1978 budget request. The major areas of this budget request are as follows:

OPERATING FUNDS

The FY 1979 operating budget for the Naval Reactors Development Program is $265.6 million, an increase of $49.0 million over FY 1978. This increase is due to the effects of escalation, continued funding for prototype cores including the Submarine Test Core and initial design of the Special Test Core, operation of the Trident prototype reactor plant which is expected to commence during FY 1979 and preparations for refueling of the A1W prototype reactor plant including initial procurement of refueling equipment.

The breakdown of the FY 1979 program is as follows:

	Millions
Submarine propulsion reactors	$177.2
Surface ship propulsion reactors	71.4
Supporting research and development	17.0
	265.6

The major efforts of these programs are as follows:

I. Submarine propulsion reactors ---------------------------------- $177.2 million

This program provides for the operation of six land prototypes, design and development of advanced submarine reactors and reactor concepts, and the continued engineering and physics design, follow, testing, and operational support of the reactors in 112 operating submarines and 32 submarines under construction.

The following specific major efforts will continue in FY 1979:

(*a*) Development of the propulsion plant for installation in the Trident strategic ballistic missile submarines. The land-prototype of the Trident reactor plant is expected to start operating during FY 1979.

(*b*) Development and support of the propulsion plant for the *Los Angeles* Class high speed attack submarines. This plant is a major advancement over previous reactor plants.

(*c*) Development of a still higher powered advanced design reactor for application to future submarine classes. This increased power rating will enable future submarines to attain higher speeds and support advanced weapon systems.

(*d*) The development of a Submarine Test Core as part of a comprehensive program of materials and materials systems development. During FY 1979, the design effort will proceed as initial fabrication work commences. Operation of this core in an existing land prototype will provide needed data for development of improved cores.

(*e*) The development, operation, testing and analysis of the core installed in Modifications and Additions to Reactor Facilities (MARF) will be supported.

II. Surface ship propulsion reactors ------------------------------ $71.4 million

This program provides for the continued development and improvement of propulsion plants for surface ships including operation and testing of two land prototypes, and testing, engineering follow and operational support for the reactor plants in 10 operating ships and 3 ships under construction. The major efforts to be pursued in FY 1979 include:

(*a*) Development of an advanced core with higher power for application to guided missile cruisers. This cruiser core is currently being operated and tested in a land prototype.

(*b*) The testing of the instrumented A4W core installed in a prototype plant in Idaho and technical follow and support for the propulsion plants for the *Nimitz* Class aircraft carriers, two of which are operating and one is under construction. This effort includes work on developing an optimum method for refueling *Nimitz* Class carriers. These carriers are powered by two reactors in contrast to the eight reactors used in the U.S.S. *Enterprise*. The cores are expected to provide about 13 years of normal ship operation.

(*c*) Development of a core having a longer life applicable to nuclear powered guided missile cruisers. The core will be tested in an existing land prototype.

III. Supporting research and development ------------------------ $17.0 million

This effort includes the development of new and improved methods, models, and computer techniques for application to reactor core analyses and design, as well as the operation of the Expended Core Facility and the High Temperature Test Facility.

The Expended Core Facility provides for the detailed examination of depleted cores and irradiation tests. Data obtained from these analyses provide confirmation of current core designs, form an essential part of the research and development effort necessary to develop longer-lived naval reactor cores, and furnish basic information on materials performance of value to all water reactor programs.

The High Temperature Test Facility provides for the operation of critical reactor assemblies to obtain reactor information necessary for development of reactor cores having longer life. This facility plays an important role in the development of higher performance cores for naval applications.

PLANT AND CAPITAL EQUIPMENT BUDGET

The FY 1979 budget for plant and capital equipment for the Naval Reactors Development Program is $25.0 million. This is a net decrease of $5.9 million from FY 1978. This budget consists of:

(1) A request for capital equipment of $22.0 million. This represents an increase of $6.9 million over FY 1978 and is necessary to provide the Naval Reactors Facility in Idaho with the capability to handle the larger components being used in current naval nuclear propulsion plants. In addition, these funds are necessary to replace or upgrade various equipment at the older prototype reactor plants due to equipment age or in order to support new core designs being installed.

(2) A request for construction of $3.0 million for general plant projects. This is a decrease of $12.7 million due to the expected completion of the S8G prototype reactor plant.

PROGRAM RESULTS

As a result of these continuing development efforts, there has been a notable improvement in the performance and lifetime of reactor cores. As an example, the first core for the U.S.S. *Nautilus* propelled the submarine 62,000 miles, while new cores are capable of propelling a submarine for over 400,000 miles. Cores now being installed in nuclear submarines and surface ships are expected to operate 10 to 13 years between refuelings compared to 2 years for the first *Nautilus* core.

In addition, the program has continued the civilian development effort started with the Shippingport Atomic Power Station. This was the first nuclear reactor plant in the world devoted exclusively to the production of electrical energy for civilian use. It was developed under the technical direction of the Division of Naval Reactors of the Atomic Energy Commission. Under the Department of Energy's Water Cooled Breeder Reactor program, Naval Reactors is currently operating the Shippingport Atomic Power Station with a light water breeder core installed. The objective of this program is to confirm the capability of breeding in existing types of pressurized water central station reactors.

Additional details of the fiscal year 1979 Department of Energy Naval Reactors Development Program budget request are included in Appendix 1 of this statement.

SURFACE WARSHIPS

The question of the direction to be followed for our surface naval strike forces continues to be the central argument concerning the Navy's future shipbuilding program.

Overall, I believe that our surface Navy is still more powerful than the Soviet Navy because of our aircraft carriers. However, even this is not reassuring since, as a land power, they do not have to depend on sea lines of communication to conduct military operations. Further, the number of deployable carriers in our Fleet continues to decline, and no new carrier has been authorized since the *Carl Vinson* five years ago. This is the longest gap in carrier authorization at any time in the past quarter century.

Any comparison of the Soviet Navy and the United States Navy must be viewed in the context that, as a maritime power, we are dependent upon being able to control sea lines of communication in order to conduct military operations overseas and support our allies. The mission assigned to our Navy is a far more difficult task than the Soviet Navy mission of preventing our Navy from maintaining such control. The United States has long since given up any chance of matching the Soviet Navy in number of ships. Therefore, the quality of our ships must be superior if we are to be able to withstand their attacks and protect the sea lines of communication.

Aircraft carriers and Aegis fleet air defense ships are the only major combatants currently planned to be built for surface naval strike forces. These ships are designed to fight in the areas of highest threat and will form the backbone of our first line naval strike forces. Considering the difficulties of providing logistic support in the area of highest threat, in my view it is essential that our first line warships be given the mobility and flexibility that only nuclear propulsion can provide. In my opinion, in the 1980's and beyond, in any area where the Soviets challenge us we will need all-nuclear carrier task forces if we are to be able to protect our sea lines of communication.

The decisions currently under consideration concerning whether or not to proceed with a nuclear carrier building program and to what extent nuclear propulsion will be povided for Aegis ships are of fundamental importance to the future of the U.S. Navy. The justification for providing nuclear propulsion for major combatants has been documented in detail through analysis, the military judgment of senior naval commanders, and experience in the Fleet.

You may recall that last year a nuclear task force consisting of the carrier *Enterprise,* the cruisers *Long Beach* and *Truxton,* and the attack submarine *Tautog* was operating in the Indian Ocean. RADM H. P. Glindeman, Jr. was in command of the task force. In a five-page classified letter, dated January 25, 1978, Admiral Glindeman reported to the Chief of Naval Operations some of the advantages of nuclear propulsion he observed during the Indian Ocean deployment. Admiral Holloway has given me permission to provide you Admiral Glindeman's letter for your record. I would like to quote to you here some excerpts from that letter which are not classified.

Dear Admiral Holloway:

As you know I am not a nuclear trained officer, but I have had the privilege to serve with the nuclear powered aircraft carrier *Enterprise* as my flagship for fourteen months while she operated in a multitude of scenarios. This experience has led me to write to you expressing some of my thoughts regarding the significant military worth of a nuclear powered task group.

All of the nuclear power cost effectiveness studies with which I am familiar have concluded that nuclear propulsion is slightly more expensive than conventional propulsion on a life cycle cost basis (3–6 percent). But what those studies did not do is provide an insight into the significant military advantages nuclear power gives to the tactical commander which cannot be provided by conventional fossil fueled ships.

Several times while I was aboard the *Enterprise,* isolated problems arose that were solved only because the ship was nuclear powered. The first one was off the coast of California during air exercises. The surface wind was 15–18 knots which would cause a conventional carrier to be steaming on only 4 or 5 boilers. A helicopter pilot had made a series of mistakes in navigation and judgment and had not returned to the *Enterprise* on schedule. After some delay, the helo pilot finally radioed that he was lost, was in extremis fuel wise, and requested the ship's homing beacon to be turned on. The homing beacon had been secured due to the tactical requirements of the exercise. The *Enterprise* immediately headed towards the helo at 30 knots which would have been impossible for a conventionally powered ship without 7 or 8 boilers on the line. The helo lost one engine due to lack of fuel about two miles from the ship and ran out of fuel on the second engine just as the helo landed safely on the flight deck.

One of the periods of operation that focuses on the advantages of nuclear power was our Indian Ocean mission. During this mission the carrier task group was composed of all nuclear powered ships; *Enterprise, Long Beach, Truxtun,* and *Tautog* (SSN 639). There were no naval logistic support ships assigned to the task group, (i.e. AO, AFS etc.). The nuclear powered task group entered the Indian Ocean on January 26, 1977. During the 42 days we were in the Indian Ocean, *Enterprise* was underway 38 days . . . Because of nuclear power, *Enterprise* has an increased JP–5 capacity over conventional carriers, providing us with nearly unrestricted flying for two weeks, and, of course, because of nuclear power the task group never required propulsion fuel oil support.

These situations demonstrated to me the importance of the sustained endurance inherent in nuclear escorts. It is also clear that the requirement for refueling can cause a direct loss in operational effectiveness of an entire task force.

A most significant demonstration of the advantages of nuclear over conventional power occurred when our task group was intercepted by a *Kynda* Class Soviet cruiser, the *Admiral Fokin. S*ince she is conventionally powered, she was accompanied by a replenishment oiler (AOR) the *Kolicchitskiy.* We were headed north up the west coast of India. The *Admiral Fokin* and the AOR came across the Arabian Sea from the vicinity of the island of Socotra and intercepted us on 8, February. She was emitting huge amounts of black smoke from her stacks at 25 knots. You may recall I sent you a picture of her smoking. The *Admiral Fokin* refueled from the AOR every other day, on 9, 11 and 13 February.

Our task force had a requirement to participate with the nuclear sub *Tautog* in a special operation. . . . It was also necessary to deny the Soviets any opportunity to observe the special operations with *Tautog.*

My plan was simple. . . . Between cycles of air operations and during the steaming periods after flight operations were secured, I kept the task group on various courses at high speed. . . . I then commenced air operations to the northeast She (the *Admiral Fokin*) arrived at her oiler and began refueling to the southwest. I ordered the nuclear cruiser *Long Beach* to trail and report her movements every hour or as significant changes occurred. Midway into the second cycle of day flight operations, I suddenly terminated air operations, and steaming at speeds over 30 knots, made an end run to the west of my track. The *Admiral Fokin* used her air search radar intermittently and when she couldn't see any aircraft anymore she terminated her refueling and took out after us with the *Long Beach* trailing her with ease.

I ordered the nuclear submarine *Tautog* to be at a position west of our track at first light. . . . We rendezvoused as scheduled, carried out the special operations while the *Admiral Fokin* searched vainly through the night for us. The *Long Beach* trailed her for twenty hours at an average speed of about 21 knots. When *Long Beach* finally broke trail, I ordered her to increase speed to 25 knots and head for Mauritius. This maneuver made the *Admiral Fokin* reverse her role and start trailing *Long Beach* for about six hours before giving up. Without nuclear power in *Long Beach*, I could not have used that particular tactic without replenishing her at least twice before detaching her for Mauritius. Obviously a conventional carrier and her fossil fuel escort could not have steamed at those speeds for that number of days without several replenishments from an oiler. During refueling there would be a penalty time incurred due to the required steady course of 12 knots, the maximum safe speed permitted during underway replenishment.

The statement is frequently heard that even nuclear powered carriers need to be replenished periodically with JP–5 fuel for aircraft. This is true. However, the amount of flying *Enterprise* aircraft did over 42 days . . . could never be accomplished by any conventional carrier. Furthermore, and more importantly in my view, is the fact, that in time of war during an open ocean transit while in a sea control mode, I would not have been conducting as many flight operations as I did until I had located the enemy forces. Under these conditions, I would be conducting anti-submarine flying operations continuously but I would keep any fighter and attack aircraft operations at a minimum until needed. . . . As a task group commander, I consider the advantage of being free from logistics support requirements provided by nuclear power, especially during wartime, far outweighs any cost argument against nuclear power. Also, as a task group commander, I believe the fossil fuel escort logistics problems are not understood or recognized by the cost effectiveness study groups. In my case, I had two escorts and both were nuclear powered. This was a tremendous advantage to me as I have indicated previously. A carrier needs four escorts as a minimum, in my view; and a nuclear carrier needs nuclear escorts to maximize its effectiveness.

Having experienced first hand, the reliability, tactical flexibility and the freedom from logistic support provided by nuclear power, I urge you to continue to support a vigorous nuclear powered warship program.

OPPOSITION TO NUCLEAR PROPULSION BY SYSTEMS ANALYSTS

The systems analysts in opposing nuclear propulsion have relied on the argument that since nuclear propulsion costs more, conventional ships should be built instead. Nowhere in their arguments do the analysts address the difficulty the Navy can expect to encounter in providing and delivering oil to its major combatants in high threat areas. They base their analyses on the assumption that propulsion fuel can be delivered whenever and wherever needed.

The cognizant Congressional Committees have studied this matter in great detail over a period of many years. It was the Congress that overrode the cost analysts arguments to get the nuclear submarine program established in the first place. Congress has had to step in many times since to keep the nuclear submarine program going.

The *Nimitz* Class nuclear carriers and the *Truxtun*, *California*, and *Virginia* Classes of nuclear cruisers evolved from similar arguments between Congress and the Department of Defense. This argument culminated in enactment by Congress four years ago of Title VIII of the Department of Defense Appropriation Authorization Act, 1975, which established as a matter of law that the policy of the United States is to provide nuclear propulsion for major combatants built for naval strike forces. The systems analysts do not accept that policy and will continue to do anything they can to circumvent it. So far they have succeeded; no nuclear powered surface warship has been authorized for construction subsequent to the incorporation of Title VIII into the law.

AIRCRAFT CARRIERS

For the forseeable future, the aircraft carrier will be the principal offensive striking arm of the Navy in a non-nuclear war. No other weapon system under development can replace the long-range sustained, concentrated firepower of the carrier air wing. Torpedo firing nuclear submarines, cruise missile firing nuclear submarines, nuclear cruisers with anti-air, anti-surface, and anti-submarine capabilities—all are needed to supplement and augment the capabilities of the nuclear carrier. But without the tactical air power provided by carriers all of our other surface forces would have greatly increased vulnerability. If an opponent is successful in developing weapons that can sink large numbers of our carriers, and we are not successful in developing adequate counter weapons—or if we simply do not build a sufficient modern carriers force to protect our sea lanes—the United States will have to change its national objectives to be consistent with our inability to conduct overseas military operations.

How many carriers the Navy must have I am not qualified to determine. However, I note that the number of overseas air bases available to us continues to decline. Since there is no known alternative to carriers for providing significant tactical air power beyond the range of provisioned and protected land bases, and the capabilities of the Soviets to attack us at sea continue to increase, our need for carriers appears to me to be increasing rather than decreasing.

I believe that your Committee has been provided the Assessment of Sea Based Air Platforms Project Report issued in February 1978 by the Office of the Secretary of the Navy. The Project Report gives the results of the study of aircraft platforms which the Congress last year directed the Secretary of the Navy to have made.

The study compares procurement and 30-year life cycle costs of various aircraft platforms ranging in size from a *Spruance* Class destroyer of about 9,000 tons, modified to carry two to four Vertical Short Take-Off and Landing, VSTOL, aircraft to a *Nimitz* Class nuclear carrier of about 95,000 tons which is capable of handling 97 VSTOL type aircraft. The carriers studied include a conventional carrier, designated CVV, of about 63,000 tons with 67 VSTOL aircraft; and a VSTOL support ship, designated VSS, of about 29,000 tons with 26 VSTOL aircraft.

The study also compares a *Nimitz* Class CVN to a CVV with current and future types of Conventional Take-Off and Landing, CTOL, aircraft. The ships smaller than the CVV included in the study are not capable of handling CTOL aircraft.

The study shows that the Navy could buy 2.5 CVV's—not three as has been suggested in the press—for the same 30-year costs as two *Nimitz* Class carriers, exclusive of aircraft costs. When the 30-year life cycle costs for aircraft are included, the study shows that the Navy could buy and operate at most 2.75 CVV's in lieu of two more *Nimitz* Class carriers. No carrier escort costs are included in these comparisons. If a larger number of conventional carriers were to be operated independently, they would require more escorts than the smaller number of nuclear carriers. Also the carrier life cycle cost figures in the study do not include the cost of escorts for underway replenishment groups; these costs would be higher for the non-nuclear ships, since they require more replenishment forces to support them.

The Project Report presents the results of analyses of engagements between enemy forces and U.S. carrier forces. The engagements analyzed include (1) a Soviet preemptive attack in the Mediterranean; (2) a Soviet attack on carriers in the Greenland, Iceland, United Kingdom—that is, the GIUK—area: and (3) a five-day projection of carrier air power in support of a land battle in the Pacific theater. The engagements were analyzed for assumed future types of CTOL aircraft and for assumed future types of VSTOL aircraft. The carrier forces of each type were selected to be of approximately equal life cycle costs. Thus, more carriers were assigned to the forces made up of smaller, conventional carriers.

The analyses were performed on the basis that all carrier forces were deployed on station fully replenished at the time the attack started. The analyses assumed replenishment groups were available whenever and wherever needed and that repenishment forces were not attacked. The analyses did not consider the advantages of nuclear propulsion.

These analyses showed that for either CTOL or VSTOL aircraft in the Mediterranean and GIUK engagements, the CVN was the most cost effective. In the analyses of the five-day land attack, the CVV was calculated to be most cost effective for CTOL aircraft and the VSS for VSTOL aircraft. Overall, the engagement analyses showed the CVN to be the most cost effective carrier. This was so despite the fact that the analyses did not take into consideration many important advantages of the CVN.

Although the costs of nuclear power were included in the analyses, its advantages were omitted.

Since the engagement analyses were all started with the ships on station fully replenished, the capability of nuclear powered ships to transit long distances at higher speed, arriving in the trouble area earlier, ready to enter combat without replenishment, was given no consideration. Nor was the ability to reposition nuclear powered ships quickly without concern for logistic support included; this ability greatly reduces vulnerability to preemptive attack and could be decisive in many actual combat situations.

Since the scenarios were all assumed to last but a few days, the larger capacity of the CVN was not considered. Further, the assumptions that replenishment forces would be available whenever and wherever needed and would not be attacked favored the non-nuclear carriers. The CVN advantage of requiring less frequent replenishment, and its ability to steam at high speed to rendezvous with replenishment forces in safer areas without concern for propulsion fuel, were not considered. Also, the higher top speed of the CVN was not considered in the analyses.

Weather was not considered in the analyses. Thus, the greater sea-keeping capability of the CVN was not considered. In this regard, carrier studies furnished to Congress in 1974 by the Chief of Naval Operations showed that sea conditions in the North Atlantic are such that a carrier of CVV size would not be able to operate aircraft about 21 percent of the time in winter, as compared to about 12 percent for a *Nimitz* size carrier— a factor of nearly two for the CVN. Further, an advantage of nuclear surface warships is their ability to take circuitous routes and use high speed to avoid storm areas during transits, because of their freedom from propulsion fuel constraints.

Without considering these features, the analyses still showed the CVN to be the most cost effective. When all these additional factors are considered, it seems to me that the CVN is overwhelmingly superior to the CVV on a cost effectiveness basis.

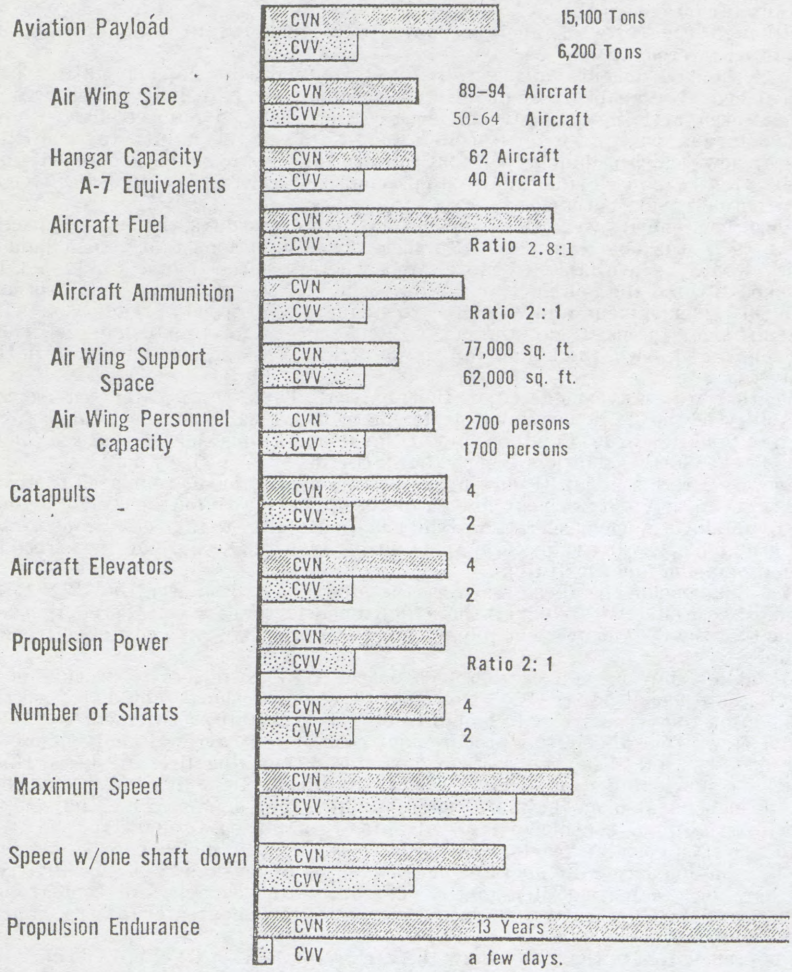
A smaller conventional carrier such as the CVV costs less to procure on a ship-for-ship basis than a CVN. However, it would be short-sighted to base the decision on the type carrier to be built entirely on initial procurement cost. The study shows that the initial procurement cost of the carrier is only about 10 percent of the total life cycle costs of buying and operating aircraft at sea. However, the survivability of aircraft and their effectiveness in combat are very heavily dependent upon the platform from which they operate. The study shows that, even without considering the advantages of nuclear propulsion, the CVN is the most survivable platform. This is so even when the dispersal of forces through buying larger numbers of cheaper ships is considered in the analyses. Further, the greater mobility, tactical flexibility, and capacity for combat consumables of the CVN makes its relative survivability even greater than calculated in the analyses.

The cost figures in the study show the life cycle cost of a CVN is 1.26 times the life cycle cost of a CVV. With a full complement of aircraft, the CVN costs 1.38 times the CVV including its smaller air wing.

The military characteristics of the CVV and CVN 71 are compared in the following table, a copy of which is on the table in front of you. Note that for 1.38 times the life cycle cost of a CVV with its aircraft the Navy will be able to buy and operate at sea 1.45 times as many aircraft on a CVN. Thus the life cycle cost per sea based aircraft is 5% less for the CVN.

Further, the CVN has the advantages of nuclear propulsion; about 5 knots greater speed; greater sea-keeping capability; capacity for twice as much aircraft ammunition; capacity for nearly three times as much aircraft fuel; twice as many catapults and aircraft elevators which provide greater ability to withstand combat damage and more rapid aircraft launch capability. Also, the four propulsion shafts in the CVN, compared to the two in the CVV, give the CVN much greater propulsion reliability, especially in combat.

Comparison of CVV and CVN 71 Military Characteristics



It is frequently argued that by buying smaller conventional carriers like the CVV, the Navy could have more ships in more places for the same cost. In this regard, it should be noted that if three CVV's and their air wings were procured, in lieu of two CVN's and their air wings, the Navy would get the same number of aircraft and one more ship. But the study shows the three CVV's would cost more, be more vulnerable, and provide less military effectiveness.

Further, I am not aware of any plan to buy more than one new carrier in the next five years. Thus from a practical standpoint, the real choice at this time is whether to spend a little more to get a lot more military capability in the one carrier now planned for procurement. The life cycle costs of the CVN and the CVV are summarized in the following table.

CVN/CVV 30-YEAR LIFE CYCLE COSTS

Without aircraft—One CVN equals 1.26 CVV's and two CVN's equals 2.5 CVV's.

With aircraft—One CVN equals 1.38 CVV's and two CVN's equals 2.75 CVV's.

Cost per sea-based aircraft is 5% less for CVN.

CVN is more cost effective overall, is more survivable, carries more aviation fuel and ammunition per aircraft, has more aircraft support facilities, has better sea-keeping ability, is about 5 knots faster, and has all advantages of nuclear propulsion.

Mr. Chairman, I continue to believe the CVN 71 for which Congress appropriated $268 million in FY 1977 should be built as soon as possible.

AEGIS SHIPS

Just as I recommend that new aircraft carriers be nuclear powered, so do I recommend that new guided-missile major combatants built for strike forces be nuclear powered. Previous studies have shown that each time a nuclear ship is substituted for a non-nuclear ship in a carrier task group, the capability of the task force as a whole will improve, with the greatest gain being made when the all-nuclear task group is achieved. The all-nuclear carrier task group has greater capability to penetrate and counter the projected Soviet naval threat than any other naval surface force we know how to build.

With existing designs of naval nuclear propulsion plants it is possible to provide enough energy for 10 to 13 years of warship operation without the need to refuel. And new reactor designs now under development will last 15 years. In contrast, oil-fired naval warships must be refueled every few days. Of what value is an oil-fired warship if it is unable to get oil? It is the need for a reliable worldwide fuel distribution system that is the Achilles' heel of our oil-fired Navy. The difficulty in obtaining foreign oil supplies to support operations in the Mediterranean and the Indian Ocean during crises in recent years amply shows this vulnerability.

If we are concerned that the improving Soviet naval capability will increase the vulnerability of our first-line strike forces then we must recognize it is no longer reasonable to assume that our underway replenishment groups can be operated with impunity. The all-nuclear carrier task group, having essentially unlimited high speed endurance, carrying more combat consumables which permits longer periods between replenishments, and with the capability to retire at high speed for replenishment in low threat areas, has far greater capability to conduct sustained combat operations than any other surface naval force we know how to build. Against a sophisticated naval threat, it could quickly turn out that our ability to conduct sustained combat operations would be controlled by the logistic support available. Under such circumstances the all-nuclear carrier task group has far greater striking capability than a conventional group.

When logistic supply lines are attacked during a real war, the decrease in the requirement for ships' fuel for the strike forces will have a compounding beneficial effect. The surviving fuel transportation and storage facilities can then all be concentrated on getting fuel for aircraft and other military vehicles to the forward areas. The escorts that would otherwise be required for the tankers which carry ships' fuel could then be assigned to assuring the safety of other supplies.

When a nuclear carrier is substituted for a conventional carrier, the range of a carrier task group, with four conventional escorts, is doubled. When two of the four escorts with the nuclear carrier are nuclear, the range of the carrier task group is doubled again. When all the escorts are nuclear, the range of the carrier task group is essentially unlimited.

Each nuclear escort substituted for a conventional escort also increases task force flexibility and mobility through advantages which are difficult to describe in numerical form. For example, none of the numerical comparisons of the relative effectiveness and cost of nuclear and conventional escorts cited in Navy cost studies take into consideration losses due to enemy action. One Navy study on "Nuclear Power for Surface Warships" showed that:

Losses of underway replenishment ships can be expected to be greater when supporting conventional than when supporting nuclear warships:

Under several of the threat conditions studied, the number of replenishment ships lost supporting conventional warships was more than twice the number lost supporting nuclear warships; and that,

The greater the threat to the underway replenishment ships, the larger is the loss differential to be expected—owing to the larger replenishment force required for the conventional warships.

The studies that have been made of the issue of nuclear propulsion for surface warships have cost millions of dollars and countless man-years of effort, including that of many high level people. Every aspect of the advantages and cost of nuclear surface warships has been exhaustively studied in minute detail over a period of many years by numerous analysts, civilian and military. These studies have brought out time and again that a nuclear surface warship has a higher initial investment cost than its conventional counterpart; but that when overall costs are taken into consideration, the nuclear ships are not much more expensive, but provide greatly increased military capabilities. I do not believe that further studies can produce any more facts.

This year again the Department of Defense request for naval ship construction authorization does not include a request for construction of any nuclear-powered guided-missile cruisers.

The last nuclear cruiser authorized was the CGN–41 in the FY 1975 program, which followed by three years the authorization of the CGN 40. In acting on the FY 1976 DOD budget request, the Congress cancelled the CGN 42 on the basis that it should be built with the Aegis air defense weapons systems. Each year since then plans for building nuclear powered Aegis ships for all-nuclear powered task groups have been cut back or deferred. Last year Congress appropriated $180 million for advance procurement for the CGN 42 with Aegis on the basis of DOD assurances that the ship would be requested for authorization in 1979. However, the Administration's latest five-year shipbuilding plan has now deferred the first nuclear powered Aegis ship to the FY 1983 program.

Navy witnesses have testified for the past several years that the Aegis system is needed to protect our surface ships against the projected Soviet air threat in the 1980's. Aegis ships are needed in the areas of highest threat, the same areas where our nuclear carrier task forces will be most needed, and where the military advantages of nuclear power may be essential to their mission. Unfortunately, repeated reductions in the planned program have raised the question of whether our nuclear carrier task groups will ever have the nuclear powered Aegis ships they need. Repeated delays have thus far prevented start of construction of even one of these ships.

In January 1977, President Ford submitted a five-year shipbuilding program from FY 1978 through FY 1982 which included two nuclear powered strike cruisers, CSGN's, and 10 DDG–47 Class conventionally powered Aegis ships. The Ford Administration FY 1978 budget request included funds for the lead DDG–47 Class ship and long lead funds for the first CSGN planned to be authorized in FY 1979.

The Carter Administration subsequently cancelled the nuclear strike cruiser program entirely and directed that instead the Navy adopt an alternative of putting Aegis in a smaller ship of the *Virginia*, CGN 38, Class size.

Funds were authorized and appropriated in FY 1978 to buy long lead material needed to support the new Administration's stated plans to request authorization for construction of the first of these ships, the CGN 42, in the FY 1979 program. However, in December 1977 the Navy budget request for construction of CGN 42 in FY 1979 was disapproved in favor of slipping the ship authorization one year to the FY 1980 program. The Administration's latest shipbuilding plan further defers the CGN 42 construction to FY 1983. If past experience repeats itself, by 1983 you will be told the ship should not be built at all, since more DDG–47 Class follow ships could be built for the same money, or that the ship should further be deferred to await some new weapon system.

The issue is whether nuclear powered Aegis ships are needed to counter the projected Soviet threat. Aegis is planned as our most capable AAW weapons system. Because Aegis ships will be expensive, regardless of their means of propulsion, there will never be a large number. In a naval war against an enemy employing sophisticated weapons systems, all strike force Aegis ships will be needed in the areas of highest threat. It is under just such circumstances that the advantages of nuclear propulsion are most urgently needed to maximize mobility and minimize logistic support. It is into such high threat areas where the nuclear carrier task forces will be sent in time of war, and they will need nuclear powered Aegis ships to accompany them. The Aegis ships should be nuclear for the same reasons that carriers should be nuclear.

In areas where the threat is great enough to require nuclear carriers and Aegis ships—our first-line naval strike forces—it is highly unlikely that oilers can survive. When a non-nuclear Aegis ship runs low on fuel, it will be necessary to remove the Aegis ship to an area of lower threat to meet the oiler, losing the Aegis protection just when it is most needed.

Another consideration is that to have a credible nuclear-powered guided-missile ship capability in both the Atlantic and Pacific Fleets, it is necessary to build a reasonable number of nuclear ships so that some ships are available for immediate deployment at all times. There are only nine nuclear cruisers authorized to date, and none of these have Aegis.

Unless nuclear powered Aegis cruisers are built, our nuclear carriers will have to be accompanied by DDG–47 Class Aegis ships when they enter the highest threat areas, thus giving up the significant military advantages of the all-nuclear carrier task force in the very areas where nuclear propulsion is most needed. Study after study has shown that the small additional life cycle cost of the all-nuclear powered carrier task group is more than justified by the added military capability it would provide.

APPENDIX 1 TO PREPARED STATEMENT OF ADMIRAL RICKOVER

DEPARTMENT OF ENERGY

NAVAL REACTORS DEVELOPMENT PROGRAM FOR FISCAL YEAR 1979

	B/A
Estimate, naval reactors development fission, fiscal year 1979	$290, 600, 000

Nuclear propulsion provides the Navy with ships having virtually unlimited high speed endurance, and freedom from the logistics umbilical cord for propulsion fuel with consequent greatly reduced vulnerability to enemy action. This allows ships to be designed for greatly increased capability for sustained combat operations. The Naval Reactor Development Program carries out essential advanced development work for nuclear submarine and surface warship programs necessary to maintain the national security of the United States. The Department of Defense Appropriation Authorization Act, 1975, states, "It is the policy of the United States of America to modernize the strike forces of the United States Navy by the construction of nuclear powered major combatant vessels and to provide for an adequate industrial base for the research, development, design. construction, operation, and maintenance for such vessels."

The Naval Reactor Development program provides for the design, development and testing of improved naval nuclear propulsion plants and reactor cores having long fuel life, increased reliability, improved performance, and simplified operating and maintenance requirements. The nuclear propulsion plants and cores under development cover a wide range of configurations and power ratings necessary to meet various military requirements. This range provides plants which are suitable for installation in naval vessels ranging in size from small submarines to large combatant surface ships. Basic areas of research include: the design and development of new and advanced reactors and reactor concepts incorporating the latest in nuclear reactor technology; the design and development of improved reactor instrumentation and control equipment; the continuing follow, testing and operational support of the reactors in operating submarines and surface ships to improve operating techniques and to obtain performance evaluations as a base for developing new and improved reactors; and the continued operation and testing of eight land based prototypes which are used to test and evaluate reactor and propulsion plant designs. The ultimate objective of the program is to develop cores that will last the lifetime of the ship.

SUMMARY OF ESTIMATES BY ACTIVITY

Activity	Estimate fiscal year 1979	
	Budget authority	Budget outlay
Operating expenses:		
Submarine propulsion reactors	$177, 210, 000	$164, 185, 000
Surface ship propulsion reactors	71, 360, 000	59, 905, 000
Supporting research and development	17, 030, 000	17, 010, 000
Subtotal, operating expenses	265, 600, 000	241, 100, 000
Capital acquisition:		
Capital equipment not related to construction:		
Submarine propulsion reactors	14, 635, 000	11, 815, 000
Surface ship propulsion reactors	5, 680, 000	4, 705, 000
Supporting research and development	1, 685, 000	1, 480, 000
Subtotal, capital equipment	22, 000, 000	18, 000, 000
Construction projects:		
Submarine propulsion reactors	1, 975, 000	2, 100, 000
Surface ship propulsion reactors	825, 000	705, 000
Supporting research and development	200, 000	195, 000
Subtotal, construction projects	3, 000, 000	3, 000, 000
Subtotal, capital acquisition	25, 000, 000	21, 000, 000
Total, naval reactors development fission	290, 600, 000	262, 100, 000

JUSTIFICATION OF ACTIVITY

Operating expenses

(1) Submarine propulsion reactors $177, 210, 000

	Estimate fiscal year 1979	
	Budget authority	Budget outlay
(a) Submarine advanced nuclear propulsion plant	$37, 220, 000	$31, 523, 000
(b) Small submarine nuclear propulsion plant	8, 865, 000	10, 253, 000
(c) Attack submarine nuclear propulsion plant	66, 829, 000	57, 692, 000
(d) Improved submarine nuclear propulsion plant	50, 132, 000	49, 676, 000
(e) Deep submergence research vehicle nuclear propulsion plant	1, 490, 000	1, 463, 000
(f) S1W reactor facility	12, 674, 000	13, 578, 000
Subtotal, submarine propulsion reactors	177, 210, 000	164, 185, 000

(*a*) Submarine advanced nuclear propulsion plant $37, 220, 000

The objective of this category is the design, development, test, evaluation and improvement of advanced submarine propulsion plants. This includes the effort associated with the Modifications and Additions to Reactor Facilities. Work under this project includes development effort directed toward achieving further significant advances to reactor technology. The Modifications and Additions to Reactor Facilities (MARF) provides for the design, development, operation, testing and evaluation of an advanced reactor. The reactor has been installed and testing and evaluation are underway. This project supports the operation of the S3G land-based prototype at the K. A. Kesselring Site, West Milton, New York. Prototype operation provides test data and experience to confirm specific reactor designs and results in improved reactor core and plant system designs and improved casualty and operating procedures.

During fiscal year 1979, work on design of the Submarine Test Core and a comprehensive program of materials and materials systems development will continue. Operation, testing and analysis of the special core installed in Modifications and Additions to Reactor Facilities (MARF) will be supported. Engineering support for fabrication of reactor servicing equipment, preparation of servicing procedures and maintenance shutdowns will continue. Procurement and engineering effort to support component refurbishments and modifications necessary for the continued operation of the S3G prototype will be provided.

Reactor instrumentation and control equipment will be upgraded as necessary to assure continued long term reliability. Operation, testing and analysis of the Advanced Test Core will continue. Significant advances are being made in core performance and advanced reactor plant concepts; however, details of this work are classified.

(*b*) Small submarine nuclear propulsion plant------------------- $8, 865, 000

The objective of the Small Submarine Nuclear Propulsion Plant category is the continued improvement, development, test, and evaluation of the nuclear propulsion plant used in small attack submarines. This objective is met by operating and testing the SIC-type prototype at Windsor, Connecticut. Specific goals include the investigation of the life-time behavior of SIC core physics and thermal characteristics, the evaluation of reactor core and powerplant components unique to this plant, and the performance of plant modifications which improve the safe and efficient operation of the prototype. Operation of the S1C prototype is an integral part of the total Naval Reactors research and development program.

An S1C-type turbine electric drive submarine propulsion plant is installed in the U.S.S. *Tullibee* (SSN 597), a small attack submarine specifically designed for anti-submarine warfare. The *Tullibee* was commissioned in November 1960 and has undergone extensive operation and evaluation at sea with naval operating forces; including test and evaluation of special features which were provided to reduce propulsion plant operating noise. As a direct outgrowth of the information obtained from the Small Submarine Nuclear Propulsion Plant project, a higher performance turbine electric drive submarine propulsion plant has been designed, developed and installed in an attack submarine, the U.S.S. *Glennard P. Lipscomb* (SSN 685), to take further advantage of the favorable noise reduction features of this system.

During fiscal year 1979, operation, testing and maintenance of the S1C prototype will continue. Operation of the S1C prototype plant will continue to provide for training and qualification of personnel for shipboard plant operations and for evaluation of equipment operation. Fabrication of replacement S1C fuel cells will continue and procurement and engineering effort will be provided.

Core procurement and design support for the refueling of the S2C reactor (*Tullibee*) will be provided. Preparation of refueling procedures will continue to support the *Tullibee* refueling overhaul.

(*c*) Attack submarine nuclear propulsion plant---------------- $66, 829, 000

The Attack Submarine Nuclear Propulsion Plant category is directed towards providing improved long-lived reactor cores for attack submarines. Specific technical objectives of the Attack Submarine Nuclear Propulsion Plant project include improving mechanical, nuclear, thermal, and hydraulic designs to reduce core manufacturing and refueling costs. This is particularly important since there are ninety-seevn nuclear powered submarines using the S5W-type reactor plant and core design improvements. Moreover, there will be a large number of ships using the other cores being developed under this budget line item.

This program also provides for the design, development and application of a high shaft horsepower reactor plant to use in *Los Angeles* (SSN 688) class high speed attack submarines and for the application of an advanced long life core to this plant. Through fiscal year 1978, 32 submarines of this class have been authorized and to date 5 of these have been commissioned. The successful performance of this class has been demonstrated in exercises conducted to date. Engineering and physics design, testing and construction follow on of *Los Angeles* class submarines will continue.

This effort also provides for the design and development of the Advanced Submarine Nuclear Propulsion Plant (ASNPP) for application to future classes of higher speed attack submarines. This effort includes designing and procuring a prototype of the ASNPP reactor for installation in an existing prototype plant. The ASNPP reactor and plant will provide significantly higher performance than any submarine propulsion plant now in use or under development. This will allow the option of developing various improved submarine configurations incorporating new weapon systems, advanced sonars and other features.

During fiscal year 1979 support will continue for the design, development, testing and operational support of the reactors and propulsion plants for the SSN 688 Class submarines. Performance of Post Shakedown Availabilities and the associated test evaluations work for the SSN 688 Class will continue as increasing numbers of these submarines become available to the fleet. Support for the design and procurement of both reactor and non-reactor equipment will continue as will support of maintenance and refueling capability. Additional efforts will include a power plant upgrading study to be completed in fiscal year 1979 and the preparation of a Safety Analysis Report. The testing of both model-sized and core sized elements will provide data of value to operating ships as well as additional confirmation of the adequacy of core design. The ASNPP prototype core and major components will be completed. Preparations will begin for installation of the core in the land prototype reactor plan.

(*d*) Improved submarine nuclear propulsion plant-------------- $50, 132, 000

The Improved Submarine Nuclear Propulsion Plant category is directed toward the design, development, test and evaluation of nuclear propulsion plants for the *Trident* Class ballistic missile submarines and the U.S.S. *Narwhal.* Both the Bettis and Knolls Atomic Power Laboratories carry out the development work for this project.

This effort provides for the design, development, testing and support of a propulsion plant for installation in the *Trident* strategic ballistic-missile submarine. The *Trident* S8G design builds on advanced submarine technology and represents a major reactor plant advancement. The S8G highly instrumented prototype is being built to confirm the performance of the reactor plant for the *Trident* class submarine.

During fiscal year 1979, construction of the S8G prototype will be completed and operation will commence. Design and engineering support for the shipboard plant design and for plant components and core procurement will continue. The propulsion plant test program, in the lead ship, *Ohio* (SSBN 726) will commence. Through fiscal year 1978, seven *Trident* submarines have been authorized and contracted for construction. During fiscal year 1979, the S5G prototype will operate full time carrying out various programs and training.

(*e*) Deep submergence research vehicle nuclear propulsion plant---- $1, 490, 000

This objective of the Deep Submergence Research Vehicle Nuclear Propulsion Plant category is to design, develop, test and support operation of a nuclear reactor core and plant for small deep-diving submarines. This program provides design, engineering and physics support for the NR–1, the application of this plant in a ship, and the new Nuclear Powered Hull Test Vehicle. Since the mission capabilities of manned deep ocean research vehicles are principally determined by the characteristics of their power supplies, the operational endurance and speed of other underseas research vehicles are severely limited by the capacity of electrochemical systems and dependence on surface support ships. However, the NR–1, being powered by a small pressurized water reactor, overcomes these limitations and has essentially unlimited propulsion endurance required for continuous, large-scale exploration of the ocean bottom.

The NR–1 reactor provides power for the propulsion and auxiliary electrical loads of the NR–1 vehicle. The NR–1 vehicle has both viewing ports and cameras for visual observation of its undersea surroundings. In addition, a remote grapple is installed to permit the gathering of items such as marine samples, which are outside of the vehicle.

