SHIPPINGPORT ATOMIC POWER STATION

DECOMMISSIONING PROGRAM AND APPLIED TECHNOLOGY

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ABSTRACT

The Shippingport Station Decommissioning Project (SSDP) will be the first decommissioning project of a large-scale, commercial nuclear power plant. The Shippingport Station, which is owned by the U. S. Department of Energy, is also the first nuclear power plant to be decommissioned which has had a long period of power operation, having operated and produced electricity for 25 years. Nuclear facilities which have been decommissioned to date have operated for much shorter time periods and have been small in comparison to commercial power reactors. The experience which has been gained from the maintenance and modification of nuclear power plant radioactive systems and components as well as the experience gained from decommissioning smaller nuclear facilities have helped to establish the technology and cost basis for Shippingport.

This paper describes the current status of the preparations being made by the General Electric Company, its integrated sub-contractor, Morrison-Knudsen, and the U. S. Department of Energy for starting the decommissioning phase of the project. One of the significant technical features of the project will be the one-piece removal of the irradiated reactor pressure vessel and neutron shield tank (RPV/NST). It is estimated that this approach will save about $7 million, reduce personnel radiation exposure by more than 100 man-rem, and reduce the total decommissioning schedule by about one year compared to segmentation of the irradiated vessel and internals. A favorable size comparison of the Shippingport RPV/NST to 1100 MWe PWR pressure vessel is also shown.

The technology that will be used at Shippingport has evolved from many years of experience gained during reactor plant maintenance and modification work. An overview of the technology which will be used during the Shippingport Station Decommissioning Project is presented. Currently applied decommissioning technology discussed in this paper include remote metal cutting, decontamination, concrete removal, liquid and solid waste volume reduction, and robotics.

As the first commercial nuclear power plant to be decommissioned, the Shippingport Project is expected to set the standard for safe, cost-effective reactor decommissioning technology. By confirming techniques for removing, handling, and transporting radioactive components and materials, the technology and work procedures employed at Shippingport will provide guidelines to the nuclear industry for the future decommissioning of other nuclear plants.

INTRODUCTION

The Shippingport Station Decommissioning Project (SSDP) will be the first decommissioning project of a large-scale, commercial nuclear power plant. Shippingport is also the first nuclear power plant to be decommissioned which has had a long period of power operation, having operated and produced electricity for twenty-five years. Nuclear facilities which have been decommissioned to date have operated for much shorter time periods and have been small in comparison to commercial power reactors. These facilities can be categorized as research, test, or prototype reactor facilities. However, the experience gained from decommissioning these facilities as well as nuclear plant maintenance and modifications have helped to establish the technology and cost basis for Shippingport and future decommissioning projects.

This paper describes the current status of the preparations being made by the General Electric Company and its integrated sub-contractor, Morrison-Knudsen, for starting the decommissioning phase of the Shippingport Atomic Power Station (SAPS). Also discussed is an overview of the technology that will be applied on the project.

In order to provide a foundation to better understand the scope of this decommissioning project, a brief description of the Shippingport Atomic Power Station (SAPS) follows. A detailed description of the SAPS was provided in Ref 1.

SHIPPINGPORT ATOMIC POWER STATION DESCRIPTION

The Shippingport Station is located twenty-five miles northwest of Pittsburgh, PA. It is on the south bank of the Ohio River and occupies seven acres of land owned by the Duquesne Light Company (DLC) and leased to the U. S. Department of Energy in 1954. Construction was started in 1955. The plant began critical operation in December, 1957. It was permanently shut down in October, 1982, after producing over 7.4 billion kilowatt hours of electricity.

The reactor plant is a four-loop, 72 MWe Pressurized Water Reactor. Figure 1 shows the "pear-shaped" reactor containment chamber and the two boiler chambers which each house two of the reactor coolant loops. A concrete shield wall separates each of the loops to reduce radiation levels when one of the loops requires maintenance. Figure 2 shows the two boiler chambers and the auxiliary equipment chamber. The reactor containment chamber is connected to the other three containment vessels via large welded steel ducts. The four steel containment vessels are

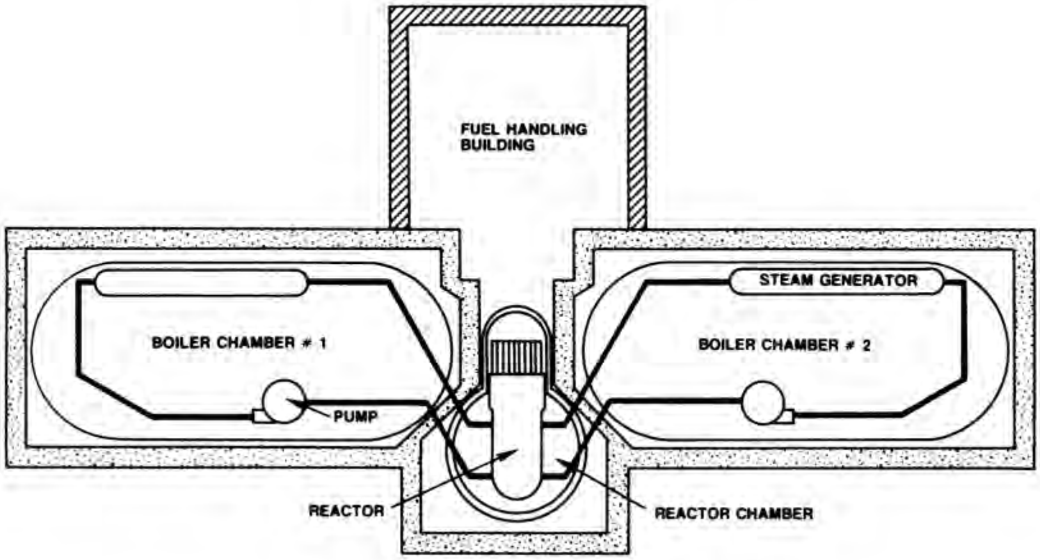

Fig. 1. Systems, Components, and Structures Prior to Removal.

