Decommissioning US DOE nuclear facilities

by Edward G. Delaney

"You will be interested to know that the Italian navigator has just landed in the new world."

This is the coded message that Karl Compton telephoned James Conant on the day Enrico Fermi achieved the first self-sustaining chain nuclear reaction in the graphite pile at Stagg Field, Chicago, on 2 December 1942.

For the next 25 years or so, a large number of facilities were built to carry out experiments and demonstrations, including test reactors, power demonstration reactors, fuel fabrication facilities, radioisotope separation and fabrication facilities, and nuclear propulsion test facilities. In addition, facilities were constructed to produce nuclear fissile and fusion materials, including those for uranium mining and milling, uranium enrichment, uranium processing, plutonium production, and tritium production.

The radioactive wastes from all these activities were disposed of in shallow land disposal facilities for the most part, except for some intermediate-level waste, which was injected into deep subsurface formations that had been hydrofractured.

Past decommissioning activities

During the 1960s, the US Government agency responsible for nuclear energy activities – the Atomic Energy Commission (AEC) – recognized the need to eventually decommission facilities so that they could be either re-used for other nuclear work, could be safely stored in a manner which caused essentially no risk to the public, or could be decontaminated sufficiently to release the facility for unrestricted use (that is, with no concern for remaining radioactivity).

The AEC began to develop techniques for decontaminating some facilities for re-use or for unrestricted use, as well as methods for safe storage of the facilities when decontamination was not a preferred option. A summary of some of the facilities decommissioned during this initial period appears in the table on page 32.

Techniques were developed (1) to safely store facilities for long periods with moderate surveillance and maintenance (the end condition of the facility is given the name SAFSTOR by the US Nuclear Regulatory Commission (NRC) and Stage-1 by the IAEA); (2) for safe storage of facilities for hundreds of years with very little surveillance and maintenance (termed ENTOMB and Stage-2); and (3) for decontamination and dismantling of facilities so that they can be released for unrestricted use (termed DECON and Stage-3).

Substantial development of technology was completed in accomplishing these early decommissioning projects. The technology developed by AEC projects, as well as some important projects in other countries, provides a foundation for decommissioning work today.

Current and planned programme

In 1977, the Energy Research and Development Administration (ERDA), the successor to the AEC, made an inventory of unused radioactively contaminated facilities and established a programme for an orderly decommissioning of these "surplus" facilities. About 500 facilities were included in the Surplus Facilities Management Program (SFMP). The SFMP is being continued under the US Department of Energy (DOE), the successor to ERDA. The 348 facilities now in the SFMP are divided into "civilian" (114 facilities) and "defense" (234 facilities) categories.

The objectives of the SFMP are to:

- Safely manage and dispose of the inventory of surplus facilities in accordance with priorities
- Maximize re-use of facilities
- Optimize use of state-of-the-art decommissioning techniques
- Transfer the decommissioning technology to US industry and collaborate with international and other national decommissioning programmes.

The safe management of DOE surplus facilities is accomplished by the removal of fuel, radioactive liquids, flammable and pressurized liquids, and other materials with potential for leakage or energy release; provision of necessary maintenance to assure facility integrity; and monitoring of the facility and the surrounding environment.

The priorities for disposal of the surplus facilities are determined by considering facility factors and assigning a ranking, generally according to the following hierarchy:

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Part of the reactor from the SRE facility in California being shipped for burial. SRE was dismantled, with the job completed in 1982. (Credit: Rockwell International)

DOE legal and contractual requirements; health risks of delayed disposition; economic impact of immediate versus delayed disposition; future plans for the facility site; cost-effective programme management (for example, maintaining continuity of decommissioning work at a location); other special factors such as potential for re-use of a facility.

The state-of-the-art technology for decommissioning generally is adequate for disposition of these DOE facilities. Techniques and equipment available from industry and DOE laboratories are being used. These techniques and equipment are adapted from other uses such as nuclear power plant maintenance operations and hazardous materials handling. Only a small amount of research and development is conducted, generally on an *ad hoc* basis for the particular project.

The transfer of technology to industry is accomplished by contracting with industry to conduct the facility disposition projects, by preparing and publishing technical reports on the projects, and by participating in and initiating technical meetings with industry. International and national collaboration is accomplished by participating in the international decommissioning activities and by exchanges with other national decommissioning projects, generally through bilateral exchange agreements.

The 348 facilities in the SFMP have been grouped into 74 projects for planning and implementation. Details of some of these major projects are shown in the accompanying tables. The overall planning for the SFMP anticipates completion of the projects during the first decade of the next century at a total cost of more than US $1.5 billion.

Following are brief descriptions of three projects.

Shippingport station project

The Shippingport Atomic Power Station is a pressurized-water reactor of 72 megawatts-electric (MWe) that started up in 1957 and was shut down in 1982. It had produced more than 7.2 terawatt-hours of electricity from three cores. DOE is preparing to dismantle the nuclear portions of the plant beginning in September 1985, with completion in January 1990. The estimated total cost for the project is US $98.3 million, and about US $19 million has been spent through September 1985.