With its depth capability, NR–1 can explore essentially all of the Continental Shelf, an area that appears to contain most of the accessible wealth in mineral and food resources in the seas. The detailed charting of the ocean bottom and locating of minerals and other resources on the Continental Shelf is extremely important to the United States. The NR–1 is also capable of engaging in a variety of other underseas research projects such as charting ocean currents, studying water temperature, and gathering other oceanographic data of military, commercial and scientific value. The performance capabilities of NR–1 are superior to those of any other undersea oceanographic research vehicle developed or planned to date due to the vastly increased endurance afforded by nuclear power. This was demonstrated when NR–1 located and recovered the phoenix missile and assisted in the salvage of the F–14 aircraft lost from the aircraft carrier U.S.S. *John F. Kennedy.* NR–1's unique depth and endurance capabilities including special abilities for search and recovery made location and salvage of the F–14 possible during periods of adverse weather and high seas, while other conventional methods attempted were unsuccessful.

The technology obtained through the NR–1 development will be applied as a basis for development of future nuclear powered oceanographic research vehicles of still greater versatility and depth capability.

This category also provides for the design, construction, testing, and operational support for the Nuclear Powered Hull Test Vehicle (NHTV). The NHTV will also be a small deep-diving submarine with a propulsion plant similar to that for NR–1. The NHTV will be capable of operating to great depths. NHTV will be a critical step in certifying HY–130 steel as a hull material for naval combatant submarines.

During FY 1979 engineering analyses, safeguards surveillance, design, physics, shielding and reactor plant design support will be provided for continued ship operation, plant modification and testing.

(*f*) S1W reactor facility $12, 674, 000

The objective of the S1W Reactor Facility is to provide for the testing, evaluation and improvement of propulsion plant systems and components, reactor fuel materials, and operating and maintenance techniques in the Naval Reactor Development program, and to provide a facility for training submarine crews. This objective is met by (1) operation and testing of the instrumented reactor and plant with emphasis on the unique nuclear and mechanical features of the reactor; (2) providing engineering support for primary, secondary, and directly related off-hull systems and apparatus; (3) training submarine crews; and (4) maintenance of the S1W plant. This facility, originally constructed as the prototype for the first nuclear powered submarine, U.S.S. *Nautilus* (SSN 571), is operated at the Naval Reactors Facility in Idaho. Operation of the S1W plant, which is the oldest operating reactor plant provides a unique opportunity to obtain information on long term reactor plant operation. The S1W plant is also a prototype of the plant installed in U.S.S. *Seawolf* and has served as a prototype for testing cores and components for other submarine propulsion plants as well as general development of naval nuclear propulsion plant technology. During FY 1979, the S1W prototype reactor plant will continue in full operation during which tests will be carried out and crew training will continue. Additionally, support will be provided for the design and procurement effort associated with an advanced fuel technology core to be installed and operated in this prototype plant.

(2) Surface ship propulsion reactors $71, 360, 000

	Estimate fiscal year 1979	
	Budget authority	Budget outlay
(a) Large ship nuclear propulsion plant	$14, 900, 000	$14, 770, 000
(b) Destroyer type dual nuclear propulsion plant	41, 960, 000	27, 335, 000
(c) Aircraft carrier type dual nuclear propulsion plant	14, 500, 000	17, 800, 000
Subtotal, surface ship propulsion reactors	71, 360, 000	59, 805, 000

(*a*) Large ship nuclear propulsion plant $14, 900, 000

The objective of the Large Ship Nuclear Propulsion Plant category is to design, develop, test, evaluate and improve nuclear propulsion plants and reactor cores for large naval surface ship application. This objective is met by operating and performing tests at the A1W prototype plant, located at the Naval Reactors Facility in Idaho, and by providing engineering support for the U.S.S. *Enterprise* (CVN 65) and U.S.S. *Long Beach* (CGN 9) which utilize A1W technology. The A1W prototype consists of two reactor plants and associated propulsion machinery required to drive one shaft.

The currently installed fuel in the A-plant will permit continued operation of the prototype core for a total of 13 years to support and confirm performance of the cores installed in the U.S.S. *Enterprise* and U.S.S. *Long Beach*. Testing and operation of both of the A and B plants provides data on the operational characteristics of surface ship reactor cores, plant systems, and plant and reactor components. Analysis of this data provides the basis to improve reactor, system, and component design and operating and maintenance procedures in the prototype, on the U.S.S. *Enterprise* and the U.S.S. *Long Beach*, and on further advanced designs such as the A4W/A1G. Operation of the U.S.S. *Enterprise* and

U.S.S. *Long Beach*, including extended deployments without logistic support, demonstrates the tactical flexibility and freedom of independent action that nuclear propulsion provides for surface warships.

During FY 1979, the A1W prototype reactor plant will continue operation. Periodic and special tests will be performed, the results will be analyzed, plant maintenance will be conducted as required, and crew training will continue. Improvements in equipment and procedures will be incorporated based on operating experience and technical developments.

Design, engineering, and physics support for operating, improving refueling and maintaining the operating surface ships will continue. Technical support for the procurement and replacement of cores for these ships will continue. Work to determine the full useful life of existing core designs will be carried out.

(*b*) Destroyer type dual nuclear propulsion plant ---------------- $41, 960, 000

The objective of the Destroyer Type Dual Nuclear Propulsion Plant category is to provide for the design, development, test, evaluation and improvement of a two-reactor nuclear propulsion plant for major fleet escort-type ships. Also included in this category is the development of a longer lived D2W core and components for use in nuclear powered cruisers. The D2W reactor is planned for installation during the initial construction of future CGN's and is capable of being backfitted in most prior CGN's.

To meet the objectives of this program, a land prototype, consisting of one D1G reactor plant and associated machinery, is in operation at the K. A. Kesselring Site, West Milton, New York. Extensive tests are carried out at the highly instrumented prototype plant to evaluate propulsion plant physics, materials, hydraulic, thermal and mechanical performance. Data from the prototype plant is evaluated to support incorporation of design improvements into follow ships in a manner consistent with ship construction schedules. A D2W core is currently operating and is being tested in the D1G prototype.

Six of the seven operational nuclear powered guided missile cruisers use two reactor D1G type nuclear propulsion plants (U.S.S. *Long Beach* uses a C1W type plant). Two additional nuclear powered cruisers using this propulsion plant, *Mississippi* (CGN 40) and *Arkansas* (CGN 41) are currently under construction. Test data and operating experience from the D1G prototype and operating nuclear cruisers provide valuable information on core and plant performance to permit design and safety improvements in the new CGN Class ships under construction and for future CGN Classes.

During FY 1979 efforts will continue to be directed toward the application of the D2W core and D1G reactor plant to the CGN 42 Class cruiser. This core will provide for at least 15 years of ship operation before refueling. A D2W core is being tested through operation in an existing prototype plant. Support for the propulsion plant development for the new class of CGN cruisers will be provided. Engineering follow up will be provided for the procurement of D2W shipboard cores. Engineering support, technical assistance, and shipyard liaison will continue to be provided for CGN commissioned ships and the new *Virginia* Class of nuclear powered cruisers under construction. Continued technical support for the improvement and manufacture of shipboard cores and reactor components will be provided.

(*c*) Aircraft carrier type dual nuclear propulsion plant ------------ $14, 500, 000

The Aircraft Carrier Type Dual Nuclear Propulsion Plant category is directed toward the design, development, test, evaluation and operational support of a long life nuclear propulsion plant for use in the Navy's *Nimitz* Class two-reactor aircraft carriers. The reactor plant for the carriers is capable of providing power for high speed operations in addition to power for operation of catapults, advanced weapons, and electronics systems. This core, designated A4W/A1G, is the largest core in the Naval Nuclear Propulsion Program. Fuel life is expected to provide about 13 years of normal ship operation.

The U.S.S. *Nimitz* (CVN 68), the first two-reactor aircraft carrier, was commissioned in May 1975. The second *Nimitz* Class aircraft carrier, the U.S.S. *Dwight D. Eisenhower* (CVN 69) was commissioned in October 1977. Construction of a third nuclear carrier of this class, the *Carl Vinson* (CVN 70) is proceeding. This program also provides technical support for the operation of the instrumented A4W core installed in a prototype plant located at the Naval Reactors Facility in Idaho. Test results from the prototype plant provide data on the operational characteristics of the A4W/A1G reactor core, plant systems and plant reactor components.

During FY 1979 support will be provided to obtain operational and test data applicable to shipboard core performance of CVN 68 Class carriers. Physics and engineering support for the operating plants on the U.S.S. *Nimitz* and U.S.S. *Dwight D. Eisenhower* will continue to assure operation of the reactors and all components and systems are in conformance with core design and plant operating parameters. Technical effort in support of the construction and testing of the reactor plants in the *Carl Vinson* (CVN 70) will also continue. Analysis of operational from the U.S.S. *Nimitz*, U.S.S. *Dwight D. Eisenhower* and the prototype will be performed on a continuing basis to identify improvements which can be factored into the reactor plant for the *Carl Vinson*.

Work to determine the full useful life of the shipboard cores will continue as will work on development of refueling methods for both prototype and shipboard cores.

Technical effort will be provided to support the procurement of the replacement core and the associated A1W–B plant refueling. This support will include the development of refueling equipment systems and procedures, and the procurement of refueling equipment.

Irradiation test programs will be conducted in support of fuel, control, and structural materials development. This irradiation testing will provide valuable data as well as additional confirmation of the adequacy of the core design. In addition, the post-irradiation examinations at the Expended Core Facility and the Bettis Hot Laboratory will provide valuable data.

(3) Supporting research and development________________________ $17, 030, 000

	Estimate fiscal year 1979	
	Budget authority	Budget outlay
(a) Expended core facility	$9, 730, 000	$9, 710, 000
(b) High temperature test facility	2, 800, 000	2, 800, 000
(c) Naval reactor design studies	4, 500, 000	4, 500, 000
Subtotal, supporting R & D	17, 030, 000	17, 010, 000

(*a*) Expended core facility_____________________________________ $9, 730, 000

The Expended Core Facility (ECF), located at the Naval Reactors Facility in Idaho, provides primarily for examination and analysis of fuel and poison elements and core structural components removed from depleted naval reactor cores to determine their physical, mechanical, and corrosion properties; and examinations, tests, and evaluations of specimens of fuel, poison and other materials irradiated in the Advanced Test Reactor in Idaho as part of the materials development program.

To accomplish the ECF program objectives, deep water pits are operated and maintained at the ECF site so that highly radioactive materials can be received, dismantled, examined, tested, and stored. Hot cells and radiochemistry laboratories are also operated and maintained to determine the extent of change in the nuclear physical and chemical properties of irradiated fuel and associated materials. This program also provides for preparation of fissionable materials from naval reactor expended cores for shipment to appropriate uranium recovery facilities and for the servicing and control of shipping containers and other apparatus essential to the overall program.

The information gained from examining expended cores and fuel element irradiation tests samples and assemblies provides essential technical data. Data obtained from these analyses provide confirmation of current core designs and form an essential part of the research and development effort necessary to improve existing designs, to develop longer lived naval reactor cores, and to furnish basic data on materials performance of value to all pressurized water reactor programs.

in FY 1979, the ECF program will continue to handle a high level of fuel and non-fuel examinations and analyses in support of the continuing irradiation test programs.

Maintenance and logistical control of shipping containers will be provided. The design of the M–106 transfer cask will be completed and fabrication will begin. The M–106 transfer cask will be used to transfer expended fuel from ECF to the Idaho Chemical Processing Plant for reprocessing.

(*b*) High temperature test facility	$2,800,000

The High Temperature Test Facility provides for the operation, modification, and maintenance of a high temperature pressurized water system used to obtain reactor physics information on critical reactor assemblies for development of cores having longer life, higher power density, and improved nuclear fuel utilization. Associated general development required for extending the life of naval reactor cores is also supported.

Work to improve the cross section sets will continue as will development of benchmark critical experiments in support of design and methods development. This facility plays an important role in the development of higher performance cores for naval application. Support will be provided to the overall Naval Reactors Development program by operation of a centralized radiation counting facility. This facility is used to determine the amount of radioactivity in activated foils and wires in support of various developmental programs. Support will also be provided for electronics maintenance of critical facilities. This will include repair of electronic equipment, calibration of instrumentation, performance of text experiments and installation of new electronic equipment.

(*c*) Naval reactor design studies	$4,500,000

The objective of this effort is to develop advanced concepts including development and qualification of advanced technical, engineering design, manufacturing and inspection methods and techniques and assisting in their application to the Naval Reactors Development program.

Capital acquisition		$25,000,000
Capital equipment not related to construction:		
1. Submarine propulsion reactors	$14,635,000	
2. Surface ship propulsion reactors	5,680,000	
3. Supporting research and development	1,685,000	
Subtotal, capital acquisition	22,000,000	

Capital Equipment funds are requested in FY 1979 to support research and development efforts directly related to Naval Propulsion Reactor Programs which have emphasis on providing reliable, economic, long lived reactor cores. The following major items of capital equipment are included in the FY 1979 request; (1) Replacement Computer Disk System. A highly reliable, high capacity and efficient disk system is needed to replace an existing deteriorating and unreliable disk system in order to maintain current computer operational capability. This new disk system offers faster access time, improved performance and reduced rate of failure. (2) Computer Aided Design and Drafting System. This system offers a potential cost and time savings and substantially increased efficiency over existing manual design and drafting techniques particularly in the production of precision schematics for training manuals. (3) Scrap Cask. A new scrap cask of increased size is required for use by the Expended Core Facility to handle and dispose of components from the large advanced naval nuclear cores now in operation. The new cask will be designed to enable handling operations in accordance with newly specified waste handling methods and will be designed to minimize personnel radiation exposure. (4) Analog Hybrid Computer. This proposed two console hybrid system is needed to replace outmoded tube type equipment 12 to 19 years old and will increase program accessibility and speed of data retrieval. (5) Reactor Plant Components for land prototype reactor plants. In several cases, existing components have been operating for more than their design lifetimes. Plans are to replace these components during the next scheduled refuelings.

Construction projects	$3,000,000

This project provides for minor plant improvements, alterations, additions, and minor new construction at Naval Reactors laboratories. In general, this project consists of performing land improvements, building alterations, utility improvements additions to existing facilities, and upgrading present facilities.

The estimate for FY 1979 general plant projects is based on experience in prior years. In the past, work under general plant projects has included modifications or betterments to existing buildings and other facilities, additions to buildings to house new machinery or equipment and personnel, construction of new, small buildings, replacement of or additions to roads and utility lines, and general area improvement and development.

NAVAL REACTORS PROPULSION

Admiral RICKOVER. Thank you, Mr. Chairman. I have a very short synopsis of my statement.

Senator JACKSON. I know that.

Admiral RICKOVER. I would appreciate it if I could start reading my statement. However, if I have previously convinced you and the senior Republican member of the need for aircraft carriers, then I will cut it very short because I know that you are busy with many other subjects.

I would like to congratulate you, Mr. Chairman, on your very lucid, persuasive, and articulate discussion on TV yesterday. Your ideas convinced me, and I am sure you must have convinced others as well. I am very critical, but I could find no error in grammar in the entire statement.

[Laughter.]

Senator JACKSON. Well, I am glad I passed part of the education test.

Admiral RICKOVER. Yes, sir. I think you would have gotten a very good mark.

Senator JACKSON. Almost as good as my son.

Admiral RICKOVER. Yes, sir. You should be very proud of his accomplishments.

Senator JACKSON. Thank you, Admiral. I will see that he gets a copy of this transcript.

Admiral RICKOVER. Thank you, sir.

In connection with that last statement of yours, there is a story about a school of rabbis who were arguing about the meaning of the Bible and one said, "I have bested God, I made the statement clearer than He did and I am sure He will be proud because I am His Son." So if you do as well as your son, you have done very well.

Senator JACKSON. Admiral, why don't you go ahead with your testimony.

Admiral RICKOVER. Mr. Chairman, I have provided the committee staff with copies of my prepared statement as you know.

The joint Department of Energy and Department of the Navy naval nuclear propulsion program involves many activities, including two Department of Energy-owned laboratories where research and development work is performed, seven land prototypes owned by the Department of Energy, reactor component manufacturing plants owned by the private sector, and shipyards, both private and naval, where nuclear ships are designed, built, and overhauled.

I make it a cardinal principle that design and fabrication work be done by private industry. Our laboratories are for providing the ideas, but almost all actual design and fabrication work is done by industry. I believe that you are in accord with this principle.

Since its inception, the nuclear Navy has grown from the world's first nuclear-powered ship. the submarine U.S.S. *Nautilus*, to the current fleet of 122 warships, including 41 ballistic missile submarines, 71 attack submarines, 3 aircraft carriers, and 7 cruisers. These ships have steamed a total of more than 37 million miles. In addition to the ships in operation, 7 Trident ballistic missile submarines, 25 *Los Angeles* class attack submarines, 1 *Nimitz* class carrier, and 2 *Virginia* class cruisers have been authorized or are under construction.

The naval nuclear propulsion program is responsible for more operating reactors than the combined total of all U.S. civilian power reactors. These statistics give you some concept of the scope of the problems that we have, and of the experience we have acquired. This experience has taught us many lessons which have been made available to the civilian nuclear power industry.

Altogether, there are 148 operating naval reactors, which have accumulated over 1,600 reactor years of operating experience. In the 25 years since the *Nautilus* land-prototype first operated, there has never been an accident involving a naval reactor, nor has there been any release of radioactivity from the naval reactors program which has had a significant effect on the environment.

The goal of the naval nuclear propulsion program is the design, development, and support of nuclear propulsion plants and reactor cores over a wide range of configurations and power ratings to meet the Navy's various military requirments.

The program has evolved so that a great deal of the effort today is directed toward the adequate maintenance of nuclear ships. As you know the Navy's nuclear powered warships are the most complex in the fleet, yet they operate for longer periods and more efficiently than the rest of the ships in the Navy despite increasing age and complexity.

Another point worth remembering is that the naval nuclear propulsion program provides support for more than 40 percent of the combatant ships in the Navy. It is not generally understood that my organization is also responsible for the maintenance of all these ships. This effort takes a considerable amount of time.

QUARTER CENTURY OF NAVAL NUCLEAR POWER

Senator Jackson. You have come a long way since the *Nautilus* went to sea 24 years ago in 1954.

Admiral Rickover. Just about.

Senator Jackson. 1954.

Admiral Rickover. 1955 but the prototype in Idaho started operating in May of 1953.

Senator Jackson. So it is 25 years this month.

Admiral Rickover. It is a quarter of a century.

As a result of continuing development efforts, there has been a notable improvement in the performance and lifetime of reactor cores. The first core for the U.S.S. *Nautilus* propelled the submarine 62,000 miles, while new cores are capable of propelling a submarine for over 400,000 miles. The nuclear cores on aircraft carriers will last for about 13 years now and on submarines over 10 years. It may be more than that but I am always conservative in making predictions before the facts are in.

I am now working on cores which are good for 15 years and I hope ultimately to have cores which will last the life of the ship. So that as far as the nuclear propulsion plant is concerned, the ultimate objective would be no need for refueling. Then we could put a core in the ship when it is built that will last the life of the ship. The significance of this is not yet understood by the Defense Department and OMB, I am very sad to admit.

They cannot see what the oil price is ultimately going to do to the Navy. We are advocating ships that will have 15 years fuel on board whereas the oil-fired ships have several days fuel. The Department of Defense officials do not see that in the nature of the President's moral equivalent of war that the need to deliver oil to our warships, is the Achilles heel of our Navy. I know that you as chairman of the Energy Committee understand that, but we cannot get the Defense Department and OMB to understand it. This is a great tragedy in my opinion and it may have tragic consequences for the United States. I don't know how to get around the problem in the Defense Department and OMB because it is one of these concepts that requires people to think beyond the immediate situation.

They have to think in the future because all the ships we are buying are for the future. We cannot get that idea across in the Department of Defense and OMB.

Senator JACKSON. When you look at the cost of a carrier, the only kind that makes any sense, in my view is the *Nimitz* class.

COST OF "NIMITZ" CLASS CARRIER

Admiral RICKOVER. But it is not really more expensive. In fact, it is less expensive per sea-based aircraft.

Senator JACKSON. What are the fuel costs? You talk in terms of the amount of nuclear fuel you have aboard, which as you pointed out lasts roughly 13 years. With the price of oil going up and up, it has quadrupled since 1973–74, that factor is important, but seems to me has been neglected and not included in the cost of the conventional carrier. You include the cost of the nuclear core, do you not?

Admiral RICKOVER. Yes, sir, the cost of the initial nuclear cores is included in the SCN budget for building the ship. That is included in the construction cost for nuclear ships. The cost of fuel oil plus its cost of delivery is not included in the costs of oil fired ships. I will give you a figure on that, sir.

Initial acquisition cost of the CVN 71 which would be the fourth *Nimitz* class carrier is estimated to be $2.4 billion. This includes $135 million to buy and install the initial reactor cores in the ship. These cores will provide the power to run the ship for at least 13 years. That is today's figure and I expect that may go up to about [deleted]. These cores will produce energy equivalent to that produced from 2.2 million tons of coal or 11 million barrels of oil.

That amount of oil would fill a train of tank cars extending from Atlanta to Washington. At today's prices the Navy would have to pay over $220 million just to buy that much propulsion fuel and much more to deliver it to the ships. I think you could safely say that today a nuclear-powered ship, considering its use in the future, is not much more expensive in overall cost to the Navy than the conventional one. But what do you get for the difference?

Now I don't know whether you have in front of you a chart that I made up.

Senator JACKSON. Yes.

Admiral RICKOVER. Which shows the differences.

Senator JACKSON. Yes.

CVN 71 COMPARED TO CVV

Admiral RICKOVER. I think if you glance through that chart comparing the CVN 71 to the CVV favored by the Department of Defense and OMB, you will see that any head of an organization thinking of the future would certainly select the CVN 71. That chart is the most convincing story there is. How do you get around it?

Senator JACKSON. You have more than doubled the payload?

Admiral RICKOVER. Yes, sir.

Senator JACKSON. I mean aviation payload.

Admiral RICKOVER. Yes, sir. On the back of that page you will get a summary of what it does on a 30-year life cycle. These are official figures, these are not my figures. These are figures that come from studies that the Navy itself has made. So there you are.

Now what do you do with the situation like that where you see what is going to happen and yet you have people keep on telling you that the initial cost was too great. I am sure if some parents knew what the initial cost of having a baby is, they would not have one. [Laughter.]

Senator JACKSON. That is well put. All right, Admiral.

Admiral RICKOVER. I don't think I need to say much more about the carrier.

Senator JACKSON. We will put all that in the record.

Admiral RICKOVER. Yes, sir. It is in my prepared statement.

NUCLEAR POWER FOR STRIKE FORCE SHIPS

Admiral RICKOVER. I have gone into the carrier issue at great length. Now it applies to the Aegis cruiser as well. If we are going to have nuclear powered carriers, there is no point to having escort ships, those that are accompanying, to have to depend on the carrier for their oil because if the carrier has to do that, then the carrier would have to use its aviation fuel capacity to supply the cruiser. That is also very detrimental because if you are in a war area what are you going to do? Are you going to slow down, when the enemy submarine is around, to refuel the ships that have to protect you? It is my opinion that we would be far better off with a fewer number of nuclear ships than to have large numbers of oil-fired ships that can't be out there in the forward areas fighting because of the real world problems of supplying them with propulsion fuel in time of war.

I do not advocate as some people have claimed, that the entire surface Navy should be nuclear. I have never advocated that. I am only talking about a relatively small part of the surface Navy, the striking force of the Navy.

Now, I don't think there is any use in my delving into that any more. I am sure that Senator Thurmond and you are fully familiar or have become familiar over a period of years with this situation. I don't know how to break through.

Now Congress did enact the law several years ago that all strike force ships, that is combatant ships assigned to the strike forces, be nuclear powered. But that law has been of no effect because the Defense Department and of course the OMB and the White House always come out against the nuclear ships. Now I am not advocating or arguing how many carriers we should have. I am merely stating that if we do build carriers they should be nuclear powered, for the reasons I have given.

Perhaps you have some suggestions where I have fallen down. I sincerely would like to hear what I can do to convince the Secretary of Defense of the wisdom of building nuclear warships for the Navy's strike force. He wants more ships but he is not going to get as much for the money by building the oil fired CVV as he would by building the CVN 71, as you can see on these curves.

Senator Jackson. Well, my view is that from a cost effective point of view, it is better to have our carriers. I would rather have one nuclear powered carrier of the *Nimitz* class than two of the non-nuclear carriers. They just do not have the kind of capability to meet our strategic requirements worldwide.

Admiral Rickover. That is correct, sir.

Senator Jackson. That gets right down to it.

Admiral Rickover. If there is an emergency, the Navy could immediately send the nuclear carrier at full speed without concern—frequently in the last 10 or 15 years we have had cases where emergencies have arisen and the only ships that could respond to that emergency situation were nuclear ships because the oil fired ships had to look for tankers, before they could respond. They had to have a tanker accompanying them to do the job at all, they had to slow down and become vulnerable to refuel from the tanker, and they had to slow their speed in order to let the tanker keep up with them.

SAFETY IN THE NAVAL REACTORS PROGRAM

Senator Jackson. Admiral, I wanted to ask a couple of questions here, one on the subject of safety. You have had an outstanding record in connection with the naval reactors program as it pertains to safety. Is there any parallel that can be drawn between your program and the civil power reactor programs? I wondered if you would wish to make some observations and comment briefly for the record on a story that got out about radiation exposure problems, reported in the press, affecting shipyard workers at naval nuclear propulsion plants and support facilities. Would you cover those two areas?

Admiral Rickover. Yes, sir. First I will take up radiation. This of course is a subject which has great emotional involvement. Because of recent concern over low level radiation exposure. I have issued a report which summarizes the history of occupational radiation exposure to Navy, civilian, and military personnel engaged in work in the naval nuclear propulsion program. I believe this report helps to put into proper perspective the basis, practices, and experience for radiation work under my control. I would like to give each of you a copy, even though you can't read it now. This is the most thorough and accurate statement on radiation insofar as it relates to the nuclear Navy and shipyards that do work on nuclear powered ships. You will see from this report that we have strictly enforced the Federal limits on occupational radiation exposure.

In fact we have gone beyond just what is minimally required and I am very proud of this record. Yet we are being castigated by some for not having done a better job.

[Additional information submitted for the hearing record follows:]

No civilian or military personnel in the naval nuclear propulsion program have exceeded the Federal limit which allows 5 rem exposure for each year of age beyond age 18. Since 1967 no person has exceeded the Federal limit which allows up to 3 rem per quarter year, nor in this 10 year period has anyone exceeded the

Navy's self imposed limit of 5 rem per year for radiation associated with naval nuclear propulsion plants.

Now I have another document here that I would like to provide the committee. This is the annual report we issue on the handling of radioactive wastes by our nuclear powered ships and their support facilities.

[Additional information submitted for the hearing record follows:]

Since the beginning of the naval nuclear propulsion program, all aspects of the program have been directed toward the proper control of radioactivity. This has been reflected in the design, construction, operation, maintenance, overhaul and refueling of these ships as well as in the procedures and selection and training of personnel.

The policy of the Navy has been to reduce the release of radioactivity to the lowest amount practically achievable. Releases have been far below standards issued by Federal agencies. For example the total amount of gamma radioactivity released to harbors within 12 miles from shore from the naval nuclear propulsion program for each of the last 7 years has been less than 0.002 curie. This is the total from 120 operating nuclear powered ships, as well as the 13 tenders, 2 bases and 9 shipyards supporting these ships.

This is not only far below any standard but it too small to have an affect on the environment. As an example, if one person were able to drink the entire amounts released into any harbor in 1977, he would not exceed the annual radiation exposure permitted for an individual worker by the U.S. Nuclear Regulatory Commission.

Now that point is rarely made by the press. There are people in this country that think radiation is harmful no matter what. The total lifetime exposure from radiation associated with the Naval Nuclear Propulsion plants to date for all personnel monitored since 1954 has averaged about 1 rem per person. A person moving from a low elevation to Denver, Colo. would increase his lifetime exposure from natural radiation by five times this one rem.

Newspapers generally don't believe they are going to sell a lot of copies by telling good news so they are out to make bad news. We are constantly being asked questions that challenge the truth of what is in these reports. These are official Government documents and anything that is said in them I do stand behind.

FALLOUT CANNOT BE DETECTED ABOARD NUCLEAR SUBMARINES

Senator JACKSON. If you are aboard a sub, the radiation background level is less than what it would be in Denver, or if you are living in a brick house.

Admiral RICKOVER. Let me give you a very striking example of that. When an atomic weapon is exploded the fallout eventually disperses all over the world. A man with radiation detection equipment can be standing on a nuclear submarine and detect the fallout. It is not dangerous but he can detect the fallout. If he goes below in a nuclear-powered submarine with the same equipment he will no longer detect it. The radiation control is so strict and the design is so good that you cannot even measure the fallout levels inside the ship. If a man carries a wrist watch on board with a radium dial he has to put that wrist watch away because it can alarm our radiation monitoring instruments.

Senator JACKSON. Set off the alarm?

Admiral RICKOVER. Yes, sir, it can set off the alarm. We had an occurrence at Portsmouth Naval Shipyard, where the dry docks are built of granite, where a submarine entering the dry dock had its radiation alarm set off by the naturally occuring radioactivity in the granite blocks. The same would happen at Grand Central Station. This is a measure of the kind of care we have taken.

[Additional information submitted for the hearing record follows:]

The specific instance referred to occurred when the *Nautilus* went into drydock at the Portsmouth Naval Shipyard for the first time in 1959. There are sensitive instruments in the ship that measure the amount of radioactivity present in areas adjacent to the reactor plant. These instruments alarm when radioactivity levels reach a point above what is considered normal when the nuclear reactor is operating. As the ship moved into the drydock, with its reactor shut down, these instruments alarmed. We then discovered that these instruments had been set off by the naturally-occurring radioactivity in the granite blocks of the drydock.

STRINGENT SHIELDING DESIGN

For example, the design of the shielding on the *Nautilus*, was so conservative that today it is still more than adequate to meet present standards, even though radiation exposure standards have been tightened considerably since the time of the *Nautilus*. I realized then that in time as more became known of the effects of radiation, the permissible limits would be reduced.

I have been very conscious of the need for care in dealing with radiation from the very beginning of this program. While I was at Oak Ridge, I had long discussions with Dr. Hermann J. Mueller the Nobel prize geneticist.

[Additional information submitted for the record follows:]

Dr. Herman J. Mueller and I were both concerned about exposure to radiation. I spent hours talking with him. I also visited him at his University of Indiana laboratory where he was conducting basic genetic studies on irradiated fruit flies. It was clear to me then that if our nuclear ships were to be viable, there would have to be assurance that workers and crews would not be subjected to excessive radiation.

In one sense I deeply resent these accusations because if there was one thing I was aware of at the very beginning of this program it was the great importance of adequately protecting people from radiation.

Senator JACKSON. I think the record speaks for itself.

Admiral RICKOVER. Thank you, sir. You know how strict we are from the navy yard in your State.

Senator JACKSON. I know, Admiral Rickover, in my conversations with you over a quarter of a century, you have given safety and health considerations overriding priority.

Admiral RICKOVER. Yes, sir, absolutely.

Senator JACKSON. That has always been the case.

Admiral RICKOVER. Yes, sir, always has.

Senator JACKSON. We all get upset when we read these stories in the paper which only give the scare aspect. They never publicize the positive aspects of the efforts that you and others have made in the way of built-in safeguards with every kind of redundancy and security that one can possibly conceive of and make it effective.

Admiral RICKOVER. Mr. Chairman, if I knew any more that could be done, I would do it. I simply do not know anything else to do. If there were, I would do it.

APPLICABLE TO CIVILIAN POWER PROGRAM

Senator JACKSON. I agree with you on that.

Do you think there are some lessons that can be learned here—I mean from the naval reactors program—that can be applied to the civilian power program? Obviously you can't follow all the operations of our nuclear powerplants but basically have they not tried to follow the lessons of the Navy, do you know?

Admiral RICKOVER. They have. They certainly have to the extent that over 60 percent of the operators employed in the civilian nuclear power program have come from the Navy program. On the other hand, they do not have the kind of central supervision that exists in the naval program. For example, I know what goes on in detail on every nuclear ship in the Navy. I get personal reports of all aspects of the operation, and I estimate about 80 percent of my time is devoted to seeing to it that these ships operate safely and properly.

You do not have any equivalent of that in the civilian program. I believe I have had discussions with you along that line, sir, and I suggested that the industry itself set up a central group to provide technical supervision that would not depend on the Government. You need Government oversight but the industry itself should have a supervisory group that inspects its plants and assures that they are being operated safely.

You remember I had discussions with you along that line.

Senator JACKSON. That is right.

Admiral RICKOVER. They have never done that. I don't understand why because it would be of considerable reassurance insofar as the public is concerned. It would have to be a neutral group. It could have one of their representatives present at all times when a civilian plant is operating with authority to shut it down.

EXPERIENCE AT THE SHIPPINGPORT ATOMIC POWER STATION

I have that at the Shippingport Atomic Power Station. I don't know if you are familiar with that. I have a representative on watch in the control room whenever the Shippingport reactor is in operation with the authority to shut the plant down if he thinks it is not being operated properly. He has done that twice in the last 20-some years, though not for many years now.

He will do that, and I think if you had something like that, it would assure the public a great deal.

Senator JACKSON. The Shippingport operation could be a model.

Admiral RICKOVER. Yes, sir. It is operated with civilians, but it is also operated with the same stringent requirements that I require in the naval program. That is the only thing that I can suggest. If I knew any other things that should be done, I would incorporate them into the naval program.

Senator JACKSON. Admiral, that is a fine statement and your prepared statement has been placed in the record.

I will ask Senator Thurmond if he has any questions.

Senator THURMOND. Thank you very much.

Mr. Chairman, first I want to say that in my 24 years in the Senate of the United States, I have not come in contact with an abler, more dedicated public servant than Admiral Rickover. I think our country is very fortunate to have him still in service and I hope you will be in service for many more years.

Now, Admiral, I have a few questions. Before I go into those, I was looking through this report which was just handed to me, dated March 1978, entitled "Occupational Radiation Exposure from U.S. Naval Nuclear Propulsion Plants and Their Support Facilities."

I observe on page 32, table 8, "Death Rates in the United States for Various Causes," and it goes on: Smoking, 150 annual deaths per 100,000 population; motor vehicle accidents, 22, and so forth.

Then the last one, "Shipyard radiation workers from radiation associated with naval nuclear propulsion plants, less than one." I think that is most impressive because some people are of the opinion that some of the radiation at the shipyards has caused deaths, and so forth.

If there is no objection, Mr. Chairman, I think it would be helpful if that table 8 could be put in the record.

Senator JACKSON. The table will go in the record.

Admiral RICKOVER. Mr. Chairman, it might be helpful if both reports I have referred to could be included in the record, sir.

[See appendixes A and B, p. 113–178.]

BASIS FOR SAFETY MEASURES

Admiral RICKOVER. Senator Thurmond, I did not take the actions cited in the report you referred to because people are expressing concern. These efforts have been going on for over a quarter of a century. They are not due to any pressures that anyone put on me. That is not relevant. Everybody thinks that you have to put pressures on people to get them to do their job. There is no pressure that can be put on me that would make me do anything differently. I have a self-imposed pressure because I feel personally responsible for every person on our ships and at our shipyards and for everyone in the surrounding communities concerning my work.

This is not anything that anyone has ordered me to do or forced me to do.

Senator THURMOND. I think it would be very helpful and I think it would be very helpful to the press too. Does the press have it?

Admiral RICKOVER. They have it, sir.

Senator THURMOND. Could you give them this?

Admiral RICKOVER. Yes, sir. The report is unclassified and has been distributed to the press. The press is generally more interested in getting scare stories and also to show that all Government officials, including Members of Congress, have something wrong with them. They want to show that we in Government are a bunch of fuds or whatever you call them. We are just seatwarmers and we feed at the public trough. That is how many in the press see us.

Senator THURMOND. Now I have a few questions and I will run through them fast.

STUDIES ON RADIATION HEALTH HAZARDS

Admiral, in the approximately 20 to 25 years we have been using nuclear powerplants, have any studies been undertaken on the long-term health hazards or radiation effects from exposure in Navy programs other than what you have included here?

Admiral RICKOVER. I do not know of any beyond what is cited in the report. However, there are two scientific groups presently conducting studies of the shipyards. One is the Center for Disease Control, which is a Government agency that is looking at the Portsmouth Naval Shipyard. Another one is a group of scientific people from Johns Hopkins, very expert, also doing a study. So there will be neutral studies which will come from these independent groups. I am glad of that.

In fact, I suggested that this be done. I can add something to the record on this.

[Additional information submitted for the hearing record follows:]

I became concerned over the question of low level radiation health effects on shipyard workers after the study on Hanford workers was published in November 1977. As a result, in December 1977 I wrote to Dr. James Liverman, Acting Assistant Secretary for Environment of the Department of Energy (DOE), requesting an epidemiological study be performed for shipyard workers. The DOE determined that the best approach for this study, and one I strongly endorsed, was to use an independent organization with the requisite expertise.

Prior to beginning this effort, however, it was necessary to ascertain whether the necessary data was available in a manner which would permit a proper study to be made. To make this evaluation, one team of investigators conducted a preliminary review for the Department of Energy at Charleston Naval Shipyard in February 1978. A team from Johns Hopkins University then did a similar type of review at Portsmouth Naval Shipyard in March 1978. I have been informed that these groups have concluded that adequate data exists so that a proper study of all six naval shipyards engaged in nuclear propulsion work can be conducted. This will include the Puget Sound Naval Shipyard and the Charleston Naval Shipyard. Dr. Liverman's organization is responsible for overseeing this effort and making final selection of the organization which will do the work. I am told that the final choice has not yet been made although Johns Hopkins University is an obvious candidate due to their prior involvement.

A second study is being performed by a team from the Center for Disease Control (CDC) of the department of Health, Education and Welfare. Members of my staff met with a team for the Center for Disease Control to determine how we could assist them by providing information they would need to perform their study. We provided them background information on the Naval Nuclear Propulsion program and in particular, covered the work procedures used in the shipyards for nuclear work. This team also went to the Portsmouth Naval Shipyard where they reviewed the records available. The CDC team has indicated that they had received full cooperation and were satisfied with the way the effort was proceeding. Microfilm copies of personnel records and copies of all annual radiation exposure records going back to 1959 have been obtaind by CDC.

Given the complexity of the type of study needed, I believe it will be several years before results are available. While our shipyard records are in excellent condition, death certificates and other health information on personnel who have left employment is generally poor. This greatly complicates and lengthens this kind of investigation.

Senator THURMOND. Admiral Rickover, with the fuel problem growing more acute each year and the likelihood of large price increases in the future, is there research being done on building nuclear powerplants for smaller vessels?

Admiral RICKOVER. We can build nuclear powerplants for smaller vessels. There are nuclear submarines of all sizes down to the research submarine, NR–1. But the problem is that because of the need for radiation shielding, we cannot reduce the size of the propulsion plant proportionately to the size of the ship. Therefore, for any ship under about 8,000 or 10,000 tons it is relatively too expensive. That is why many years ago after considerable study—and this was agreed to by Congress—the Navy decided that only surface warships over 8,000 tons, and only combatant vessels should be nuclear powered. I think it would be wrong to consider nuclear power for smaller ships like the patrol frigates or destroyer escorts. We could do it but I think it would be wrong and it would be too expensive to do it on all ships.

I am being accused improperly of advocating that the entire Navy have nuclear power. I have never said that nor do I believe it should be. Does that answer your question?

Senator THURMOND. Yes, sir. Thank you.

Admiral, in my opinion there has been too much delay in building a nuclear carrier and also the Aegis ships. It would take 7 or 8 years to build a nuclear carrier and the higher cost is mainly due to the inflation in the past 5 years when we have not built a new carrier and the 7 or 8 years of construction. Is that not a key reason the cost of the nuclear carrier is so high?

Admiral RICKOVER. Yes, sir. Well, let me give a comparison. The *Nimitz* cost about $700 million, something along that line. Now the CVN 71 would be over three times as much and that is due almost entirely to inflationary costs. As far as the time is involved, it does take a long time to build a carrier because everything about it is so large. It also takes a great amount of time to get authorization to get started. Now, for example, to give you a comparison, it took about 5 years on the *Nautilus* from the time we got authorization to develop it and to build it. The whole leadtime to develop and build was 5 years.

Today you cannot do that. When it came to the latest class of submarines, the SSN 688 or *Los Angeles*, it took many years, it took I think about 4 or 5 years just to get the permission to start the work.

LENGTHY AUTHORIZATION PROCESS

Shipbuilding programs involve a lengthy authorization process both in the Defense Department and in Congress. This process takes more time than does the actual time to build a ship. The whole Government suffers from this lengthy authorization process but its effects are most dangerous in military matters because the operating forces cannot get the ships when they need them.

Senator THURMOND. Yes.

Admiral RICKOVER. The authorization process in the entire Government is too cumbersome. For example, to get money in the Defense Department means that I have to work through about 18 different echelons of bureacracy.

Senator THURMOND. It is ridiculous. I agree with you.

Admiral RICKOVER. Yes, sir, but I have to live with this system. I don't know what to do about it, but I think that this committee could help make arms procurement less expensive and more timely by conducting a thorough investigation of how many layers of people are involved in the military budget process.

The higher you get in any organization the less familiar the officials are with technical issues. My rule if I were a legislator, and legislators do just that, would be to judge the credibility of a witness. Congress knows that it is impossible for them to get into every detail of the vast amount of work they have so they use the expedient of judging the credibility of a witness, particularly his accomplishments. If I were a Member of Congress, I would ask every witness, "what have you done in your life?" If he tells you he built a reactor, the next question is "has it worked?" If he has done something that has worked, then you have got something. But the Defense Department has ipso facto taken for granted that any civilian supervisor knows more than any of his subordinates.

These people claim to know more regardless of what previous background they had.

Congressmen or Senators have to run for office and that chastens you. Having to run for office teaches a lot of things that a civilian appointed bureaucrat does not know. However, these bureaucrats often use their authority, privileges and prerogatives far more than Members of Congress who have the actual authority. They want their subordinates to stand outside their doors and hear the muffled sounds that come out and applaud them, but they don't want to tell their subordinates what they are doing.

The Secretary of the Navy has never asked to talk to me at any time. Of course that is his privilege.

Senator THURMOND. Admiral, I thank you for your good judgment and human nature.

Admiral, some feel this country can no longer afford to build aircraft carriers. The only reason the U.S. Navy is so powerful today rests on the aircraft carriers. Do you feel we can remain a naval power in the future without building more carriers today?

AIRCRAFT CARRIERS AND LAND BASES

Admiral RICKOVER. No, sir. I cannot say whether we should build them or not. But I think our air power is necessary today and it is necessary to have aircraft carriers. I am not advocating that we build more. That is not my job. All I say is we need aircraft carriers to use our air power because the aircraft carriers are the only way to apply air power when we have a problem in foreign countries where we do not have land air bases.

Well, someday after the initial fighting, there will be land bases there but even that poses a problem. Suppose there is an air strip somewhere in a foreign country and you say, "We will use these air strips for a land air base." But do you think the enemy is going to be so foolish as to permit that air strip to remain operable when he seizes that base? What is the alternative? Kits are being developed to be used for converting available runways into military airfields. However, for one tactical aircraft wing—approximately 90 aircraft—the equivalent of one air wing—the kit includes over 6,000 people, 7,000 tons of cargo and 1,500 vehicles in its initial lift. It must be maintained by a daily logistic resupply flow of 3,200 tons of consumables. This daily resupply, if provided by airlift, would require more than 100 C–5A transport aircraft. Since this is obviously impractical, overseas land bases are dependent on keeping the sea lanes open for logistic support. In many areas the Navy cannot do this without carrier aircraft. Now that is a real logistic problem.