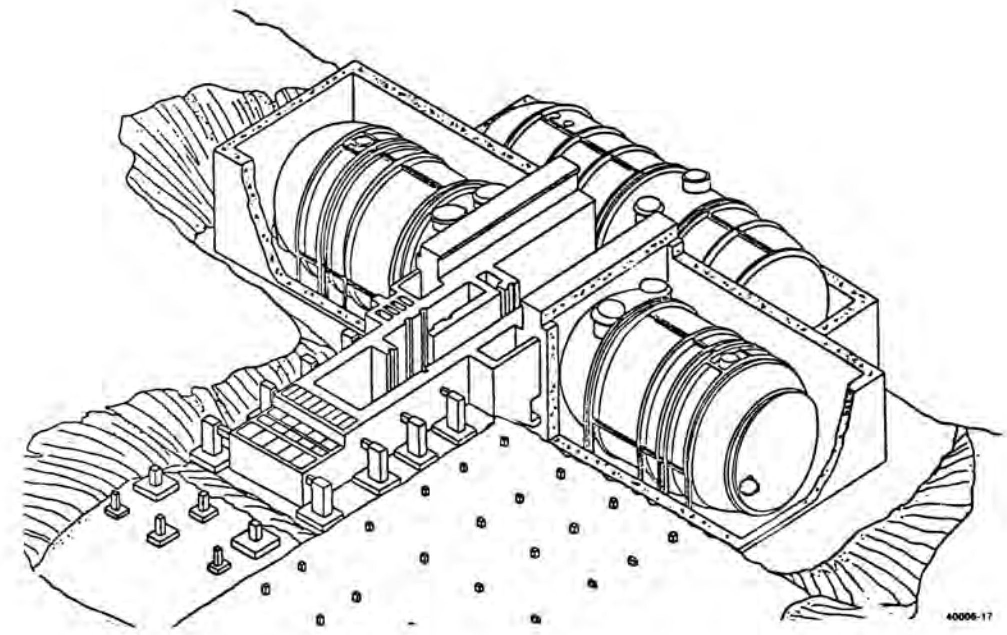

Fig. 2. Shippingport Atomic Power Station Underground Structures.

housed in underground concrete vaults with the refueling canal connected to the reactor containment chamber's concrete vault. The Fuel Handling Building covers the reactor containment chamber and the refueling canal. A Radioactive Waste Processing (RWP) facility, a Heat Dissipation System, and numerous tanks for storage of liquids were used to service the reactor plant.

GENERAL ELECTRIC SCOPE OF WORK

The Shippingport Station Decommissioning Project is in its final phase; physical decommissioning.

Decommissioning Operations objectives are:

- o To maintain Shippingport in a radiologically safe condition.
- o To demonstrate safe, cost-effective dismantlement of a large scale nuclear power plant.
- o To provide useful data for future decommissioning projects.

Defueling of the Shippingport Atomic Power Station was completed during the summer of 1984. The last spent fuel shipment left the station the morning of September 6, 1984. At 1755 hours on September 6, 1984 responsibility for the SAPS was transferred from the Department of Energy - Naval Reactors to Department of Energy - Richland Operations Office. At that time operational responsibility for station surveillance, maintenance, and operations was transferred on schedule from the Duquesne Light Company to the General Electric Company, the Decommissioning Operations Contractor (DOC).

For General Electric, Shippingport is a construction management project. In involves:

- o Site management and administration
- o Maintaining decommissioning readiness and the site in a safe condition
- o Awarding sub-contracts
- o Training and indoctrination of personnel
- o Managing the decommissioning operations, including
  - Removal of radioactive systems and components
  - Processing of radioactive water
  - Removal of Government owned site structures and property disposal
  - Transportation of radioactive materials to Government depositories

Figure 3 is a plan view of the Shippingport Site which shows the buildings, tanks, pads, and other structures that will be removed.

PROJECT ORGANIZATION

General Electric has developed a project organization which fully responds to the DOE requirements for the Decommissioning Operations Contractor (DOC). It takes into account the changing requirements of the project by providing a flexible organization which can be expanded and contracted readily to meet changing program needs. The DOC organization for the Decommissioning Phase is shown in Fig. 4. This basic organizational structure will remain essentially the same throughout the decommissioning operations, with staffing levels and technical skills adjusted in response to the schedule and cost dictates of the project.

The Surveillance, Maintenance, and Station Operations (SMO) period commenced with the turnover of the Shippingport Station to General Electric on September 6, 1984 and ended with successful completion on December 31, 1984.

DECOMMISSIONING OPERATIONS

Decommissioning Operations began on January 1, 1985 and will continue to project completion. Since January, 1985 additional manpower has been mobilized and detailed planning and bid package preparations for major sub-contracts were initiated. The mobilization of all management manpower is completed and the DOC organization is now a self-contained construction management group with a small plant operations component.

Key activities during Calendar Year 1985 are:

- o Bid package preparation, sub-contract award, and administration
- o Completion of site modifications required before the start of physical decommissioning. These include:
  - Construction of a Craft Entry Structure
  - Security fence and lighting modification
  - Establishment of areas for parking, trailers, storage pads, and material warehousing
  - Installation of temporary power distribution centers
  - Installation of air, water, steam, and temporary sanitary services and facilities
- o Initiate work on long lead activities (e.g., transportation permits, RPV lifting beam design)
- o Develop detailed work plans and procedures
- o Establish radiation worker training programs

General Electric will optimize the sub-contracting of decommissioning work. The engineering and procurement activities required to support the start of physical decommissioning work are identified in 17 activity specifications prepared by Burns and Roe for DOE during the Phase I Engineering Contract. Most of the activity specifications are in a format that can be converted to a bidding document by the addition of Terms and Conditions and a Request for Bid Form. Selected specifications are planned for direct execution by the DOC and are not in a biddable format.