The decommissioning operations contractor, General Electric, took possession of the site from the operations contractor in September 1984, after removal of all fuel from the site. During the past year, the decommissioning operations contractor has been performing surveillance and maintenance of the plant, mobilization and training of personnel, bid package preparation for subcontractor awards, development of detailed work plans and procedures, and site modifications needed prior to start of dismantling.

Work has started on removal of all asbestos from piping and equipment. During the next year, work will be started for removal of piping, decontamination and removal of equipment, removal of primary system components, and removal of the power and control systems. In 1987, removal of concrete and structures will begin. Removal of the containment chambers will begin in 1988, and the reactor vessel will be removed in 1989.

Some technical features of the project include:

• Removal of the reactor vessel and surrounding neutron shield tank as a single unit weighing over 770 tonnes with

Selected US experience from decommissioning projects

Facility name and location	Facility type	Capacity	Type of D/D	Date	Experience
Reactors					
Carolina/Virginia Tube Reactor (CVTR) (Parr, South Carolina)	HWR	65 MW(th)	Stage-1	1968	Basic Stage-1 procedures developed; periodic surveillance.
Pathfinder (Sioux Falls, South Dakota)	BWR with nuclear superheat	190 MW(th)	Stage-1 for BWR with conversion of facility to other use	1972	Isolation of steam plant and replacement of nuclear reactor with fossil-fired boiler; continuous surveillance.
Saxton (Saxton, Pennsylvania)	PWR	23.5 MW(th)	Stage-1	1973	Remote intrusion alarms for security to minimize work force.
Fermi I (Monroe County, Michigan)	FBR	200 MW(th)	Stage-1	1975	Sodium handling experience for Stage-1.
Peach Bottom I (York County, Pennsylvania)	GCR	115 MW(th)	Stage-1	1978	Core graphite fuel handling and disposal.
Hallam, (Hallam, Nebraska)	Graphite-moderated, sodium-cooled	256 MW(th)	Stage-2	1968	Basic Stage-2 procedures developed; no continuous surveillance.
Piqua Reactor (Piqua, Ohio)	Organic-cooled and -moderated	45 MW(th)	Stage-2	1970	Entombment with conversion of reactor building to warehouse; reactor vessel entombed in sand; no continuous surveillance.
Boiling Nuclear Superheat Reactor (BONUS) (Rincon, Puerto Rico)	BWR	50 MW(th)	Stage-2	1970	Concrete entombment of vessel; decontamination of systems; release of site as exhibition center; no continuous surveillance.
Elk River Reactor (ERR) (Elk River, Minnesota)	BWR, fossil-fuelled superheater	58 MW(th)	Stage-3	1974	Remote segmentation of vessel & internals; explosive demolition of concrete; survey and release of site for unrestricted use.
Fuel cycle facilities					
Redox (Hanford, Washington)	Reprocessing facility	Production size	Stage-1	1967	Plutonium recovery programme using various flushes; system drained and air dried; external flushing of equipment, cells, and deck; entrances locked.

Notes: MW(th) = megawatts-thermal; HWR = heavy-water reactor; BWR = boiling-water reactor; PWR = pressurized-water reactor; GCR = gas-cooled, graphite-moderated reactor; D/D = decontamination and decommissioning

concrete shielding and lifting fixture. The reactor vessel will be shipped by barge from Shippingport to Hanford, Washington, for shallow land burial.

- The four steam generators will be shipped as units without other packaging on the barge to Hanford. Other radioactive components also will be included in the barge shipment.

- No primary system decontamination will be conducted. Some materials will be decontaminated for disposal as ordinary waste or scrap.

- Underground concrete structures below three feet (0.9 metres) will not be removed. The site will be backfilled with clean rubble and soil and levelled to grade.

Selected decommissioning projects completed under the SFMP

Facility name and location	Facility type	Type of decommissioning	Year completed
Reactors			
Los Alamos Molten Plutonium Reactor Experiment, New Mexico	Molten plutonium reactor	Dismantlement Stage-3	1980
Organic-Moderated Reactor Experiment, Ohio	Organic-moderated reactor	Dismantlement Stage-3	1980
Special Power Excursion Reactor Test II, III, IV; Idaho	Safety test reactors	Dismantlement Stage-3	1980
Sodium Reactor Experiment Facility, California	Sodium-graphite reactor	Dismantlement Stage-3	1982
Fuel cycle facilities			
Monticello Mill Site, Utah	Uranium ore mill	Dismantlement (restricted site)	1979
Advanced Fuel Laboratory, California	Plutonium fuel fabrication	Dismantlement Stage-3	1982
Plutonium Fuel Fabrication Facility, Pennsylvania	Plutonium fuel fabrication	Dismantlement Stage-3	1982
Building 350, ANL, Illinois	Plutonium fuel fabrication	Dismantlement Stage-3	1982

Note: SMFP = Surplus Facilities Management Program.

Mound laboratory project

The fabrication of radioisotope heat sources fuelled with plutonium-238 was conducted in several buildings at the Mound Laboratory at Miamisburg, Ohio, from the late 1960s through the late 1970s. These heat sources were used to supply power in many outer space applications.