Senator THURMOND. Admiral, your statement clearly justifies a nuclear carrier over the smaller, less capable conventional carrier. What points do you feel are overlooked in current studies which deserve more attention?

STUDIES OF AIRCRAFT CARRIERS

Admiral RICKOVER. Well, the latest study by the Navy itself came out with the conclusion that the CVN 71 is the most cost effective choice. Yet the Secretary of the Navy went up to the House Armed Services Committee and testified against the results of his own study which pointed out that, without even giving credit for the advantages nuclear power would give the CVN 71, the nuclear carrier was more cost effective. Yet he, the first time he went up to the House, testified against it. I don't know why.

Senator THURMOND. Maybe he had orders from higher up?

Admiral RICKOVER. Well——

Senator THURMOND. Admiral——

Admiral RICKOVER. If he had orders from higher up, he really should quit. If he really believes something when he gets up to Congress, he should tell Congress not what he is told but what he thinks; otherwise, he should not have the job.

LAND BASE AND TASK FORCE COSTS

Senator THURMOND. Admiral, I wonder if anyone has ever added up the cost of all the land air bases we have lost in Vietnam, Thailand, Africa, and elsewhere. There is certainly a value to an air field you can bring home with you. Also I wonder if the cost of oilers and Navy replenishment bases are figured in cost studies by those who oppose nuclear power for carriers or large cruisers?

Admiral RICKOVER. Would you like me to get some figures along that line?

Senator THURMOND. If you would, I would appreciate it.

Admiral RICKOVER. I will. You have a good point there and I think you will find the overall peacetime costs of the nuclear ships are not much more than conventional ships. In wartime, if bases are lost, the capability of the conventional ships will be greatly reduced.

[Additional information follows:]

Subsequent to my testimony, I obtained from the Navy the following information concerning the loss of land air bases in recent years.

Bases lost in South Vietnam cost about $500 million when built. The cost to build these same bases now would exceed $1 billion in fiscal year 1979 dollars. About $300 million was spent in Thailand; this equates to about $600 million in 1979 dollars. The investment in bases would have, of course, been recoverable, had they been aircraft carriers, when the war ended. Further, some of the South Vietnamese bases, were and can continue to be used by the enemy against United States/Allied interest in South East Asia (SEA). Also, over 1,000 friendly aircraft were captured by the enemy; these are in addition to the United States aircraft destroyed on the ground during United States participation in hostilities. No carrier has ever been captured by the enemy.

In addition to bases lost in SEA to military action the United States lost an extensive basing structure in France in the early 1960's due to political factors. Over $250 million was spent on these bases in the 1950's; this equates to $1 billion in fiscal 1979 dollars.

There have been other involuntary withdrawals from bases in Morocco, Pakistan, Libya and Okinawa since the early 1960's.

Concerning the overall cost of nuclear warships compared to conventional warships the following comparisons of total costs of an all-nuclear carrier task force for conventional force with the same numbers and types of ships shows that the extra cost of nuclear propulsion is small compared to the great increase in military capability achieved through nuclear propulsion.

On a total task force basis, the peacetime, undiscounted, 30-year life cycle cost of an all-nuclear carrier task force consisting of 1 CVN 68 Class carrier, 2 CGN 42 Class Aegis cruisers and 2 CGN 38 Class crusiers is estimated to be less than 7 percent greater than the comparable cost of an all-conventional carrier task force consisting of 1 CV 67 Class carrier, 2 DDG 47 Class Aegis destroyers and 2 CG 26 Class cruisers (modified to have CGN 38 Class combat system).

Inherent in the above cost calculations are the following assumptions that make cost comparisons alone an incomplete basis for decision:

(1) Peacetime costs were assumed. No wartime attrition of either strike force ships or underway replenishment groups (URG's) was considered. Prior

studies have shown that greater attrition of replenishment ships can be expected when supporting oil-fired strike forces because of the larger number of replenishment ships and the more frequent replenishments required.

(2) The cost calculations were based on the assumption that replenishment will be provided in the operations area. Because of this assumption, the number of combatant ships allocated to protect the task group underway replenishment forces was assumed to be the same for the nuclear and non-nuclear forces.

(3) It was assumed that the current or projected number of oilers is sufficient to replenish the task group. Consideration of replenishment in wartime was not considered.

(4) The comparison is of cost only. It does not account for any of the military advantages of nuclear propulsion. The nuclear carrier has 50 percent more aircraft ammunition and almost twice as much aviation fuel as the conventional carrier. Further, the all-nuclear carrier task group is independent of the need to resupply ship propulsion fuel. Therefore, the all-nuclear group has much greater tactical flexibility and mobility, and greater capability for sustained combat without replenishment. When replenishment is required, the all-nuclear group can steam at high speed to meet replenishment forces in low threat areas and then return to the high threat combat areas at high speed, without concern for conserving propulsion fuel. The conventional forces however must frequently slow for refueling of escorts, and the carrier may have to be replenished in forward areas, thereby making logistic supply more difficult and increasing task force vulnerability during replenishment.

The calculation of comparative task force life cycle costs is based on an update of the 1976 comparative study made by the Systems Analysis Division, Office of Chief of Naval Operations as follows:[1]

[In millions of dollars]

	Conventional	Nuclear
Aircraft[1]	12.326	12.326
CV/CVN[2]	4.096	4.633
DDG47/CGN42[3]	1.280	1.771
DDG47/CGN42[3]	1.280	1.771
CG26/CGN38	1.074	1.513
CG26/CGN38	1.074	1.513
FFG7 (3 ships)	1.329	1.329
FF 1052 (3 ships)	1.473	1.473
AE assets	.478	.478
AF assets	.061	.061
AFS assets	.281	.281
AOE assets	.322	.218
AOR assets	.378	.203
AO assets	.774	.373
Total (fiscal year 1976)	26.226	27.943
Ratio	1.065	

[1] Aircraft cost based on information in the "Assessment of Sea Based Air Platforms Project Report," dated February 1978, by the Office of the Secretary of the Navy. See table VI–6, p. VI–13. Costs used were "future CTOL aircraft." Fiscal year 1979 costs of $15,400,000,000 were deescalated to fiscal year 1976 giving $12,326,000,000 in fiscal year 1976 dollars.

[2] CVN platform costs were unchanged from 1976 Navy systems analysis study on the basis CVN costs were consistent with the sea based air study. Also, the sea based air study did not price a CV–67.

[3] DDG47/CGN42 life cycle costs were updated based on current estimated procurement costs, from those furnished by SECDEF Brown on Oct. 1, 1977, and deescalated to fiscal year 1976 dollars.

Senator THURMOND. Now I have just a few questions here on Aegis ships.

Admiral, the threat of antiship missiles from the Navy version of the Soviet Backfire bomber and cruise missiles from Soviet surface ships or submarines pose the greatest threat to our Navy. Now what do you see as our best counter to that threat?

Do you want me to repeat that question?

Admiral RICKOVER. Senator, I would like to give it some more thought.

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[1] Life cycle cost analysis is printed on pp. 7280–7284 of part 13 of the hearings before the Committee on Armed Services, U.S. Senate concerning fiscal year 1977 defense procurement. Hearings dated May 4 and 5, 1976. Analysis figures for aircraft and CGN42/DDG47 were updated as described in footnotes 2, 3, and 4 below.

Senator THURMOND. Do you want to answer that for the record?

Admiral RICKOVER. I do not pose as an expert on other parts of the Navy than those I am directly concerned with but I will get you the answer.

Senator THURMOND. I will be glad for you to answer that for the record.

Admiral RICKOVER. Thank you.

[The information follows:]

(The following information was provided for the record by VADM J. H. Doyle, the Deputy Chief of Naval Operations for Surface Warfare.)

In addition to the long range defense afforded by carrier tactical aircraft, our best counter to the threat posed by anti-ship cruise missiles fired by Soviet Backfire bombers and naval vessels is the Aegis weapons system with its superior detection capabilities in both clear and jamming environments, its automatic rapid reaction, high fire power, area coverage and high reliability.

This system, which entered production in April 1978, recently demonstrated these capabilities against high speed, high altitude targets simulating the type of threat posed by Backfire launched missiles. On 21 March and again on April 24, 1978, the Navy's Aegis test ship, the U.S.S. *Norton Sound* (AVM-1), successfully engaged a high altitude supersonic target (HAST), launched from a F-4 Phantom jet which simulated a Backfire.

Aegis is scheduled to begin entering the fleet in 1983, with the delivery of the lead ship of the DDG-47 Class, which was authorized and funded by the Congress in FY 1978. Aegis will also be installed in the CGN 42 Class nuclear cruisers.

Senator THURMOND. Admiral, has not the cost of the nuclear cruiser program increased because we are not buying the ships in an orderly progression?

DELAY INCREASES COST

Admiral RICKOVER. That is correct, sir. Even if the CGN-42 is authorized in fiscal year 1979, there will be a 4-year gap between the delivery of the CGN-41 and the CGN-42. When shipyard and component manufacturing workload decreases below currently available capacity, the shipyards and vendors must lay off trained workers or direct them to other work. Then any later increase in work or startup of a production line requires that they assign or hire new people who must be trained since, once a work force is dispersed or disbanded, it is virtually impossible to reassemble the same work force. The training and startup cost is then reflected in the new ships. Similar considerations apply to making macaroni. If you had a macaroni factory making so many boxes of macaroni and then disbanded the factory and you had to start over again, your macaroni would be more expensive. I am taking a very simple case. That would be very true anywhere, but it is particularly true in the case of shipbuilding and nuclear component manufacturers. The skills required to make macaroni are very simple—most people could do it—but to build a ship requires many, many experienced people. The loss of industrial base for building ships and naval nuclear propulsion plant components is a serious consequence of the declining nuclear ship construction program which will result in higher costs if the construction program is later increased.

Senator THURMOND. Yes.

Admiral, what are the main advantages of the Aegis nuclear cruiser over the DDG-47?

ADVANTAGE OF NUCLEAR POWERED AEGIS SHIPS

Admiral RICKOVER. The major advantage is that the Aegis nuclear cruiser has nuclear propulsion. Its cores contain enough fuel for about 15 years of operation. In time of war, it will be able to operate at sustained high speed independent of vulnerable propulsion fuel oil supply lines. Furthermore, it will not require the aircraft carrier it is operating with to divert fuel from its aircraft to propel the Aegis cruiser. If you have a nuclear or conventional carrier with conventional Aegis ships, you have to refuel each of the Aegis ships or other escorts after every few days of operations. If you refuel the escorts from the carrier, the carrier must steer a steady course and interrupt aircraft landing and launching. The task force must slow down. It becomes more vulnerable. Even if a tanker should be available, the Aegis ship must leave its station, slow down, and refuel, thereby no longer being available to protect the carrier.

It is very simple.

Senator THURMOND. Yes.

Admiral RICKOVER. And one difficulty we have, Senator, and you may not be aware of it, the very same systems analysts that did so much to create Mr. McNamara's reputation are still around. The very same bunch. They are still plying their trade.

Senator THURMOND. Thank you.

Admiral RICKOVER. Do you understand what the significance of that statement is?

Senator THURMOND. I certainly do and again I say you are a man of good judgment.

Admiral, can the DDG–47 support our nuclear carriers in high-threat areas?

CONVENTIONAL AEGIS SHIPS WITH AIRCRAFT CARRIERS

Admiral RICKOVER. No, sir; they cannot. That is why it is essential they be nuclear; if not they must be refueled every few days.

(Additional information submitted for the hearing record follows:)

Unless we have a sufficient number of nuclear powered Aegis ships, the DDG–47's will have to support our nuclear carriers as best they can. However, to obtain the full additional offensive and defensive capability from essentially unlimited high-speed endurance provided by nuclear power, all ships in the carrier task force should be nuclear powered.

Because the DDG–47's will have to be refueled after every few days of high-speed operations and because of the difficulty of bringing supplies into the remote and high threat areas in which the carrier task force may have to operate, our carrier task forces will not be as capable as they would be if given all nuclear Aegis escort ships. That is why it is essential that we provide nuclear-powered ships that are not dependent on vulnerable tankers for their mobility. There were 130 tankers sunk in the Atlantic in World War II by enemy diesel submarines far less capable than the nuclear submarines of today. None of the tankers were larger than about 25,000 tons. Most were 10,000 to 15,000 tons.

Today many of our tankers are 100,000, 200,000 and even 300,000 tons. They are much more vulnerable and furthermore, each loss will have greater impact.

It does not take much vision to see that the ships in the forward areas must be as self-sustaining as possible. You can get most people to see that but you can't get the system analysts to see it.

LIFE CYCLE COSTS

Senator THURMOND. Admiral, what is the difference in life cycle costs between the two?

Admiral RICKOVER. There is very little difference. When all costs are considered. I will get the figures.

Senator THURMOND. You put that in the record if you like to.

[The information follows:]

On a ship-to-ship basis the peacetime, undiscounted, 30-year life cycle cost (in the same year program dollars) of a CGN–42 class ship is estimated to be 1.38 times that of a DDG–47, not considering the cost of delivering the fuel to the DDG–47. However, the figures I supplied in answer to an earlier question show that the overall life cycle cost of an all-nuclear carrier task force including two Aegis nuclear cruisers is less than 7 percent more than the equivalent cost of an all-conventional carrier task force with the same number of ships and weapons systems. As I noted earlier these are peacetime costs, and do not take into consideration the great military superiority of the nuclear ships—especially in wartime.

The basis for the calculation of the life cycle cost comparison of the CGN–42 and DDG–47 on a ship-to-ship basis is as follows: Secretary of Defense Brown, by letter dated October 1, 1977, to Chairman of House and Senate Armed Services Committees provided the following 30-year undiscounted life cycle cost comparison of the first follow ship of the DDG–47 class and CGN–42 Class (in fiscal year 1978 dollars).

	Initial procurement	Outfit post. del.	Midlife conversion		Midlife recore	30-yr fuel	Ann. op. cost	Total 30-yr LCC (billions)
			Number	Percent				
DDG47	567	17	198	35	------------	63	15.2	1.301
CGN42	835	25	251	30	64	------------	26.8	1.979

The current Naval Sea Systems Command (Navsea) estimate of first follow DDG–47 class is $806 million (fiscal year 1980 dollars). This is $711 million in fiscal year 1978 dollars. The current Navsea estimate if the first follow CGN–42, in fiscal year 1978 dollars, is $906 million.

Using these initial procurement costs and corresponding calculated mid-life conversion costs yields the following life cycle costs:

	Billions
Fiscal year 1978:	
First follow—CGN–42	$2.076
First follow—DDG–47	1.500

Ratio: 1.38

Senator THURMOND. Admiral, thank you very much. We are delighted to have you with us and it is always refreshing to me to have you come before this committee.

Admiral RICKOVER. Thank you, Senator Thurmond, I try insofar as I can tell you the facts of these matters. I can do no more than that.

Senator THURMOND. That is what I admire about you, your courage in speaking your convictions, and further your great knowledge in the fields about which you speak.

Admiral RICKOVER. Thank you, sir.

Mr. COTTER. The chairman will be right back.

Admiral RICKOVER. I will wait for the chairman, Senator.

Senator THURMOND. It is a pleasure to see you again.

Admiral RICKOVER. And please remember me to your charming wife.

SIGNIFICANCE OF RISK ESTIMATE

Senator THURMOND. Thank you. I will be glad to.

Admiral, I might ask you one question while we are waiting for the chairman. The chairman referred to table 8, page 32, "Shipyard radiation workers from radiation associated with nuclear propulsion plants, less than one." Has there been an accident in which anyone was killed?

Admiral RICKOVER. No, sir, not in our program.

Senator THURMOND. How do you come to this statement, "Less than one"? Would that not be just zero then? See, that is the death rates for 100,000 population.

Admiral RICKOVER. Well, it is less than one. Of course——

Senator THURMOND. That is an estimate.

Admiral RICKOVER. That would be an accumulation, that is what it is.

Mr. WEGNER. There has been none directly related to radiation. That is why the epidemiological studies are going on.

Senator THURMOND. I just wondered why he didn't put the zero instead of one.

Mr. WEGNER. That is going on a statistical projection.

Senator THURMOND. I would like to have a little more information on that.

Admiral RICKOVER. I will supply that.

[The information follows:]

RISK ESTIMATE FOR SHIPYARD WORKERS FROM EXPOSURE TO RADIATION ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

The most recent authoritative reports on risk to humans from exposure to radiation were published in 1977 by the International Commission on Radiological Protection and by the United Nations Scientific Committee on the effects of atomic radiation. The risk estimates in these two reports are similar to those in the 1972 U.S. report by the National Academy of Sciences—National Research Council Advisory Committee on the Biological Effects of Ionizing Radiations. These risk estimates can be briefly summarized as follows:

In a large population group (such as 100,000 people) receiving an annual total of 10,000 man-rem year after year, the increased risk from this radiation appears to be in the region of about one fatal cancer case each year and about one leukemia case every five years in excess of the normal numbers of cases.

These scientific organizations caution that this risk estimate may be too high for gamma radiation in the range of exposures received in the Naval nuclear propulsion program. In applying this estimate to shipyard workers, the size of the group (about 100,000) is the same, but the shipyard workers have received less than the steady 10,000 man/rem per year of the above example. Because of this and the caution that the above estimate may be too high, the summaries in Tables 7 and 8 estimate the risk of fatal cancer from radiation associated with naval nuclear propulsion plants as less than 1 per year from the entire group of 100,000 shipyard workers. Although this risk is small, it is not zero.

Mr. LEIGHTON. The reason it is not shown as zero is there is a statistical calculability greater than zero that something could happen to somebody. You could never get a statistical projection that goes to zero so you have to say it is less than one. The statistical projection comes out less than one and that is why it is listed that way. It included a projection as to the statistical probability of a death occurring due to low level radiation exposure. There has been no shipyard employee who has died from exposure to radiation in our program.

Senator THURMOND. No one died. Was anyone injured?

Mr. Wegner. No shipyard workers have ever been injured from radiation exposure so far as we know.

Senator Thurmond. This is a fight I have all the time with some of these so-called environmentalists when I advocated nuclear power, nuclear ships, because I am a strong proponent of those things and then I have some fellow that comes by, so-called environmentalist. I don't think they feel that way—so-called environmentalists.

Mr. Wegner. One of the reasons the study is going on by the CDC and Johns Hopkins is to go back and see if they can find some correlation between the low level radiation effects and mortality.

As of right now we don't know that there is such a connection but that is why these studies are going on.

Admiral Rickover. In dealing with probabilities like this you cannot ever say zero. But we don't know of any shipyard worker injuries or deaths due to radiation exposure.

Senator Thurmond. I see.

Admiral Rickover. Perhaps that should have been explained more thoroughly and I will put something in the record if that is satisfactory to you, sir.

Senator Thurmond. Thank you very much.

Thank you, Mr. Chairman.

Senator Jackson. Thank you, Senator Thurmond.

Admiral Rickover, once again we on behalf of the committee want to express to you and your associates our deep appreciation for a very fine presentation here.

Admiral Rickover. Thank you, sir.

May I have your permission to extend and correct my remarks?

Senator Jackson. Certainly. And any additional material you wish to include in the record, that will be so ordered.

You agree on that?

Senator Thurmond. Yes, sir.

QUESTIONS SUBMITTED BY SENATOR HELMS FOR DR. KERR TO BE ANSWERED FOR THE RECORD

Senator Helms. Does DOE have any responsibility for setting the requirements for the operational use or utility of nuclear weapons?

Dr. Kerr. No. The determination of need, the concept of employment, and the military characteristics are principally responsibilities of the DOD. These DOD responsibilities are delineated in joint agreements between the two agencies. However, the development of nuclear weapons is conducted by the DOE under the oversight of joint DOE/DOD project officers groups; and factors such as the eventual operational use and utility of a weapon under development are routinely discussed and influenced in project officer meetings. The inherent features of specific nuclear weapons designs have a very definite impact on the operational use and utility of the weapons and the final form of these features in a stockpiled weapon reflect the result of many tradeoffs between idealized statements of requirements and practical economic and technological design approaches.

Senator Helms. How would production of the B61 fulfill the Air Force requirement of a survivable weapon against hard, irregular targets?

Dr. Kerr. [Deleted.]

A requirement for evaluating performance of the B61 against certain irregular targets, i.e., [deleted]. A computer-aided study was made to assess the probability that the B61 will survive and function after impact on irregular, composite targets. [Deleted.]

The irregular target study did not take into account the use of larger, Kevlar reinforced parachutes which are now available. Such parachutes are capable of dramatically reducing the severity of impact conditions. Recent testing by

Sandia Laboratories in simulated aircraft releases, using rocket sled tracks, against irregular target arrays appears to validate the results of the earlier computer simulation and the benefits gained through the use of Kevlar reinforced parachutes. These parachutes are already planned for use in the B61-3 and B61-4 bombs and could be incorporated into any new production bomb or could be retrofitted into older bombs.

Senator HELMS. Would the B61 give you capability of being able to [deleted]?

Dr. KERR. [Deleted.]

Senator HELMS. Dr. Kerr, if it is decided that the Soviets have not responded to the President's restraint on the production of the Enhanced Radiation warhead, how quickly thereafter could that warhead be fielded?

Dr. KERR. [Deleted.]

Senator HELMS. Dr. Kerr, what specific concessions by the Soviets would prompt the President to decide not to retain the option to produce the Enhanced Radiation warhead?

Dr. KERR. [Deleted.]

Senator HELMS. [Deleted.]

Dr. KERR. [Deleted.]

Senator HELMS. [Deleted.]

Dr. KERR. [Deleted.]

Senator HELMS. Would a Comprehensive Test Ban Treaty related testing cutoff [deleted].

Dr. KERR. [Deleted.]

Senator HELMS. Dr. Kerr, do we have the capability, at present, to verify nuclear detonations above ground of yields [deleted].

Dr. KERR. The U.S. Atomic Energy Detection System operated by the Department of Defense now relies principally on satellites for the detection and location of nuclear explosions in the atmosphere and in space. [Deleted.]

Senator HELMS. If we continue with present developments, when can we expect to be able to verify nuclear detonations above or below ground of [deleted].

Dr. KERR. [Deleted.]

With reference to underground explosions, our capability to reduce the present detection and identification threshold will depend upon the achievable capability of the AEDS external network (i.e., the programmed improvements and the additional, but unprogrammed improvements, to achieve an optimized network external to the USSR) as well as location, numbers, and types of seismic installations internal to the Soviet Union which in turn will depend upon the results of the ongoing CTB negotiations. With an optimum network of internal stations, the detection and indentification threshold might be reduced [deleted] in the absence of evasive testing.

Even the most optimum internal network will not effectively monitor evasive testing. For example, the Soviets could conduct clandestine tests in salt cavities which would effectively decouple the resulting seismic signal and result in masking this signal entirely. Tests up to several 10s of KT could be conducted in this evasive manner with little risk of detection.

Senator HELMS. Since the programmed budget for nuclear test verification activities for the fiscal year 1979 request is almost a year old, would it now be more feasible to add monies for verification capabilities for the Comprehensive Test Ban Treaty? Specifically, as you are working on an onsite seismic verification, could more funds be used this year to meet a possible requirement for such capability? How much?

Dr. KERR. The Soviets have, in principle, accepted the concept of seismic installations in their country to monitor compliance with a Comprehensive Test Ban Treaty. The numbers and types of such installations will, of course, depend on what is eventually negotiated. [Deleted.]

Senator HELMS. Dr. Kerr, would the Department of Energy development and production of the W80 warhead for the air-launched cruise missile be made simpler and more efficient if you were not required to adhere to the present limited operational capability [deleted] but rather, could work toward a more realistic definition of an IOC?

Dr. KERR. Yes. The present limited operational capability schedule imposes difficult warhead production/delivery requirements on the DOE production system. [Deleted.] The uniqueness of the LOC concept imposes unique support costs upon the DOE warhead program.

Senator JACKSON. The committee stands adjourned.

[Whereupon, at 12:22 p.m. the subcommittee adjourned.]

APPENDIX A

Report NT-78-2
March 1978

OCCUPATIONAL RADIATION EXPOSURE FROM U. S. NAVAL NUCLEAR PROPULSION PLANTS AND THEIR SUPPORT FACILITIES

1977

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SUMMARY

Radiation exposures to Navy and civilian personnel monitored for radiation associated with U. S. Naval nuclear propulsion plants are summarized in this report. Navy personnel manned thirteen tenders, two submarine bases, 110 nuclear-powered submarines and 10 nuclear-powered surface ships which were in operation at the end of 1977. Nine shipyards engaged in construction, overhaul, and refueling of these ships are manned primarily by civilian personnel. During 1977, 15,788 personnel at shipyards and 20,716 aboard ships and bases were monitored for radiation associated with nuclear propulsion plants. A total of approximately 200,000 personnel have been monitored for radiation since the USS NAUTILUS reactor plant began operating in 1954; approximately half of these have been shipyard personnel.

Figure 1 shows that over the last dozen years the total radiation exposure has been reduced to less than half of the amount in the peak year of 1966 even though the number of nuclear-powered ships nearly doubled during that period. Total man-rem in this figure is the sum of the annual exposures of each person monitored for radiation. The average exposure of each person monitored has been about one quarter rem per year. This is only slightly greater than the average radiation exposure everyone in the U. S. receives each year from cosmic radiation, natural radioactivity in the earth and in building materials and food, and from medical and dental examinations.

The total lifetime exposure from radiation associated with Naval nuclear propulsion plants to date for all personnel monitored since 1954 has averaged about one rem per person. A person moving from a low elevation to Denver, Colorado would increase his lifetime exposure from natural radiation by five times this one rem.

No civilian or military personnel in the Naval nuclear propulsion program have exceeded the Federal limit which allows five rem exposure for each year of age beyond age eighteen. Since 1967 no person has exceeded the Federal limit which allows up to three rem per quarter year, nor in this ten year period has anyone exceeded the Navy's self-imposed limit of 5 rem per year for radiation associated with Naval nuclear propulsion plants.

No civilian or military personnel in the Naval nuclear propulsion program have ever received more than one tenth the Federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with Naval nuclear propulsion plants.

According to the standard methods for estimating risk, the risk to the group of personnel occupationally exposed to radiation associated with Naval nuclear propulsion plants is less than the risk these same personnel have from exposure to natural background radiation or to medical radiation. This risk is small compared to the risks accepted in normal industrial activities.

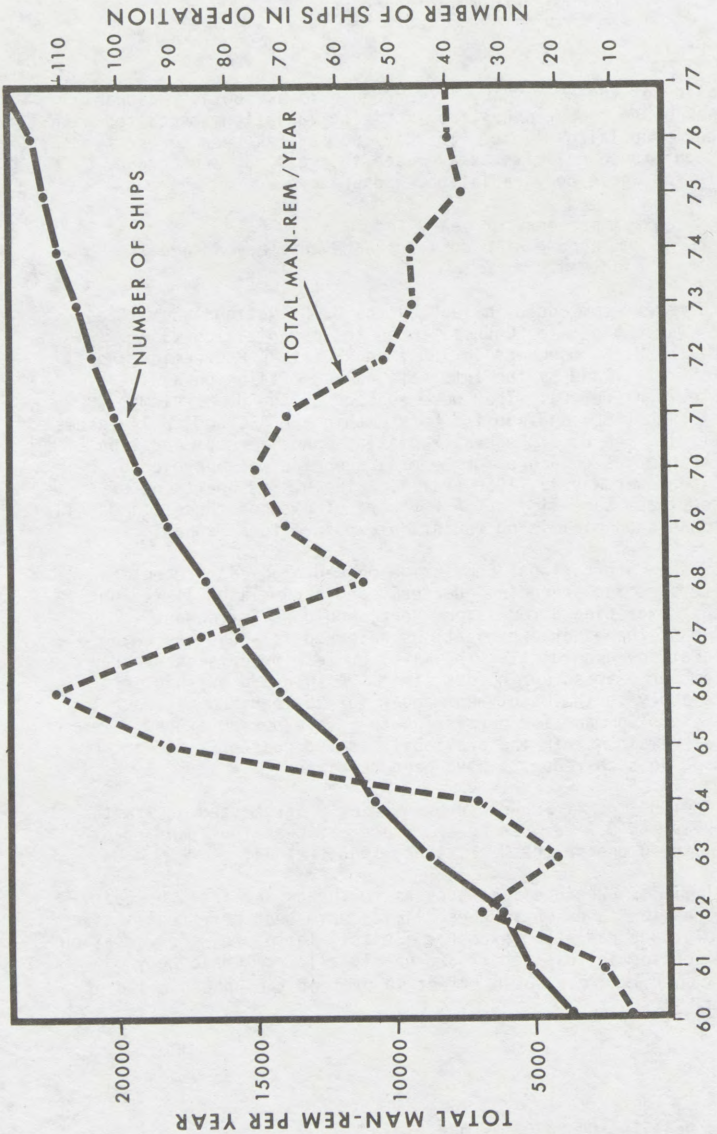

FIGURE 1

TOTAL RADIATION EXPOSURE RECEIVED BY MILITARY AND CIVILIAN PERSONNEL IN THE NAVAL NUCLEAR PROPULSION PROGRAM 1960 - 1977

EXTERNAL RADIATION EXPOSURE

Policy and Limits

The policy of the U. S. Navy is to reduce to as low as reasonably achievable exposure to personnel from ionizing radiation associated with Naval nuclear propulsion plants. The Navy policy has been to use the same radiation exposure limits as are used in the U. S. and abroad. These limits for whole body radiation exposure are

3 rem per quarter year, and
5 rem accumulated dose for each year beyond age eighteen.

These limits were recommended in 1958 by the U. S. National Committee ("Committee" was changed to "Council" when the organization was chartered by the U. S. Congress in 1964) on Radiation Protection and Measurements (ref 1) and by the International Commission on Radiological Protection (ref 2). They were adopted by the U. S. Atomic Energy Commission (AEC) and applied both within the AEC and to licensees in 1959 (ref 3). The U. S. Federal Radiation Council recommendation that these be used as guidance for Federal agencies was approved by President Eisenhower May 13, 1960 (ref 4). The U. S. Department of Labor adopted these same limits. A key part of each of these standards has been emphasis on minimizing radiation exposure to personnel.

In 1965 the International Commission on Radiological Protection (ref 5) reiterated the preceding quarterly and accumulated limits but suggested that exceeding 5 rem in one year should be infrequent. Although none of the other organizations referred to above has changed its recommendations accordingly, the Naval nuclear propulsion program adopted 5 rem per year as a rigorous limit. A shipyard or ship is permitted to apply to the Deputy Commander for Nuclear Propulsion, Naval Sea Systems Command for permission to have a person exceed 5 rem in a year but remain within the previously stated quarterly and accumulated limits. No such requests have been received.

Prior to 1959 the Naval nuclear propulsion program used as limits 15 rem per year and 0.3 rem per week. These had been the standard exposure limits in use in the U. S. since 1948 (ref 1).

Special limits are in effect such as for hands and feet, however, there have been few cases where these limits have been more restrictive than the whole body radiation exposure limits. Therefore, the radiation exposures discussed in this report are nearly all from whole body radiation. Controls are also in effect to protect the unborn child of a pregnant worker.

References are listed on pages 40 and 41.

Each organization in the Naval nuclear propulsion program is required to have an active program to reduce radiation exposure to personnel. Organizations therefore establish their own radiation control levels lower than the Navy's quarterly and annual limits as part of their programs to reduce radiation exposures to the minimum practicable. Each organization is also required to minimize the number of personnel exposed to radiation as an additional aid in reducing total man-rem of radiation exposure.

Source of Radiation

The radiation discussed in this report originates from pressurized water reactors. Water circulates through a closed piping system to transfer heat from the reactor core to a secondary steam system isolated from the primary cooling water. Trace amounts of corrosion and wear products are carried by reactor coolant from reactor plant metal surfaces. Some of these corrosion and wear products are deposited on the reactor core and become radioactive from exposure to neutrons. Reactor coolant carries some of these radioactive products through the piping systems where a portion of the radioactivity is removed by a purification system. Most of the remaining radionuclides transported from the reactor core deposit in the piping systems. The radionuclide of most concern for radiation exposure is cobalt 60. It emits two high energy gammas and a low energy beta for every radioactive decay. Its half-life is 5.3 years.

The reactor core is installed in a heavy-walled pressure vessel within a primary shield. This shield limits radiation exposure from the gammas and neutrons produced when the reactor is at power. Reactor plant piping systems are installed primarily inside a reactor compartment which is surrounded by a secondary shield. Access to the reactor compartment is permitted only after the reactor is shutdown. Most radiation exposure to personnel comes from inspection, maintenance, and repair inside the reactor compartment. The major source of this radiation is cobalt 60 deposited inside the piping systems.

Neutrons produced when reactor fuel fissions are shielded by both primary and secondary shields before penetrating to ocupied areas. Radiation exposure to personnel from these neutrons during reactor operation has been much less than from gammas. After reactor shutdown when shipyard and other support facility work is done, no neutron exposure is detectable. As a result, the radiation exposures discussed in this report are nearly all from gamma radiation.

Control of Radiation During Reactor Plant Operation

Reactor plant shielding is designed to minimize radiation exposure to personnel. Shield design criteria establishing radiation levels in various parts of each nuclear-powered ship are personally approved by the Deputy Commander for Nuclear Propulsion, Naval Sea Systems Command. Conservatism is built into the designs. For example, although the first nuclear-powered submarine USS NAUTILUS (SSN 571) was designed when the exposure limit was 15 rem per year, it meets the Navy's current 5 rem per year limit.

Ship design is also controlled to keep locations such as duty stations where personnel need to spend time as far as practicable away from the reactor compartment shield. Special attention is paid to living quarters. For example, in NAUTILUS the shield design criteria were established such that a person would have to spend more than 120 hours per day in living quarters to exceed exposure limits (which is impossible since there are only 24 hours in a day). In subsequent designs this conservatism was reduced to 48 hours per day for living quarters.

Resulting radiation exposure to those aboard ship outside propulsion plant spaces during reactor plant operation is not any greater than natural background radiation. For submarine operating personnel outside the propulsion plant, the combination of low natural radioactivity in ship construction materials and reduced cosmic radiation under water provides less radiation exposure at sea than the public receives ashore. Those who operate the nuclear propulsion plant receive more radiation exposure in port during maintenance and overhaul periods than they receive from operating the propulsion plant at sea.

Control of Radiation in Support Facilities

Tenders for nuclear-powered submarines and surface ships are designed so that radioactive material is handled only in specially designed and shielded nuclear support facilities. Submarine bases and shipyards limit to the minimum the number of places where radioactive material is allowed. Specific traffic routes are required to be used for any movement of radioactive material outside these nuclear support facilities. A radioactive material accountability system is used to ensure no radioactive material is lost or misplaced in a location where personnel could unknowingly be exposed. Regular inventories are required for every item in the radioactive material accountability system. Radioactive material is tagged with yellow and magenta tags bearing the standard radiation symbol and the measured radiation level. Radioactive material removed from a reactor plant is required to be placed in yellow plastic, and the use of yellow plastic is reserved solely for radioactive material. All personnel assigned to a tender, submarine base, or shipyard are trained to recognize that yellow plastic identifies radioactive material and to initiate immediate action if radioactive material is discovered out of place.

Access to radiation areas is controlled by radiological control personnel. Personnel are required to wear dosimetry badges to enter these areas. Dosimetry badges are also posted outside these areas to verify that personnel outside these areas do not require monitoring. Frequent radiation surveys are required using instruments which are checked before use and calibrated regularly. Areas where radiation levels are greater than 0.1 rem per hour are locked or guarded.

Dosimetry

Thermoluminescent dosimeters (TLDs) are the dosimetry badges worn by personnel to measure their exposure to gamma radiation. The thermoluminescent dosimeter contains two chips of calcium fluoride, with added manganese. It is characteristic of thermoluminescent material that radiation causes internal changes which make the material, when subsequently heated, give off an amount of light directly proportional to the radiation dose. In order to make it convenient to handle, these chips of calcium fluoride are in contact with a metallic heating strip with heater wires extending through the ends of a surrounding glass envelope. The glass bulb is protected by a plastic case designed to permit the proper response to gammas of various energies. To read the radiation exposure, a trained operator removes the glass bulb and places it in a TLD reader so that the metal heater wires contact an electrical circuit. An electronically controlled device heats the calcium fluoride chips to several hundred degrees centigrade in a timed cycle, and the intensity of light emitted is measured and converted to a digital readout in units of rem. The heating cycle also anneals the calcium fluoride chips so that the dosimeter is zeroed and ready for subsequent use. The entire cycle of reading a TLD described here takes about thirty seconds.

TLDs are required to be processed at least daily in all support facilities. Aboard ship TLDs are required to be processed at least monthly except that daily processing is required for anyone entering a reactor compartment or high radiation area. To ensure accuracy, a number of calibration checks are performed on the TLD system. For example, each TLD is checked every six months for response within fifteen percent of a known exposure. Also each TLD reader must check within one percent against its internal calibration standard prior to each use and at least hourly when the reader is in use. Special TLDs made of lithium fluoride chips are used when exposures to neutrons need to be measured.

Pocket ionization chambers with an eyepiece permit the wearer to read his own radiation exposure. This pocket dosimeter is required in addition to a TLD when entering a reactor compartment or a high radiation area. Pocket dosimeters are used to enable the wearer to keep track of his own radiation exposure during a work period. The official record of radiation exposure is obtained from the TLD.

Prior to 1974 film badges were used to measure radiation exposure. Film packets like those used for dental X-rays were placed in holders designed to allow differentiating between types of radiation. The darkness of the processed film was measured with a densitometer and converted to units of radiation exposure. When the first personnel radiation exposures were measured for NAUTILUS, there already was widespread photodosimetry experience in the Navy and precise procedures existed to provide reproducible results. One reason for changing from film to TLDs was that radiation exposure information can be obtained from TLDs in less than a minute compared to several hours for film badges. Use of TLDs permits more frequent measurement of a worker's radiation exposure than film badges. Many organizations in the nuclear industry have also changed from film to TLDs. Monitoring exposures to betas and low energy gammas is also done with film badges in the infrequent cases such monitoring is required.

Physical Examinations

Radiation medical examinations have been required since the beginning of the Naval nuclear propulsion program for personnel exposed to radiation. In these examinations the doctor pays special attention to any condition which might indicate that radiation exposure would cause an increased degree of risk. Passing this examination is a prerequisite to obtaining the dosimetry badge which permits entry to areas where radiation exposure can be received. For military personnel who have already been screened by physical examinations, few fail this radiation physical. For civilian shipyard workers the failure rate is a few percent. However, failure of this examination does not mean a shipyard worker will not have a job. Since shipyard workers spend most of their time on nonradioactive work, inability to perform radioactive work does not restrict their job opportunities. No shipyard worker in the Naval nuclear propulsion program has been fired for inability to pass a radiation medical examination.

Radiation medical examinations are given prior to initial radiation work, and at termination of radiation work in the nuclear propulsion program (or at termination of employment) if the worker has received more than 0.5 rem in any year. In addition, during each three year period anyone who has received more than 0.5 rem in one year receives a radiation medical examination. The basis for selecting 0.5 rem as a criterion for examination is that those who receive less than 0.5 rem in a year have not exceeded radiation exposures permitted by Federal regulations for members of the general population.

A radiation medical examination includes review of medical history to determine, among other subjects, past radiation exposure, history of cancer, history of radiation therapy, and family history of cancer. In the physical examination particular attention is paid to evidence of cancer as well as cataracts in the eyes. Laboratory procedures include urinalysis, blood analysis, and comparison of blood constituents to a specific set of standards. Chest X-rays with full size film to reduce radiation exposure were also a routine part of all radiation medical examinations until 1977. At that time routine chest X-rays were discontinued, further reducing radiation exposure of workers. Chest X-rays are now performed when clinically indicated at the discretion of the medical officer. In event disqualifying conditions are found in an examination of Naval civilian or military personnel, the individual is barred from receiving occupational radiation exposure until the results of the examination are reviewed by the Bureau of Medicine and Surgery Radiation Effects Advisory Board. Only after approval of the board would the individual be permitted to receive occupational radiation exposure.

Shipyard Training

Periodic radiological control training is performed to ensure each person understands the general and specific radiological aspects which he might encounter, understands his responsibility to the Navy and the public for safe handling of radioactive materials, and understands his responsibility to minimize his own radiation exposure. Prior to being authorized to perform radiation work, an employee is required to complete satisfactorily a radiological control training course, including a written examination. In written examinations on radiological controls short answer questions such as multiple choice and true-false questions are not normally used. The initial course includes explanation of all items in Figure 2, a notice which is conspicuously posted in applicable areas throughout the shipyard. Considerations of radiation exposure are prominent in this notice. Many radiological subjects are covered in this training; following are the requirements under just one subject, radiation exposure control:

a. State the limits for whole body penetrating radiation. Explain that the rem is a unit of biological dose from radiation.

b. Explain how "stay times" are used.

c. Be aware of the seriousness of violating instructions on radiation warning signs and unauthorized passage through barriers; be aware of penalties for violating these requirements.

d. Discuss procedures and methods for minimizing exposure such as working at a distance from a source, reducing time in a radiation area, and shielding.

e. Discuss potential sources of radiation associated with work performed by individual's trade.

f. State where dosimetry equipment shall be placed on an individual's body

g. Demonstrate ability to read all types of dosimeters in use.

h. Discuss importance of the individual keeping track of his own exposure.

i. Discuss biological risks of radiation exposure to the unborn child.

Figure 2

NOTICE TO SHIPYARD PERSONNEL

RADIOLOGICAL CONTROL STANDARDS FOR RADIOACTIVITY ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

STANDARDS

Standards for protection of employees against radiation associated with Naval nuclear propulsion plants are contained in NAVSHIPS 389-0288, "Radiological Controls for Shipyards," copies of which are required to be readily available for examination by shipyard personnel upon request. These standards are based on recommendations of the Federal Radiation Council, and are consistent with those of the U.S. Nuclear Regulatory Commission and the U.S. Department of Labor.

YOUR RESPONSIBILITY AS A WORKER

Although personnel specially trained in radiological controls normally oversee radioactive work, each individual involved in these operations must constantly remain aware of the potential radiological problems. Each of your actions directly affects your exposure, contamination, and the overall radiological problems associated with the operation. The following "rules" should be followed by individuals to minimize radiological problems:

1. Obey promptly "stop-work" and "evacuate" orders of radiological control personnel.
2. Obey posted, verbal, and written radiological control instructions.
3. Wear dosimetry equipment where required by signs or by radiological control personnel.
4. Keep track of your own radiation exposure status and avoid exceeding exposure limits.
5. Remain in as low radiation areas as practicable to accomplish work.
6. Do not loiter in radiation areas.
7. Do not smoke, eat, drink or chew in contaminated areas.
8. Wear anticontamination clothing and masks properly and wherever required by signs or radiological control personnel.
9. Remove anticontamination clothing and masks properly to minimize spread of contamination.
10. Frisk yourself or be frisked for contamination when leaving a contaminated area.
11. For a known or possible radioactive spill, minimize its spread and notify radiological control personnel promptly.
12. Do not unnecessarily touch a contaminated surface or allow your clothing, tools, or other equipment to do so.
13. Place contaminated tools, equipment, and solid waste on disposable surfaces (for example, sheet plastic) when not in use and inside plastic bags when work is finished.
14. Limit the amount of material that has to be decontaminated or disposed of as radioactive waste.
15. Report the presence of open wounds to radiological control and medical personnel prior to work in areas where radioactive contamination exists and immediately if a wound occurs while in such an area.

YOUR EMPLOYER'S RESPONSIBILITY

The shipyard is required to:

(a) maintain records of your occupational radiation exposure and, upon your written request, advise you of your recorded occupational radiation exposure.

(b) notify you immediately of any radiation exposure which exceeds the quarterly or lifetime cumulative limits of NAVSHIPS 389-0288.

(c) provide you after termination of employment, upon your written request and within 30 days after the request, with a written summary of your cumulative recorded occupational radiation exposure received during your period of employment.