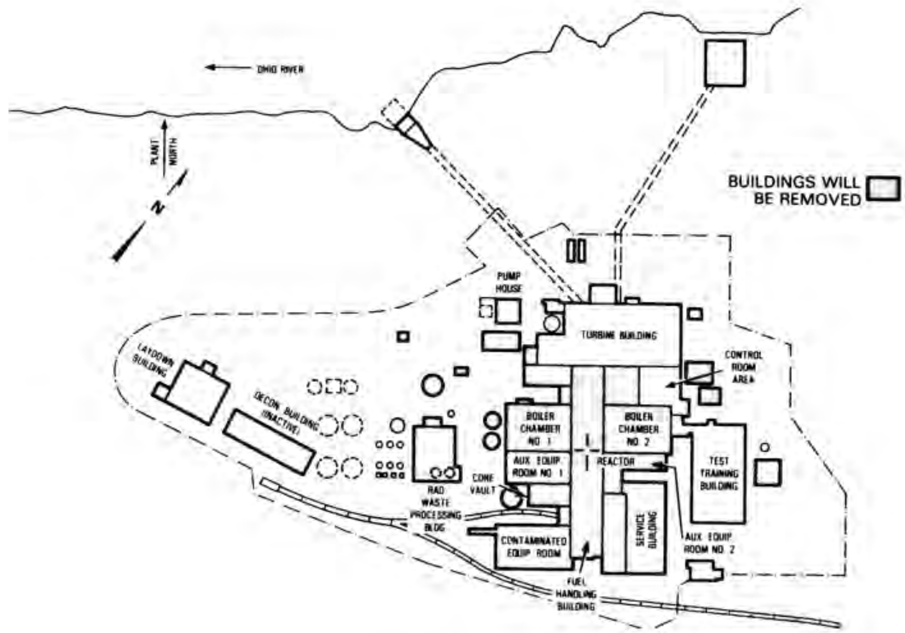

Fig. 3. Shippingport Station Site Plan.

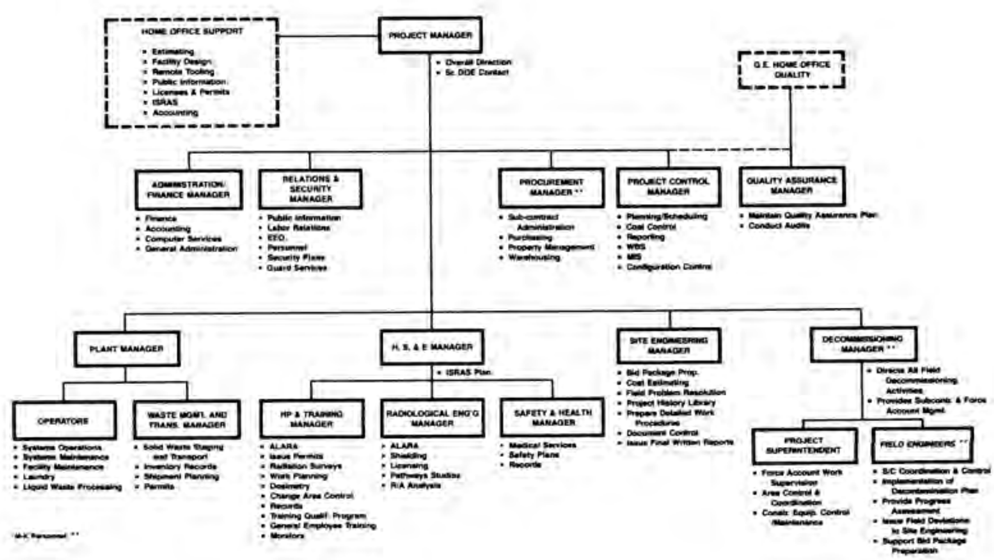

Fig. 4. Key Positions.

The activity specifications define what is to be done. They only describe how the work is to be done when radiological safety is involved or when the salvage or scrap value of the material is to be preserved. The activity specifications logically group the work so that radioactive work is separated from non-radioactive work. Similar work is grouped together considering contractor qualifications and craft jurisdictions. Detailed work procedures will be developed by the sub-contractor(s) and approved by the DOC. For certain critical work operations, the DOC will include the detailed work procedure as part of the bid package.

Particular emphasis is being placed on the critical path work involving asbestos removal from components in the boiler chambers. This work will be sequenced and completed so as to permit the start of the exterior decontamination of the piping and components in one chamber in mid-September, 1985. GE and M-K corporate resources are being utilized as needed for support services to the DOC organization. These services include independent safety reviews, facility design work, and special design needs such as remote tooling.

Preparations are well underway for the second DOE Readiness Review which will be conducted prior to the start of physical decommissioning work. Key areas being covered in the Readiness Review include: Plant Configuration Control, the Project Cost/Schedule Control System, and the DOC's ALARA program. The review will also include the adequacy and completeness of selected procedures and documents required for the decommissioning phase.

Periodic weekly information/coordination meetings are being held with DOC Functional Groups to assess plant status, identify problem areas and actions required to resolve them, and to establish work plans for the next three weeks. DOC operations personnel provide plant/site surveillance and are responsible for maintenance of the systems and equipment required to support the decommissioning. The operations personnel also participate in general planning for the decommissioning operation phase.

Routine on-site and off-site radiation surveys and environmental monitoring are currently being performed and will continue throughout the decommissioning phase.

SCHEDULE

The schedule for Decommissioning Operations is shown in Fig. 5. The decommissioning logic diagram, Fig. 6, developed by Burns and Roe shows the sequence of events from the start of DOC Training in May, 1984 to site restoration and preparation of the final decommissioning report.

TECHNICAL FEATURES

Two features of the Shippingport Station Decommissioning Project which are noteworthy are:

- o No primary system decontamination
- o One-piece removal of the reactor pressure vessel

Figure 7 shows the result of a recent radiation survey of the Shippingport Plant primary system. Because of the low radiation levels that exist in the primary system and the reactor containment chambers, gross reactor systems decontamination is not required. The estimated occupational exposure for the entire project is approximately 1,000 man-rem. It is estimated that at the peak work period, approximately 250-300 people will be applied to the decommissioning effort. Figure 8 is a plot of manpower loading versus man-rem exposure over the life of the project.

With regard to radiation, the Shippingport Station Decommissioning Project will provide relevant information for future decommissioning projects. Although the general area dose rates are low compared to many other nuclear plants, low levels of radiation and contamination require the same strict controls and attention to detail as high radiation levels. One difference is that fewer workers will be required for a nuclear plant with lower radiation levels.

A unique feature of the Shippingport decommissioning will be the one-piece removal of the reactor pressure vessel. It has been estimated that this approach will save about $7 million, reduce personnel radiation exposure from 250 man-rem to 140 man-rem, and reduce the total decommissioning schedule by about one year compared to segmentation of the vessel and internals. Figure 9 shows how the pressure vessel is shielded and prepared for removal. Figure 10 shows the lifting tower used to remove the vessel. This approach has direct application for decommissioning commercial nuclear plants constructed during the 1960's and will help to provide relevant information for decommissioning the large 1100 MWe nuclear plants being constructed and operated today.