DOE decided to decommission the facilities because they do not meet current design standards for processing plutonium. A project was initiated for this purpose by the Monsanto Research Corporation, the operator of the facilities, in 1978 and is expected to be completed in September 1988 at a total estimated cost of US $69 million.

Plutonium fabrication and waste handling facilities in three buildings consisting of about 1100 linear feet (335.3 metres) of gloveboxes, 900 feet (274.3 metres) of conveyor housing, and associated piping equipment and structures are being removed. The rooms are being decontaminated sufficiently for personnel occupancy without protective clothing.

In addition, about 2600 feet (792.5 metres) of dual underground liquid waste lines and contaminated soil around these lines are being removed. Approximately 30 000 curies of plutonium-238 have been removed in waste and scrap residues. These wastes have been sent to the Idaho National Engineering Laboratory for storage.

As a result of this work, much valuable experience has been gained in the techniques for worker exposure control, contamination control, decontamination, equipment removal, structural decontamination, and waste packaging. This experience can be applied to decommissioning of other fuel cycle facilities.

Weldon Spring project

During 1955 through 1957, the AEC constructed a large chemical plant at Weldon Spring, Missouri, to process uranium ore concentrates into intermediate uranium chemicals and finally into metallic uranium. Thorium ore concentrates also were processed into other chemical forms. The residues from this processing were disposed of in four large open pits. The plant extends over about 70 hectares and the disposal pits over about 21 hectares.

During operations of the plant, the buildings, equipment, immediate terrain, process sewer system, and a drainage area became contaminated with uranium, thorium, and their decay products. In addition, a nearby formerly used quarry was contaminated from scrap and rubble that was dumped into it.

DOE has established a project to conduct cleanup of the quarry, the contaminated properties surrounding the chemical plant, and the chemical plant. The plant will be decontaminated and demolished. The radioactive wastes from these operations are estimated to exceed 600 000 cubic metres, and more than 80 million gallons (about 302 million litres) of contaminated water must be treated and released. The project is scheduled to start in 1987 and be completed in 1996 at a cost of US $357 million.

Experience to prove valuable

In summary, many hundreds of radioactively contaminated facilities have resulted from the nuclear research, development, and production activities of the US Government agencies. These facilities will be

Selected major projects in the DOE Surplus Facilities Management Program

Project/location	Type of facilities	Decommissioning plan*	Timetable	Cost**
Mound Lab Advanced Nuclear and Space Power Facilities (Miamisburg, Ohio)	Plutonium-238 fabrication facilities, waste transfer and handling facilities.	Removal of plutonium fabrication equipment, decontamination of structures to permit occupancy and re-use; removal of waste transfer and handling facilities; shipment of all decommissioning wastes to Idaho National Engineering Laboratory.	1978–1988	69
Niagara Falls Storage Site (Lewiston, New York)	Storage facility for uranium processing residues and radium-containing wastes.	Cleanup of contaminated areas surrounding the storage site; cleanup and consolidation of residues and wastes onsite into near-surface entombment facility.	1981–1986 (Stage-1), 1995–1996 (Stage-2)	51
Monticello Mill Site (Monticello, Utah)	Storage site for tailings from uranium mill processing.	Cleanup of contaminated areas surrounding the storage site; surface and groundwater drainage modifications; entombment of the tailings onsite.	1987–1994	35
Shippingport Atomic Power Station (Shippingport, Pennsylvania)	Pressurized-water reactor with power capability of 72 MWe.	Dismantlement of nuclear portions of the plant; shipment of intact reactor vessel and other major components to Hanford, Washington for near-surface burial.	1985–1990	98
Weldon Spring Site Remedial Action Project (Weldon Spring, Missouri)	Uranium and thorium processing facility to convert mill concentrates to metallic form.	Cleanup of contaminated areas near the plant, including a quarry; dismantlement of a large uranium processing plant; entombment of the wastes onsite.	1987–1996	357
Experimental Boiling Water Reactor (Argonne, Illinois)	Boiling-water reactor with power capability of 100 MW(th).	Decontamination and removal of all radioactive material from the containment to permit its unrestricted use for other purposes.	1987–1995	22
Heavy-Water Components Test Reactor (Savannah River, South Carolina)	Heavy-water moderated, uranium-fueled reactor.	Dismantlement of reactor and near-surface burial of the components and wastes.	1988–1993	15
Homogeneous Reactor Experiment (Oak Ridge, Tennessee)	Light-water uranium solution reactor.	Dismantlement of reactor and near-surface burial of the components and wastes.	1989–1997	25
Molten-Salt Reactor Experiment (Oak Ridge, Tennessee)	Uranium-233 fuel in fluoride salts reactor.	Processing of fuel salts into a stable form, disposing of the stabilized fuel; dismantling the reactor and disposing of the waste.	1992–2001	68

* Subject to completion of environmental review process for each project.
** Estimated in millions of US dollars.

very expensive to decommission. DOE has a vigorous programme underway to maintain these facilities in a safe condition and to decommission them in a manner to provide for the long-term protection of the public and the environment. Valuable experience is being gained from this programme that is expected to be of use in the eventual decommissioning of commercial nuclear facilities.