(d) notify personnel of the above procedures by posting this Notice conspicuously.

INSPECTIONS

Shipyard work associated with U.S. Naval nuclear propulsion plants is subject to periodic inspection by Naval Sea Systems Command.

INQUIRIES

Inquiries concerning radiological controls should be addressed to your employer. Additional inquiries may be addressed to Naval Sea Systems Command, Navy Department, Washington, D.C. 20362.

In addition to passing a written examination, completion of this training course requires satisfactory performance during basic types of simulated work operations. For an employee to continue as a radiation worker he has to requalify in a manner similar to the initial qualification at least every two years. In between these qualification periods personnel are required to be selected at random for additional examination to determine how well the knowledge has been retained. Training is also conducted by individual shop instructors in the specific job skills for radiation work within each trade. For complex jobs this is followed by special training for the specific job, frequently using mockups outside radiation areas.

Radiological control technicians are required to complete an extensive course in radiological controls, to demonstrate their practical abilities, and to pass comprehensive written and oral examinations. Radiological control supervisors are required to have at least the same technical knowledge and abilities as the technicians; however, passing scores for supervisors' examinations are higher or supervisors' examinations are more difficult than for technicians. Oral examinations are conducted by senior radiological control personnel and require personnel to be able to evaluate symptoms of unusual radiological control situations. The radiological control technician or supervisor is required to evaluate initial symptoms, state immediate corrective action required, state what additional measurements are required, and do a final analysis of the measurements to identify the specific problem. Subsequent to qualification, periodic training sessions are required in which each radiological control technician and supervisor demonstrates ability to handle situations such as are used in the oral examinations. At least every two years radiological control personnel have to requalify through written and oral examinations similar to those used for initial qualification. Radiological control technicians and supervisors are required to demonstrate their practical abilities frequently through unannounced drills.

In addition to the above training for those who are involved in radioactive work, each shipyard employee not involved in radioactive work and each person assigned to a nuclear-powered ship or a support facility is required to receive basic radiological training, which is repeated at least annually. This training is to ensure personnel understand the posting of radiation areas, the identification of radioactive materials, and not to cross radiation barriers. This instruction also explains that the radiation environment of personnel outside radiation areas and outside the ship or shipyard is not significantly affected by nuclear propulsion plant work.

Nuclear Power Training

Military personnel who operate Navy nuclear propulsion plants are required to pass a six month basic training course at nuclear power school and a six month qualification course at a land-based prototype of a shipboard reactor plant. Each nuclear-trained officer and enlisted man receives extensive radiological control training including lectures, demonstrations, practical work, radiological control drills, and written and oral examinations.

This training has emphasized the ability to apply the basic information. An example of the type of material in use about 15 years ago for background information on radiation and radioactivity is included as Appendix 1. This material continues in use in expanded form.

Those enlisted personnel who will have additional responsibilities for radiological control are designated Engineering Laboratory Technicians and receive an additional three months training after completion of the one year program.

Prior to becoming qualified as the engineering officer, that is the head of the engineering department of a nuclear-powered ship, a nuclear-trained officer must pass a one day written examination and a sequence of oral examinations conducted at Naval Reactors headquarters. A key part of those qualification examinations is radiological controls.

Prior to becoming a commanding officer of a nuclear-powered ship, an officer completes the one year nuclear power training program. Immediately before serving as commanding officer he attends a three month course at Naval Reactors headquarters. The radiological controls portion of this is an advanced course and assumes the officer starts with detailed familiarity with shipboard radiological controls. The officer must pass both written and oral examinations in radiological controls during this course to become a commanding officer of a nuclear-powered ship.

Radiation Exposure Reduction

Following is a brief checklist which has been in use for years in maintaining personnel radiation exposure as low as practicable during maintenance, overhaul, and repair. Operations, maintenance, and repair personnel are required to be involved in this subject; it is not left solely to radiological control personnel.

Preliminary Planning

- Plan in advance
- Delete unnecessary work
- Obtain expected radiation levels

Preparation of Work Procedures

- Plan access to and exit from work area
- Provide for service lines (air, welding, ventilation, etc.)
- Provide communication (sometimes includes closed-circuit television)
- Remove sources of radiation
- Plan for installation of temporary shielding
- Decontaminate
- Work in lowest radiation levels
- Perform as much work as practicable outside radiation areas
- State requirements for standard tools
- Consider special tools
- Include inspection requirements (these identify steps where radiological control personnel must sign prior to work proceeding)
- Minimize discomfort of workers
- Estimate man-rem

Temporary Shielding

- Control installation and removal by written procedure
- Inspect after installation
- Conduct periodic radiation surveys
- Minimize damage caused by heavy lead temporary shielding
- Prohibit use of lead shot for temporary shielding
- Balance radiation exposure received in installation against exposure to be saved by installation
- Shield travel routes
- Shield components with abnormally high radiation levels early in the maintenance period
- Shield position worker occupies
- Perform directional surveys to improve design of shielding by locating sources of radiation
- Use mockups to plan temporary shielding design and installation

Rehearsing and Briefing Workers

- Rehearse
- Use mockups duplicating working conditions
- Use photographs
- Brief workers

Performing Work

- Post radiation levels
- Keep excess personnel out of radiation areas
- Minimize beta radiation exposure (anticontamination clothing effectively shields cobalt 60 betas)
- Supervisors and workers keep track of radiation exposure
- Workers assist in radiation and radioactivity measurements
- Delegate radiological control monitoring responsibilities when necessary to minimize radiation exposure
- Evaluate use of fewer workers
- Re-evaluate reducing radiation exposures

Radiation Exposure Data

Radioactive materials had been handled in shipyards for years before Naval nuclear propulsion plant work started. Examples of such work include non-destructive testing using radiography sources and radiation instrument calibration using radioactive sources. Since this work is licensed by the Nuclear Regulatory Commission or by a State under Agreement with the Nuclear Regulatory Commission, the radiation exposure from this licensed work has been excluded whenever practicable from this report.

Table 1 shows the dates when radioactive work associated with Naval nuclear propulsion plants started in each of eleven shipyards. Seven of these shipyards have constructed Naval nuclear-powered ships, however little radiation exposure is received in new construction. The dates of starting reactor plant overhaul, therefore, are the significant dates for start of radioactive work. In 1977 Naval nuclear-powered ships were undergoing overhaul in all nine shipyards listed as performing overhaul work.

Table 2 summarizes radiation exposure received in nuclear-powered ships and their supporting tenders and submarine bases since the first nuclear-powered ship went to sea in January 1955. Most of the radiation exposure in this table results from inspection, maintenance and repair work in the reactor compartments of ships. Radiation exposures for reactor compartment work increase as reactor plant radiation levels increase with age of the plant. By 1962 four submarine reactor plants had been overhauled and major efforts were underway to reduce radiation levels. In 1966 there were seventeen ships in overhaul as indicated by the buildup to the peak in total man-rem. Subsequently, the number of ships in overhaul more than doubled again. Table 2 shows the results of efforts to reduce radiation exposures.

TABLE 1

SHIPYARD FIRST REACTOR PLANT OPERATION AND FIRST RADIOACTIVE OVERHAUL WORK

	YEAR FIRST NEW CONSTRUCTION REACTOR STARTED OPERATION	YEAR FIRST REACTOR PLANT OVERHAUL STARTED
Electric Boat Division Groton, Connecticut	1954	1957
Portsmouth Naval Shipyard Portsmouth, New Hampshire	1958	1959
Mare Island Naval Shipyard ** Vallejo, California	1958	1962
Pearl Harbor Naval Shipyard Pearl Harbor, Hawaii	None	1962
Charleston Naval Shipyard** Charleston, South Carolina	None	1963
Newport News Shipbuilding and Dry Dock Company Newport News, Virginia	1960	1964
Bethlehem Steel Shipbuilding* (Subsequently Electric Boat Division) Quincy, Massachusetts	1961	None
New York Shipbuilding Corporation* Camden, New Jersey	1963	None
Norfolk Naval Shipyard Norfolk, Virginia	None	1965
Puget Sound Naval Shipyard** Bremerton, Washington	None	1967
Ingalls Shipbuilding Division Pascagoula, Mississippi	1961	1970

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* Work on Naval nuclear-powered ships was discontinued at Camden, New Jersey in 1967 and at Quincy, Massachusetts in 1969.

** Radioactive work of less extent than in an overhaul commenced in Mare Island in 1958, in Charleston in 1961, and in Puget Sound in 1965.

TABLE 2
OCCUPATIONAL RADIATION EXPOSURES RECEIVED BY PERSONNEL ASSIGNED TO TENDERS, BASES, AND NUCLEAR-POWERED SHIPS FROM OPERATION AND MAINTENANCE OF NAVAL NUCLEAR PROPULSION PLANTS

	Number of Persons Monitored Who Received Exposures In The Following Ranges of Rem for the Year						Total Personnel Monitored	Total Man-Rem
Year	0-1	1-2	2-3	3-4	4-5	>5*		
1955	90	11	0	0	0	0	101	25
1956	108	10	4	0	0	0	122	50
1957	293	7	1	0	0	0	301	60
1958	562	11	3	0	0	0	576	100
1959	1057	41	8	3	0	0	1109	200
1960	2607	88	8	4	3	1	2711	375
1961	4812	106	31	4	4	0	4957	680
1962	6788	182	75	31	17	1	7094	1312
1963	9188	197	39	14	3	1	9442	1420
1964	10317	331	93	35	15	4	10795	1964
1965	11883	592	224	96	30	24	12849	3421
1966	18118	541	156	95	44	28	18982	3529
1967	21028	339	139	48	11	0	21565	3084
1968	24200	373	103	20	2	0	24698	2463
1969	26969	577	127	39	6	0	27718	2918
1970	26206	610	134	30	0	0	26980	3089
1971	26090	568	122	31	2	0	26813	3261
1972	33312	602	180	13	1	0	34108	3271
1973	30852	600	102	15	1	0	31570	3160
1974	18375	307	65	2	0	0	18749	2142
1975	17638	330	28	1	0	0	17997	2217
1976	17795	369	56	9	0	0	18229	2642
1977	20236	346	95	36	3	0	20716	2812

Note: Data obtained from summaries rather than directly from original medical records. However, it is expected that the large effort to compile comparable data from original medical records would show differences no greater than five percent. Total Man-Rem was determined by adding actual exposures for each individual during the year.

* Limit in the Naval nuclear propulsion program was changed to 5 rem per year late in 1966

As expected, the number of personnel monitored for exposure to radiation increased with the increasing number of nuclear-powered ships. Initially everyone aboard a nuclear-powered submarine was monitored for radiation exposure. After years of experience showed that personnel outside propulsion plant spaces received exposures indistinguishable from background, the number of personnel monitored for occupational exposure to radiation was sharply reduced in 1974. For example, in 1973 almost sixty percent of those monitored were recorded as receiving zero radiation exposure; in 1977 as a result of reducing numbers of personnel monitored unnecessarily, about ten percent were recorded with zero exposure. Personnel outside propulsion plant spaces in submarines now wear dosimetry badges to verify they receive no occupational exposure.

Table 3 summarizes radiation exposures from shipyard personnel starting in 1962. For earlier years data is not available in this same form, however, the total radiation exposure for the eight year period before 1962 was about 11,700 man-rem. Decreases in total annual exposures, numbers of personnel monitored, and numbers of personnel with annual exposures over 3 rem have been results of the program to reduce radiation exposures to the minimum practicable. The total annual exposure for the shipyards has been about 6600 man-rem and for ships has been almost 2000 man-rem averaged over the period starting in 1955.

Since a worker usually is exposed to radiation in more than one year, the total numbers of personnel monitored cannot be obtained by adding the annual numbers. The total number of shipyard personnel monitored for radiation exposure associated with the Naval nuclear propulsion program starting with 1955 has been about 100,000. Nearly all of these are civilians, almost half of whom are U. S. Government employees at the six Naval shipyards. Table 4 provides further information about the distribution of their radiation exposures. In recent years about 80 percent of those monitored for radiation in shipyards and about 93 percent of those in ships received less than 0.5 rem in a year, the limit allowed by Federal regulations for a member of the general public. The average exposure per year for each person monitored has been about 0.4 rem in shipyards, which is less than one tenth the occupational exposure limit. The average exposure per year for those monitored in ships has been 0.13 rem, which is less than the annual exposure a person receives from natural background and medical radiation.

Table 4 also lists the numbers of personnel who have exceeded the 3 rem quarterly exposure limit. In no case have personnel exceeded the accumulated limit of 5 rem for each year of age over eighteen. The total number of persons who have exceeded the quarterly limit since the limit was imposed in 1959 is 36, of whom 3 were military personnel aboard ships. (Eight of the 36 exposures exceeding limits occurred in 1959, before the period covered by Table 4.) Twenty-nine of the 36 personnel had quarterly exposures in the range of 3 to 4 rem, and the highest exposure was 9.7 rem in a quarter. Navy procedures require any person who receives greater than 25 rem in a short time period to be placed under medical observation. None of the exposures have reached this level.

TABLE 3
OCCUPATIONAL RADIATION EXPOSURES RECEIVED BY SHIPYARD PERSONNEL FROM WORK ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

1962 - 1977

Year	Number of Persons Monitored Who Received Exposures In The Following Ranges of Rem for the Year						Total Personnel Monitored	Total Man-Rem
	0-1	1-2	2-3	3-4	4-5	> 5*		
1962	11409	657	548	486	164	123	13387	5600
1963	19568	445	164	73	35	28	20313	2711
1964	19367	751	413	199	143	30	20903	5132
1965	21434	1895	1108	726	623	600	26386	14735
1966	22787	1787	1252	794	1038	486	28144	18763
1967	26941	1737	1131	826	733	1	31369	13876
1968	30948	1277	755	499	289	0	33768	8665
1969	25846	1689	1031	636	373	0	29575	11033
1970	21319	1968	1326	723	492	0	25828	11974
1971	20214	1801	1029	641	240	0	23925	10647
1972	17390	1668	846	139	5	0	20048	6998
1973	13095	1379	605	203	6	0	15288	6110
1974	12447	1452	746	310	50	0	15005	7209
1975	12833	1115	598	81	42	0	14669	5303
1976	13057	1270	633	30	0	0	14990	5309
1977	13900	1277	586	25	0	0	15788	5207

Note: Data obtained from summaries rather than directly form original medical records. However, it is expected that the large effort to compile comparable data from original medical records would show differences no greater than five percent. Exposures from Nuclear Regulatory Commission or State licensed radiation sources have been excluded as far as practicable. Total Man-Rem was determined by adding actual exposures for each individual during the year.

* Limit in the Naval nuclear propulsion program was changed to 5 rem per year late in 1966

TABLE 4
SHIPYARD, SHIPS, TENDERS, AND SUBMARINE BASES DISTRIBUTION OF PERSONNEL RADIATION EXPOSURES

Year	Average Rem Per Person Monitored		Percent of Personnel Monitored Who Received Greater Than 1 Rem		Number of Personnel Who Exceeded 3 Rem/Quarter
	Fleet	Shipyard	Fleet	Shipyard	
1962	.18	.42	4.3	14.8	9
1963	.15	.13	2.7	3.7	2
1964	.18	.25	4.4	7.3	3
1965	.27	.56	7.5	18.8	5
1966	.19	.67	4.6	19.0	6
1967	.14	.44	2.5	14.1	3
1968	.10	.26	2.0	8.4	0
1969	.11	.37	2.7	12.6	0
1970	.11	.46	2.9	17.5	0
1971	.12	.45	2.7	15.5	0
1972	.10	.35	2.3	13.3	0
1973	.10	.40	2.3	14.3	0
1974	.11	.48	2.0	17.0	0
1975	.12	.36	2.0	12.5	0
1976	.14	.35	2.4	12.9	0
1977	.14	.33	2.3	12.0	0
16 Year Average	.13	.40	2.8	13.4	
NAVYWIDE AVERAGE	.27		8.3		

The average lifetime accumulated exposure from radiation associated with Naval nuclear plants for all shipyard personnel is 1.5 rem. Since the average annual exposure per person is about 0.4 rem, this means that the average shipyard radiation worker is monitored because of Naval nuclear propulsion plant work for about four years. The average lifetime accumulated exposure for the 42,000 Naval officers and enlisted men trained to operate a nuclear propulsion plant is about 1 rem. These radiation exposures are much less than the exposure the average American receives from medical diagnostic X-rays during his working lifetime.

Table 5 provides information on the distribution of lifetime accumulated exposures. For shipyards this table includes every employee who at some time during 1977 was authorized to receive radiation exposure. For ships the data was obtained by sampling selected ships. Federal radiation exposure limits allow accumulating 100 rem in twenty years of work, or 200 rem in forty years. The fact that no one shown in Table 5 comes close to having accumulated this much radiation exposure is the result of deliberate efforts to keep well below the lifetime accumulated radiation exposure limit.

TABLE 5

DISTRIBUTION OF TOTAL LIFETIME OCCUPATIONAL RADIATION EXPOSURES ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS FOR THOSE AUTHORIZED TO RECEIVE RADIATION EXPOSURE IN 1977

RANGE OF ACCUMULATED LIFETIME RADIATION EXPOSURES (REM)	PERCENT OF PERSONNEL WHO HAVE LIFETIME ACCUMULATED EXPOSURES IN THE RADIATION EXPOSURE RANGE	
	SHIPS	SHIPYARDS
0 - 5	98	75
5 - 10	2	12
10 - 15	0.1	6
15 - 20	.05	3
20 - 25	0	2
25 - 30	0	1
30 - 50	0	Less than 1
Greater than 50	0	0

Table 6 provides a basis for comparison between the radiation exposures for light water reactors operated by the Navy and commercial power reactors licensed by the Nuclear Regulatory Commission. The 1976 data in this Nuclear Regulatory Commission table covers 62 licensees with a total of 26,555 man-rem. Licensees of commercial power reactors reported 114 overexposures to external radiation and 43 exposures to excessive concentrations of radioactive material during the years 1971 through 1976.

TABLE 6

PERSONNEL RADIATION EXPOSURE FOR LIGHT WATER REACTORS LICENSED BY U. S. NUCLEAR REGULATORY COMMISSION

SUMMARY OF ANNUAL WHOLE BODY EXPOSURES BY INCREMENT - LWRS

YEAR	TOTAL MONITORED	NUMBER OF INDIVIDUALS											
		EXPOSURE INCREMENT - REM											
		NOT MEASURABLE	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	>10
1969	2836	2607			144	70	26	5	2	0	0	0	0
1970	7513	6953			184	175	92	102	11	1	0	0	0
1971	10,245	9660			328	146	107	17	11	0	0	0	0
1972	15,713	14,783			536	205	114	47	23	10	6	6	0
1973	35,918	20,717	10,249	2449	1585	432	237	117	71	38	16	7	0
1974	32,965	16,475	12,079	2348	1313	437	210	76	25	2	0	0	0
1975	45,659	20,188	18,277	3892	1903	707	426	169	60	24	12	0	1
1976	**66,800**	**30,085**	**27,901**	**4882**	**2355**	**789**	**487**	**188**	**70**	**26**	**11**	**5**	**1**

Source: NUREG 0323 "Occupational Radiation Exposure at Light Water Cooled Power Reactors - 1976"

INTERNAL RADIOACTIVIT'

Policy and Limits

The Navy's policy on internal radioactivity for personnel associated with the nuclear propulsion program continues to be the same as it was more than two decades ago, to prevent significant radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by Federal regulations for radiation workers. The results of this program have been that no one has received more than one-tenth the Federal annual internal occupational exposure limits from internal radiation exposure caused by radioactivity associated with the Naval nuclear propulsion plants.

The basic Federal limit for radiation exposure to organs of the body from internal radioactivity has been 15 rem per year. There have been higher levels applied at various times for thyroid and for bones, however, use of these specific higher limits has not been necessary in the Naval nuclear propulsion program.

Fifteen rem per year is the limit recommended for most organs of the body by the U. S. National Committee on Radiation Protection in 1954 (ref 1), by the U. S. Atomic Energy Commission in the initial edition of ref 3 applicable in 1957, by the International Commission on Radiological Protection in 1959 (ref 2), and was adopted for Federal agencies when President Eisenhower approved recommendations of the Federal Radiation Council May 13, 1960.

Source of Radioactivity

Radioactivity can get inside the body through air, through water or food, and through surface contamination via the mouth or skin or a wound. The radioactivity of primary concern is the metallic corrosion products on the inside surfaces of reactor plant piping systems. These are in the form of insoluble metallic oxides, primarily iron oxides. Fission products are retained within the fuel elements. Therefore, reactor fission products such as strontium 90 and cesium 137 as well as alpha emitters such as plutonium are not accessible to personnel operating or maintaining a Naval nuclear propulsion plant. Ref 6 contains more details on why cobalt 60 is the radionuclide of most concern for internal radioactivity.

Control of Airborne Radioactivity

Airborne radioactivity is controlled in maintenance operations such that masks are not normally required. To prevent exposure of personnel to airborne radioactivity when work might expose radioactivity to the atmosphere, contamination containment tents or bags are used. The areas inside these containments are ventilated to the atmosphere through high efficiency filters which have been tested to remove at least 99.95 percent of particles of a size comparable to cigarette smoke. The occupied area outside these containments is required to be ventilated through high efficiency filters any time work which could cause airborne radioactivity is in progress inside an area such as a reactor compartment. Airborne radioactivity surveys are required to be performed regularly in radioactive work areas. Any time airborne radioactivity above the limit is detected in occupied areas, work which might be causing airborne radioactivity is stopped. This conservative action is taken to minimize internal radioactivity even though the Navy's airborne radioactivity limit would allow continuous breathing for forty hours per week throughout the year to reach an annual exposure to the lungs of one-tenth the Federal limit. Personnel are also trained to use masks when airborne radioactivity is detected, however, masks are seldom needed and are not relied upon as the first line of defense against airborne radioactivity.

It is not uncommon for airborne radioactivity above the limit to be caused by radon naturally present in the air. Atmospheric temperature inversion conditions can allow this buildup of radioactive particles from radon. Radon can build up above the limit in sealed or poorly ventilated rooms in homes or buildings made of stone. Most cases of airborne radioactivity above the limits in occupied areas in the Naval nuclear propulsion program have been caused by radioactive particles from radon, and not from the reactor plant. Procedures have been developed to allow work to continue after it has been determined that the elevated airborne radioactivity is from naturally occurring radon.

Radon also is emitted from radium used for making dials luminous. There have been a number of cases where a single radium dial has caused the entire atmosphere of a submarine to exceed the airborne radioactivity limit used for the nuclear propulsion plant. Radium in any form has been banned from submarines to prevent interference with keeping airborne radioactivity from the nuclear propulsion plant as low as practicable.

Control of Radioactive Surface Contamination

Perhaps the most restrictive regulations in the radiological control program are established in the requirements for the control of radioactive contamination. Work operations involving potential for spreading radioactive contamination are planned using containment to prevent personnel becoming contaminated. The controls for radioactive contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into nuclear areas because the contamination control limits used in the nuclear areas were below the levels of fallout and natural contamination occurring outside in the general public areas.

Anticontamination clothing, including coverall, hood to cover the head, ears and neck, shoe covers, and gloves, is provided when needed. However, the basic approach is to avoid the need for anticontamination clothing by containing the radioactivity. As a result, most work on radioactive materials is performed with hands reaching into gloves installed in containments, making it unnecessary for the worker to wear anticontamination clothing. In addition to providing better control over the spread of radioactivity, this method has reduced radiation exposure since the worker can usually do his job better and faster in his normal work clothing. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves and their performance is checked by radiological control personnel. Personnel monitor before, not after, they wash. Therefore, washing or showering at the exit of radioactive work areas is not required. The basic approach is to prevent contamination, not wash it away.

Surveys for radioactive contamination are taken frequently by trained radiological control personnel. Results of these surveys are reviewed by supervisory personnel to provide a double-check that no abnormal conditions exist. The instruments used for these surveys are checked against a radioactive calibration source daily and prior to use and they are calibrated at least every six months.

Control of Food and Water

Smoking, eating, drinking and chewing are prohibited in radioactive areas. Aboard ship drinking water is distilled from seawater by using steam. However, the steam is not radioactive because it is in a secondary piping system separate from the reactor plant radioactive water. In the event radioactivity were to leak into the steam system, sensitive radioactivity detection instruments which operate continuously would give early warning.

Wounds

In the radiation medical examination, skin conditions or open wounds which might not readily be decontaminated are cause for disqualification. If the medical officer determines the wound is sufficiently healed or considers the wound to be adequately protected from radioactive contamination, the medical officer may remove the disqualification. The Notice to Shipyard Personnel in Figure 2 and the radiological training call attention to this need to control open wounds.

There have been only a few cases of contaminated wounds in the Naval nuclear propulsion program. In most years, including 1977, none occurred. Examples of such injuries have included a scratched hand, a metallic sliver in a hand, a cut finger, and a puncture wound to a hand. These wounds occurred at the same time the person became contaminated. Insoluble metallic oxides which make up the radioactive contamination remain primarily at the wound rather than being absorbed into the blood stream. These radioactively contaminated wounds have been easily decontaminated. No case of a contaminated wound is known where the radioactivity initially present in the wound was as much as one one-thousandth of that permitted for a radiation worker to have in his body.

Monitoring for Internal Radioactivity

The radioactivity of most concern for internal radiation exposure from Naval nuclear propulsion plants is cobalt 60. Although most radiation exposure from cobalt 60 inside the body will be from beta radiation, the gammas given off make cobalt 60 easy to detect. Complex whole body counters are not required to detect cobalt 60 at low levels inside the body. For example, one millionth of a curie of cobalt 60 inside the lungs or intestines will cause a measurement of two times above the background reading with a standard radiation survey instrument. This amount of internal radioactivity will cause the instrument used to monitor personnel for radioactive contamination on their body to reach the alarm level. Every person is required to monitor his entire body every time he leaves an area with radioactive surface contamination. Monitoring the entire body is a requirement in the Naval nuclear propulsion program; monitoring just hands and feet is not permitted. Therefore, if a person had as little as a millionth of a curie of cobalt 60 inside him, it would readily be detected.

Swallowing one millionth of a curie of cobalt 60 will cause internal radiation exposure of about 0.06 rem. The radioactivity will pass through the body and be excreted within a period of a little more than one day.

One millionth of a curie of cobalt 60 deposited in the lungs as a result of an inhalation incident will cause a radiation exposure of about 1.4 rem to the lungs over the following year. The cobalt 60 is gradually removed from the lungs through biological processes and it also decays with a 5.3 year half-life.

In addition to the control measures to prevent internal radioactivity and the body monitoring frequently performed on those who work with radioactive materials, more sensitive monitoring is also performed during radioactive overhaul work. Shipyard procedures for monitoring internal radioactivity use the type of scintillation detector with multichannel analyzer which has been used for detecting radioactivity at low levels in samples from the environment. These detectors will reliably detect an amount of cobalt 60 inside the body that is more than one hundred times lower than the one millionth of a curie used in the examples above. Shipyards typically monitor for internal radioactivity as part of each radiation medical examination, which includes before an employee initially performs radiation work, after he terminates radiation work, and periodically in between. Shipyards also monitor periodically during the year groups of personnel who did the work most likely to have caused spread of radioactive contamination. Any person who has radioactive contamination above the limit anywhere on his body during regular monitoring at the exit from a radioactive area is monitored for internal radioactivity with the sensitive detector. Also any person who might have breathed airborne radioactivity above limits is monitored with the sensitive detector.

Results of Internal Monitoring in 1977

At the nine shipyards performing work associated with Naval nuclear propulsion plants a total of 10,696 personnel were monitored for internal radioactivity in 1977 using sensitive scintillation detectors. Equipment and procedures provide detection levels at least one hundred times lower than one-millionth of a curie. Two persons were found with internal radioactivity in their lungs above this level, one with 0.06 millionths and the other with 0.02 millionths of a curie. Both persons received their internal radioactivity from work outside the Naval nuclear propulsion program.

EFFECTS OF RADIATION ON PERSONNEL

Control of radiation exposure in the Naval nuclear propulsion program has always been based on the assumption that any exposure no matter how small involves some risk; however, exposure within the accepted exposure limits represents a risk small compared with normal hazards of life. The basis for this statement is presented in this section.

Exposure to Radiation Involves Some Risk

At the start of operation of the Navy's first reactor plant the best information available was in the 1954 report of the National Committee on Radiation Protection and Measurements (ref 1), which stated under the subject "acceptable risk":

> "As a matter of principle it is sound to avoid all unnecessary exposure to ionizing radiation, because it is desirable not to depart from the natural conditions under which man has developed by evolutionary processes. However, man has always lived in a field of ionizing radiation due to the presence of radioactive material in the earth and to cosmic rays. Whether exposure to this level of radiation is beneficial or deleterious to man (and the race) is a matter of speculation. The obvious fact is that it cannot be avoided and it is, therefore, normal for man to live in this environment. We have then a lower limit of continuous exposure to radiation that is (unavoidably) tolerated by man."
>
> "The only statement that can be made at the present time about the lifetime exposure of persons to penetrating radiation at a permissible level considerably higher than the background radiation level, but within the range of radiological experience, is that appreciable injury manifestable in the lifetime of the individual is extremely unlikely. It is, therefore, necessary to assume that any practical limit of exposure that may be set up today, will involve some risk of possible harm. The problem then is to make this risk so small that it is readily acceptable to the average individual; that is, to make the risk essentially the same as is present in ordinary occupations not involving exposure to radiation."

The April 15, 1958 addendum to this report stated:

> "The risk to the individual is not precisely determinable but, however small, it is believed not to be zero. Even if the injury should prove to be proportional to the amount of radiation the individual receives, to the best of our present knowledge, the new permissible levels are thought not to constitute an unacceptable risk."

The International Commission on Radiological Protection stated in its first recommendations in 1958 (ref 2) ". . . the Commission recommends that all doses be kept as low as practicable and that any unnecessary exposure be avoided." It also stated:

> "Any departure from the environmental conditions in which man has evolved may entail a risk of deleterious effects. It is therefore assumed that long continued exposure to ionizing radiation additional to that due to natural radiation involves some risk. However, man cannot entirely dispense with the use of ionizing radiations, and therefore the problem in practice is to limit the radiation dose to that which involves a risk that is not unacceptable to the individual and to the population at large."

The Commission added an explanation to this in 1962 (ref 7):

> "The basis of the Commission's recommendations is that any exposure to radiation may carry some risk. The assumption has been made that, down to the lowest levels of dose, the risk of inducing disease or disability in an individual increases with the dose accumulated by the individual, but is small even at the maximum permissible levels recommended for occupational exposure."

The National Academy of Sciences-National Research Council Advisory Committee on the Biological Effects of Atomic Radiation included in its reports in the 1956-1961 period conclusions comparable to those stated above. In 1960 the Federal Radiation Council stated in ref 4 that its radiation protection guidance did not differ substantially from recommendations of the National Committee on Radiation Protection and Measurements, the International Commission on Radiological Protection, and the National Academy of Sciences.

One conclusion from these reports is that radiation exposures to personnel should be minimized. This is not a new conclusion. It has been taken as a major driving force from the inception of the Naval nuclear propulsion program.

Studies of the Effects of Radiation on Humans

Tens of thousands of reports have been written on the effects of radiation. Even the list of summary reports is voluminous. In spite of the fact that there are many unanswered questions concerning the effects of radiation on humans, there is more detailed knowledge available on this subject than on almost any other hazard humans face. The following brief summary of the effects of low-level whole body external radiation is primarily from ref 12.

The most important data on the effects of whole body external radiation exposure on humans comes from the almost 30 years of extensive study of the Japanese atomic bomb survivors. In addition, studies have been made of the Marshall Islands inhabitants who received about 12,000 man-rem from fallout in 1954. Studies have been made on groups of patients who have had frequent diagnostic x-ray examinations. Numbers of studies have been made on patients who have had radiation therapy for a disease of the bones of the back and for other conditions. These studies predominantly involved radiation doses of greater than 100 rem. The determinations of damage from doses greater than 100 rem have been reasonably consistent from numerous different studies. Extensive irradiation studies of animals have also been used to show what to look for in humans. These animal studies also show under controlled conditions not available in studies on humans how the radiation effects change with amount and frequency of radiation exposure.

Results of radiation studies on humans show the highest rates of cancer occur in the thyroid and the female breast, although the death rate for thyroid cancer is low. The cancer rates from radiation are lower for leukemia and lung cancer, and lower still for cancers of the bone and other organs. Leukemia has been associated with radiation exposure in almost every study of radiation on humans. Reasons for this include the improved diagnosis of leukemia in recent decades and the low natural incidence of leukemia compared to other cancers. However one type of leukemia, chronic lymphatic leukemia, has not been found in any study to be associated with radiation.

Some organs appear to be so resistant to radiation-induced cancer that there has been no clear association between radiation and cancer in these organs. One example is the prostate gland.

One characteristic of cancer caused by low-level radiation is the long delay time between time of radiation exposure and time of diagnosis of cancer. Cancer is not diagnosed until more than a few years have elapsed. In the Japanese atomic bomb survivors the end of the latent period for leukemia was about 25 years. For the sum of all types of cancers ref 12 assumes that in 25 years one half the cancers will have occurred.

Cataracts of the eyes can be caused by radiation. However, cataract formation appears to have more evidence of having a threshold radiation dose than any other radiation damage studied. Very high radiation doses have been required to produce cataracts. Ref 11 concludes that 1500 rem is below the threshold for producing damage to the lens of the eye sufficient to interfere with vision.

Radiation also produces mutations of the genes which can have an effect on the descendents of those exposed to radiation. Most data on this subject comes from studies on animals although data from the Japanese atomic bomb survivors is important. Radiation effects on heredity have to be considered in light of the existence of a background of mutations already present. Ref 12 estimates that more than five percent of disease in humans is caused by gene mutations. Some of these mutations are caused by the natural background radiation man has always lived with. Ref 12 estimates that for gamma radiation about 100 rem would be required to double the natural mutation rate. The genetic effect on the first two generations of descendents of those exposed to radiation would be about the same as the damage to the parents. The total of the genetic effects on all subsequent generations would be about the same as the effect on the first two generations.

Scientific reports of several decades ago speculated that radiation might cause a general effect that would shorten life, similar to aging. Reports in the last decade conclude such an effect has not been found in studies on humans. Nor have numerous other diseases such as heart diseases been associated with radiation in these studies. To date the chief effects of radiation on humans have been found to be cancer and genetic effects as summarized above.

Numerical Estimates of Risk from Radiation

In 1972 both the United Nations Scientific Committee on the Effects of Atomic Radiation and the National Academy of Sciences-National Research Council Advisory Committee on the Biological Effects of Ionizing Radiations issued reports (refs 8 and 9) estimating numerical risks for specific types of cancer from radiation exposure to humans.

In contrast, the National Council on Radiation Protection and Measurements reviewed these two reports and other information particularly related to estimates of cancer risk at low doses and low dose rates in 1975 (ref 10) and stated:

> "The NCRP continues to hold the view that risk estimates for radiogenic cancers at low doses and low dose rates derived on the basis of linear (proportional) extrapolation . . . cannot be expected to provide realistic estimates of the actual risks from low level, [gamma] radiations, and have such a high probability of overestimating the actual risk as to be of only marginal value, if any, for purposes of <u>realistic</u> risk-benefit evaluation."

However, the NCRP did initiate action to determine as accurately as possible the true risk of cancer from exposure to radiation.

In 1978, Publication 26 of the International Commission on Radiological Protection became available (ref 11). This report concentrated its risk estimates on cancers of various types, because for other than cancer,

> ". . . there is not good evidence of impairment of function of organs and tissues at the levels of dose normally encountered in radiation work. The evidence for life-shortening from effects other than tumour induction is inconclusive and cannot be used quantitatively. Moreover, it seems unlikely that any major hazard from irradiation at recommended levels has been overlooked, as judged by the evidence from heavily irradiated populations, observed for periods up to 30 years."

The United Nations Scientific Committee on the Effects of Atomic Radiation made a similar statement in ref 12 which also became available in 1978:

> "There is increasing evidence that in human beings . . . the induction of malignancies [cancers] represents the most important effect produced at low doses in the exposed individual . . . ."

These latest two reports contain similar estimates of risk from cancer. This should not be surprising since both organizations evaluated the same information from long-term studies of humans exposed to radiation. Both organizations used data primarily from humans for their numerical risk estimates. Both organizations caution that their risk estimates may substantially overstate the actual risk for low radiation exposures. The risk estimates from both refs 11 and 12 can be briefly summarized as follows:

> In a large population group (such as 100,000 people) receiving an annual total of 10,000 man-rem year after year, the increased risk from this radiation appears to be in the region of about one fatal cancer case each year and about one leukemia case every five years in excess of the normal numbers of cases.

This can be used to develop a risk estimate for personnel exposed to radiation associated with Naval nuclear propulsion plants. In all shipyards there have been a total of about 100,000 personnel monitored for exposure to radiation and their exposure rate has averaged somewhat less than 10,000 man-rem per year. (The 23 year average is 6600 man-rem and the average for the last 16 years is 8700 man-rem). Therefore according to refs 11 and 12 there should be less than one excess fatal cancer per year and less than one excess leukemia case every five years among the total 100,000 shipyard personnel who have every been monitored for radiation associated with Naval nuclear propulsion plants. According to refs 11 and 12 this risk estimate is likely to be substantially overstated because the radiation exposures are from gamma radiation at low doses and low dose rates. Also, exposures to neutrons and internal radioactivity in the Naval nuclear propulsion program are too low to have the confusing effects noted in some studies of the effects of radiation on humans.

Radiation exposure received by Naval personnel assigned to nuclear-powered ships and their support facilities is about 30 percent of the total exposure to shipyard personnel. Therefore according to refs 11 and 12 there should be less than one excess fatal cancer every three years and less than one excess leukemia case every fifteen years among the approximately 100,000 Naval personnel who have ever been monitored for occupational exposure to radiation associated with Naval nuclear propulsion plants. Since only a few percent of the total man-rem to ship personnel is from neutrons, the same qualifications apply as were mentioned for shipyard personnel and this risk estimate is likely to be substantially overestimated.

The risk estimates should be compared to the current rates of cancer and leukemia deaths in the U. S., which are shown in Table 7 (from ref 13). These rates are given in terms of the average numbers of deaths that occurred in the U. S. in a population group of 100,000 people. These are from all causes, including natural background radiation and medical radiation. Cancer rates vary with age, with socioeconomic group, with sex, with race, with region of the country, and with industrialization.

TABLE 7
CANCER DEATH RATES FOR U. S. WHITE MALES IN 1973

	ANNUAL DEATHS PER 100,000 POPULATION	
AGE IN YEARS	LEUKEMIA	ALL CANCER
15-24	2.4	9
25-34	2.2	16
34-44	3.6	49
45-54	6.1	171
55-64	14.5	493
65-74	34.3	1018
75-84	74.1	1672
85 and over	104.3	2063
Overall	8.4	190
Shipyard radiation workers from radiation associated with Naval nuclear propulsion plants (risk estimate)	Less than 0.2	Less than 1

These risk estimates for radiation should also be compared to other risks normally encountered in industrial activities, using Table 8 for examples.

TABLE 8
DEATH RATES IN U. S. FOR VARIOUS CAUSES

CAUSE	ANNUAL DEATHS PER 100,000 POPULATION
Smoking (ref 14)	150
Motor vehicle accidents (ref 15)	22
Work accidents (ref 15)	
Mining, quarrying	63
Construction	57
Agriculture	54
Transportation and Public Utilities	31
All Industries Average	14
Government	11
Service	9
Manufacturing	9
Trade	6
Industrial accidents in a Naval Shipyard (eight shipyards 1972-1977)	7
Commercial air travel (ref 15)	1
Coal-fired electric power (estimate derived from ref 16)	1 to 10
Shipyard radiation workers from radiation associated with Naval nuclear propulsion plants (risk estimate)	less than 1

Because of these estimates on the risk of low-level radiation, extra hazard pay for radiation work has never been paid in the Naval nuclear propulsion program. Civil Service Commission regulations do not provide for hazard pay for radiation work. A serious disadvantage to extra pay for radiation risks is that it would tend to increase the difficulty in minimizing radiation exposure because some personnel would press for more radiation to maximize their pay.

Current Controversies on Radiation Mortality Studies

The following section is summarized from a large number of reports. Because of the preliminary nature of much of this information, it can change readily. This summary is included so that readers with little background in radiological subjects can more easily interpret other portions of this report.

In 1977 concerns grew over the possibility that the rate of leukemia has increased in military personnel involved in tests of U. S. atomic weapons primarily in the 1950's. Radiation doses have not been reconstructed for most of these personnel, however, some reports claim doses of tens of rem. For some personnel radiation doses from unmonitored internal radioactivity may have been much higher than external radiation doses. The Center for Disease Control of the U. S. Department of Health, Education, and Welfare began a study in early 1978 to resolve this controversy. Conclusions of any kind on the effects of radiation on personnel involved in the atomic weapons tests cannot be drawn until much more complete information is obtained on who was present at the tests, how many of these have died and of what causes, and what radiation doses they received.

In late 1977 a long-term study of radiation workers at Hanford, Washington was reported to show higher incidences of several types of cancer than had been expected. This study has followed the 30,000 radiation workers present at Hanford any time since the 1940's. The average lifetime radiation exposure of these personnel is 1.6 rem. This group is much more like that at reactor plants than any other group studied for radiation effects. Preliminary analyses of the death rate of these workers have been made by a number of different investigators. The group overall has had a lower death rate than the general population; that is, they have been healthier than average in the U. S. The overall death rate for those receiving higher radiation exposure apparently has been the same as the overall death rate for those receiving low or no radiation exposure.

In spite of heated controversies widely reported, there appears to be agreement on several results among the various groups analyzing the results of this study of Hanford radiation workers. First, there has been no increase in the rate of leukemia of those exposed to radiation. This is unusual since most studies of radiation effects on humans have shown increase in leukemia. Second, the only types of cancer which show statistically clear increases are cancer of the pancreas and a type of cancer of the bone marrow called multiple myeloma. These two cancers caused less than ten percent of the cancer deaths, and all cancers caused about twenty percent of the total deaths to date of Hanford radiation workers.

It is premature to dismiss the results of numerous prior studies recently summarized by refs 11 and 12 on the basis of these preliminary analyses of Hanford radiation workers. However, the Navy will continue to watch these studies closely for any implications that may affect the Naval nuclear propulsion program.

In 1978 preliminary results of a re-examination of the 1959-1962 Tri-State Study of medical radiation in New York, Minnesota, and Maryland have also been reported to show risks of leukemia higher than expected. There is considerable scientific debate over the statistical methods used to analyze the Tri-State leukemia data. This study has generated widespread interest. However, more work needs to be done before a scientific consensus is reached on its significance.

The reason for singling out leukemia can be shown from an example. The overall U. S. death rate from leukemia is about 4 percent of the death rate from all cancers. Doubling the leukemia rate would therefore cause a 4 percent increase in the total cancer death rate, or a little less than 1 percent increase in the total death rate for all causes. It is far easier to detect a doubling of leukemia than a 1 percent increase in overall death rate. The corollary of this example is of interest in evaluating the significance of reports on radiation effects on humans: doubling the leukemia rate raises the overall death rate about one percent.

In late 1977 a hematology specialist was consulting in treatment of aplastic anemia in a patient who had retired as a welder from Portsmouth Naval Shipyard. Aplastic anemia may be a precursor to leukemia. The welder stated that many of his friends who did the same job he had done in a 1959 overhaul were dead. The shipyard identified this job as mockup training in preparation for radioactive work, but not involving any radiation or radioactivity. The shipyard found three of the eleven-man group were dead, and all died of heart disease at ages 45, 48, and 57. Heart disease has not been associated with radiation exposure. The shipyard had promptly responded to separate requests for the welder's radiation history and had provided detailed information to the patient's wife, his private physician, and later to the hematologist.