One of the most complex tasks in any nuclear plant decommissioning is the removal of the Reactor Pressure Vessel (RPV). This task is complicated because the reactor pressure vessel is the most highly irradiated component in the nuclear system and represents the largest and heaviest component to be removed. Figure 11 compares the Shippingport Reactor Pressure Vessel and Neutron Shield Tank (RPV/NST) with a 1100 MWe PWR Pressure Vessel. As can be seen, the Shippingport RPV/NST is as large as a 1100 MWe PWR vessel. It is also representative of the diameter of a BWR vessel. Weight wise the Shippingport RPV/NST is in the same weight category as a 1100 MWe PWR or BWR pressure vessel.

DECOMMISSIONING TECHNOLOGY

Some attempts have been made to sensationalize the difficulty of decommissioning a large nuclear power plant like Shippingport. The public has been told that the Shippingport Decommissioning Project is complex, it has never been done before, and has implied that decommissioning technology does not exist. However, as stated at the beginning of this paper, decommissioning technology and the cost basis for the Shippingport Station Decommissioning Project are based on (a) the technology and experience gained in maintaining and modifying nuclear power plants for the past twenty-eight years, and (b) the experience gained from decommissioning small nuclear facilities.

Since the birth of commercial nuclear power, the nuclear industry has had to maintain radioactive reactor equipment and systems. At times this also involved the removal of large radioactive components such as steam generators

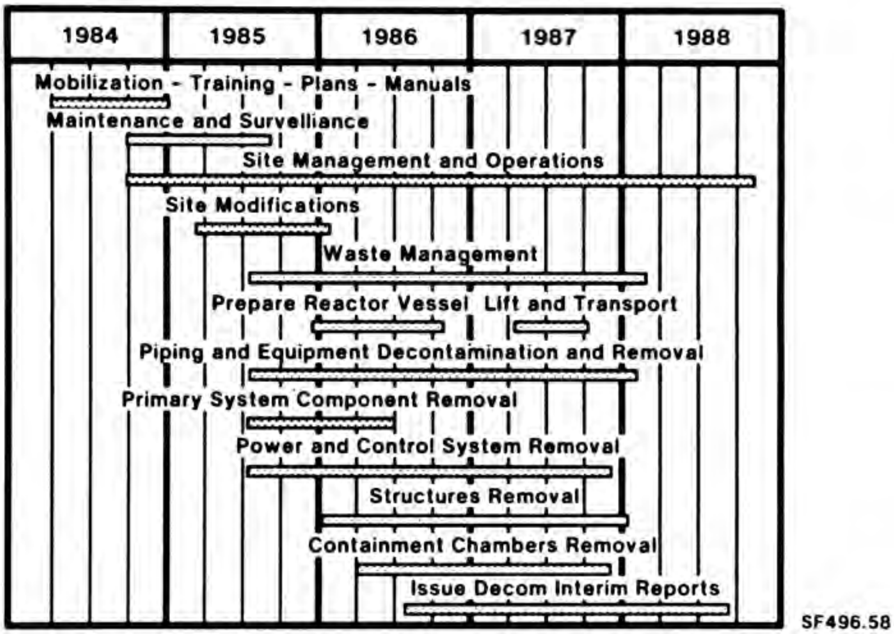

Fig. 5. DOC Schedule.

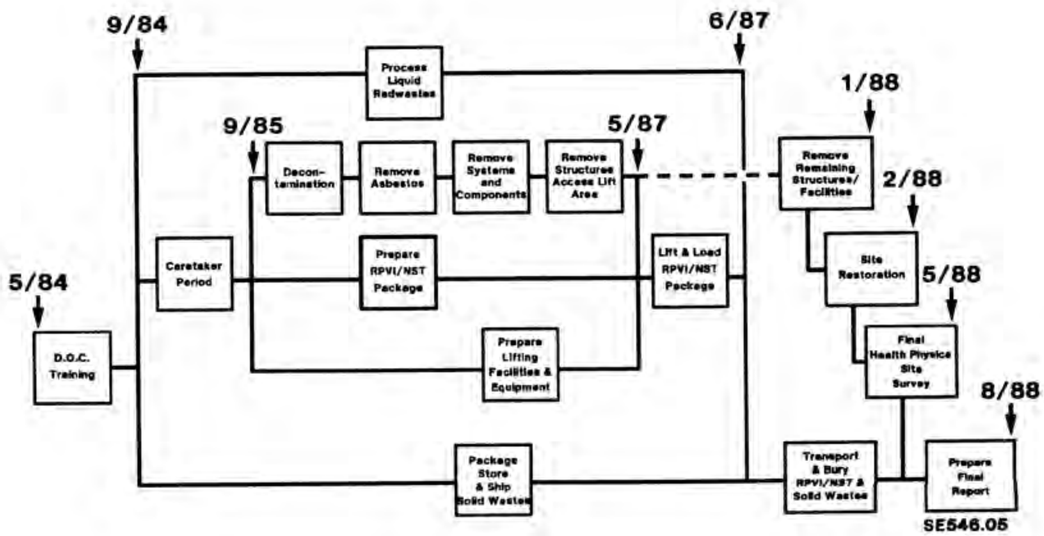

Fig. 6. Decommissioning Logic.

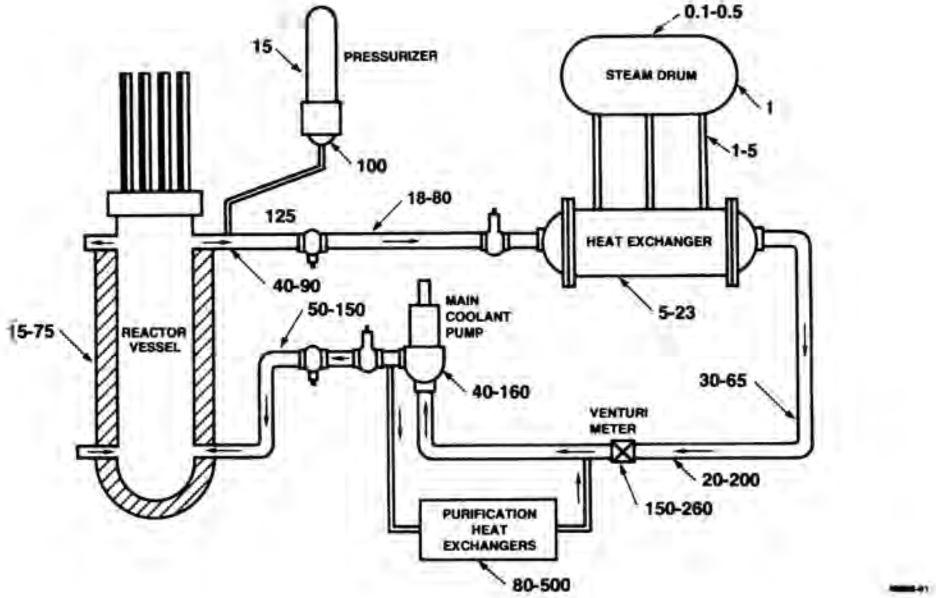

Fig. 7. Shippingport Plant Primary System Radiation Survey-MR/HR.

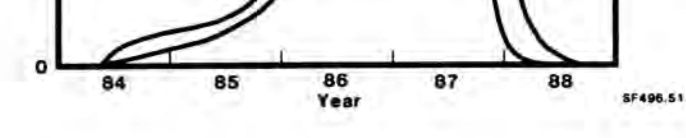

Fig. 8. Manpower Loading and Exposure.

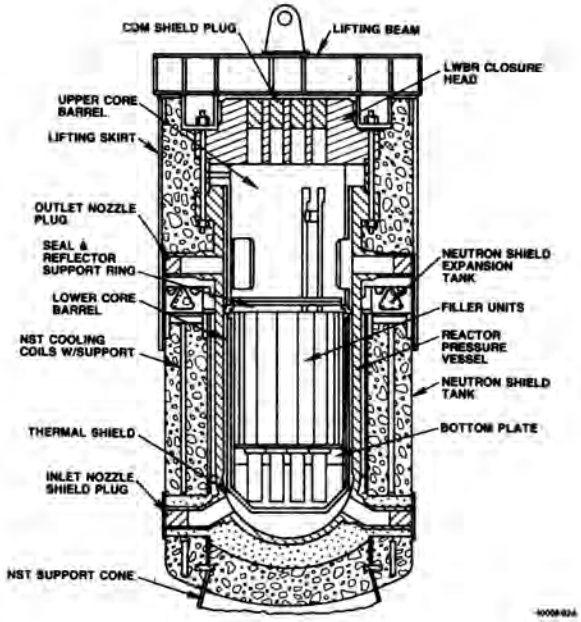

Fig. 9. Reactor Vessel Package.

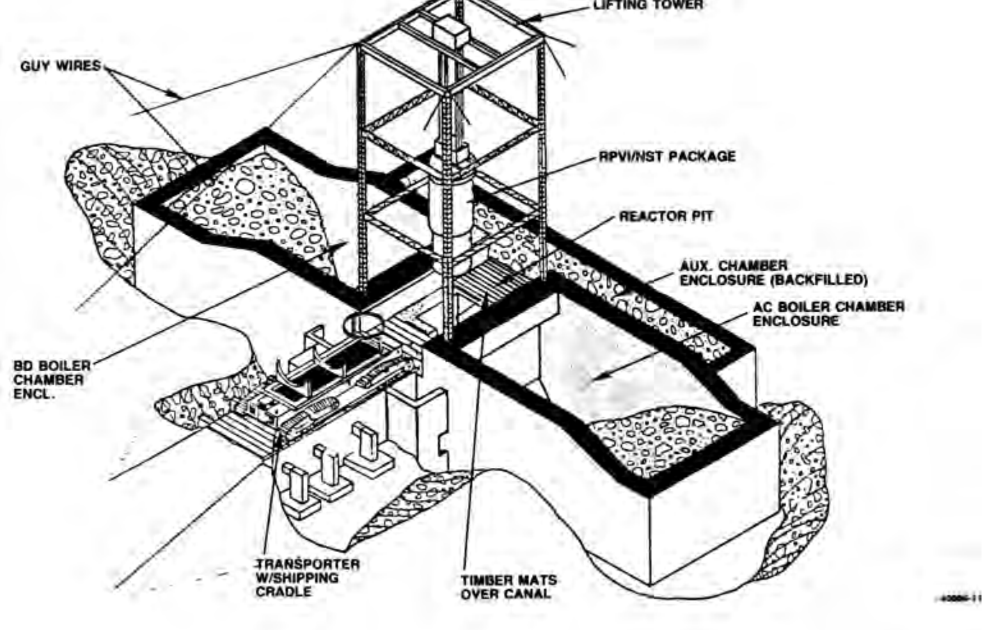

Fig. 10. Lifting of RPVI/NST Package.

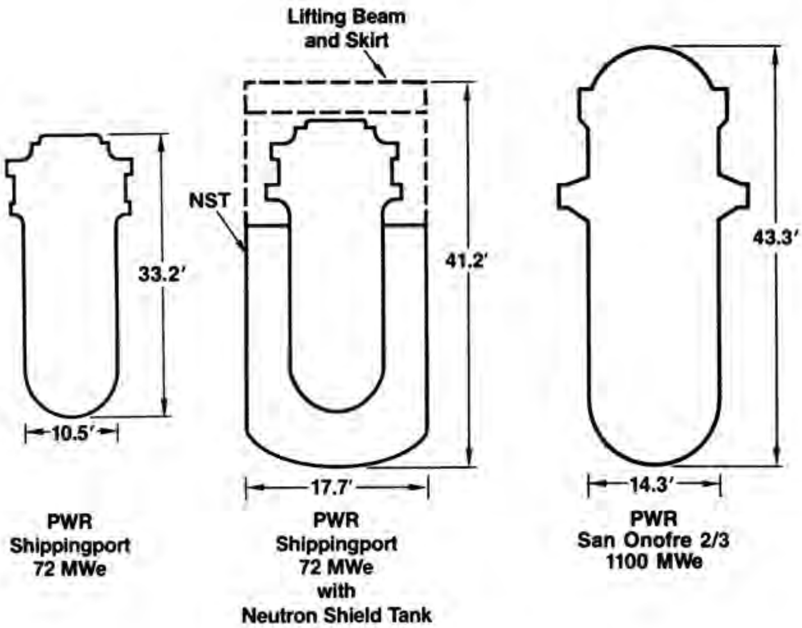

Fig. 11. Reactor Pressure Vessel-Dimension Comparison.

and the removal and modification of portions of radioactive reactor systems. The experience and technology that have evolved from nuclear plant maintenance and modification are being used at Shippingport. This can best be demonstrated by a review of existing techniques that have been used successfully for nuclear plant maintenance and modification. Some of the existing technology that may be applied to Shippingport are:

- o Remote Cutting
  - Mechanical Cutting
  - Plasma Arc
- o Concrete Removal
  - Scabblers
  - Spalling Devices
  - Water Cannon
  - Concrete Cutting
- o Decontamination
- o Volume Reduction
  - Liquids
  - Solids
- o Robotics

A short discussion of each of these areas of technology follows.