In spite of the report that the welder's lifetime exposure was 1.53 rem and that the example of other workers remembered by the welder was not valid, the hematologist stated he was commencing a study of the synergistic effect on health of radiation and welding at Portsmouth Naval shipyard.

On 19 February 1978 the results of the doctor's study performed in conjunction with the investigative reporting team from a newspaper were published by the newspaper. This story was also carried in other newspapers and caused great interest among U. S. Senators and Congressmen. A Congressional hearing took place the following week.

The newspaper report of the study stated that the investigating team had reviewed over 100,000 death certificates in Maine, New Hampshire and Massachusetts. They selected 1722 death certificates as representing shipyard workers based on the occupation listed on these certificates. The team contacted next of kin for 592 of these and classified them as nuclear workers or non-nuclear worker based on recollection of next of kin on whether the worker wore a film badge. Of the one quarter so identified as nuclear workers, 56 workers or 38 percent had died of cancer. Of the three quarters identified as non-nuclear workers, 22 percent had died of cancer. The national death rate for cancer was stated for comparison to be 18 percent. The newspaper also reported that the rate of leukemia for radiation workers aged 60 to 69 was 450 percent higher than expected.

The Navy concluded more work should be done before the significance of this simplistic evaluation could be properly determined. There were numerous problems in the study such as the small sample size, the lack of radiation exposure data, and the bias in selection caused by the method of collecting death certificates. Some of these problems were unavoidable because the Navy was constrained by law from providing personal information about the workers to a private individual or newspaper.

Navy Studies on the Effects of Radiation on Humans

The Naval Reactors Program has done no medical research work. At the start of the program extensive research work had already been done on the effects of radiation, and a national and international consensus existed on radiation standards. Studies on radiation effects by agencies assigned this mission and by independent organizations have increased during the more than twenty-five years since the start of the Navy's nuclear propulsion work. If it became apparent that others were not performing the necessary work, the Navy would be obliged to obtain an adequate basis to justify its radiation exposure limits. However, if the Navy does the work itself, the results might be viewed as biased and self-serving.

There is a large fundamental problem in doing radiation effects studies on humans. Consider a group of 100,000 radiation workers exposed for at least the median latent period for cancer of 25 years. Assume the 1972 risk estimates of ref 9 or the risk estimates of refs 11 and 12 are valid. It would require an annual average of more than 70,000 man-rem for this 25 years to cause the approximately two percent increase in cancer rate needed to be statistically detectable above the current cancer rate. This is roughly ten times the radiation exposure of the Navy's nuclear propulsion program in all the shipyards. It has seemed unlikely that the large number of past radiation effects studies were in error by as much as ten times concerning overall numbers of cancers.

There also are a number of hazards associated with modern life in industrial areas that increase death rates. Any study of radiation effects in shipyard workers would have to distinguish among the various potential causes of changes in death rates. Not many studies of industrial hazards in Naval shipyards have been performed because Naval shipyards have had considerably lower accidental death rates than the average U. S. industry.

Because of the preceding considerations the Navy has followed the work of other organizations rather than doing its own studies on the effects of radiation on personnel associated with nuclear propulsion plants. However, early in December 1977 the report on the Hanford radiation workers discussed on page 33 became available. Because the Hanford radiation workers had more similarities to radiation workers in the Naval nuclear propulsion program than any others previously studied, the Navy immediately initiated efforts to arrange for studies on the effects of radiation on shipyard workers.

The Navy has made arrangements with the Department of Energy to cooperate in an independent study on the effects on shipyard employees of low-level radiation associated with Naval nuclear propulsion plants. This study will be funded by the Department of Energy and conducted by an independent university, not by employees of either the Department of Energy or the Department of the Navy. Because of the nature of this kind of study, years will be required to obtain results. Tens of thousands of personnel need to be followed for many years after their radiation exposure. Comparison groups matched closely in everything except for history of radiation exposure also need to be followed. To obtain good statistics for the low incidences of effects expected from radiation requires obtaining reliable results on the causes of death of probably 90 or 95 percent of those from these groups who are dead.

As discussed on pages 34-35 a brief study of a fraction of the deaths of those who worked at Portsmouth Naval Shipyard was reported in early 1978. As a result of interest in these results from the U. S. Congress, the Center for disease Control of the Department of Health, Education, and Welfare is conducting a study of the effects of low-level radiation on workers at Portsmouth Naval Shipyard. The Navy is cooperating fully in this study.

The Navy is also expanding its ongoing study of the health of military personnel who operate nuclear-powered submarines to include special consideration to determine if any effects of low-level radiation exposure can be found in this group.

Rumors have persisted that radiation-induced cancer has killed the crew of the first nuclear-powered ship, USS NAUTILUS. Therefore, in February 1978 the Navy traced every one of the 96 officers and enlisted men of the first crew of NAUTILUS. One had died of cancer. He was a steward and his film badges showed that he had received no radiation exposure during his assignment aboard NAUTILUS. A second man had died of heart disease. He was a torpedoman and had a total of 0.8 rem occupational radiation exposure. None of the officers or enlisted men associated with the nuclear propulsion plant were dead. Of the 96 men, 94 were reported alive and well.

Conclusions on the Effects of Radiation on Personnel

Each recommendation on radiation exposure limits from the key organizations referenced in this report has emphasized the need to minimize radiation exposure. Thus, the Navy is committed to keeping radiation exposure to personnel as low as reasonably achievable. No level of radiation exposure has been identified for which responsible organizations have stated there is no effect. Similarly it is difficult to find a single activity of man for which one can confidently state the risk is zero. However, the summaries in this section show that the risk from radiation exposure associated with Naval nuclear propulsion plants is low compared to hazards normally accepted in industrial work.

The risk from occupational radiation exposure in the Naval nuclear propulsion program is also less than the risks these same personnel face from natural background radiation or from medical radiation. To demonstrate this, the 100,000 personnel monitored for radiation in all shipyards over the last 23 years will receive, about 10,000 man-rem per year from natural background and about the same from medical radiation. The average occupational exposure to this group has been less than 10,000 man-rem per year.

CLAIMS FOR RADIATION INJURY TO PERSONNEL

Personnel who consider they have or might have had occupational injury are encouraged to file claims. Naval shipyard personnel are employees of the U.S. Government and therefore file claims with the U.S. Department of Labor's Office of Workmen's Compensation. Shipyards have no hearings on these claims. They are not handled in an adversary procedure. The Navy has no rights to present a case to the Labor Department. The claim does not even have to be filed through the shipyard. The shipyard is not permitted to appeal a decision but the employee may appeal. The primary consideration in the Federal laws and procedures set up for injury compensation is to take care of the Federal employee. This injury compensation program is well publicized as shown by the filing of claims since 1969 by more than 21,000 workers in the eight Naval shipyards out of an annual average employment of 60,000.

In private shipyards injury compensation claims are handled through insurance companies and through a state hearing system where procedures allow for cross examination. Claims from military personnel concerning prior duty are handled through the Veterans Administration.

The compensation systems make allowance for the long latent period for radiation-induced cancer.

There have been a total of 60 claims filed claiming injury from radiation associated with Naval nuclear propulsion plants. Fifty-eight originated from employees of the six Naval shipyards, two from one private shipyard, and none that the Navy is aware of from Navy personnel. These claims are summarized in Appendix B.

Three of these claims have been awarded to the employees, one for leukemia in 1968 and two for cataracts of the eyes in 1971 and in 1977. The Navy considers all three of these awards were incorrect:

- The leukemia case developed within two years of the occupational exposure of 5.38 rem. This is too short a latency period. The claimant had received hundreds of rem in medical radiation exposure for adenoids. If radiation were to be selected as the cause of this leukemia, then the occupational exposure could not have been more than a tiny part of this total radiation.

- The two cataract cases each had total lifetime radiation exposures of about 3 rem, which is hundreds of times smaller than needed to produce cataracts in the eyes.

From the radiation injury claims filed to date, the Navy has been unable to draw any conclusions concerning radiation injury to personnel occupationally exposed to radiation associated with Naval nuclear propulsion plants.

AUDITS AND REVIEWS

Checks and cross-checks and audits and inspections of numerous kinds have been shown to be essential in maintaining high standards of radiological control. First, each worker is specially trained in radiological control as it relates to his own job. Second, written procedures exist which require verbatim compliance. Third, radiological control technicians and their supervisors oversee radioactive work. Fourth, personnel independent of radiological control technicians are responsible for personnel radiation exposure records.

Fifth, a strong independent audit program is required covering all radiological control requirements. In all shipyards this radiological audit group is independent of the radiological control organization and its findings are reported regularly to senior shipyard management including the shipyard commander. This group performs continuing surveillance of radioactive work. It conducts in-depth audits of specific areas of radiological control. This group checks all radiological control requirements at least annually.

Sixth, the U. S. Department of Energy assigns to each shipyard a representative who reports to the Director, Division of Naval Reactors at headquarters. One assistant to this representative is assigned full time to audit radiological controls, both in nuclear-powered ships and in the shipyard. And seventh, the Naval Sea Systems Command also conducts periodic inspections of radiological control in each shipyard. Similarly, there are multiple levels of audits and inspections for the other Navy shore facilities, tenders, and nuclear-powered ships.

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APPENDIX A

PRIMER ON REMS AND CURIES

This article is an attempt to help personnel in the Naval Reactors Program improve their basic understanding of radiation and radioactivity. Only background information* (rather than rules and regulations) is presented.

Temperature is a concept we all have learned about from childhood, both for comfort as well as safety. We all know, intuitively, that 0°F is cold, 100°F is hot, -100°F is dangerously cold, and 300°F is dangerously hot. Yet can you define what a degree Fahrenheit is? Even though you probably would have to look up the definition, you undoubtedly understand temperature well enough not only to assure your own safety, but also to assure your comfort (most of the time, at least).

Most of us do not have a similar understanding of nuclear radiation. Like temperature, we all have lived with radiation all our lives; but unlike temperature, we cannot feel radiation, nor were we taught radiation in elementary school. We do, however, have just as much need to understand radiation and radioactivity as temperature if we are to work safely and effectively on nuclear propulsion plants. Just as temperature is measured in certain units, such as degrees Fahrenheit, radiation and radioactivity are measured in the units rems and curies as discussed in following sections.

REM

The stark unsatisfying definition of the unit of radiation, rem, is that it is the amount of radiation that will cause damage equivalent to that from absorbing 100 ergs of gamma** radiation per gram of tissue. Like many other dictionary type definitions, this does not provide very much help in understanding what a rem is. Instead let us try to understand by looking at examples of radiation levels we have been living with:

1. Background Radiation: You have been exposed all your life to natural radiation of about 100 mrem per year ("m" stands for milli, thus 1000 mrem = 1 rem). This comes from cosmic radiation, natural radioactivity in the ground and in building construction materials, and natural radioactivity (mostly potassium 40) in your body. The natural background radiation level varies considerably depending on such factors as

a. location: Cosmic radiation (normally about 45 mrem/year) will nearly disappear under water, or increase to about 120 mrem/year if you go to Denver at 1 mile evaluation above sea level;

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*The basic facts in this article have been repeatedly published in a great number of unclassified books, journals, and reports. These facts have been used by the Federal Radiation Council, the Atomic Energy Commission, and the National Council on Radiation Protection and Measurements in developing radiation protection standards.

**This article does not include discussions of alphas, betas, or neutrons.

b. construction materials: The average 45 mrem per year may be tripled in granite New England houses with relatively high radioactive content of the granite, and is reduced to a few mrem per year aboard ship because steel has low natural radioactivity;

c. diet: Most of the natural internal exposure, about 25 mrem per year, is from about 0.1 microcurie* of naturally radioactive potassium inside the body. Potassium is an important part of the normal diet which does not vary greatly from person to person. Higher internal exposures do occur in people living where water supply wells have high concentrations of radium.

Since there are slightly more than 8700 hours in a year, this means natural background level is 0.01 to 0.02 mrem/hour (100 mrem/year ÷ 8700 hours/year). This level is barely detectable on most standard radiation survey meters.

2. Luminous Dial Watches: Luminous dials on watches have been activated with radium. Typical dose rates are 1 or 2 mrem/hour localized near the crystal. Dose rates through the back of the watch are considerably less because the gammas are partly shielded by the watch case. Note that 1 mrem/hour (times 8700 hours per year) adds up to 8.7 rem (8700 mrem) in a year. Watches with ten or more times these radiation levels are not uncommon. However in most cases the radiation dose to the body is considerably less than the dose at the surface of the watch crystal. Many unreasonable radiation exposures continue to occur through lack of sufficient regard for radiation levels from radium dials. As one example, the highest level in normally occupied spaces including engineering spaces of USS BAINBRIDGE (CGN 25) during initial sea trials was found in the Captain's Sea Cabin from a 100 mrem/hour radium dial instrument stored in the adjacent navigation chart desk.

3. Medical and Dental X rays: Typical exposures used for diagnosis in the 1960's were approximately

a. 700 mrem for annual chest x-ray. Newest mass processing equipment can reduce this to about 70 mrem. Use of relatively more expensive large film can reduce this to about 30 mrem.

b. 15 rem (15,000 mrem) localized exposure to jaw for dental x-ray. Dose to reproductive organs can be limited to less than 10 mrem if equipment is properly collimated and shielded.

c. 10 rem (10,000 mrem) per minute for fluoroscopes, once used to fit shoes, now used to investigate intestinal and other internal disorders.

The average exposure to people in the United States from diagnostic x-rays, such as the above, is about 100 mrem per year per person. Thus we in the United States have accepted a doubling of normal background exposure to obtain the great benefits of medical and dental x-rays.

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*See next section for a discussion of microcuries.

Exposures used for treatment, such as to destroy cancer, are usually localized exposures in the thousands of rem, and have not been considered in the above examples.

4. Fallout: The average radiation dose received by people in the United States from fallout of fission products from early nuclear weapons atmospheric tests to date is about 4 mrem per year.

5. Radiography: Radiography is used extensively for detecting defects in welds, castings, and forgings. Exposures of hundreds of rem from gamma sources or x-ray machines are needed for heavy sections. Personnel are cleared from affected areas because of these high radiation levels. Radiography is done routinely with sources as large as 100 curies* of iridium 192; the radiation level 3 feet away from such a source is about 50 rem/hour.

From the preceding examples we might conclude correctly that exposures as low as normal background (about 100 mrem per year) should not be of great concern, since we have lived with such exposures all our lives. Our predecessors have also lived with such exposures for centuries. If operation, maintenance and repair of nuclear propulsion plants could be accomplished without anyone ever exceeding 100 mrem per year, then we could stop this section on rem here. Unfortunately, significant amounts of work must be accomplished where radiation levels over 100 mrem per hour exist. In order to accomplish such work, a reasonable balance must be made between the risk from the exposure to radiation and the benefits to be gained.

Recognizing the need for such a balance affecting the entire Nation from many sources of radiation, Congress set up the Federal Radiation Council (FRC) in 1959 to advise the President. FRC members include the Secretary of Health, Education and Welfare, Secretary of Defense, Chairman of the Atomic Energy Commission and several other Cabinet Members; thus these men should be well qualified to make the judgement from economic, political and physiological considerations of how much exposure is reasonable for how much benefit. The FRC adopted and the President approved as guidance for Federal agnecies the average limit for radiation workers of 5 rem per year**, which is approximately equivalent to an average of 100 mrem per week.

This 5 rem per year average limit has been selected after analysis of a vast number of experiments with animals and evaluation of the effects of radiation exposure of many people. Most of these analyses have been for radiation exposures considerably higher than 5 rem per year, therefore large safety factors were applied in developing the limits. The effects of radiation exposure appear similar to those of aging. No diseases or mutations that do not already occur naturally are known to be produced by radiation. Compared with widely accepted everyday risks from automobiles, pesticides, air and water pollution, drugs, and industrial and home accidents, the risk from radiation exposures for many years at up to 5 rem per year appears slight.

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*See next section for a discussion of curies.

**Precise FRC limits are 5(N-18) rem accumulated at any age over 18 years (N is age in years), as long as the dose does not exceed 3 rem in any quarter year. These limits apply to external, whole body, penetrating radiation. The FRC was later incorporated in the Environmental Protection Agency.

Most treatises on radiation go into gory detail on the effects of high radiation exposures, since these have been studied in great detail by analysis of people at Hiroshima and Nagasaki, of 8 people killed to date from nuclear criticality accidents, and of extensive animal radiation studies. The conclusions from these studies of short time period whole body exposures may be summarized as follows:

a. No changes have been observed after brief exposures less than about 25 rem.

b. Brief exposures of about 100 rem may cause radiation sickness, followed by apparent complete recovery.

c. Brief exposures of about 500 rem will cause death (although there appears to be some hope of survival under specialized medical treatment at considerably higher doses).

Summarizing the preceding information on rem, a useful number to remember is 100:

100 MREM PER YEAR IS WHAT MOST PEOPLE AVERAGE FROM NATURAL SOURCES.

100 MREM PER WEEK AS AN AVERAGE WILL MEET THE LIMITS FOR RADIATION WORKERS.

100 REM IN A SHORT PERIOD MAY CAUSE RADIATION SICKNESS.

CURIES

As discussed here the subject of curies is essentially the subject of internal exposure, that is, exposure from radioactivity inside the body. In the preceding section on rem we were concerned with external exposure. The dictionary-type definition of the unit of radioactivity, curie, is that it is the radioactivity of material decaying at the rate of 3.7×10^{10} disintegrations per second. This definition is useful sometimes for radiological control personnel, but it does not help most people understand radioactivity. Since the previous section developed benchmarks to understand rem, let us begin by relating curies to rem:

A CURIE GIVES A RADIATION LEVEL OF ABOUT 1 REM/HOUR
AT ONE METER (ABOUT 3 FEET).*

Look what happens to dose rate when you try to get near a curie (represented by a speck of 1 thousandth of a gram of cobalt 60):

At 1 meter, the radiation level is about 1 rem/hour.
At 1 foot, the radiation level is about 10 rem/hour.
At 1 inch, the radiation level is about 1500 rem/hour.
At 1 centimeter, the radiation level is about 10,000 rem/hour.

From the section on REM these radiation levels show that a curie is too much radioactivity to consider inside the body. Therefore, the microcurie (μc) is usually used to consider more realistic amounts of radioactivity. (Micro means millionth; 10^6 microcuries = 1 curie). Now look at the radiation from a microcurie:

At 1 foot the radiation level is about 0.01 mrem/hour.
At 1 inch the radiation level is about 1.5 mrem/hour.
At 1 centimeter the radiation level is about 10 mrem/hour.

The level at 1 foot is too low to detect on most standard radiation survey meters; it is less than the 0.02 mrem/hour natural background level. However, for isotopes inside the body, distances of most interest are less than a few centimeters; radiation levels this near a microcurie are high enough to be of concern if exposures will continue more than a few hours.

For external radiation exposure the limit discussed in the preceeding section was equivalent to 100 mrem/week. Internal exposure can also be expressed in mrem, as hinted at above. Instead of 100 mrem/week, however, the equivalent limit for most internal organs (such as lungs, intestines, liver) is 300 mrem/week. Normally internal exposures are limited to less than one tenth the limits (or 30 mrem/week for most organs) for the following reasons:

1. Internal exposure is difficult to measure accurately.

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*This relation differs for different isotopes; it figured historically in the initial description of the characteristics of 1 gram of radium. For cobalt 60 gammas the more accurate radiation level at 1 meter is 1.3 rem/hour. For many approximation purposes, including all purposes of this article, the relation as given is sufficiently accurate.

2. Internal exposures higher than about one tenth the limits should logically cause corresponding reductions in the external exposure allowed. (Since reducing external exposures usually requires shielding, it is generally more difficult and costly than reducing internal exposures.) Thus a 30 mrem internal exposure would seem to call for a 10 percent reduction in the 100 mrem/week external exposure limit. This change is too small to be significant, but repeated larger exposures might justify such compensation. The safest way to avoid this probelm is to keep internal exposures negligible.

3. The effects of swallowing or breathing a specific amount of an isotope vary greatly depending on many factors such as age, weight, diet, state of health, and on the chemical and physical state of the isotope.

To examine microcuries more closely, we will investigate them in water, in air, and on surfaces. Since cobalt 60 is usually the isotope of most concern in the Naval Reactors Program, in the following sections all radioactivity is assumed to be cobalt 60.

1. Radioactivity in Water:

Cobalt 60 at $3 \times 10^{-5} \mu c/ml$* consumed in drinking water will cause internal exposure of about 30 mrem/week (equivalent to 10 mrem/week of whole body radiation). The following may help explain this relationship.

a. Most of the cobalt 60 available from reactor plants does not dissolve in water; it is suspended in the form of very small particles and agglomerations of particles. THese particles are not expected to dissolve any more readily in the stomach or intestines than in water. Therefore their primary effect after being swallowed will be to irradiate the stomach and intestinal tract on the way through the body.

The following example suggests a crude approximation to more correct formulas to show that the relationship underlined above is reasonable:

> Typical daily fluid intake is 2200 ml, or slightly more than two quarts. At $3 \times 10^{-5} \mu c/ml$, this 2200 ml would contain 0.066 μc. The radiation level at one inch from 0.066 μc is about 0.1 mrem/hour. During the typical 13 hours to transit the lower large intestine, the total exposure at one inch would be 1.8 mrem. In seven days of repeating this consumption, total exposure at one inch would be 13 mrem. If a more realistic representation of the intestine were used this 13 mrem would turn out to be approximately 30 mrem.

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*μc/ml represents microcuries per milliliter. One thousand milliliters is one liter or about one quart.

b. If the cobalt were soluble, a small portion of it would be absorbed into the blood stream. Because cobalt 60 has a five year half life, you might expect it to build up in the body over long periods of time. To the contrary, soluble cobalt has an effective half life in the body of roughly ten days because of the rate it is used and excreted from the body. Because this half life in the body is short, cobalt 60 cannot build up in the body over long periods of time as radium or strontium does. Also as a result of this short effective half life, the dose to the intestinal tract is greater than the doses to other organs from swallowed cobalt 60, either soluble or insoluble. As shown in the example in a. above, most of the dose to the intestinal tract, and therefore most of the dose from swallowing cobalt 60, occurs in the first day.

c. Instead of the fictitious case of continuously drinking contaminated water, how much exposure would you receive from accidentally swallowing one microcurie of cobalt 60?

> In a. above 0.066 μc/day gave a dose of 30 mrem/week (= 4.3 mrem/day). Since the exposure all occurred the same day, we can conclude that swallowing 0.066 μc causes a dose of about 4.3 mrem to the intestines. Therefore swallowing 1 μc would cause $\frac{1}{.066} \times 4.3 = 65$ mrem exposure to the intestines. This is approximately equivalent to 22 mrem whole body external penetrating radiation.

For comparison with the 3×10^{-5} μc/ml value for cobalt 60, normal levels of radioactivity observed in fresh water rivers are about 10^{-8} μc/ml; sea water contains naturally radioactive potassium, therefore its normal radioactivity is about 10^{-7} μc/ml. Some isotopes have considerably lower concentrations than cobalt 60 in drinking water to correspond to a whole body dose of 10 mrem/week; for example, the corresponding limit for radium 226 is 1×10^{-8} μc/ml.

Summarizing the above information on radioactivity in water, useful numbers are:

> COBALT 60 AT 3×10^{-5} μc/ml IN DRINKING WATER CORRESPONDS TO 10 MREM PER WEEK OF WHOLE BODY RADIATION.
>
> SWALLOWING ONE MICROCURIE OF COBALT 60 WILL CAUSE A SMALL* DOSE, MOST OF WHICH IS RECEIVED IN LESS THAN ONE DAY.

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*Equivalent to about 20 mrem whole body external penetrating radiation.

2. Radioactivity in Air:

Breathing cobalt 60 at 1 x 10^{-9} μc/ml* in air for 8 hours a day will cause internal exposure of about 30 mrem/week (equivalent to 10 mrem/week of external radiation). The following may help explain this relationship.

a. Consider exposure during normal working hours throughout the year:

> At 10^{-9} μc/ml the normal 10^7 ml of air inhaled in an average 8 hour work day would contain 10^{-2} μc. The fate of this activity is dependent on such usually unknown factors as particle size, particle shape, chemical form, density, and the state of health of the person breathing it. As a rough approximation, assumptions are usually made that for insoluble material one quarter is exhaled, more than half is swallowed, and about one eighth remains deposited in the lungs. The swallowed portion goes through the intestines as described in the preceding section; however, the resulting dose to the intestines is negligible compared to the dose to the lungs from the deposited cobalt. The deposited portion gradually is excreted from the body with a 120 day half life. Thus one eighth of 10^{-2} μc is deposited in the lungs each work day; this builds up with a 120 day half life to an equilibrium level of about 0.1 μc in the lungs after many months of exposure. This 0.1 μc will cause a dose to the lungs of 30 mrem/week; but remember this activity has a fairly long half life in the lungs. The total dose to the lungs accumulates week after week.

b. In the more realistic case where cobalt 60 is breathed for a short period of time, what is the dose from inhaling 1 μc of cobalt 60?

> About on eighth of this will be deposited in the lungs, or 0.1 μc In the preceding case 0.1 μc caused a lung dose of 30 mrem per week; however, in this case the dose will be about 10 mrem the first week because of excretion. The total dose to the lungs will be about 200 mrem, equivalent to a whole body dose of about 70 mrem. Note the companson with swallowing one microcurie of cobalt 60; breathing it is more than ten times worse.

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*The correct figure of 0.9 x 10^{-9} μc/ml is rounded off to 1 x 10^{-9} for simplicity. Milliliter is used for simplicity here since it is used in the preceding section on water concentrations. Milliliter and cubic centimeter are considered identical here.

c. What would be your exposure from breathing cobalt 60 at 100 times 1×10^{-9} μc/ml for one hour?

You would inhale about 0.12 μc ($1/8 \times 10^{7}$ ml/8 hrs $\times 100 \times 1 \times 10^{-9}$ μc/ml). This is one eighth of the amount in example b. above, therefore the equivalent whole body dose over the following year would be about 10 mrem.

For comparison with the 10^{-9} μc/ml disucssed above, natural background activity in the air typically is in the range of 10^{-10} to 10^{-9} μc/ml. Most of this is from short-lived daughters of radon gas, which exudes from radium in the ground.

Summarizing the above information on radioactivity in air, useful numbers are:

COBALT 60 AT 1×10^{-9} μc/ml IN AIR DURING WORKING HOURS CORRESPONDS TO 10 MREM PER WEEK OF WHOLE BODY RADIATION.

BREATHING ONE MICROCURIE OF COBALT 60 WILL CAUSE A MODERATE* TOTAL DOSE OVER THE FOLLOWING YEAR.

3. Radioactivity on Surfaces:

The limit for radioactive loose surface contamination in uncontrolled areas is 450 μμc measured on a swipe over an area of $100 cm^2$. Rough approximations can be made as follows to show that use of this limit adequately protects people from internal and external exposure:

a. Airborne radioactivity: Assume a room nine feet (approximately 3 meters or 300 centimeters) on a side has 450 μμc/$100 cm^2$ loose surface contamination on the deck and that some of this activity becomes airborne while walking through or working in the room.

The deck area is about 300 cm x 300 cm = 9×10^{4} cm^2; therefore there are 450 μμc/100 cm^2 $\times 9 \times 10^{2}$ (100 cm^2) = 4×10^{5} μμc) = 0.4 μc loose on the deck. If one tenth percent of this activity is continuously distributed in the air where it can be breathed, airborne radioactivity in the room will be (0.4 μc $\times 10^{-3}$) $\div$ $(300 \text{ cm})^3 = 1.3 \times 10^{-11}$ μc/ml. Such an exposure continuously during working hours would cause a dose to the lungs of only 0.4 mrem/week or 20 mrem/year.

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*Equivalent to about 300 mrem whole body external penetrating radiation.

b. External radiation exposure: Measurements have shown that a surface that has loose surface contamiantion of 10,000 μμc/100 cm^2 from cobalt 60 will have a radiation level of roughly 0.1 mrem/hour near the surface. If the surfaces nearest a person, such as clothing, were continuously contaminated at the limit of 450 μμc/100 cm^2, then the radiation exposure would be about .0045 mrem/hour. This is only 39 mrem/year.

c. Ingestion: Some activity will be transferred from surfaces to hands to mouth.

> If the loose activity from one square foot were so transferred from surfaces contaminated to 450 100 cm^2, then 4500 μμc, or 0.005 μc would be swallowed. By comparison with the preceding discussion of waterborne radioactivity, this intake will cause exposure equivalent to about .1 mrem of whole body radiation.

Since the above examples imply that 450 μμc/100 cm^2 is a more stringent limit than necessary for surface contamination, why control to such a low level? This control has been considered essential to minimize the increase in natural background radioactivity.

Summarizing the above information on radioactivity on surfaces, useful numbers are:

> LOOSE SURFACE CONTAMINATION OF 10,000 μμc/100 cm^2 FROM COBALT 60 WILL CAUSE RADIATION LEVELS OF ROUGHLY 0.1 MREM/HOUR

THE POLY BOTTLE

Now sufficient background has been explored to allow reasonable evaluation of a typical radiological problem. Take a small poly bottle containing 100 ml of radioactive water with 10^{-2} μc/ml of cobalt 60. Now it's your turn to figure out what kind of radiological problems it can cause.*

1. Radiation: What is the radiation level? Can you carry it around in your pocket? Sleep with it?

2. Assume you swallowed it: Is stomach pumping or more serious action warranted? What dose would you receive? How would you measure this dose with no knowledge of how much activity was originally in the bottle?

3. Assume the water is sprayed into the air in a small room and you breathe this air: What dose would you receive? How would you measure this dose?

4. Assume you spilled it on the deck: What surface contamination levels would result? What radiation levels would exist?

5. Compare swallowing, breathing and spilling: Which would be worst with respect to the normally used continuous exposure limits? Which would be worst with respect to personnel radiation exposure?

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*Even if in these cases radiological problems are insignificant, you should not use these results to justify violations of established radiological control procedures.

Appendix B

SUMMARY OF ALL CLAIMS FROM RADIATION EXPOSURE ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

Shipyard	Claims Filed	Claims Awarded	Claims Rejected or Deferred	Claims Active
Portsmouth Naval Shipyard	3	0	3	0
Electric Boat Division of General Dynamics	2	0	2	0
Norfork Naval Shipyard	1	1	0	0
Newport News Shipbuilding and Drydock Company	0	0	0	0
Charleston Naval Shipyard	2	0	2	0
Ingalls Shipbuilding	0	0	0	0
Mare Island Naval Shipyard	25	2	9	14
Puget Sound Naval Shipyard	24	0	12	12
Pearl Harbor Naval Shipyard	3	0	2	1
Nuclear-powered ships and their supporting tenders and bases	0	0	0	0
TOTALS	60	3	30	27

SUMMARY OF LEUKEMIA CLAIMS FROM RADIATION EXPOSURE ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

Shipyard	Claims Filed	Claims Awarded	Claims Rejected or Deferred	Claims Active
Portsmouth Naval Shipyard	0	0	0	0
Electric Boat Division of General Dynamics	0	0	0	0
Norfork Naval Shipyard	1	1	0	0
Newport News Shipbuilding and Drydock Company	0	0	0	0
Charleston Naval Shipyard	0	0	0	0
Ingalls Shipbuilding	0	0	0	0
Mare Island Naval Shipyard	0	0	0	0
Puget Sound Naval Shipyard	2	0	1	1
Pearl Harbor Naval Shipyard	2	0	1	1
Totals	5	1	2	2

SUMMARY OF CANCER (OTHER THAN LEUKEMIA) CLAIMS FROM RADIATION EXPOSURE ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

Shipyard	Claims Filed	Claims Awarded	Claims Rejected or Deferred	Claims Active
Portsmouth Naval Shipyard	2	0	2	0
Electric Boat Division of General Dynamics	1	0	1	0
Norfork Naval Shipyard	0	0	0	0
Newport News Shipbuilding and Drydock Company	0	0	0	0
Charleston Naval Shipyard	0	0	0	0
Ingalls Shipbuilding	0	0	0	0
Mare Island Naval Shipyard	4	0	1	3
Puget Sound Naval Shipyard	3	0	2	1
Pearl Harbor Naval Shipyard	0	0	0	0
Totals	10	0	6	4

SUMMARY OF CLAIMS OTHER THAN CANCER OR LEUKEMIA FROM RADIATION EXPOSURE ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

Shipyard	Claims Filed	Claims Awarded	Claims Rejected or Deferred	Claims Active
Portsmouth Naval Shipyard	1	0	1	0
Electric Boat Division of General Dynamics	1	0	1	0
Norfolk Naval Shipyard	0	0	0	0
Newport News Shipbuilding and Drydock Company	0	0	0	0
Charleston Naval Shipyard	2	0	2	0
Ingalls Shipbuilding	0	0	0	0
Mare Island Naval Shipyard	21	2	8	11
Puget Sound Naval Shipyard	19	0	9	10
Pearl Harbor Naval Shipyard	1	0	1	0
Totals	45	2	22	21

INJURY CLAIMS FROM RADIATION EXPOSURE ASSOCIATED WITH NAVAL NUCLEAR PROPULSION PLANTS

PORTSMOUTH NAVAL SHIPYARD

Occupation	Date Filed	Injury Claim	Lifetime Radiation Exposure-Rem	Status*
Machinist	10/60	Bone Cancer	1.855	REJECTED
Metals Inspector	11/73	Cryptogenic epileptic condition	7.381	REJECTED
Shipfitter	12/73	Lymphosarcoma	2.326	DEFERRED

*AWARDED means Department of Labor concluded injury was job related and compensation paid.
REJECTED means Department of Labor concluded injury was not job related.
DEFERRED means Department of Labor concluded claimant did not provided sufficient justification that injury was job related and that claimant has not replied to Department of Labor requests for more information.
ACTIVE means claim is being evaluated by the Department of Labor.

Occupation	Date Filed	Injury Claim	Lifetime Radiation Exposure-Rem	Status*
ELECTRIC BOAT DIVISION OF GENERAL DYNAMICS				
Welder	2/74	Radiation and Head injury	0.010	REJECTED by State Workmen Compensation. However, State paid for psychiatric examination.
Shipping Carpenter	1967	Overexposure; Cancer of Lip	0.068	DEFERRED by insurancy company. Removal of lip cancer paid by insurance company.
NORFOLK NAVAL SHIPYARD				
Boilermaker	3/67	Acute Myelogenous Leukemia	5.38	AWARDED The Navy disagreed with this award. The basis of the Navy disagreement was that (1) his occupational exposure was small compared to his medical exposure, and (2) the leukemia occurred only 2 years after his first occupational exposure which is a too short a latency period.
NEWPORT NEWS SHIPBUILDING AND DRYDOCK COMPANY			NONE	
CHARLESTON NAVAL SHIPYARD				
Sheet metal worker	11/66	Impaired Vision	4.173	REJECTED
Shipfitter	9/71	Cataract	10.156	REJECTED

Occupation	Date Filed	Injury Claim	Lifetime Radiation Exposure-Rem	Status*
MARE ISLAND NAVAL SHIPYARD				
Machinist	4/63	Skin condition	0	DEFERRED
Helper electrician	4/64	Blackouts	0	REJECTED
Chemistry Technician	6/65	Cataract	2.961	AWARDED in 1971. The Navy disagrees with this award because the individual's radiation exposure was well below the level considered necessary to produce cataract. Experts generally agree that many hundreds of rem are required to cause cataracts.
Component cleaner	4/69	Gonad injury	6.180	DEFERRED
Crane Operator	6/69	Cataract	0	ACTIVE
Janitor	2/70	Partial vision loss, skin condition	0	REJECTED
Radiation Technician	4/70	Tumor caused arm amputation	11.760	DEFERRED
Rigger	12/70	Cataract	0.160	REJECTED
Crane Operator	12/70	Cataract	0.080	REJECTED
Crane Operator	1/71	Cataract	0	ACTIVE
Marine Machinist	7/71	Cataract	0.580	REJECTED

MARE ISLAND NAVAL SHIPYARD (Continued)

Occupation	Date Filed	Injury Claim	Lifetime Radiation Exposure-Rem	Status*
Shipfitter	9/71	Cataract from steam generator repair work	3.441	AWARDED in 1977. The Navy disagrees with this award because radiation caused cataracts generally start in the posterior part of the lens. The claimant's cataracts started in the anterior portion of the lens. In addition the claimant's radiation exposure was well below the threshold level considered necessary to produce cataracts.
Crane Operator	1/72	Cataract	0	REJECTED
Sand Blaster	3/72	Hearing Loss	0	ACTIVE
Rigger	5/73	Eye Trouble	1.015	ACTIVE
Electrician	2/74	Skin problem on hand	0	ACTIVE
Component cleaner	3/74	Radiation face burn	26.213	ACTIVE
Pipefitter	5/75	Eye trouble	0.060	ACTIVE
Radiation Technician	6/75	Vision loss - many causes including radiation	7.635	ACTIVE
Nuclear inspector	11/75	Cancer (liposarcoma) - many causes including radiation	11.889	ACTIVE
Industrial cleaner	1/76	Internal injuries, blood changes	11.430	ACTIVE

MARE ISLAND NAVAL SHIPYARD (Continued)

Occupation	Date Filed	Injury Claim	Lifetime Radiation Exposure-Rem	Status*
Laborer	2/76	Heart condition	0	ACTIVE
Health physicist	11/76	Chest cancer	2.331	ACTIVE
Lagger	1/77	Lung disease	7.003	ACTIVE
Security guard	4/77	Brain tumor	0.016	ACTIVE
PUGET SOUND NAVAL SHIPYARD				
Welder	6/71	Leukemia	0.079	REJECTED
Radiation monitor	9/71	Stomach cancer	10.566	REJECTED
Metal inspector	9/72	Cataract	29.655	ACTIVE
Cement finisher	4/74	Emphysema - many causes including radiation	0	REJECTED
Sheet metal worker	8/74	Cancer - many causes	0	ACTIVE
Welder	9/74	Lung cancer - many causes	0	DEFERRED
Pipefitter	10/74	Lung ailment - many causes	0	REJECTED FOR RADIATION - AWARDED FOR FOR OTHER CAUSES
Various Shipyard Laboring Occupations	10/74	Lung ailment - many causes	0	ACTIVE
Shipwright	10/74	Bronchitis - many causes	0	REJECTED FOR RADIATION - AWARDED FOR FOR OTHER CAUSES
Welder	10/74	Bronchial pain - many causes	0	DEFERRED
Rigger	10/74	Bronchitis, pneumonia - many causes including radiation	0.052	REJECTED FOR RADIATION - AWARDED FOR OTHER CAUSES

Occupation	Date Filed	Injury Claim	Lifetime Radiation Exposure-Rem	Status*
PUGET SOUND NAVAL SHIPYARD (Continued)				
Shipfitter	10/74	Lung ailment - many causes	0	ACTIVE
Laborer	11/74	Bronchitis - many causes	0	REJECTED FOR RADIATION - AWARDED FOR OTHER CAUSES
Sheet Metal Worker	12/74	Bronchitis, emphysema - many causes	0	ACTIVE
Electrician	12/74	Lung injury - many causes	0	ACTIVE
Pipefitter	12/74	Bronchitis - many causes	0.064	REJECTED
Pipefitter	12/74	Epilepsy - many causes	9.548	DEFERRED
Welder	2/75	Back injury - many causes	0	ACTIVE
Machinist	3/75	Cataract	0	REJECTED
Materials Engineer	1/76	Lung injury - many causes	0.037	ACTIVE
Shipfitter	12/75 and 7/76	Stress from radiological written examinations and nuclear work	5.247	ACTIVE
Radiographer	1/77	Lymphocytosis	16.529	ACTIVE
Shipfitter	11/77	Leukemia	0.059	ACTIVE
Welder, Reactor Plant Foreman	11/77	Lung injury - many causes	8.607	ACTIVE

Occupation	Date Filed	Injury Claim	Lifetime Radiation Exposure-Rem	Status*
INGALLS SHIPBUILDING				
NONE–				
PEARL HARBOR NAVAL SHIPYARD				
Pipefitter	2/70	Leukemia	0.020	REJECTED
Electronic Mechanic	8/73	Upset metabolism	0.180	DEFERRED
Mechanic	11/74	Leukemia	6.140	ACTIVE

APPENDIX B

Report NT-78-1
February 1978

ENVIRONMENTAL MONITORING AND DISPOSAL OF RADIOACTIVE WASTES FROM U. S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES

1977

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ABSTRACT

The environmental effect of disposal of radioactive wastes originating from U. S. Naval nuclear propulsion plants and their support facilities is assessed. The total gamma radioactivity in liquids, less tritium, discharged to all ports and harbors from the more than one hundred Naval nuclear-powered ships and supporting tenders, Naval bases and shipyards was less than 0.002 curie in 1977. The total tritium released to all ports and harbors was less than one curie in 1977. This report confirms that procedures used by the Navy to control releases of radioactivity from U. S. Naval nuclear-powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public.

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SUMMARY

The radioactivity in wastes discussed in this report originates in the pressurized water reactors of U. S. Naval nuclear-powered ships. As of the end of 1977, the U. S. Navy had 110 nuclear-powered submarines and ten nuclear-powered surface ships in operation. Support facilities involved in construction, maintenance, overhaul and refueling of these nuclear propulsion plants include nine shipyards, thirteen tenders and two submarine bases. This report describes disposal of radioactive liquid wastes, disposal of solid wastes and monitoring of the environment to determine the effect of radioactive releases, and updates reports on this subject issued by the Navy in references 1 through 12.* This report concludes that radioactivity associated with U. S. Naval nuclear-powered ships has had no significant or discernable effect on the quality of the environment. A summary of the radiological information supporting this conclusion follows:

From the start of the Naval nuclear propulsion program the policy of the U. S. Navy has been to reduce to the minimum practicable the amounts of radioactivity released into harbors. Navy procedures to accomplish this have been reviewed with the U. S. Department of Energy and the U. S. Environmental Protection Agency. The total gamma radioactivity released within twelve miles from shore from all U. S. Naval nuclear-powered ships and their support facilities in recent years is shown in Table 1; this includes all harbors both U. S. and foreign entered by these ships.

TABLE 1 RADIOACTIVE LIQUID WASTE RELEASED TO HARBORS FROM U. S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES

Year	Number of Ships In Operation	Radioactivity-Curies (less tritium)
1971	100	less than 0.002
1972	104	less than 0.002
1973	107	less than 0.002
1974	111	less than 0.002
1975	113	less than 0.002
1976	115	less than 0.002
1977	120	less than 0.002

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*References are listed on page 26

As a measure of the significance of these data, if one person were able to drink the entire amount of radioactivity discharged into any harbor in 1977, he would not exceed the annual radiation exposure permitted for an individual worker by the U. S. Nuclear Regulatory Commission.

Environmental monitoring is conducted by the U. S. Navy in U. S. and foreign harbors frequented by the U. S. Naval nuclear-powered ships. This monitoring consists of analyzing harbor water, sediment and marine life samples for radioactivity associated with Naval nuclear propulsion plants, radiation monitoring around the perimeter of support facilities and effluent monitoring. Environmental samples from each of these harbors are also checked at least annually by a U. S. Department of Energy Laboratory to ensure analytical procedures are correct and standardized. The U. S. Environmental Protection Agency has conducted independent surveys in U. S. harbors; results have been consistent with Navy results. These surveys have confirmed that U. S. Naval nuclear-powered ships and support facilities have had no significant effect on the radioactivity of the marine environment.

RADIOACTIVE LIQUID WASTE PROCESSING AND CONTROL

Policy and Procedures Minimizing Release of Radioactivity in Harbors

The policy of the U. S. Navy is to reduce to the minimum practicable the amounts of radioactivity released to the environment but particularly within twelve miles from shore including into harbors. This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated in Environmental Protection Agency in 1970), U. S. Nuclear Regulatory Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection, International Atomic Energy Agency, and National Academy of Sciences—National Research Council (references 13 through 20). Keeping releases small minimizes the radioactivity available to build up in the environment or to concentrate in marine life. To implement this policy of minimizing releases, the Navy has issued standard instructions defining the radioactive waste disposal limits and procedures to be used by U. S. Naval nuclear-powered ships and their support facilities. These instructions were reviewed by the U. S. Department of Energy and the U. S. Environmental Protection Agency.