REMOTE METAL CUTTING

Mechanical Cutting

Table I compares some of the mechanical cutting processes which will be used at Shippingport. As can be seen the cost of mechanical cutting with these devices is low relative to plasma arc or laser beam cutting. The final selection of which device will be used for specific decommissioning operations is being evaluated at this time and will be the subject of a future paper. Some of the remotely operable mechanical cutting equipment which have been successfully used for reactor plant maintenance include powered hacksaws, hydraulic and pneumatic shears, circular cutting machines, and guillotine saws. Figure 12 shows a typical remotely operable guillotine saw and a circular cutting machine.

Plasma Arc

Figure 13 shows an underwater plasma arc cutting system used to cut irradiated and highly contaminated components removed from nuclear power plants. This cutting process is fairly easy to adapt for remote operation and can be used to cut any metal section up to six (6) inches thick. For thicker metal sections up to 36 inches, the Plasma Arc torch can be replaced with the Arc Saw. Very little plasma arc cutting will be used because of its relatively high cost and because the Shippingport reactor pressure vessel will be removed in one piece.

CONCRETE REMOVAL

The removal of radioactively contaminated concrete requires dust control and selection of a concrete removal process which does not cross contaminate clean concrete and other materials.

Scabblers

Commercial floor and wall scabblers are effective in removing contaminated concrete from large surface areas to a depth of 1/16 to 1/8 inches. Figure 14 shows a typical floor scabbler. Scabbler devices can be adapted easily with vacuum systems equipped with HEPA filters for effective dust control. The cost of concrete surface removal is about $1.50/square yard of floor surface to $6.70/square yard of wall surface.

Spalling Devices

Spalling devices are used to remove contaminated concrete to a depth of 1/16 to 2 inches. A commercially available mechanical concrete spaller is shown in Fig. 15. The concrete spalling device is powered by a commercial hydraulic or pneumatic head similar to those used in the stone quarries and the construction industry since the late 1800's.

Water Cannon

A high-pressure jet spalling device known as a water cannon is an effective method of spalling contaminated concrete from small areas. Shots are fired about three (3) inches apart in a triangular pattern. High strength concrete requires about 24 shots to remove one (1) square foot of concrete. A schematic of a water cannon is shown in Fig. 16.

Concrete Cutting

At this time there is no identified need for cutting large sections of contaminated concrete. Because of the plant's conservative radiation shielding design, there is no irradiated concrete that needs to be removed. However, if large concrete sections must be removed, conventional concrete saws, concrete splitters, flame cutters, or thermic lances will be used. Again the cutting equipment will be modified for contamination control and the cutting process selected will be based on safety and cost considerations.

DECONTAMINATION

As indicated previously, there will be no primary system decontamination of the reactor plant. However, contaminated pipes and components will be decontaminated if they can be released economically for unrestricted use subsequent to decontamination.

Table II shows some of the decontamination solutions that may be used at Shippingport. In addition, when supported by a cost-benefit analysis, electropolishing may be utilized.

To reduce general area dose rates, high pressure, low volume water lance units will be used to reduce surface contamination of the fuel storage canal walls and fuel storage racks. Figure 17 shows a portable water lance unit.

VOLUME REDUCTION

Liquids

Currently there is approximately 500,000 gallons of slightly contaminated water stored in

TABLE I

Application Characteristics of Mechanical Cutting

Process	Application	Relative Cost	Note
Hacksaws and Guillotine Saws	All metals Piping ≤ 18" in diameter	Low	P, R
	All metals Piping or Stock ≤ 24"	Low	S
Circular Cutter	All metals Piping ≥ 6" diameter with wall thickness ≤ 3"	Low	P, R
Abrasive Cutter	All metals Piping and stock ≤ 2" chord length	Low	P
	All metals Piping and stock ≤ 8" chord length	Low	S
Mechanical Nibbler	All metals ≤ 1/4" in thickness	Low	P, R
Mechanical and Hydraulic Shears	All metals Piping ≤ 2" in diameter	Low	P, R
Plasma Arc	All metals ≤ 6"	High	R, S
Laser	All metals ≤ 2"	Very High	R, S

NOTE:

Recommended operating modes for the cutting processes include:

(P) Portable application where personnel bring the process equipment to components being disassembled.
(R) Remote application where remotely operated mechanisms are required to segment components.
(S) Stationary application where material is brought to a permanently established work station for segmenting.

TABLE II

Typical Decontamination Materials

SOLVENTS

- o TURCO 4324NP
- o NUTAK PRODUCTS
  - N-600EL
  - N-69B
  - N-70U
- o AMWAY 3D

STRIPPABLE COATING

- o IMPERIAL'S ALARA 1146
- o LATEX PAINT

SEALER AND COATING REMOVERS

- o CONCRESIVE 6003
- o TURCO 5351, 5873, 601T

ABSORBERS

- o TURCO DECON 4306D

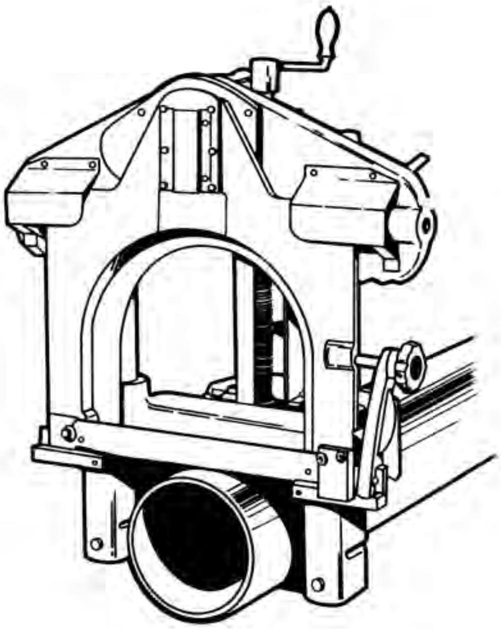

Fig. 12a. Portable Air-Powered Guillotine Saw.

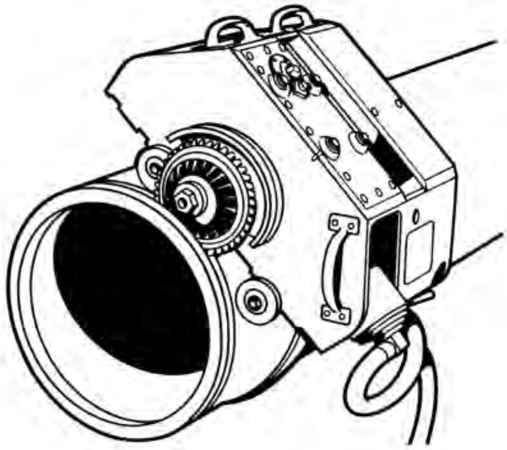

Fig. 12b. Circular Cutting Machine.

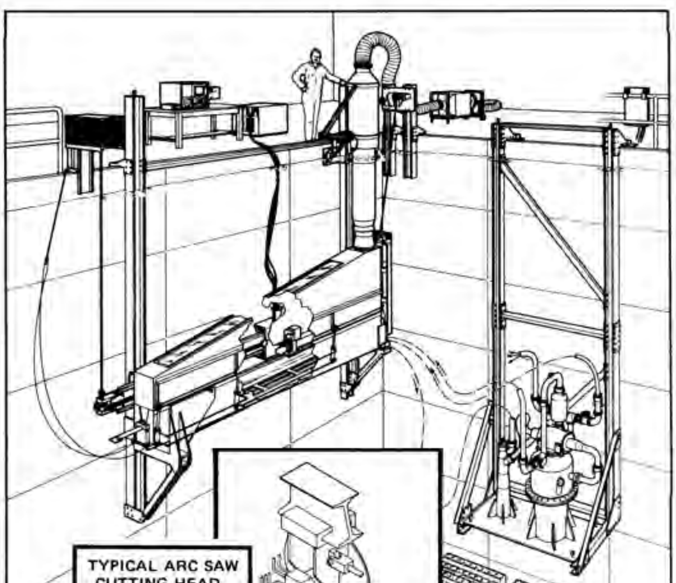

Fig. 13. Plasma Arc Cutting System.

Fig. 14. Floor Scabbler.

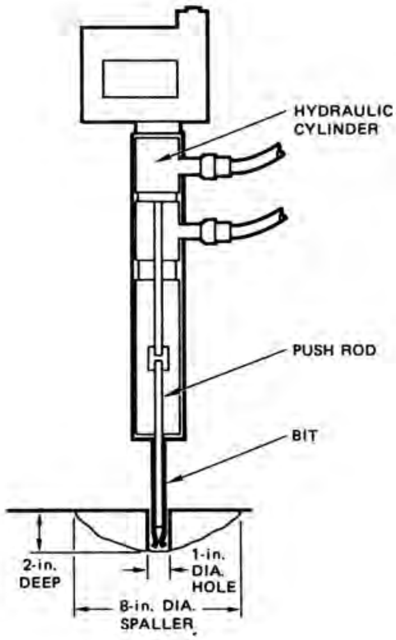

Fig. 15. Concrete Spaller with Hydraulic Cylinder.

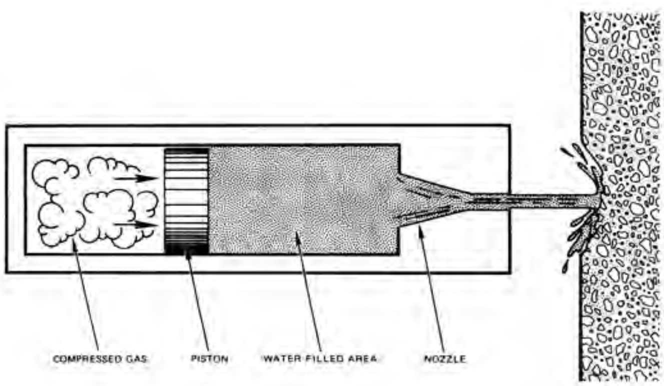

Fig. 16. Schematic of a Water Cannon Basic Components.

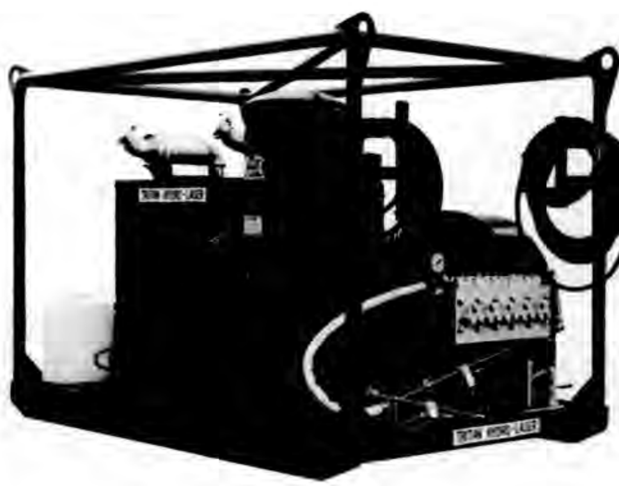

Fig. 17. Water Lance Unit.

the fuel handling canal and radioactive liquid storage tanks at the Shippingport Station. Because of the relatively low radioactivity, most of the water will be processed through filters to remove particulate material, and discharged when within the approved discharge limits. Approximately 25,000 gallons of liquid will be processed using the thin film evaporator currently located in the Shippingport Radioactive Waste Processing System. The sludge generated by the evaporation process will be solidified using the cement solidification process and existing equipment.

Solids

- Volume reduction of low level solid waste will be accomplished with an existing hydraulic compactor. The Shippingport compactor is capable of achieving compaction ratios of 8 to 10.
- Approximately 2,000 cubic feet of spent resin is located in the resin storage tanks. The current plan is to package the resin in High Integrity Containers (HIC's) which will be dewatered and then transported to a government waste repository.

ROBOTICS

Because of the relatively low, general area dose rates in the Shippingport containment chambers, there is limited opportunity for the use of robotics. However, a literature review has been initiated and it appears that with an investment of approximately $100,000 a general purpose robot, capable of lifting 100 pounds can be obtained and equipped to hold metal cutting equipment. Such a robot, if properly mobilized, could perform repetitive operations and reduce the man-hours and total man-rem exposure for the Shippingport Project. A robot that could be used for repetitive type operations is shown in Fig. 18.