Source of Radioactivity

In the shipboard reactors, pressurized water circulating through the reactor core picks up the heat of nuclear reaction. The Reactor cooling water circulates through a closed piping system to heat exchangers which transfer the heat to water in a secondary steam system isolated from the primary cooling water. The steam is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Releases from the shipboard reactors occur primarily when reactor coolant water expands as a result of being heated to operating temperature; this coolant passes through a purification system ion exchange resin bed prior to being transferred from the ship.

The principal source of radioactivity in liquid wastes is from trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Radionuclides with half-lives greater than one day in these corrosion and wear products include tungsten 187, chromium 51, hafnium 181, iron 59, iron 55, nickel 63, zirconium 95, tantalum 182, manganese 54, cobalt 58, and cobalt 60. The most predominant of these is cobalt 60, which has a 5.3 year half-life; cobalt 60 also has the most restrictive concentration limit in water listed by organizations which set radiological standards in references 13, 14, and 15 for these corrosion and wear radionuclides. Therefore, radioactive waste disposal is conservatively controlled by assuming that all the long-lived radioactivity is cobalt 60.

Radioactivity Removal From Liquid Wastes at Shore Facilities.

Radioactive liquid wastes at shore facilities are collected in stainless steel tanks and processed through a processing system to remove most of the radioactivity (exclusive of tritium) prior to collection in a clean tank for reuse. Even after processing to approximately 10^{-8} microcuries of gamma radioactivity per milliliter, reactor coolant is reused rather than discharged. Illustration 1 shows a simplified block diagram of the waste processing system which consists of particulate filters, activated carbon bed filters, mixed hydrogen hydroxyl resin and colloid removal resin beds. This type of processing system has been developed and used successfully to produce high quality water containing very low radioactivity levels.

Liquid Waste Releases in Harbors

The total amounts of long-lived gamma radioactivity released into harbors and seas within twelve miles from shore has been less than 0.002 curie during each of the last seven years. This total is for releases from U. S. Naval nuclear-powered ships and from the supporting shipyards, tenders and submarine bases, and at operating bases and home ports in the U. S. and overseas and all other U. S. and foreign ports which were visited by Naval nuclear-powered ships. This quantity is conservatively reported as if it consisted entirely of cobalt 60, which is the predominant long-lived gamma radionuclide and also has the most stringent concentration limits.

To put this small quantity of radioactivity into perspective, it is less than the quantity of naturally occurring radioactivity (reference 21) in the volume of saline harbor water occupied by a single nuclear-powered submarine.

Although volumes are of less significance than the amount of radioactivity released, Table 1 of earlier reports has also shown that the total volume of liquids released within twelve miles from shore has been reduced from millions of gallons per year in the 1960's to less than 25 thousand gallons per year beginning in 1973. Thus, the Navy has achieved its policy of reducing releases of radioactive liquids in harbors to the minimum practicable amounts. Therefore, volumes have been deleted from this report.

Short Lived Radionuclides

Reactor coolant also contains short-lived radionuclides with half-lives of seconds to hours. Their highest concentrations in reactor coolant are from nitrogen 16 (7 second half-life), nitrogen 13 (10 minute half-life), fluorine 18 (1.8 hour half-life), argon 41 (1.8 hour half-life) and manganese 56 (2.6 hour half-life). Total short-lived radioactivity released in water in a year to any harbor has been less than 0.001 curie.

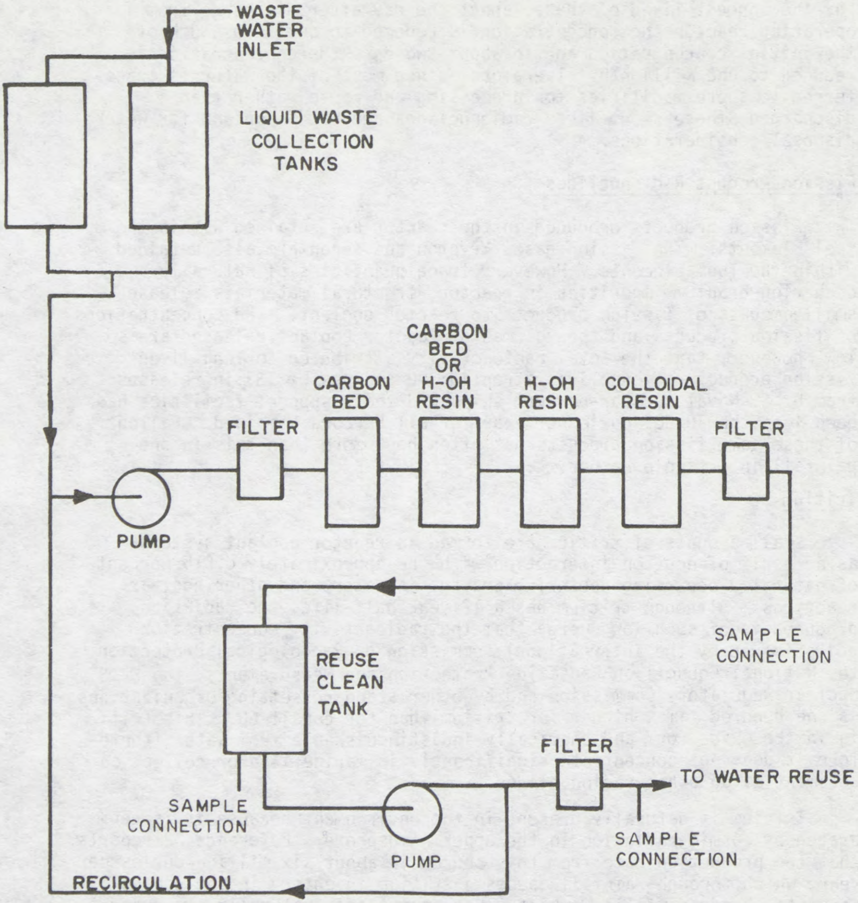

ILLUSTRATION 1
SIMPLIFIED DIAGRAM OF WASTE PROCESSING SYSTEM

For the longest-lived of these, about one day after discharge from an operating reactor the concentration is reduced to one thousandth of the initial concentration and in about two days the concentration is reduced to one millionth. Therefore, since most of the water is transferred to shore facilities for processing and reuse rather than discharged, these short-lived radionuclides are not important for water disposal considerations.

Fission Product Radionuclides

Fission products produced in the reactor are retained within the fuel elements. The fission gases krypton and xenon are also retained within the fuel elements. However, trace quantities of naturally occurring uranium impurities in reactor structural materials release small amounts of fission products to reactor coolant. The concentrations of fission products and the volumes of reactor coolant released are so low, however, that the total radioactivity attributed to long-lived fission product radionuclides, strontium 90 and cesium 137, in releases from U. S. Naval nuclear-powered ships and their support facilities has been less than 0.001 curie per year for all harbors combined. Fallout of these same fission products has often been more than this in one rainfall in a single harbor.

Tritium

Small amounts of tritium are formed in reactor coolant systems as a result of neutron interaction with the approximately 0.015 percent of naturally occurring deuterium present in water, and other nuclear reactions. Although tritium has a 12 year half-life, the radiation produced is of such low energy that the radioactivity concentration guide issued by the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, the U. S. Nuclear Regulatory Commission and by other standard-setting organizations is one hundred times higher for tritium than for cobalt 60. This tritium is in the oxide form and chemically indistinguishable from water; therefore it does not concentrate significantly in marine life or collect on sediment as do other radionuclides.

Tritium is naturally present in the environment because it is generated by cosmic radiation in the upper atmosphere. Reference 22 reports that the production rate from this source is about six million curies per year, which through rainfall causes a tritium inventory in the oceans of about one hundred million curies. Because of this naturally occurring tritium, much larger releases of tritium than are conceivable from Naval nuclear reactors would be required to make a measurable change in the background tritium concentration.

The total amount of tritium released during each of the last ten years from all U. S. Naval nuclear-powered ships and their supporting tenders, bases and shipyards has been less than 200 curies. Most of this has been into the ocean greater than twelve miles from shore. The total tritium from the entire nuclear Navy is less than single electrical generating nuclear power stations typically release each year (reference 23). Total tritium released into harbors within twelve miles from shore was less than one curie in 1977. Such releases are too small to increase measurably the tritium concentration in the environment. Therefore, tritium has not been combined with the data on other radionuclides in other sections of this report.

Carbon 14

Carbon 14 is also formed in small quantities in reactor coolant systems as a result of neutron interactions with nitrogen and oxygen. Carbon 14 decays with a half-life of 5730 years; however, only low energy beta radiation is emitted as a result of this decay process. As a result, the radioactivity concentration guide for carbon 14 in its chemical form in air issued by the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, the U. S. Nuclear Regulatory Commission and by other standard-setting organizations is three thousand times higher than for cobalt 60.

Carbon 14 occurs naturally in the environment. It is generated from cosmic radiation interactions with nitrogen and oxygen in the upper atmosphere and oxidized to form carbon dioxide. Carbon 14 is chemically indistinguishable from other radionuclides of carbon. The carbon dioxide diffuses and convects throughout the atmosphere and enters the earth's carbon cycle. Reference 24 states that the earth's carbon 14 inventory is estimated to be about three hundred and ten million curies. The total amount of carbon 14 released during each of the last ten years from the operation of all U. S. Naval nuclear-powered ships and their supporting tenders, bases and shipyards has been less than 100 curies, most of which is released into the atmosphere at sea beyond twelve miles from shore. The total carbon 14 radioactivity released in a year in any harbor has been less than 0.1 curie. Since the inventory of naturally occurring carbon 14 is so large, it is extremely unlikely that releases from Naval nuclear reactors could result in a measurable change in the background concentration of carbon 14. Therefore, carbon 14 has not been combined with the data on other radionuclides in other sections of this report.

Liquid Waste Releases at Sea

Radioactive liquids incidental to the operation of the nuclear propulsion plants are released at sea under strict controls. These ocean releases are consistent with recommendations the Council on Environmental Quality made in 1970 to the President in reference 25, and consistent with the Marine Protection, Research and Sanctuaries Act, reference 26. Procedures and limits for ocean releases have been consistent with recommendations made by the National Academy of Sciences—National Research Council in reference 17 and by the International Atomic Energy Agency in reference 18. These releases have contained much less radioactivity than these reports considered would be acceptable. Total long-lived radioactivity excluding tritium, released farther than twelve miles from shore by U. S. Navy nuclear-powered ships and supporting tenders is shown in Table 2 for recent years. This is the total amount released from over 100 ships at different times of the year in the open sea at long distances from land in small incremental amounts, and under rapid dispersal conditions due to wave action. The quantity of radioactivity released to the open ocean in 1977 was 0.4 curie, which is less than the naturally occurring radioactivity in a cube of sea water approximately 100 yards on a side.

TABLE 2 TOTAL RADIOACTIVITY IN LIQUID WASTE RELEASED AT SEA ORIGINATING FROM U. S. NAVAL NUCLEAR-POWERED SHIPS

	Radioactivity-Curies (less tritium)
1973	0.4
1974	0.4
1975	0.4
1976	0.4
1977	0.4

Loss of USS THRESHER and USS SCORPION

Two U. S. Navy nuclear-powered submarines have been lost at sea in the Atlantic Ocean. The submarine THRESHER sank 10 April 1963, 100 miles from land in water 8,500 feet deep at latitude 41°45'N and longitude 65°00'W. The submarine SCORPION sank between 21 and 27 May 1968, 400 miles southwest of the Azores in more than 10,000 feet of water. The reactors used in all U. S. Naval submarines and surface ships are designed to minimize potential hazards to the environment even under the most severe casualty conditions such as actual sinking of the ship. First, the reactor core is so designed that it is physically impossible for it to explode like a bomb. Second, the reactor fuel elements are made of materials that are extremely corrosion resistant, even in sea water. The reactor core could remain submerged in sea water for decades without releases of fission products while the radioactivity decays, since the protective cladding on the fuel elements corrodes only a few millionths of an inch per year. Thus, in the event of a serious accident where the reactor is completely submerged in sea water, the fuel elements will remain intact for an indefinite period of time, and the radioactive material contained in these fuel elements should not be released. The maximum rate of release and dispersal of the radioactivity in the ocean, even if the protective cladding on the fuel were destroyed, would be so low as to be insignificant.

Radioactive material could be released from this type of reactor only if the fuel elements were actually to melt and, in addition, the high-strength, all-welded reactor system boundary were to rupture. The reactor's many protective devices and inherent self-regulating features are designed to prevent any melting of the fuel elements. Flooding of a reactor with sea water furnishes additional cooling for the fuel elements and so provides added protection against the release of radioactive fission products.

Radiation measurements, water samples, bottom sediment samples and debris collected from the area where THRESHER sank were analyzed for radioactivity shortly after the sinking and again in 1965 by various laboratories with highly sensitive equipment. Similarly, sea water and bottom sediment samples taken near SCORPION's hull were analyzed for radioactivity. None of these samples showed radioactivity above naturally occurring background levels and none showed evidence of radioactivity released from either THRESHER or SCORPION.

In 1977 followup samples of water, sediment, marine life and debris were collected from the immediate THRESHER debris areas. None of these samples showed any evidence of release of radioactivity from the reactor fuel elements. However, cobalt 60 released from THRESHER coolant systems was detectable at low levels in sediment samples from a localized area which was not sampled during previous surveys. The cobalt 60 radioactivity in these sediment samples was small compared to naturally occurring radioactivity. Cobalt 60 was not detectable in the samples of water, marine life or debris. Thus, the THRESHER and SCORPION have not had a significant effect on the radioactivity in the environment.

SOLID RADIOACTIVE WASTE TRANSPORTATION AND DISPOSAL

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

Solid radioactive waste materials are packaged in strong tight containers, shielded as necessary and shipped to burial sites licensed by the U. S. Nuclear Regulatory Commission or a State under agreement with the U. S. Nuclear Regulatory Commission. Shipments are made in accordance with U. S. Department of Transportation regulations in containers approved for the specific quantity, type, and form of radioactivity. Shipments of radioactive waste material associated with the Naval nuclear propulsion program have not resulted in any measurable release of radioactivity to the environment.

Solid radioactive materials from Naval nuclear-powered ships have not been dumped at sea since 1970 when the Navy issued procedures prohibiting sea disposal of solid radioactive materials. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites.

Table 3 summarizes total radioactivity and volumes of radioactive solid waste disposal for the last five years. Table 3 includes all waste generated at the listed facilities because any radioactive waste generated by U. S. nuclear-powered ships is transferred to the listed facilities. The quantity of solid radioactive waste in any one year from a particular facility depends on the amount and type of support work performed that year. On the average, one waste shipment per month is made from each facility.

Table 3 does not include expended fuel or high level radioactive material associated with expended fuel. Expended fuel is shipped from the refueling shipyard by the U. S. Department of Energy to its facilities in Idaho for processing in the same manner as other expended nuclear fuel. It is required to be shipped in accordance with the requirements of the Department of Transportation, the Nuclear Regulatory Commission, and the Department of Energy. Each shipment is escorted by a specially trained U. S. Government representative. Each shipping container is specifically designed to withstand extreme accident impacts, fire, or water immersion, and to prevent releases of the material to the environment in the event of accident. The cargo is non-explosive and non-flammable.

Because of efforts to minimize solid waste and the utilization of compaction equipment, total volumes have remained nearly constant in spite of increasing work caused by increasing numbers of ships. The average annual volume for the entire Naval nuclear propulsion program could be contained in a cube measuring fifteen yards on a side. The total annual volumes of solid radioactive waste from the Naval nuclear propulsion program listed in Table 3 are less than one tenth of the total volumes of radioactive solid waste buried in all U. S. commercial burial grounds each year (reference 27).

TABLE 3 RADIOACTIVE SOLID WASTE FROM U. S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES FOR 1973 THROUGH 1977

	1973		1974		1975		1976		1977	
Facility	Thousand Cubic Feet	Curies	Thousand Cubic Feet	Curies	Thousand Cubic Feet	Curies	Thousand Cubic Feet	Curies	Thousand Cubic Feet	Curies
Portsmouth, New Hampshire Naval Shipyard	7	3	7	4	14	6	6	7	9	6
Groton, New London, Conn. Electric Boat Div., Tender at State Pier, & Sub Base	12	2	7	4	5	3	7	4	8	14
Newport News, Virginia Newport News Shipbuilding	6	5	4	4	2	2	2	5	2	5
Norfolk, Virginia Naval Shipyard and Tenders	4	2	3	5	4	4	11	5	6	1
Charleston, South Carolina Naval Shipyard and Tenders	6	19	4	22	3	13	4	20	7	13
Pascagoula, Mississippi Ingalls Shipbuilding Div	1	4	3	5	2	6	3	1	3	10
San Diego, California Tenders	<1	<1	<1	<1	<1	2	1	<1	1	4
Long Beach, California Naval Shipyard and Base	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
Vallejo, California Mare Island Naval Shipyard	6	23	7	34	11	19	8	10	7	27
Bremerton, Washington Puget Sound Naval Shipyard	10	21	20	306	14	7	8	34	6	10
Pearl Harbor, Hawaii Naval Shipyard & Sub Base	7	143	6	3	2	1	3	6	4	1
TOTALS	59	222	62	387	58	63	53	92	53	91

NOTES:

(1) This table includes all radioactive waste from tenders and nuclear-powered ships. This radioactivity is primarily cobalt 60. This radioactive waste is shipped to burial facilities licensed by the U. S. Nuclear Regulatory Commission or State.

(2) Volumes less than 500 cubic feet are reported <1 thousand and less than 0.5 curie is reported <1.

ENVIRONMENTAL MONITORING

To provide additional assurance that procedures used by the U. S. Navy to control radioactivity are adequate to protect the environment, the Navy conducts environmental monitoring in harbors frequented by its nuclear-powered ships. Environmental monitoring surveys for radioactivity are periodically performed in harbors where U. S. Naval nuclear-powered ships are built or overhauled and where these ships have home ports or operating bases. Samples from each harbor monitored are also checked at least annually by a U. S. Department of Energy laboratory to ensure analytical procedures are correct and standardized. The Department of Energy laboratory results have been consistent with shipyard and operating base results.

Navy Environmental Monitoring Program

The current Navy environmental monitoring program consists of analyzing samples of harbor water and sediment, supplemented by shoreline surveys, posted dosimeters and effluent monitoring. Sampling harbor water and sediment each quarter year is emphasized since these materials would be the most likely affected by releases of radioactivity. Marine life samples have also been collected from some harbors.

Five water samples are taken in each harbor once each quarter year in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross gamma radioactivity and for cobalt 60 content. A sodium iodide or germanium lithium scintillation detector with a multichannel analyzer is used to measure gross gamma activity in an energy range from 0.1 MeV to 2.1 MeV expressed in terms of cobalt 60 equivalent and to analyze the resulting gamma data for the presence of cobalt 60. Procedures for analysis will detect cobalt 60 if its concentration exceeds one three hundredth of the U. S. Nuclear Regulatory Commission limit of reference 13. No cobalt 60 has been detected in any of the water samples from all harbors monitored.

A radiological laboratory of the Environmental Protection Agency has analyzed samples from harbors to identify radionuclides present in sediment. These analyses showed cobalt 60 was the predominant radionuclide added to sediment from Naval nuclear reactor operations. Therefore, Navy monitoring procedures require collecting in each harbor approximately 20 to 120 sediment samples once each quarter year for cobalt 60 and gross gamma analyses. Locations and numbers of sediment samples for a particular harbor depend on the size of the harbor and the number and separation of locations where nuclear-powered ships berth. Sampling points are selected to form a pattern around ship berthing locations and to provide points in areas away from these berthing locations. The sampling locations are selected individually for each harbor considering characteristics of the harbor. Sediment samples are collected using the dredge shown in Illustration 2. The dredge samples a surface area of 36 square inches and has been modified to collect only the top one-half to one inch of sediment. The top layer was selected because it should be more mobile and more accessible to marine life than deeper layers. After the dredge is lowered to the harbor bottom the messenger weight lowered on the support from the surface causes the spring-loaded jaws on the dredge to close and trap the sediment. The samples are placed directly into a one quart container lined with a plastic bag. Each sediment sample is analyzed for gamma activity in the container in which collected using the scintillation detector with a multichannel analyzer. Gross gamma activity in an energy range from 0.1 MeV to 2.1 MeV is expressed in terms of equivalent cobalt 60 and the resulting gamma data is analyzed for the presence of cobalt 60 activity. Results of the sediment samples from harbors monitored by the Navy in the U. S. and possessions for 1977 are summarized in Table 4.

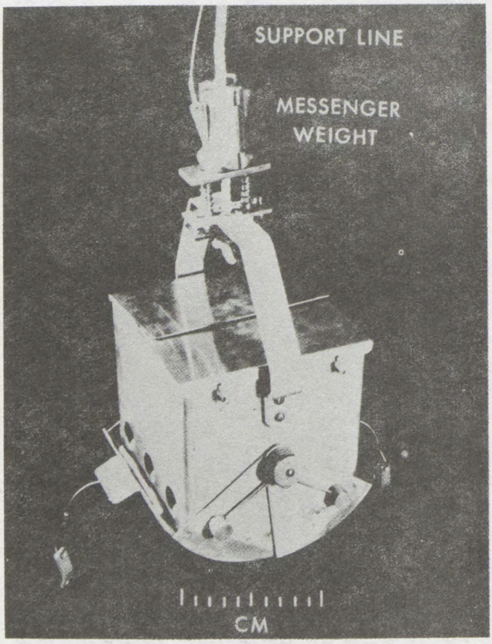

ILLUSTRATION 2

DREDGE FOR SAMPLING HARBOR SEDIMENT

TABLE 4 SUMMARY OF 1977 SURVEYS FOR COBALT 60 IN BOTTOM SEDIMENT OF U. S. HARBORS WHERE U. S. NAVAL NUCLEAR-POWERED SHIPS HAVE BEEN REGULARLY BASED, OVERHAULED OR BUILT

	Number of Samples with Cobalt 60			Total Bottom Area with Cobalt 60 over 3 pCi/g** (Square Kilometers)	Estimated Total*** Cobalt 60 in Top Layer of Sediment (Curies)
	less than 3 pCi/g*	3 to 30 pCi/g	greater than 30 pCi/g		
Portsmouth, New Hampshire Naval Shipyard	176	0	0	0	ND
Groton, New London, Conn. Electric Boat Division, State Pier and Submarine Base	537	4	0	0.1	0.02
Newport News, Virginia Newport News Shipbuilding	141	0	0	0	ND
Norfolk, Virginia Naval Shipyard and Base	231	0	0	0	ND
Charleston, South Carolina Naval Shipyard and Bases	210	1	0	0	ND
Pascagoula, Mississippi Ingalls Shipbuilding Division	80	0	0	0	ND
San Diego, California Navy Piers	245	0	0	0	ND
Long Beach, California Naval Shipyard and Base	156	0	0	0	ND
Vallejo, California Mare Island Naval Shipyard	224	0	0	0	ND
Bremerton, Washington Naval Shipyard and Base	248	0	0	0	ND
Pearl Harbor, Hawaii Naval Shipyard and Sub Base	172	0	0	0	ND
Apra Harbor, Guam	124	0	0	0	ND
Port Canaveral, Florida	73	0	0	0	ND

NOTE: *Minimum detectable radioactivity is approximately 1 pCi/g (picocurie per gram). Results in units of pCi/cm^2 range from two to four times the value of pCi/g. 1pCi = 1×10^{-12}Ci

**One square kilometer is approximately equal to 0.4 square mile. Areas with cobalt 60 over 3 pCi/g were in immediate vicinity of piers used for berthing nuclear-powered ships.

***Where total cobalt 60 in the surface sediment layer is less than 0.01 curie, ND is reported. Samples more than one foot deep from several harbors show that total cobalt 60 present may be two to five times that measured in the surface layer.

Evaluation of the data summarized in Table 4 shows that low-level cobalt 60 radioactivity in harbor bottom sediment is detected around a few piers at operating bases and shipyards where nuclear-powered ship maintenance and overhauls have been conducted over a period of several years. The activity detected is from operations in the early 1960's since releases such as shown earlier in Table 1 are too small to be detectable in the harbors. Cobalt 60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U. S. harbor is less than 0.1 curie of cobalt 60. This radioactivity is small compared to background; based on the typical concentrations of naturally occurring radioactivity such as potassium 40, radium, uranium and thorium which are described in reference 21 for marine sediment, the natural radioactivity in the sediment of a typical harbor amounts to hundreds of curies. Comparison to previous environmental monitoring data in references 1 through 12 shows that these environmental cobalt 60 levels have been steadily decreasing.

The first data column in Table 4 includes all samples with less than three picocuries of cobalt 60 per gram of sediment. Most of the sediment samples did not contain detectable cobalt 60 and are tabulated in this range. In this range cobalt 60 is difficult to distinguish from the levels of naturally occurring radioactivity such as potassium, radium, uranium and thorium. Cobalt 60 in sediment in this low range may also be detectable as a result of world wide dispersion from atmospheric nuclear weapons testing.

The value of 30 picocuries per gram was selected for the top of the second range of data in Table 4. A measure of the significance of this range is that if a person's food consumption were to contain cobalt 60 in this range of activity throughout the year, he would not exceed radiation exposure levels permitted in references 13, 14, and 15 for members of the general public. Only a small fraction of the sediment samples are in this second range and none of the samples exceeded this range in 1977. Data on uptake of this cobalt 60 by marine life obtained to date show that in the salt water harbor bottom environments, no significant buildup of cobalt 60 occurs in marine life. EPA evaluation in reference 28 shows that the cobalt 60 from Naval nuclear propulsion plants is in the form of metallic corrosion product particles which do not appear to be concentrated in the food chain. Because of the nature of the radioactivity and low concentrations noted in Table 4, extensive monitoring of radioactivity in marine life has not been necessary as part of routine environmental monitoring programs in these harbors.

In addition to Navy analysis of environmental samples at least two sediment samples from each harbor monitored have been sent each year to a U. S. Department of Energy laboratory, as a check of Navy results. This Department of Energy laboratory provides a further check on the quality of environmental sample analyses by participating in the quality control programs sponsored by the Department of Energy and the Environmental Protection Agency.

The check samples were analyzed for gamma radionuclides in a manner similar to Navy procedures but with greater sensitivity. Illustration 3 depicts the gamma spectra for two such samples. Both spectra show the presence of abundant naturally occurring radionuclides which contribute to measured radioactivity even if cobalt 60 were not present. The upper spectrum is for a sample to which cobalt 60 has been added to an activity of approximately 3 picocuries per gram and shows recognizable energy peaks due to the presence of this small activity of cobalt 60. The lower spectrum depicts the appearance of most of the sediment samples in the first column in Table 4.

In addition to the extensive routine monitoring of harbor water and sediment, selected samples of marine life such as mollusks, bottom-feeding fish, barnacles and starfish have been collected in 1977 from most harbors monitored. Marine life samples are also analyzed using a sodium iodide or germanium lithium detector with a multi-channel analyzer. No cobalt 60 associated with U. S. Naval nuclear-powered ships has been detected in these samples of marine life.

For comparison, references 29 and 30 contain evaluations by laboratories of the Environmental Protection Agency and of the Department of Energy of the effects on the environment from the accumulation near points of discharge of radionuclides from several nuclear facilities. The referenced reports conclude for these other facilities that radioactivity levels much greater than shown in Table 4 have caused no significant radiation exposure to the general public.

In all monitored harbors, twice per year shoreline areas uncovered at low tide are surveyed for radiation levels with sensitive scintillation detectors to determine if any radioactivity from bottom sediment washed ashore. All results were the same as background radiation levels in these regions, approximately 0.01 millirem per hour. Thus, there is no evidence in these ports that radioactivity from sediment is washing ashore.

Ambient radiation levels are measured using sensitive thermoluminescent dosimeters continuously posted at locations outside the boundaries of areas where radioactive work is performed. These dosimeters are also posted at locations remote from support facilities to measure background radiation from natural radioactivity. Results of dosimeters posted at support facilities between radiologically controlled areas and the general public are compared with dosimeters posted at remote background locations up to several miles away. These results showed that radiation exposure to the general public from radioactive work on Naval nuclear propulsion plants was not increased above that received from natural background radiation.

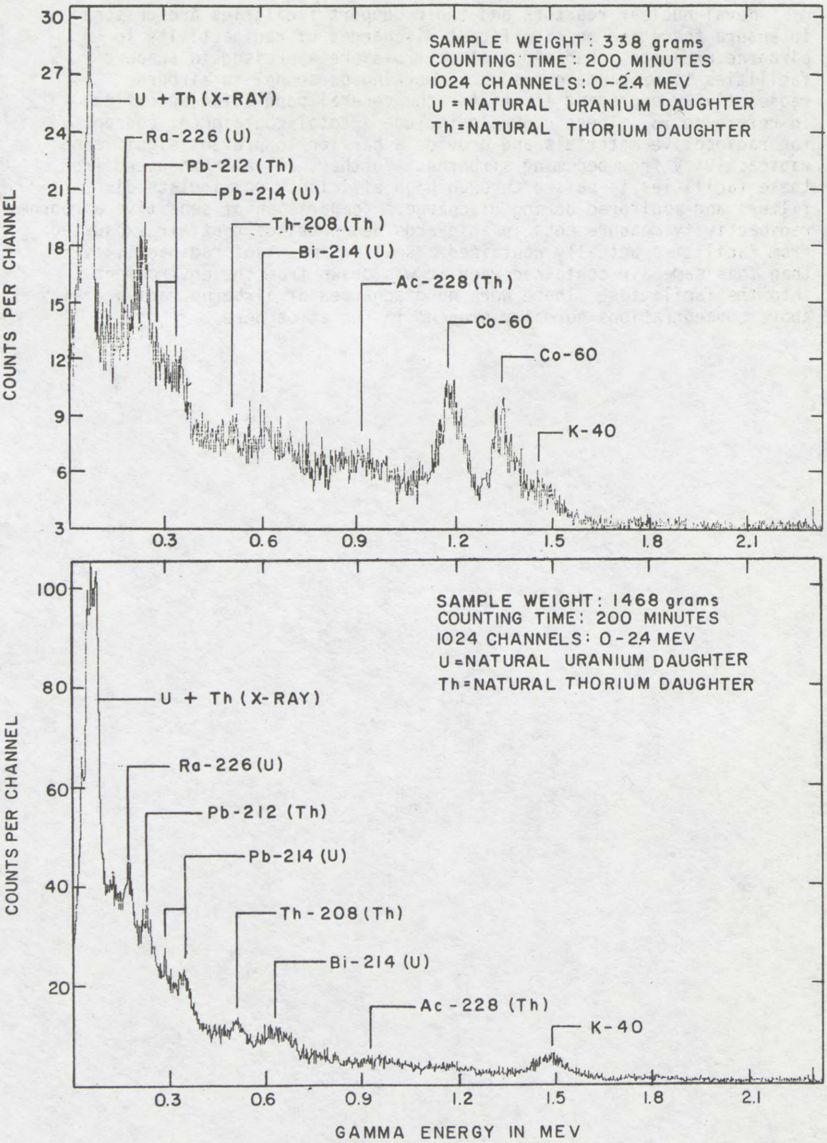

ILLUSTRATION 3 GAMMA SPECTRA OF HARBOR BOTTOM SEDIMENT SAMPLES WITH SODIUM IODIDE DETECTOR

Naval nuclear reactors and their support facilities are designed to ensure there are no significant discharges of radioactivity in airborne exhausts. Radiological controls are exercised in support facilities to preclude exposure to working personnel to airborne radioactivity exceeding limits for the general population specified in reference 13. These controls include a total containment concept for radioactive materials and provide a barrier to prevent significant radioactivity from becoming airborne. Further, all air exhausted from these facilities is passed through high efficiency particulate air filters and monitored during discharge. Comparision of sensitive airborne radioactivity measurements in shipyards demonstrates that air exhausted from facilities actually contained a smaller amount of radioactivity than this same air contained when it was drawn from the environment into the facilities. There were no discharges of airborne radioactivity above concentrations normally present in the atmosphere.

ENVIRONMENTAL PATHWAYS ANALYSIS

Results of monitoring of environmental samples described above have shown that environmental radioactivity levels have not been changed appreciably and therefore radiation exposure to the public from operations of nuclear-powered ships and their support facilities is too low to measure. Nevertheless, a detailed analysis has been performed to provide a quantitative estimate of the radiation exposure to which any member of the general public might be exposed as a result of radioactivity in liquid and airborne effluents.

This analysis has been performed in a conservative manner which ensures that the estimated exposure is higher than any actual exposure would be. For example, the sites chosen for analysis were shipyards since the amount of radiological work at these facilities is considerably higher than at other types of support facilities. Quantities of radioactivity from shipyard releases used in this analysis are higher than have been measured from any shipyard in the last five years. Values of environmental parameters including meteorological conditions and radionuclide concentration factors have been chosen to provide conservative results. In addition, the analysis assumes the individual receiving the maximum exposure is located right at the site boundary. Thus, the actual exposures to members of the public are expected to be lower than the results of this analysis.

The environmental pathways which were considered are depicted in Illustration 4, which is based on reference 15. The hypothetical releases assumed are listed in Table 5. Table 6 shows the assumed usage parameters which are based on reference 31. Concentration factors for radionuclides in the marine environment were assumed as published in reference 32 and are also in Table 6. The pathways analysis, including meteorology, population distribution, and radiological exposure rates was performed in a manner consistent with that employed by the U. S. Nuclear Regulatory Commission in reference 31.

Results of the analysis are summarized in Tables 7 and 8. Table 7 compares the estimated maximum exposure to a member of the public with guidelines of the Nuclear Regulatory Commission, although these guidelines are not applicable to nuclear-powered ships and their support facilities. Those numerical guidelines on calculated radiation exposures have been issued by the Nuclear Regulatory Commission in reference 20 for implementing the concept that radioactivity in effluents from light water nuclear electric power reactors should be limited to amounts and quantities as low as reasonably achievable. These numerical guidelines of the NRC are consistent with environmental standards for the uranium nuclear fuel cycle issued by the Environmental Protection Agency in reference 33. Table 8 presents the estimated total whole body radiation exposure to the total population within 50 miles from the assumed radioactivity releases compared with the radiation exposure received by the same population from natural background radioactivity, as reported in references 19, 24 and 34. As shown in Tables 7 and 8, conservative estimates of the exposures to members of the public from the Naval nuclear propulsion program are far less than either the EPA standards, the guidelines of the Nuclear Regulatory Commission or the exposure from natural background radioactivity.

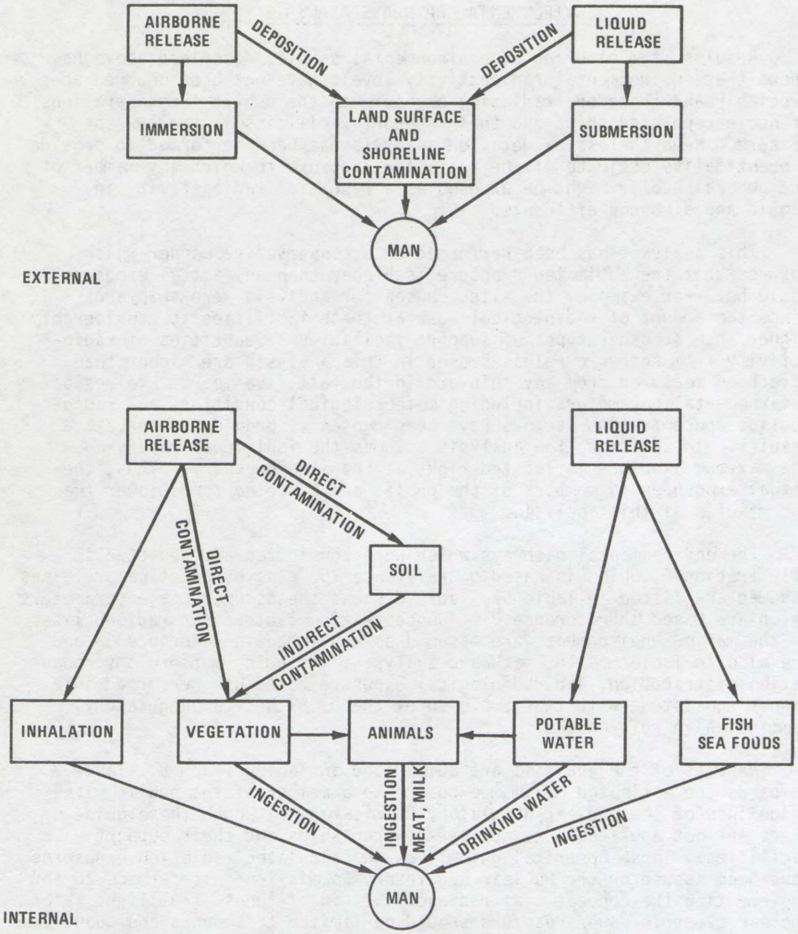

ILLUSTRATION 4

PATHWAYS FOR EXTERNAL AND INTERNAL EXPOSURE OF MAN FROM AIRBORNE AND LIQUID RELEASES OF RADIOACTIVE EFFLUENTS

TABLE 5 RADIONUCLIDE RELEASES ASSUMED FOR ENVIRONMENTAL PATHWAYS ANALYSIS

Radionuclide	Assumed Annual Release, Curie	
	Liquid Release	Airborne Release
Cobalt 60	0.001	0.001
Tritium	0.100	0.001
Carbon 14	*	0.100
Krypton 83m	*	0.020
Krypton 85m	*	0.024
Krypton 85	*	0.001
Krypton 87	*	0.050
Krypton 88	*	0.020
Xenon 131m	*	0.005
Xenon 133m	*	0.010
Xenon 133	*	0.210
Xenon 135	*	0.250
Argon 41	*	0.410

*These gaseous radionuclides are released into the air, not into water.

TABLE 6 ENVIRONMENTAL EXPOSURE TIMES, CONSUMPTION AND CONCENTRATION PARAMETERS ASSUMED FOR ENVIRONMENTAL PATHWAYS ANALYSIS

Pathway Parameter*	Assumed Parameter Value For Highest Individual	 For Average Individual
Fraction of Year Occupancy		
For Air Immersion	1	1
For Land Deposition	1	1
Along Shoreline	.05	.0005
Swimming	.01	.0001
Boating	.01	.0001
Food Consumption		
Leafy vegetables, Kg/year	72	18
Water, liters/year	730	180
Fish,** Kg/year	18	2.3
Mollusks,** Kg/year	9	.25
Crustacea,** Kg/year	9	.90
Sediment, Kg/year	1	.10

* Refer to Illustration 4

** Cobalt 60 was assumed to concentrate from sea water to the edible flesh of fish, mollusks, and crustacea by factors as follows: fish, 650; mollusks, 170; crustacea, 1700, based on reference 32.

TABLE 7 ESTIMATED MAXIMUM RADIATION EXPOSURE TO AN INDIVIDUAL FOR ASSUMED LIQUID AND AIRBORNE RADIOACTIVITY RELEASES FROM SHIPYARDS ENGAGED IN NAVAL NUCLEAR PROPULSION WORK

	Maximum Exposure To An Individual	
	NRC Guideline millirem/year	Estimated Value millirem/year
From Radionuclides In Liquid Releases	3 whole body, or 10 any organ	less than 1
From Gaseous Radionuclides In Airborne Releases	5 whole body, or 15 skin	less than 1
From Other Radionuclides In Airborne Releases	15 any organ	less than 1

TABLE 8 ESTIMATED TOTAL WHOLE BODY RADIATION EXPOSURE TO GENERAL PUBLIC WITHIN 50 MILES FOR ASSUMED LIQUID AND AIRBORNE RADIOACTIVITY RELEASES FROM SHIPYARDS ENGAGED IN NAVAL NUCLEAR PROPULSION WORK

Exposure Due to Natural Background Radiation	Exposure Due to Assumed Radioactive Releases
Approximately 100,000 man rem per year	less than 1 man rem per year

AUDITS AND REVIEWS

The requirements and procedures for control of radioactive waste are important parts of the training programs for everyone involved with radioactivity in the Navy nuclear propulsion program. Such training is part of the initial qualification of shipyard workers and of Naval personnel assigned to ships and bases, and is required to be repeated regularly. Emphasis on this training is part of the concept that radiological control personnel alone cannot cause radiological work to be well performed; production and operations personnel and all levels of management are required to be involved in the control of radioactivity.

Checks and balances of several kinds are also set up to help ensure control of radioactivity. First, written procedures exist which require verbatim compliance. Radiological control personnel monitor various steps in radioactive waste processing. In each shipyard an independent organization, separate from the radiological control organization, audits all aspects of radioactive waste processing. Audits are performed by representatives from Naval Reactors headquarters who are assigned full time at each shipyard. Radiological control personnel from headquarters also conduct periodic inspections of each shipyard. In addition, shipyards have made detailed assessments of the environmental effects of shipyard operations and have published reports on the results of these assessments. Similarly, there are multiple levels of audits and inspections for the other Navy shore facilities, tenders, and nuclear-powered ships.

The Navy has reviewed radioactive waste disposal and radiological environmental monitoring with the states where Navy nuclear-powered ships are based or overhauled. The Navy is continuing its long-standing policy of ensuring that state radiological officials are notified of occurrences that might cause concern because of radiological effects outside the ships or shore facilities. Although there were no occurrences in 1977 which did cause radiological effects to the public outside these facilities, states were notified when inquiries showed public interest in the possibility that such events had occurred. The Navy has encouraged states to conduct independent radiological environmental monitoring in harbors where Naval nuclear-powered ships are based or overhauled; available results of monitoring by states have been consistent with Navy results.

The U. S. Environmental Protection Agency (EPA) conducts detailed reviews of the Navy's procedures for controlling radioactive waste and for radiological environmental monitoring. An EPA laboratory has conducted detailed environmental surveys of selected U. S. harbors (references 28, 35, 36, 37, 38). This laboratory has performed these surveys in the harbors at Charleston, South Carolina; Pearl Harbor, Hawaii; San Diego, California; Vallejo, California; New London, Connecticut; Newport News, Virginia; Norfolk, Virginia; Bremerton, Washington; and Kittery, Maine—Portsmouth, New Hampshire. EPA results have been consistent with Navy results.

CONCLUSIONS

1. The total gamma radioactivity in liquids, less tritium, released into all ports and harbors from the U. S. Naval nuclear propulsion program was less than 0.002 curie in 1977. The total tritium released into all ports and harbors was less than one curie in 1977.

2. No increase of radioactivity above normal background levels has been detected in harbor water where U. S. Naval nuclear-powered ships are based, overhauled, or constructed.

3. Liquid wastes from U. S. Naval nuclear-powered ships and support facilities have not caused a measurable increase in the general background radioactivity of the environment.

4. Low-level cobalt 60 radioactivity in harbor bottom sediment is detectable around a few piers at operating bases and shipyards from low level liquid releases in the 1960's. Cobalt 60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U. S. harbor of less than 0.1 curie of cobalt 60 is small compared to the naturally occurring radioactivity. Comparison to previous environmental data summarized in references 1 through 12 shows that these environmental cobalt 60 levels are continuing to decrease.

5. Conservative estimates of radiation exposures to members of the public from the Naval nuclear propulsion program are far less than either the EPA environmental standards, the guidelines of the Nuclear Regulatory Commission or the exposure from natural background radioactivity.

6. Procedures used by the Navy to control discharges of radioactivity from U. S. Naval nuclear-powered ships and their support facilities have been effective in protecting the environment and the health and safety of the general public. Independent radiological environmental monitoring performed by the U. S. Environmental Protection Agency and states have confirmed the adequacy of these procedures.