MATERIAL SHIPMENTS

The radioactive components and the waste generated during the Shippingport Station Decommissioning Project will be loaded onto a 4,000 ton ocean-going barge (Fig. 19) and shipped to the Department of Energy's waste repository located at Hanford, Washington. A barge slip will be constructed on the south bank of the Ohio River next to the Shippingport Atomic Power Station and when loaded, the barge will be transported down the Ohio River and the Mississippi River to the Gulf of Mexico. The barge will be transported to Hanford, Washington via the route shown in Fig. 20.

Figure 21 presents key technical features of the Shippingport Station Decommissioning Project. Key statistics are presented in Fig. 22.

CONCLUSION

It is fitting that the Shippingport Station, which was the world's first commercial nuclear power plant, should become the first commercial-size nuclear power plant to be decommissioned. Just as Shippingport "led the industry" in reactor technology development and demonstration, it will now "lead the industry" in the development and demonstration of safe, cost-effective reactor decommissioning technology.

REFERENCES

1. F. P. Crimi's Paper "Decommissioning Program for the Shippingport Atomic Power Station," presented at the Atomic Industrial Forum "Fuel Cycle Conference 84," April 4, 1984.

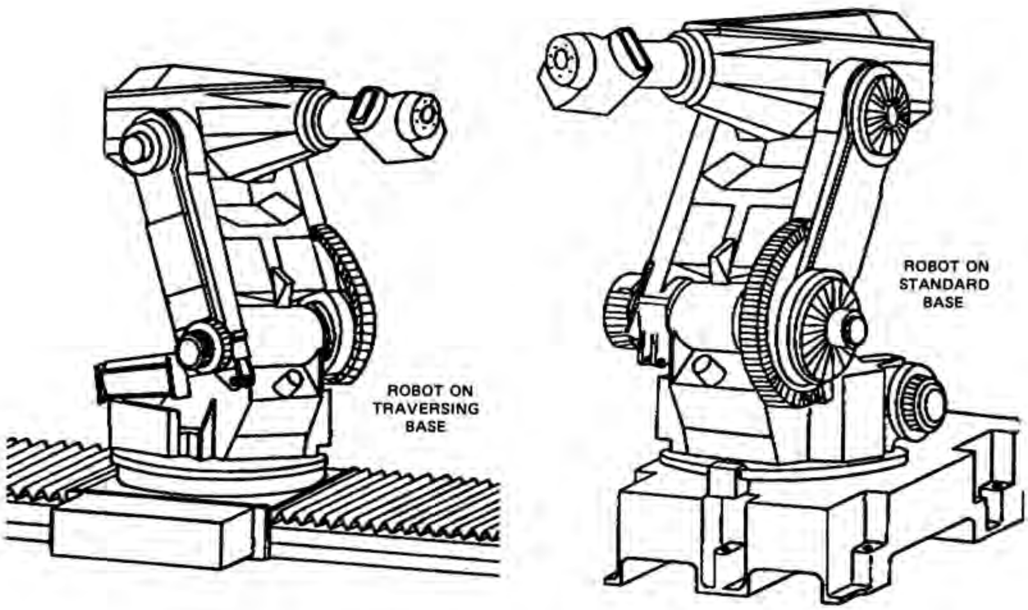

Fig. 18. Robot Used for Repetitive Decommissioning Operations.

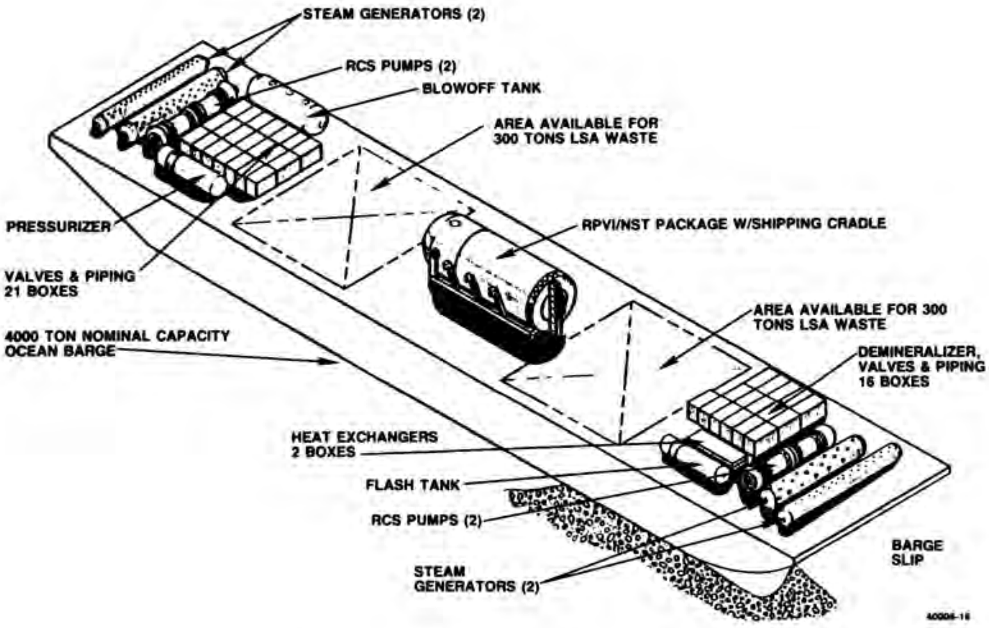

Fig. 19. 4000-Ton Ocean-Going Barge.

Fig. 20. Barge Transportation Route.

- One-Piece Reactor Vessel Removal
- Steam Generators as Own Package
- Maximum Shipment by Barge
- No Primary System Gross Decontamination
- Construction-Type Electrical Service
- Use of Plant Radwaste Systems
  - Solidify Evaporator Bottoms
  - Dewater Resins in HIC'S
- Underground Structures to Remain
  - Three Feet Below Grade
  - Filled with Clean Rubble

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Fig. 21. Key Statistics.

- Reactor Vessel Package - 770 Tons
- Radwaste Volume - 3000 Cu. Yds
- Radioactive Contents - 14,500 Curies
- Vessels/Tanks - 130
- Chamber Steel - 22,400 Tons
- Contaminated Concrete - 50 Cu. Yds
- Non-Contaminated Rubble - 15,000 Cu. Yds
- Contaminated Pipe - 56,000 LF
- Non-Contaminated Pipe - 55,000 LF
- Asbestos Waste - 100 Cu. Yds

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Fig. 22. Technical Features.