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(8) U. S. Navy Report--"Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and Their Support Facilities, 1972," by M. E. Miles and G. L. Sjoblom, issued in Radiation Data and Reports, September 1973.

(9) U. S. Navy Report--"Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and Their Support Facilities, 1973," by M. E. Miles, G. L. Sjoblom and J. D. Eagles, issued in Radiation Data and Reports, October 1974.

(10) U. S. Navy Report-- "Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and Their Support Facilities, 1974," by M. E. Miles, G. L. Sjoblom and J. D. Eagles - NT-75-1, May 1975.

(11) U. S. Navy Report - "Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and Their Support Facilities, 1975," by M. E. Miles, G. L. Sjoblom and J. D. Eagles - NT-76-1, August 1976

(12) U. S. Navy Report - "Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and Their Support Facilities, 1976," by M. E. Miles, G. L. Sjoblom and J. D. Eagles - NT-77-1, June 1977

(13) Code of Federal Regulations, Title 10 (Nuclear Regulatory Commission), Part 20, "Standards for Protection Against Radiation."

(14) National Council on Radiation Protection and Measurements, Report No. 22, "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure," (Published as National Bureau of Standards Handbook 69, Issued June 1959, superseding Handbook 52).

(15) International Commission on Radiological Protection, Publication 2, "Report of Committee II on Permissible Dose for Internal Radiation (1959)," with 1962 Supplement Issued in ICRP Publication 6; Publication 9, "Recommendations on Radiation Exposure (1965)"; ICRP Publication 7 (1965), amplifying specific recommendations of Publication 9 concerning environmental monitoring; and ICRP Publication 26 (1977)

(16) Federal Radiation Council Memoranda, approved by President Eisenhower on May 13, 1960, President Kennedy on September 20, 1961, and President Johnson on July 31, 1964.

(17) National Academy of Sciencies—National Research Council, Publication 658, "Radioactive Waste Disposal from Nuclear-powered Ships," 1959.

(18) International Atomic Energy Agency, "Radioactive Waste Disposal into the Sea," Safety Series No. 5, Vienna 1961.

(19) National Council on Radiation Protection and Measurements, Report No. 39, "Basic Radiation Protection Criteria," January 1971.

(20) Code of Federal Regulations, Title 10 (Nuclear Regulatory Commission), Part 50, "Licensing of Production and Utilization Facilities, Appendix I, Radioactive Material In Light-Water Cooled Nuclear Power Reactor Effluents," published in Federal Register, May 5, 1975.

(21) National Academy of Sciences—National Research Council, "Radioactivity in the Marine Environment," 1971.

(22) U. S. Atomic Energy Commission Report—"Sources of Tritium and Its Behavior Upon Release to The Environment," by D. G. Jacobs, TID-24635, 1968.

(23) U. S. Nuclear Regulatory Commission Report—"Summary of Radioactivity Released in Effluents From Nuclear Power Plants During 1973," NUREG-75/001 National Technical Information Service, 1975.

(24) National Council on Radiation Protection and Measurements, Report No. 45, "Natural Background Radiation In the United States," November 1975.

(25) Council on Environmental Quality Report to The President "Ocean Dumping: A National Policy," October 1970.

(26) Marine Protection, Research and Sanctuaries Act of 1972, United States Public Law 92-532.

(27) U. S. Environmental Protection Agency Report—"A Summary of Low-Level Radioactive Waste Buried at Commercial Sites between 1962-1973, With Projections to the Year 2000," by M. F. O'Connell and W. F. Holcomb, issued in Radiation Data and Reports, December 1974.

(28) U. S. Environmental Protection Agency Report—"Radiological Surveys of Pearl Harbor, Hawaii, and Environs," by D. F. Cahill, H. D. Harvey, Jr., et al., issued in Radiation Data and Reports, June 1972.

(29) U. S. Energy Research and Development Administration, ERDA 1537, Final Environmental Statement, "Waste Management Operations, Savannah River Plant."

(30) U. S. Environmental Protection Agency Report—"Environmental Radiation Effects of Nuclear Facilities in New York State," by M. S. Terpilak and B. L. Jorgensen, issued in Radiation Data and Reports, July 1974.

(31) U. S. Nuclear Regulatory Commission, Regulatory Guide 1.109, "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents For the Purpose of Evaluating Compliance With 10CFR50, Appendix I."

(32) "Concentration Factors in the Aquatic Environment," S. M. Jinks and M. Eisenbud, issued in Radiation Data and Reports, May 1972.

(33) Code of Federal Regulations, Title 40 (Environmental Protection Agency), Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

(34) U. S. Environmental Protection Agency Report—"Radiological Quality of the Environment in the United States, 1977," by Kurt L. Feldman et. al., EPA Report-520/1-77-009, September 1977.

(35) U. S. Public Health Service Report—"Radiological Survey of Major California Nuclear Ports," by D. F. Cahill, D. C. McCurry and W. D. Breakfield, Clearinghouse for Federal Scientific and Technical Information No. PH178728, April 1968.

(36) U. S. Environmental Protection Agency Report—"Radiological Survey of New London Harbor, Thames River Connecticut and Environs," by S. T. Windham and C. R. Phillips, issued in Radiation Data and Reports, November 1973.

(37) U. S. Public Health Service Report—"Radiological Survey of Hampton Roads (Norfolk—Newport News), Virginia," by H. D. Harvey, Jr., E. D. Toerber and J. A. Gordon, Clearinghouse for Federal Scientific and Technical Information No. AD683208, January 1968.

(38) U. S. Environmental Protection Agency Report—"Radiological Survey of Puget Sound Naval Shipyard, Bremerton, Washington, and Environs," by R. S. Callis, S. T. Windham, and C. R. Phillips, EPA Report—520/5-77-001, February 1977.

APPENDIX
ENVIRONMENTAL MONITORING SURVEY CHARTS

Environmental monitoring survey charts for harbors monitored for radioactivity associated with U. S. Naval nuclear-powered ships in the U. S. and possessions during 1977 are listed below and included in this appendix. The sampling locations for harbor water and harbor sediment are shown. In addition, shoreline survey areas and the locations of posted dosimetry devices are shown on the figures.

Figure No.	Location
	California
1	U. S. Naval Air Station, Alameda
2	Hunters Point Naval Shipyard, San Francisco
3	Mare Island Naval Shipyard, Vallejo
4	Long Beach Harbor
5	Long Beach Harbor, Anaheim Bay Area
6	San Diego Harbor
7	San Diego Harbor, Ballast Point Area
	Connecticut
8	Electric Boat Division, Groton
9	U. S. Naval Submarine Support Facility, New London Harbor
10	State Pier, New London
	Florida
11	Port Canaveral
	Guam
12	Apra Harbor
	Hawaii
13	Pearl Harbor Area
14	Pearl Harbor Naval Shipyard
15	U. S. Naval Submarine Base, Pearl Harbor
	Mississippi
16	Ingalls Shipbuilding Division, Pascagoula
	New Hampshire/Maine
17	Portsmouth Naval Shipyard
	South Carolina
18	U. S. Naval Station and Naval Shipyard, Charleston
19	U. S. Naval Weapons Station, Charleston

Virginia

20 Newport News Shipbuilding and Dry Dock Co., Newport News

21 Norfolk Naval Shipyard, Portsmouth

22 U. S. Naval Station Norfolk, Destroyer and Submarine Piers

23 Norfolk—Portsmouth Virginia Area

Washington

24 Puget Sound Naval Shipyard

25 Bangor/Hood Canal

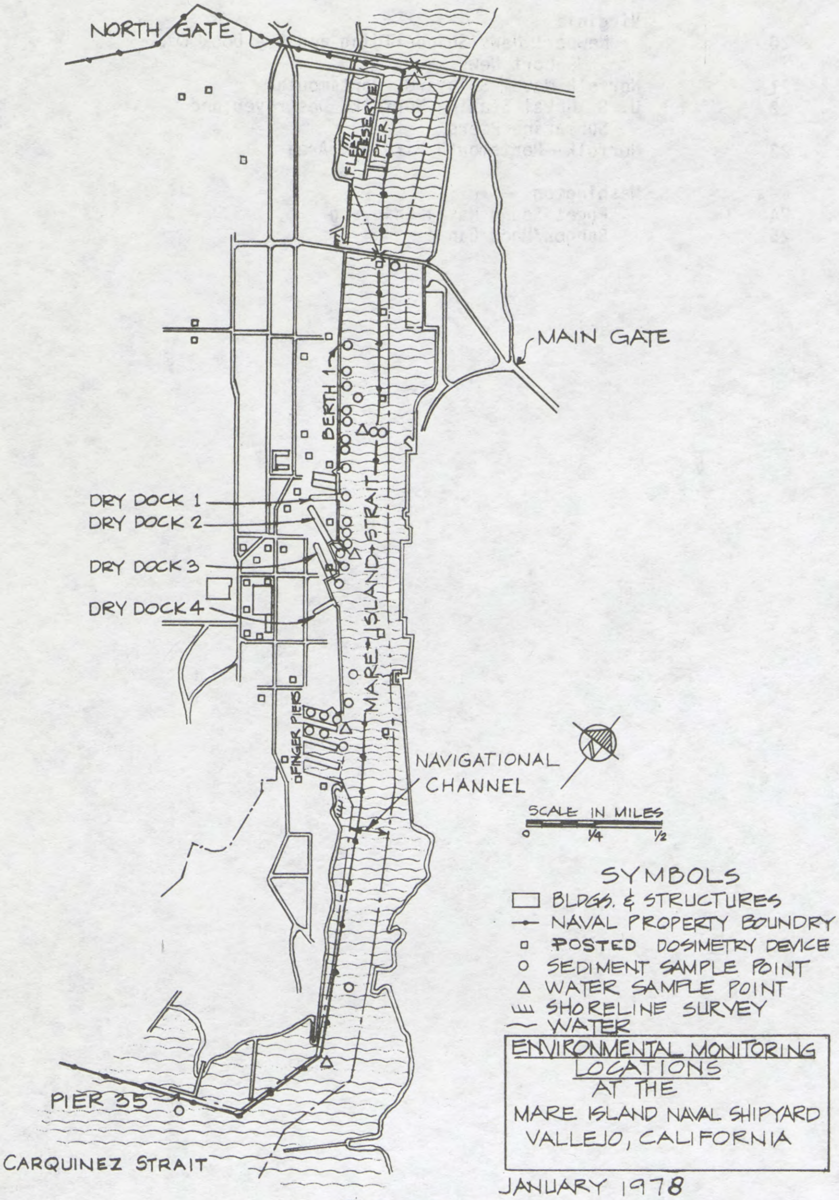

NORTH GATE
FLEET RESERVE PIER
MAIN GATE
BERTH 1
DRY DOCK 1
DRY DOCK 2
DRY DOCK 3
DRY DOCK 4
MARE ISLAND STRAIT
FINGER PIERS
NAVIGATIONAL CHANNEL
SCALE IN MILES
0
1/4
1/2
SYMBOLS
BLDGS. & STRUCTURES
NAVAL PROPERTY BOUNDRY
POSTED DOSIMETRY DEVICE
SEDIMENT SAMPLE POINT
WATER SAMPLE POINT
SHORELINE SURVEY
WATER
PIER 35
CARQUINEZ STRAIT
ENVIRONMENTAL MONITORING LOCATIONS
AT THE
MARE ISLAND NAVAL SHIPYARD
VALLEJO, CALIFORNIA
JANUARY 1978

FIGURE 1

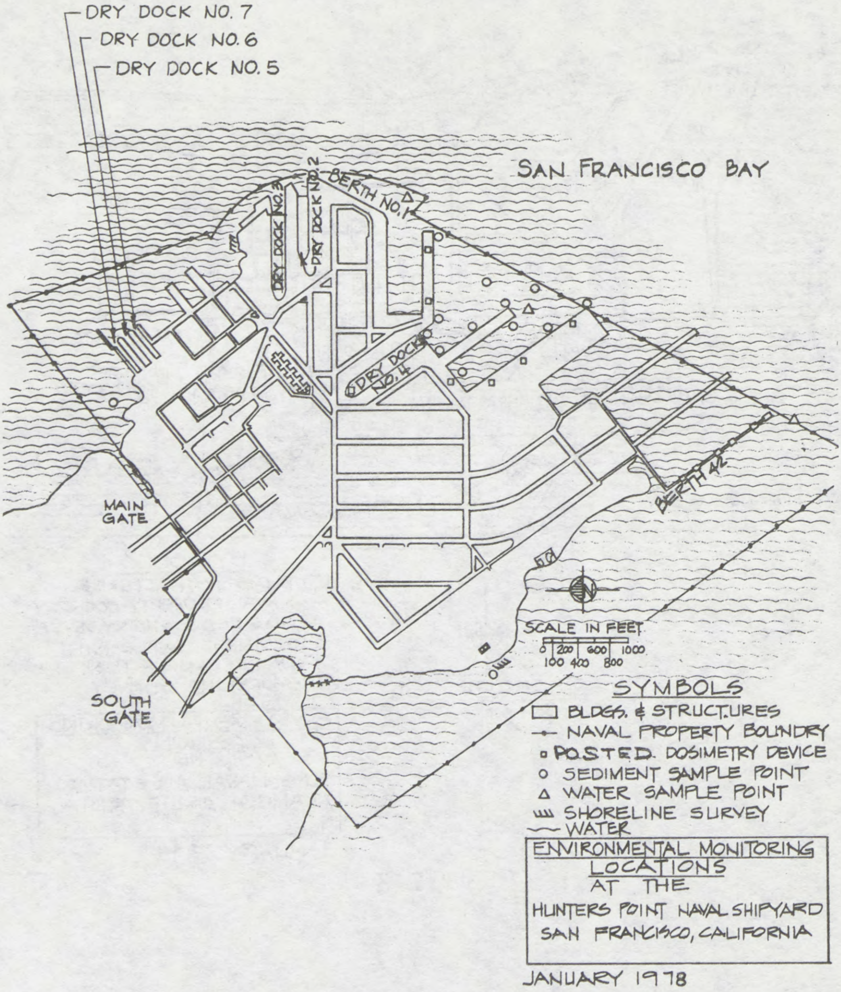

DRY DOCK NO. 7
DRY DOCK NO. 6
DRY DOCK NO. 5
SAN FRANCISCO BAY
DRY DOCK NO. 3
DRY DOCK NO. 2
BERTH NO. 1
DRY DOCK NO. 4
BERTH 42
MAIN GATE
SOUTH GATE
N
SCALE IN FEET
0 200 600 1000
100 400 800
SYMBOLS
BLDGS. & STRUCTURES
NAVAL PROPERTY BOUNDRY
POSTED DOSIMETRY DEVICE
SEDIMENT SAMPLE POINT
WATER SAMPLE POINT
SHORELINE SURVEY
WATER
ENVIRONMENTAL MONITORING LOCATIONS AT THE HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CALIFORNIA
JANUARY 1978

FIGURE 2

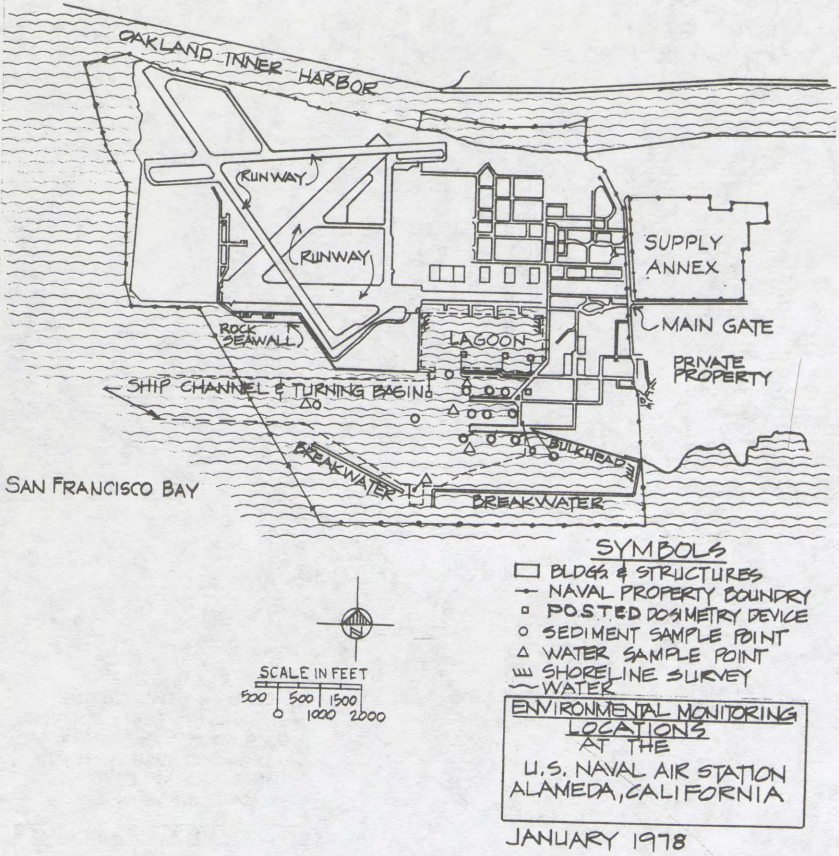

OAKLAND INNER HARBOR
RUNWAY
RUNWAY
SUPPLY ANNEX
MAIN GATE
PRIVATE PROPERTY
ROCK SEAWALL
LAGOON
SHIP CHANNEL & TURNING BASIN
BREAKWATER
BULKHEAD
BREAKWATER
SAN FRANCISCO BAY
N
SCALE IN FEET
500
0
500
1000
1500
2000
SYMBOLS
□ BLDGS. & STRUCTURES
NAVAL PROPERTY BOUNDRY
▫ POSTED DOSIMETRY DEVICE
○ SEDIMENT SAMPLE POINT
△ WATER SAMPLE POINT
SHORELINE SURVEY
WATER
ENVIRONMENTAL MONITORING LOCATIONS AT THE
U.S. NAVAL AIR STATION ALAMEDA, CALIFORNIA
JANUARY 1978

FIGURE 3

ENVIRONMENTAL MONITORING SURVEY CHART
LONG BEACH HARBOR, CALIFORNIA

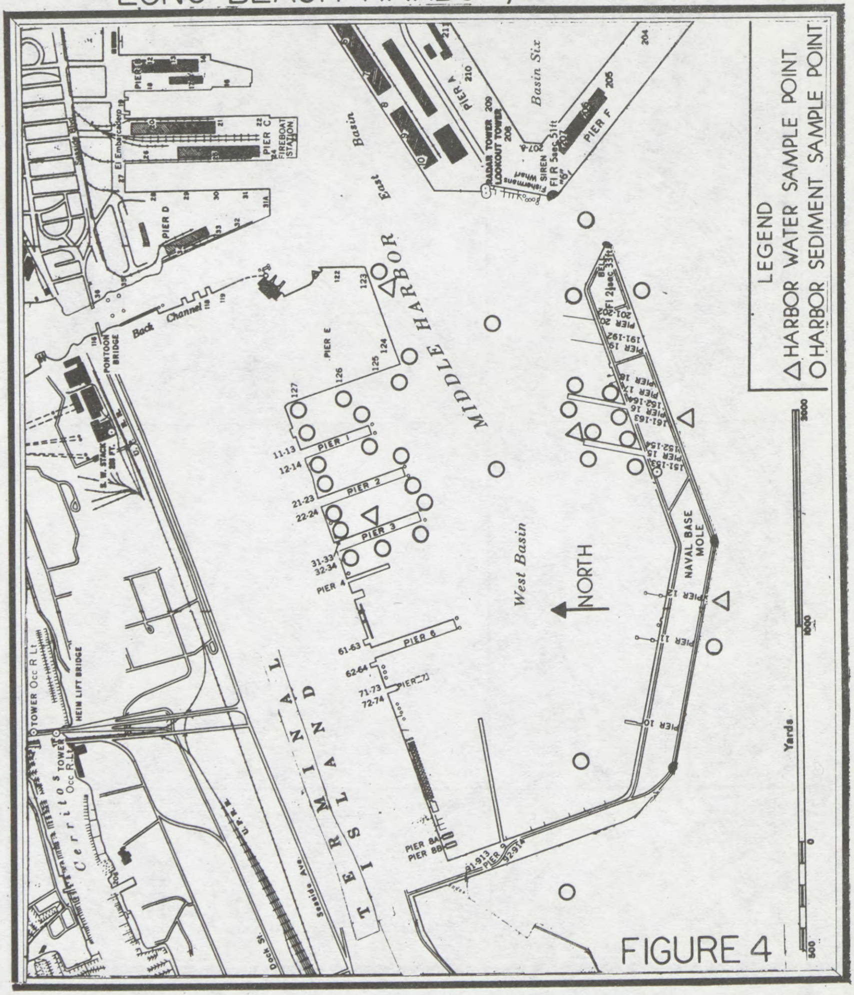


FIGURE 4

ENVIRONMENTAL MONITORING SURVEY CHART
LONG BEACH, CALIFORNIA—ANAHEIM BAY AREA

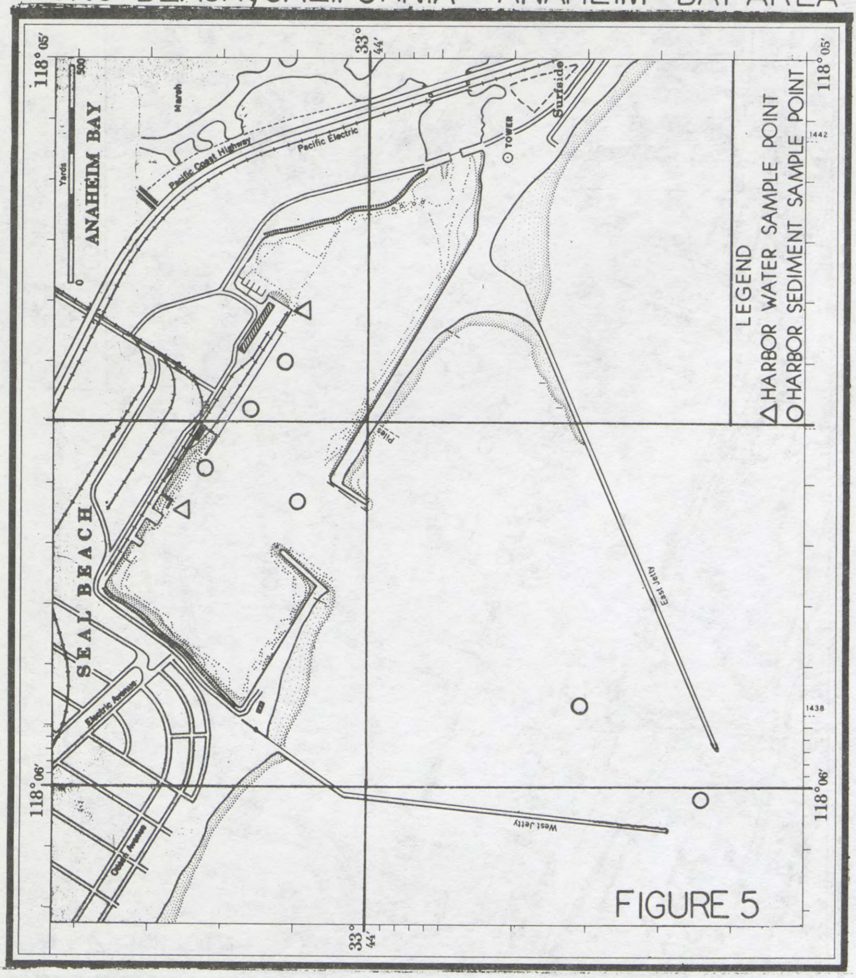


FIGURE 5

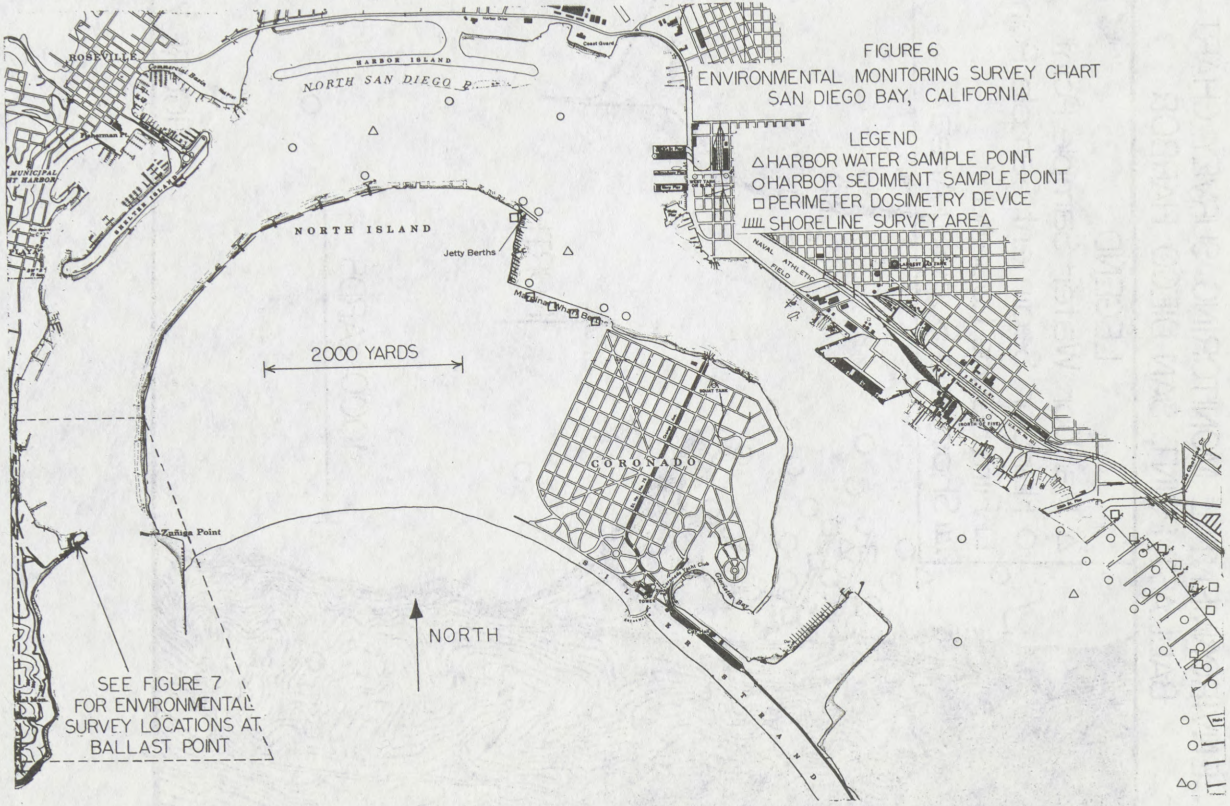


FIGURE 6

ENVIRONMENTAL MONITORING SURVEY CHART
SAN DIEGO BAY, CALIFORNIA

LEGEND
- △ HARBOR WATER SAMPLE POINT
- ○ HARBOR SEDIMENT SAMPLE POINT
- □ PERIMETER DOSIMETRY DEVICE
- ⫼ SHORELINE SURVEY AREA

ENVIRONMENTAL MONITORING SURVEY CHART
BALLAST POINT, SAN DIEGO HARBOR

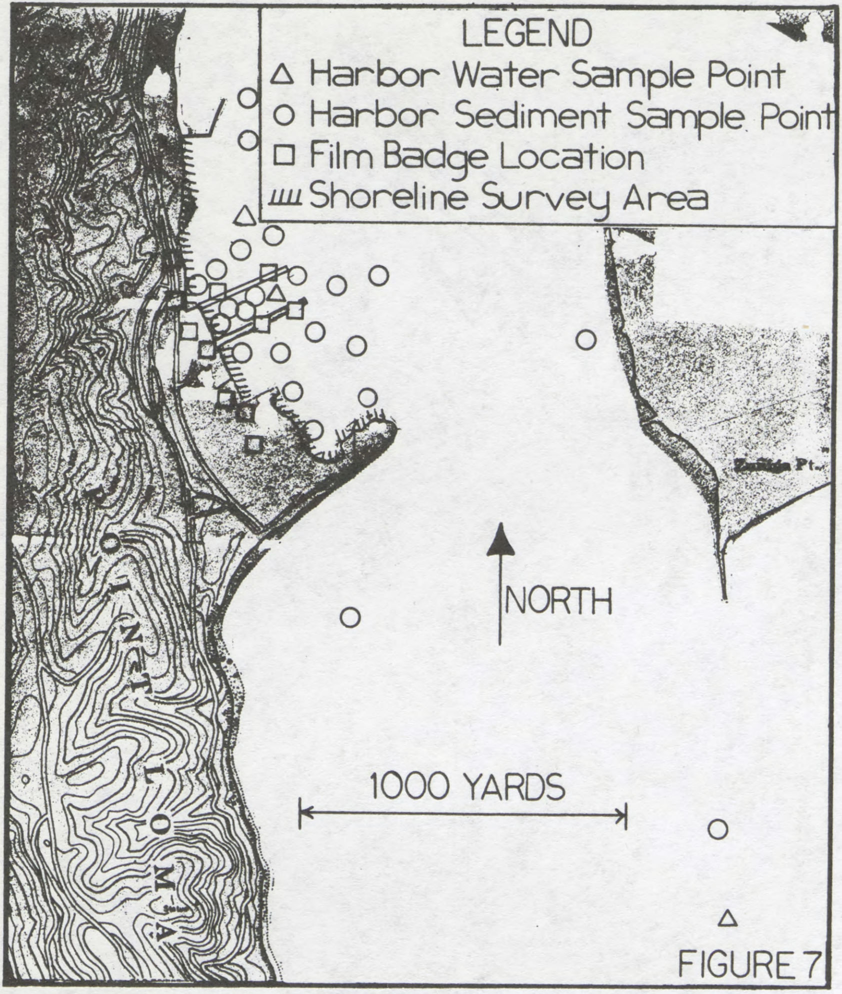
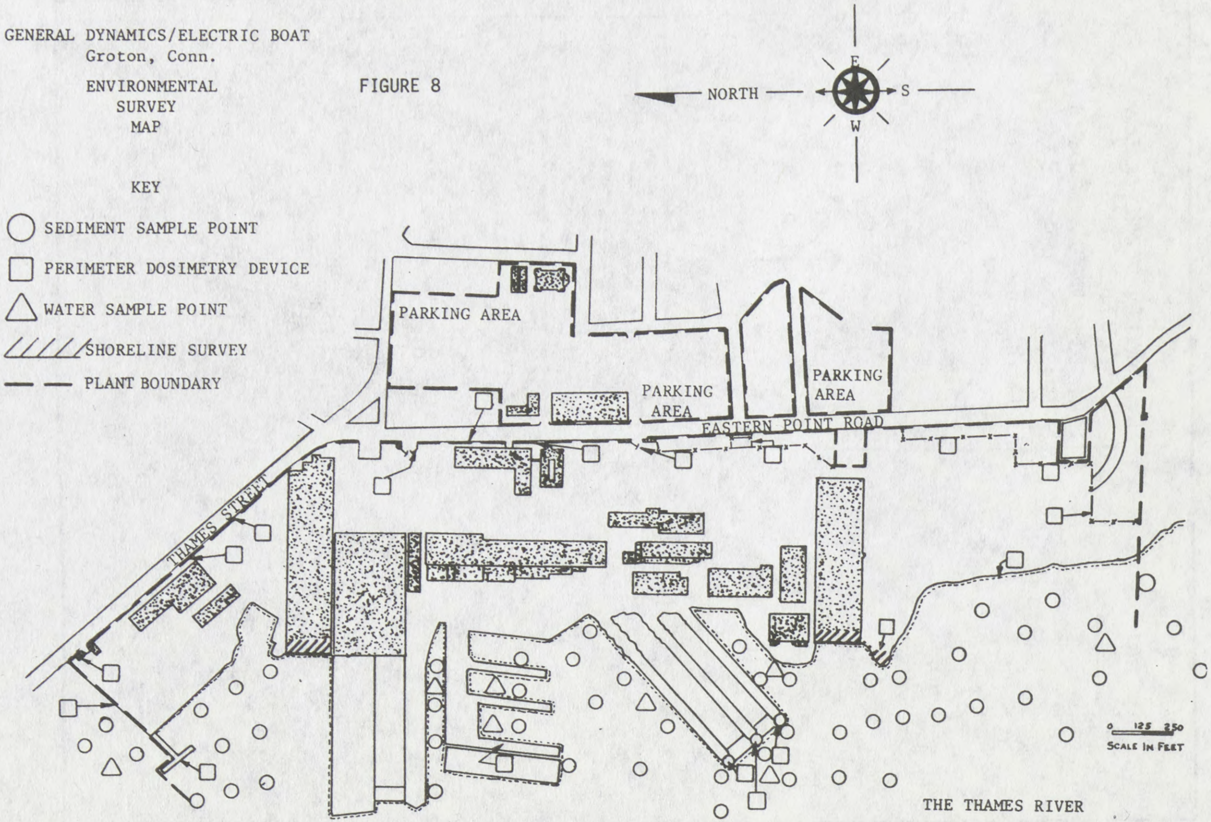


FIGURE 7

GENERAL DYNAMICS/ELECTRIC BOAT
Groton, Conn.

ENVIRONMENTAL
SURVEY
MAP

FIGURE 8



KEY

○ SEDIMENT SAMPLE POINT
□ PERIMETER DOSIMETRY DEVICE
△ WATER SAMPLE POINT
▨ SHORELINE SURVEY
— — PLANT BOUNDARY

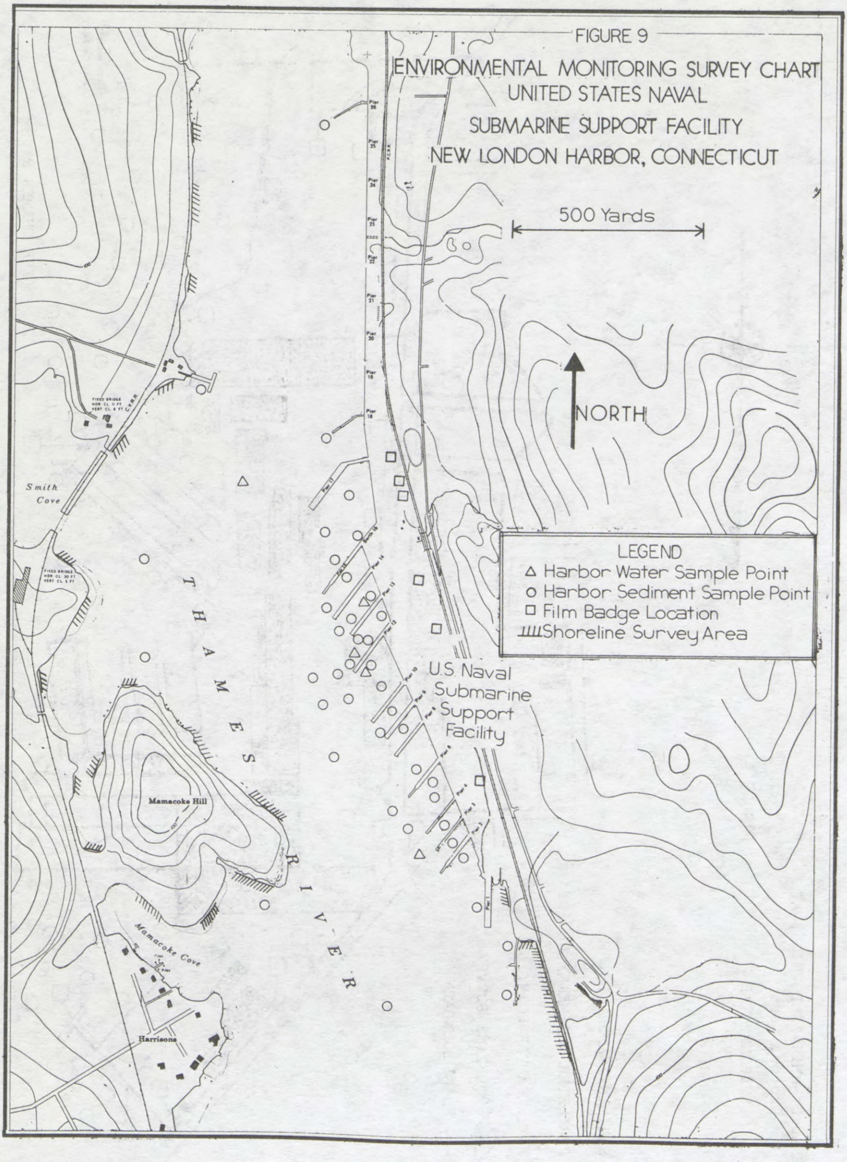


FIGURE 9

ENVIRONMENTAL MONITORING SURVEY CHART
UNITED STATES NAVAL
SUBMARINE SUPPORT FACILITY
NEW LONDON HARBOR, CONNECTICUT

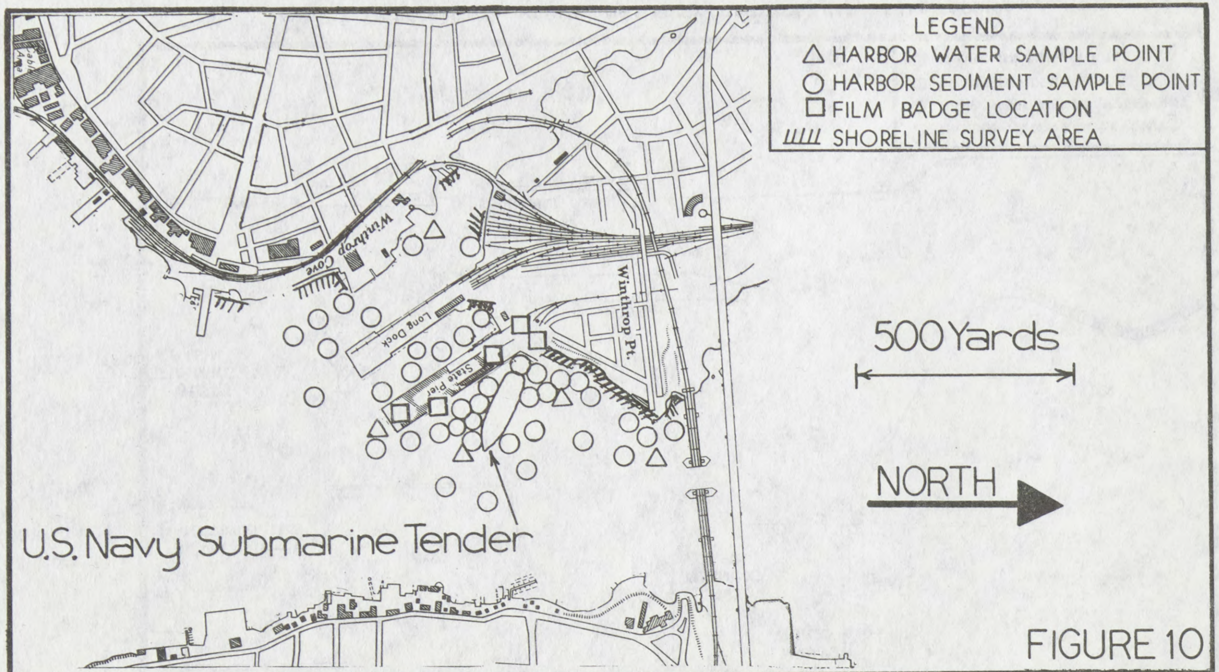


FIGURE 10

ENVIRONMENTAL MONITORING SURVEY CHART
STATE PIER, NEW LONDON, CONNECTICUT

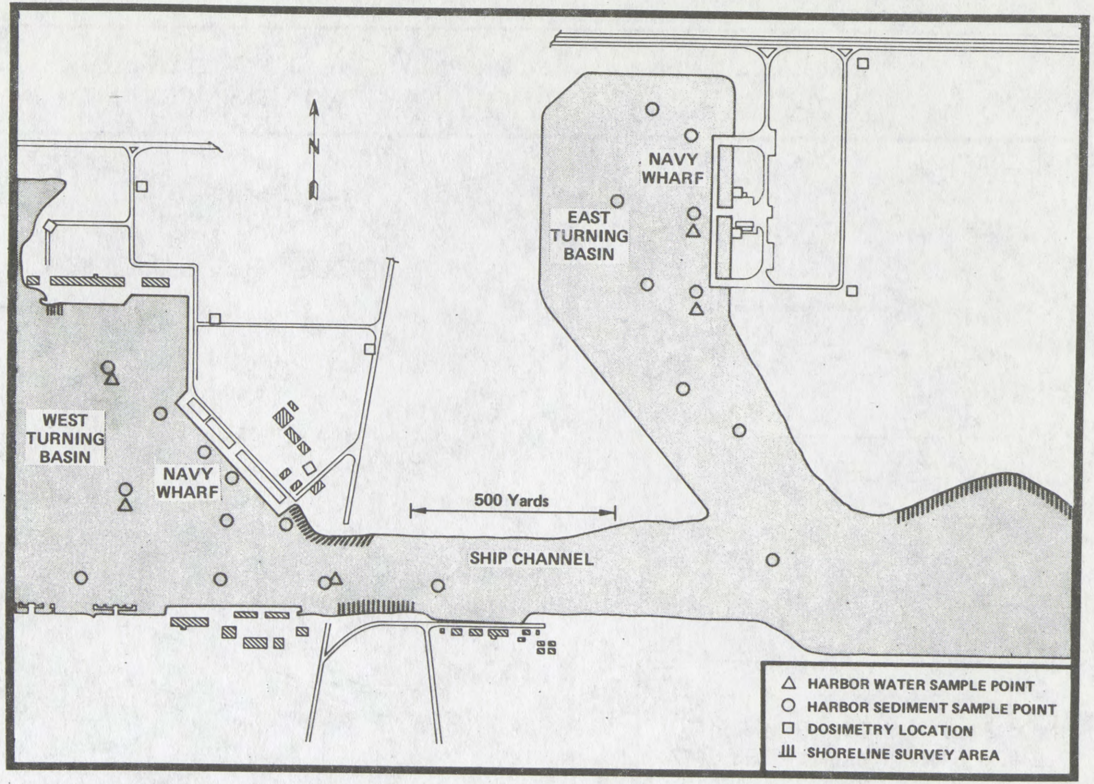


Figure 11. ENVIRONMENTAL MONITORING SURVEY CHART PORT CANAVERAL, FLORIDA

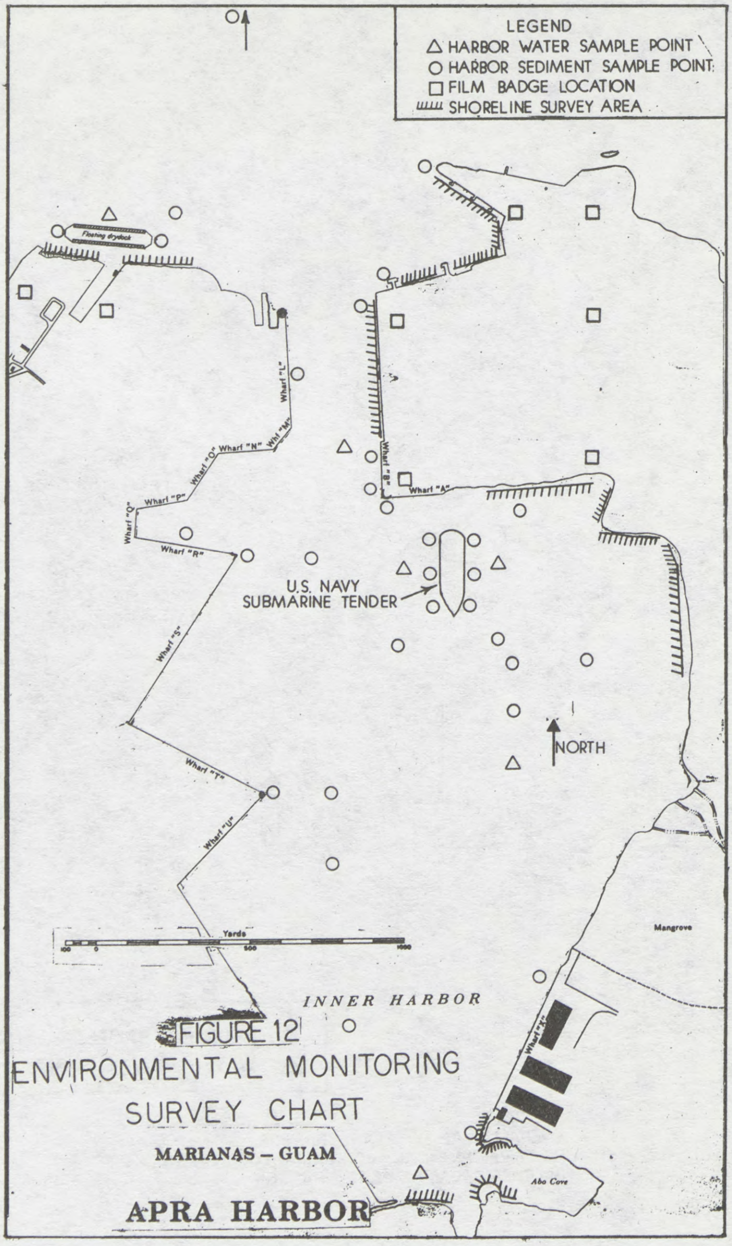


FIGURE 12

ENVIRONMENTAL MONITORING SURVEY CHART

MARIANAS – GUAM

APRA HARBOR

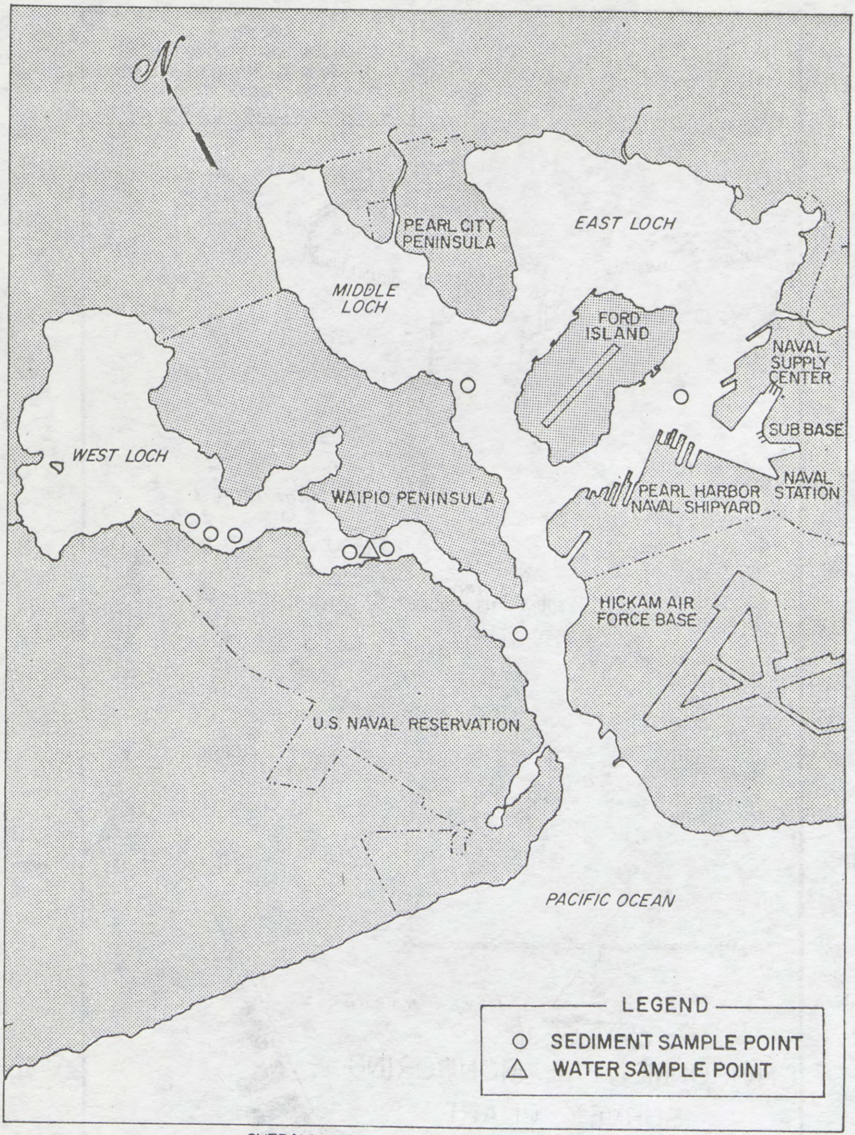


FIGURE 13

OVERALL MAP OF PEARL HARBOR
SHOWING ENVIRONMENTAL MONITORING LOCATIONS
IN OTHER AREAS OF PEARL HARBOR

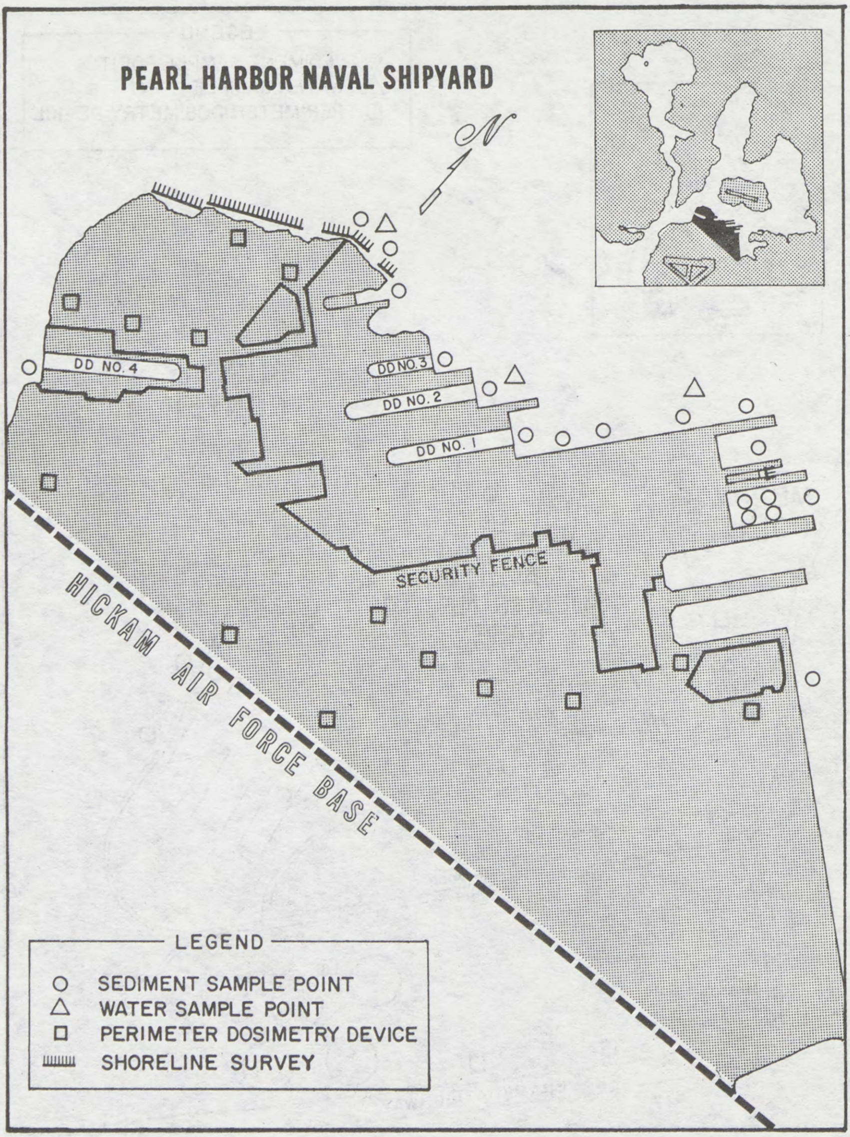


FIGURE 14

ENVIRONMENTAL MONITORING LOCATIONS
PEARL HARBOR NAVAL SHIPYARD

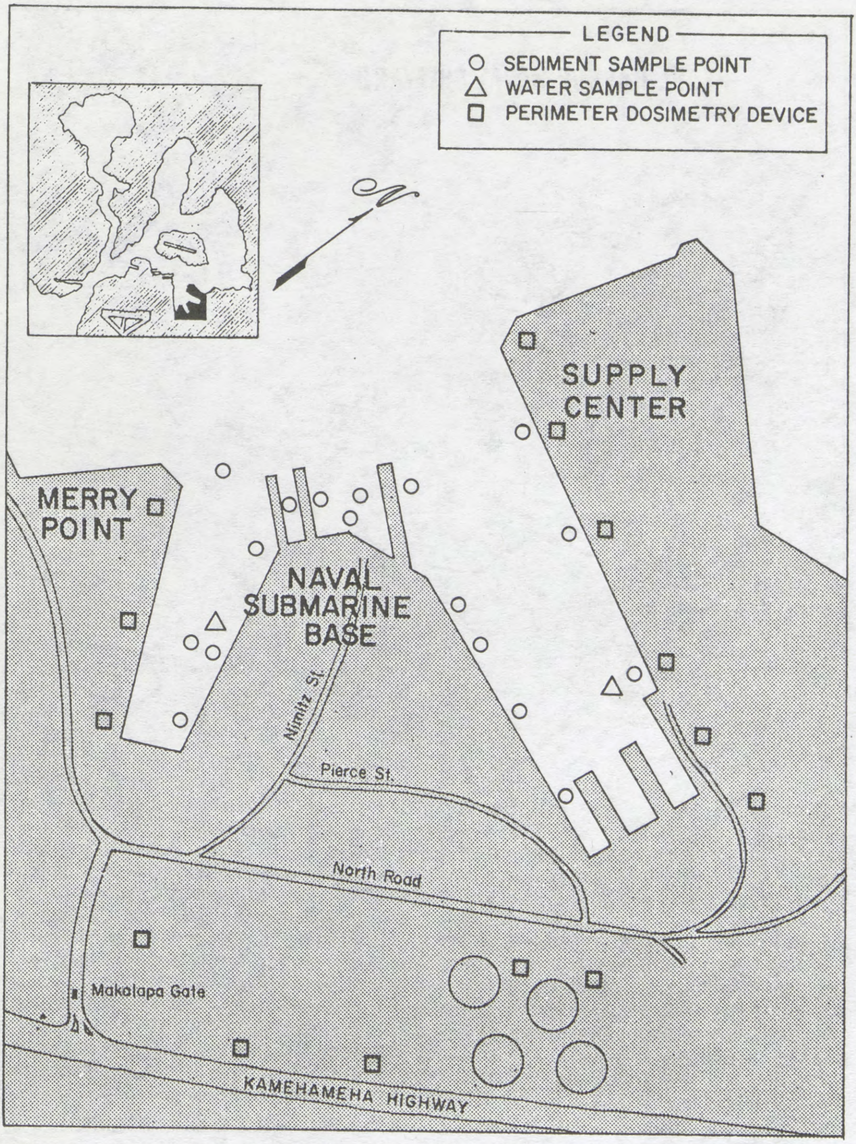


FIGURE 15 ENVIRONMENTAL MONITORING LOCATIONS
PEARL HARBOR NAVAL SUBMARINE BASE

FIGURE 16: INGALLS ENVIRONMENTAL MONITORING CHART

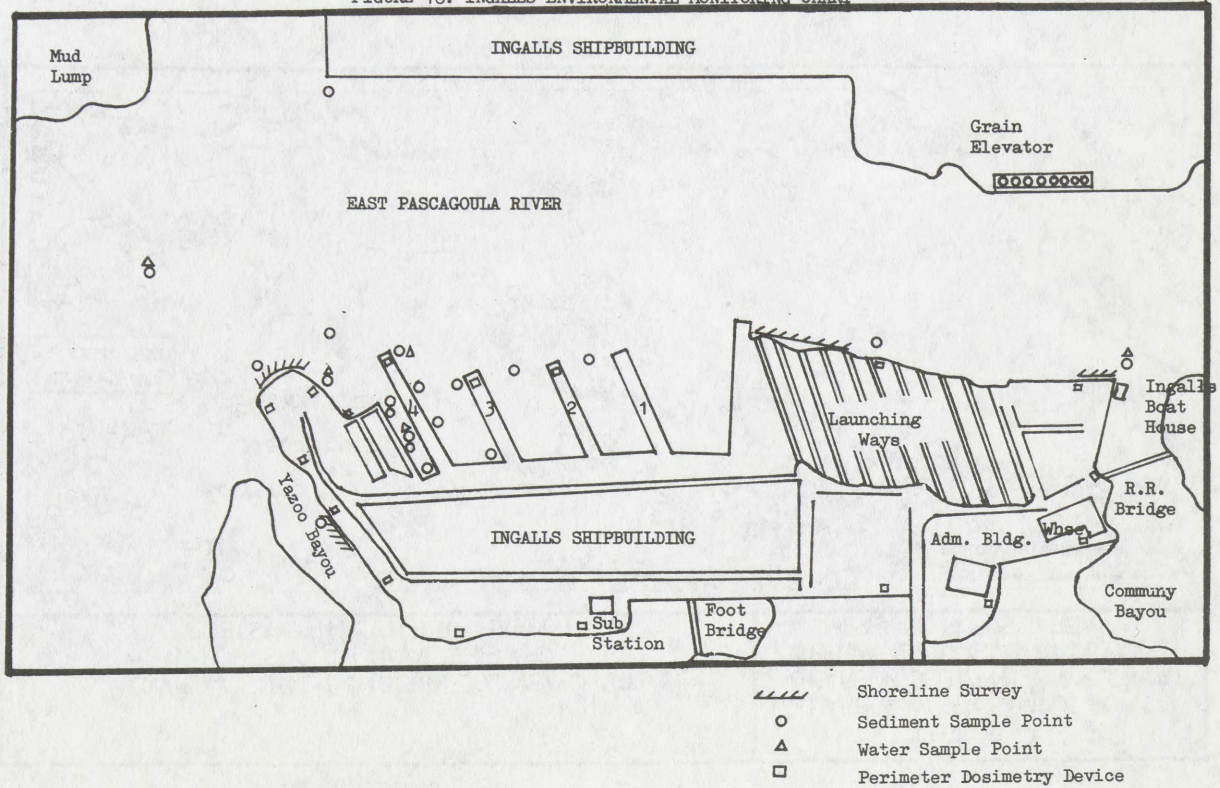
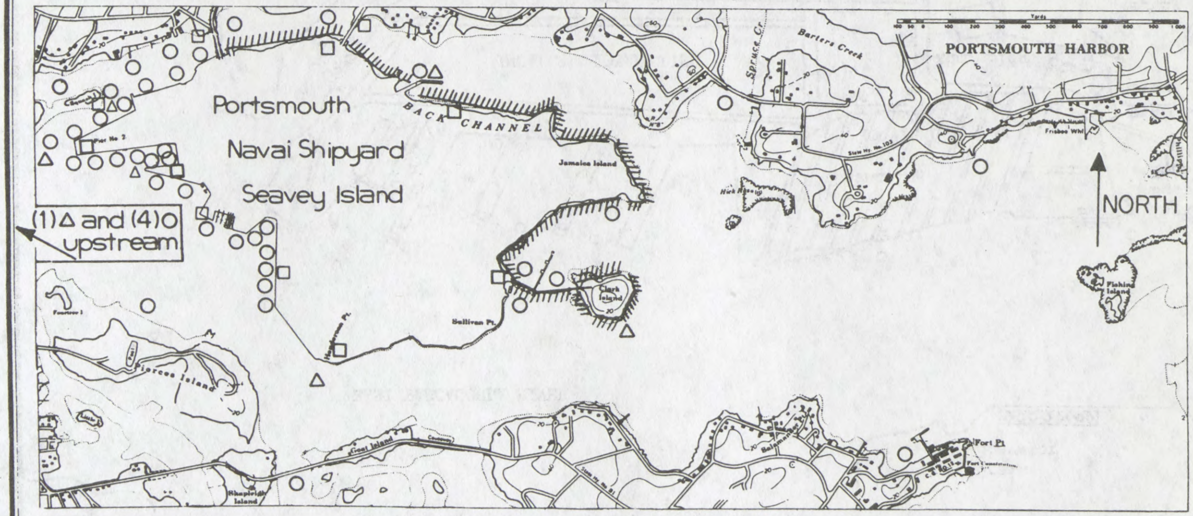


FIGURE 17

ENVIRONMENTAL MONITORING SURVEY CHART
PORTSMOUTH NAVAL SHIPYARD
PORTSMOUTH - KITTERY HARBOR

LEGEND
△ HARBOR WATER SAMPLE POINT
○ HARBOR SEDIMENT SAMPLE POINT
□ PERIMETER DOSIMETRY DEVICE
⫼ SHORELINE SURVEY AREA



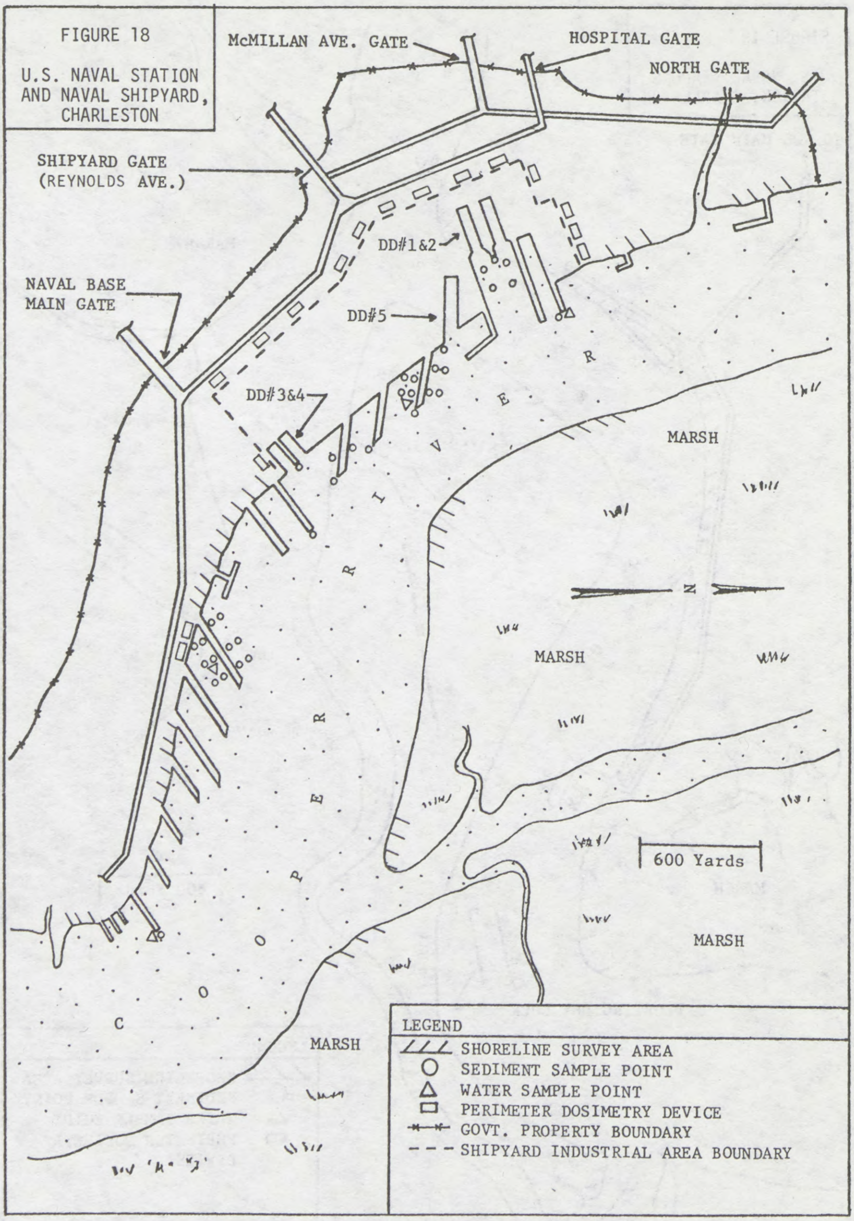


FIGURE 18

U.S. NAVAL STATION AND NAVAL SHIPYARD, CHARLESTON

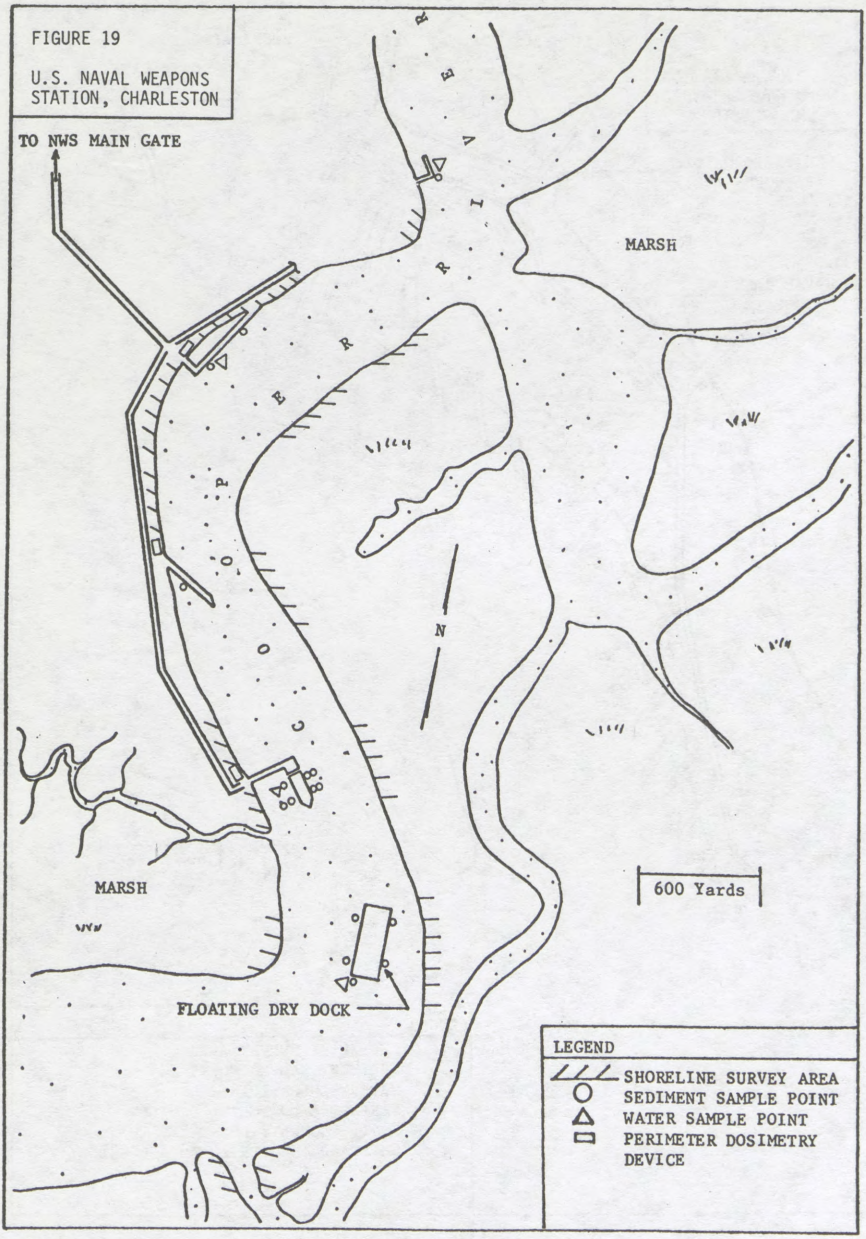


FIGURE 19

U.S. NAVAL WEAPONS STATION, CHARLESTON

NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY
ENVIRONMENTAL MONITORING SURVEY LOCATIONS

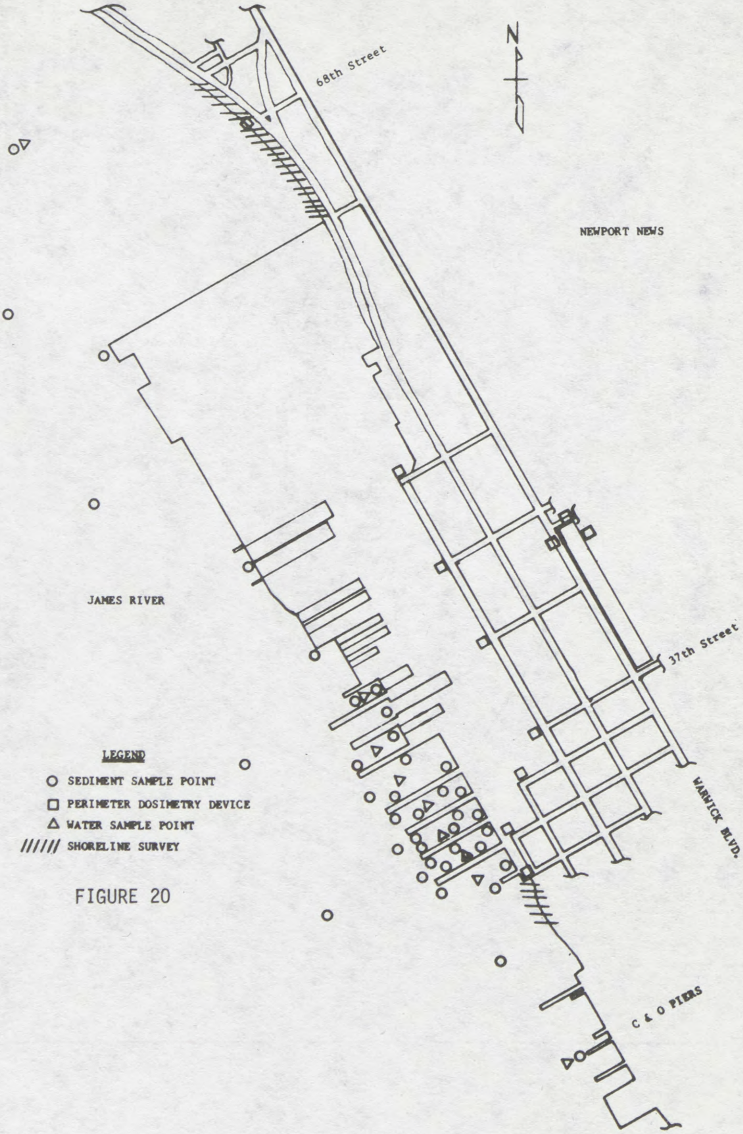


FIGURE 20

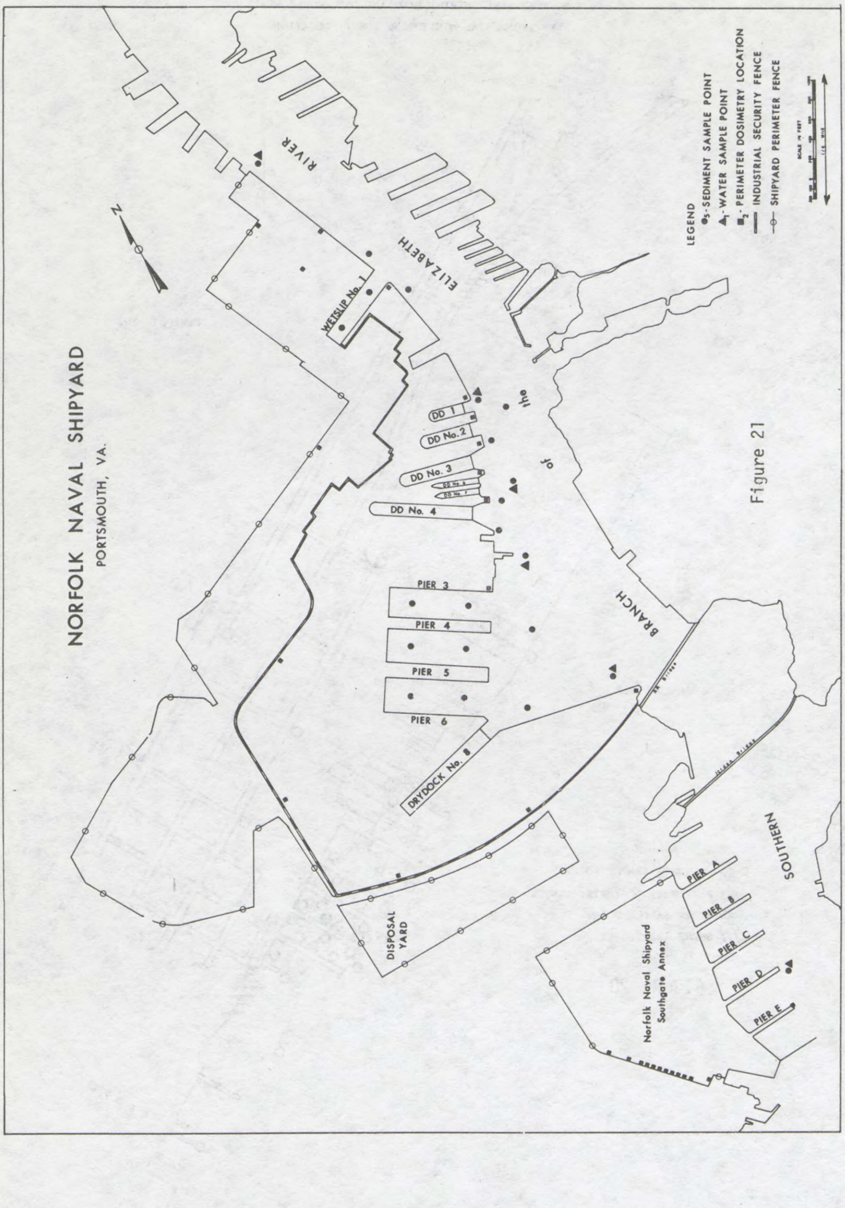

NORFOLK NAVAL SHIPYARD
PORTSMOUTH, VA.
N
ELIZABETH
RIVER
of the
SOUTHERN
BRANCH
WETSLIP No. 1
DD 1
DD No. 2
DD No. 3
DD No. 4
PIER 3
PIER 4
PIER 5
PIER 6
DRYDOCK No. 8
DISPOSAL YARD
Norfolk Naval Shipyard Southgate Annex
PIER A
PIER B
PIER C
PIER D
PIER E
LEGEND
●₅-SEDIMENT SAMPLE POINT
▲₁-WATER SAMPLE POINT
■₂-PERIMETER DOSIMETRY LOCATION
INDUSTRIAL SECURITY FENCE
SHIPYARD PERIMETER FENCE
SCALE IN FEET
1/4 MILE

Figure 21

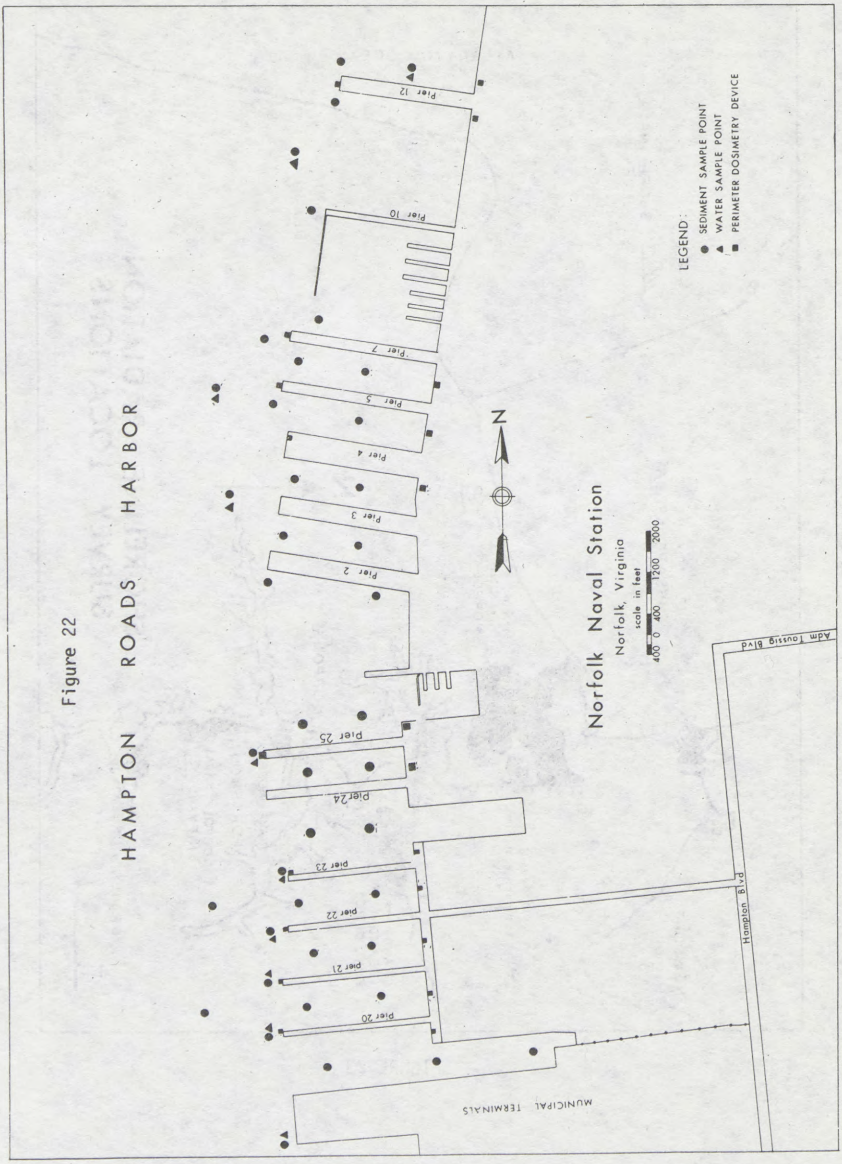


Figure 22

HAMPTON ROADS HARBOR
Norfolk Naval Station
Norfolk, Virginia
scale in feet
400 0 400 1200 2000
LEGEND:
● SEDIMENT SAMPLE POINT
▲ WATER SAMPLE POINT
■ PERIMETER DOSIMETRY DEVICE
N
Pier 12
Pier 10
Pier 7
Pier 5
Pier 4
Pier 3
Pier 2
Pier 25
Pier 24
pier 23
pier 22
pier 21
Pier 20
MUNICIPAL TERMINALS
Hampton Blvd
Adm Taussig Blvd

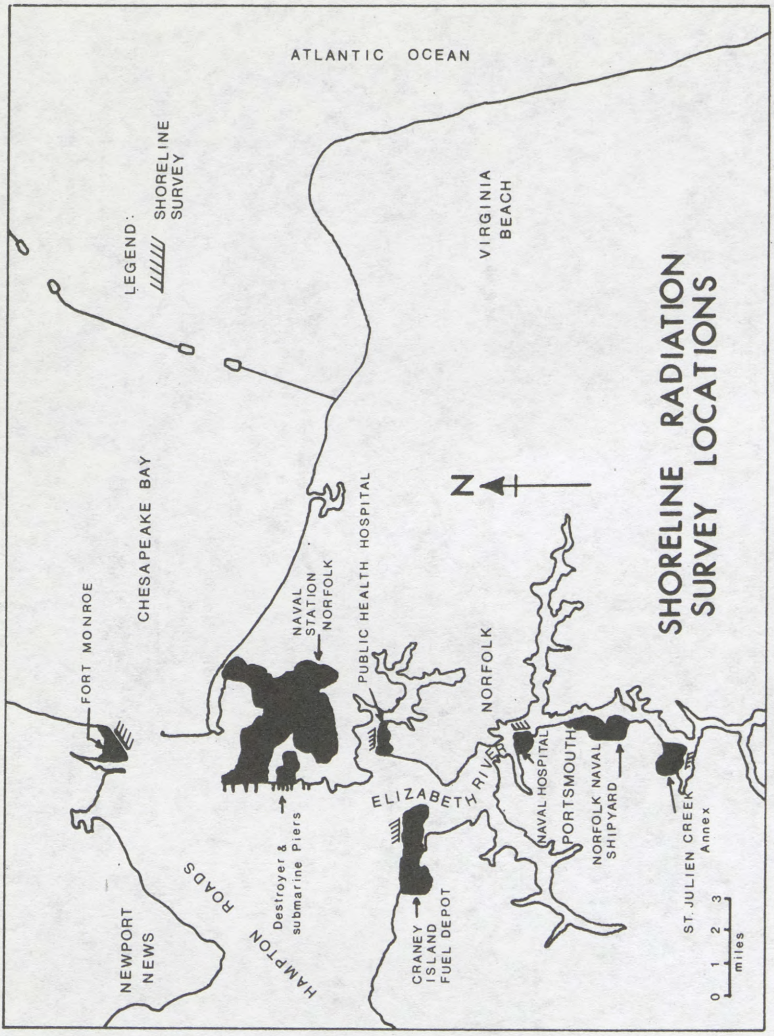
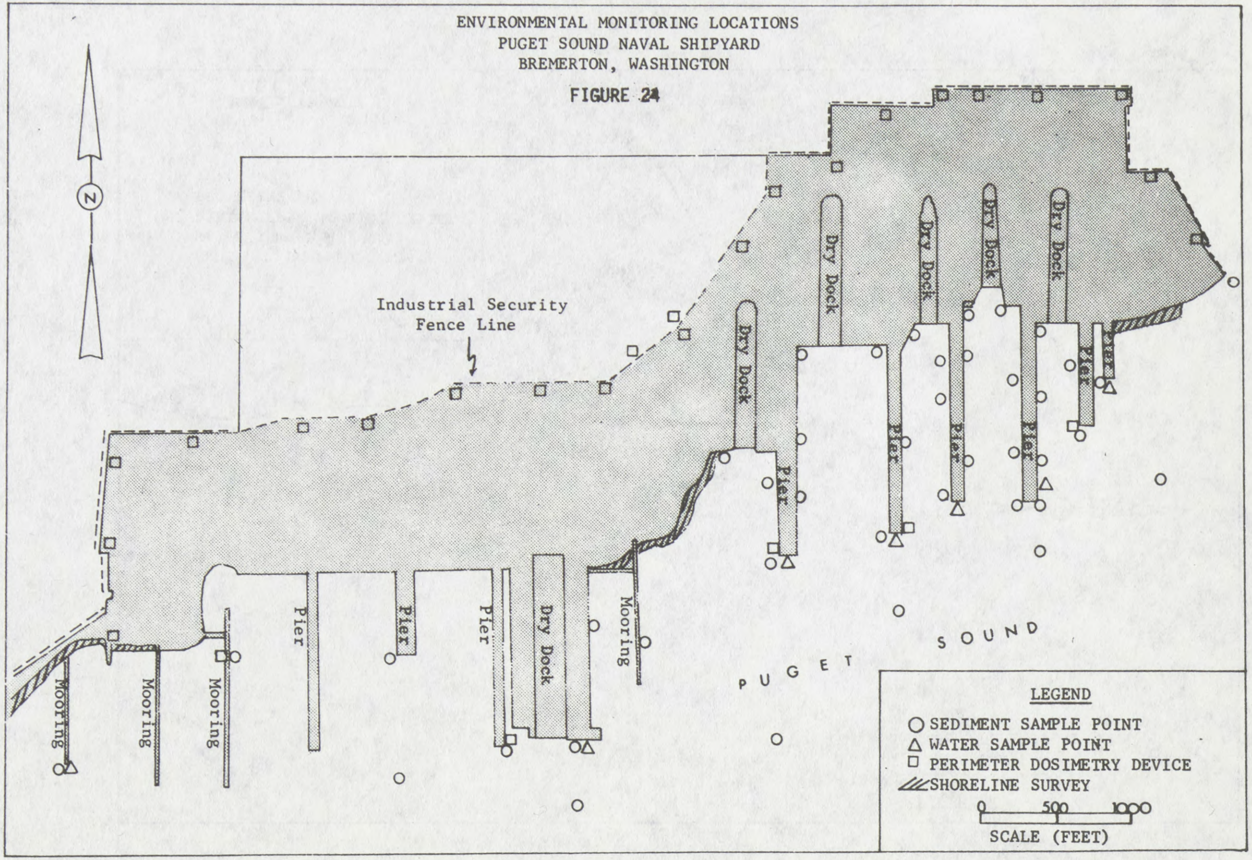

SHORELINE RADIATION SURVEY LOCATIONS
LEGEND: SHORELINE SURVEY
ATLANTIC OCEAN
CHESAPEAKE BAY
VIRGINIA BEACH
FORT MONROE
NAVAL STATION NORFOLK
PUBLIC HEALTH HOSPITAL
NORFOLK
N
Destroyer & submarine Piers
ELIZABETH RIVER
NAVAL HOSPITAL
PORTSMOUTH
NORFOLK NAVAL SHIPYARD
ST. JULIEN CREEK Annex
CRANEY ISLAND FUEL DEPOT
NEWPORT NEWS
HAMPTON ROADS
0 1 2 3 miles

FIGURE 23

ENVIRONMENTAL MONITORING LOCATIONS
PUGET SOUND NAVAL SHIPYARD
BREMERTON, WASHINGTON

FIGURE 24



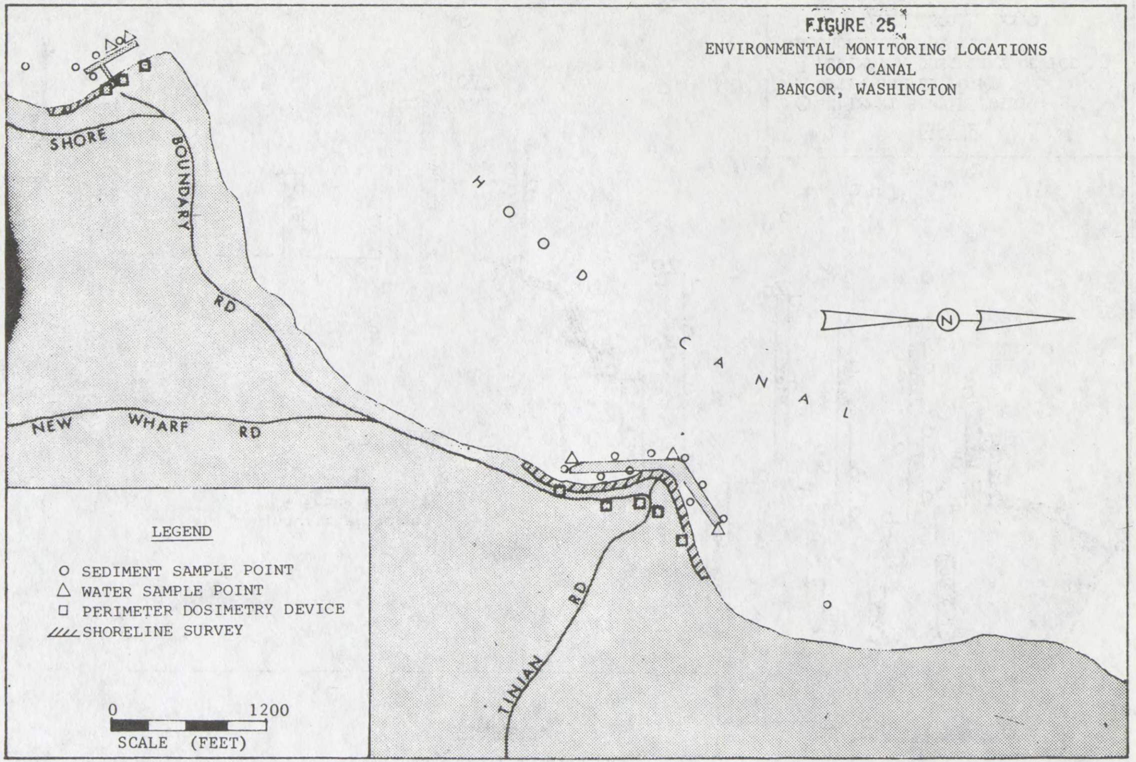


FIGURE 25
ENVIRONMENTAL MONITORING LOCATIONS
HOOD CANAL
BANGOR, WASHINGTON