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ENTRY AND DECONTAMINATION OF THE REACTOR CONTAINMENT BUILDING

AT THREE MILE ISLAND UNIT 2

Highlights of a "Planning Study"

conducted by

BECHTEL POWER CORPORATION

for

GPU SERVICE CORPORATION, INC.

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THE PLAN: A PRELIMINARY STUDY

Following the March 28 accident at three Mile Island (TMI) Unit 2, GPU Service Corporation (GPUSC) retained Bechtel Power Corporation, a leading engineering and construction firm in the nuclear power industry, to prepare recovery plans for the re-entry and decontamination of the Unit 2 reactor containment building.

A top priority in developing the plan was to analyze, without benefit of building entry, the radioactive content in the water on the building floor (the sump water), in the air inside the building, and on the various surfaces. This analysis was required to plan for the decontamination of the building and equipment, a prerequisite to the eventual recovery of the plant.

The Bechtel study also describes:

* An assessment of the physical condition of the containment building and the degree of damage.
* Preliminary plans for entering the containment building for the first time since the accident and completing its decontamination.
* Conceptual design for new systems and modifications to existing systems that will be needed for re-entry and decontamination.

The re-entry and decontamination work will be directed by engineers and technicians, who have been appropriately trained in decontamination and in the practices that are essential to protect the public, themselves and those working with them.

The Bechtel study does not specifically address several areas related to Unit 2 recovery efforts such as removal of the water in the containment building, disposal of contaminated materials or removal of the fuel from the reactor vessel. These and other areas are or will be the subjects of other studies and evaluations. To the extent we may know the preliminary plans, some of these areas are covered in these summary highlights.

The Bechtel study also outlines in a separate assessment a preliminary estimate of costs and a scedule related to the recovery effort. They caution that since no entry has been made into the Containment Building the cost estimate is highly speculative.

The scope of the estimate includes efforts related to re-entering and cleaning up of the containment, including waste disposal; removing and disposing of the fuel; refurbishing or replacing in-containment systems, structures and components, and preparing the unit for restart.

A copy of the July 16 News Release announcing the Bechtel Study (included in this information kit) outlines cost parameters.

Important Note:

Bechtel and GPUSC caution that since the containment building has not been entered since the accident, there are uncertainties about levels of radiation and the condition of the facilities within structure. As knowledge of these factors improves, changes undoubtedly will be made in the preliminary planning. New studies already are in process and still others will be made.

For these reasons, GPUSC and Bechtel identify the study as preliminary and recognize that further investigation and planning must precede initial entry.

<u>COSTS AND SCHEDULE</u>

Bechtel estimates that decontamination and reactivation of TMI-2 will take about four years, but that this schedule could vary by as much as six months.

The Bechtel study estimates that the decontamination and reactivation of the plant will cost about $320 million. This figure includes a contingency fund of $80 million.

The Bechtel estimate does not include the cost of replacing the reactor core. GPUSC's investment in the core at the time of the accident was about $35 million. With increases of uranium, enrichment and fabrication prices, a new core will cost between $60 million and $80 million.

Additionally, GPUSC has added $25 million to the Bechtel estimate to cover possible further unforeseen contingencies. This brings the estimated cost of decontaminating and restarting TMI-2 to about $400 million.

The schedule of major milestones in the TMI-2 recovery effort is difficult to estimate because of uncertainties in the timing of regulatory approvals and because information or developments in an earlier effort may effect the planning for subsequent efforts. The following generalized schedule should be considered in that context and may be suject to significant later changes:

1.	Back up reactor decay heat removal systems and other safe shutdown mechanisms in place.	Summer 1979
2.	Auxiliary Building water treated and building decontamination completed.	Fall 1979
3.	Reactor containment building (RCB) water removed from RCB and treated.	Winter 1980
4.	Remote decontamination of RCB and RCB equipment completed.	Sping 1980

5. Re-entry of work personnel into the RCB, followed by hands-on decontamination work in RCB. — Sping 1980

6. Reactor vessel opened, head removed, fuel damage assessed. — Spring 1981

7. Fuel core removed. — Fall 1981

8. Reactor coolant system decontamination completed. — Summer 1982

9. Component Systems inspected, analyzed and prepared for requalification. — Fall 1982

10. Evaluation completed on the feasibility/advisability of return to commercial operation. — Fall 1982

This schedule does not include consideration for a number of potential delaying factors. Among the more important are extraordinary legal or political hindrances, major changes in existing regulations, or wide variations from anticipated conditions in the containment building or reactor coolant system. Any of these or other factors could significantly increase the time and budget requirements for safe cleanup and recovery.

For planning purposes, Unit 2 restart, if approved, is scheduled for mid-1983.

INITIAL HUMAN ENTRY OF THE

CONTAINMENT BUILDING

Using the Bechtel plan, human entry into the containment building would be attempted only after remote decontamination, removal of radioactive gases from the air and draining of the water from the floor.

During the entry, worker safety precautions must be taken and release of airborne radiation and contamination to the control and service building must be minimized. To accomplish this, a temporary contamination control envelope would be built around the existing personnel airlock through which the initial entry would be made. This would close off the area around the entry point with two or more barriers. Each control zone would be vented to temporary filters to remove any escaped contamination.

The initial entry would be made by a team of three well trained engineers and technicians who would know what to look for once inside, what to do and how to guard themselves from over-doses of radiation. A standby team of three other qualified workers would be ready outside the airlock in case of emergency need.

Those inside the containment building would be in constant radio communications with their supervisors in the containment service building.

The initial reentry personnel would wear several layers of protective clothing, including hard hats, three to five layers of full anticontamination clothing with surgical caps, hoods, rubber boots, outer layer plastic suits and full rain gear, including hat and coat.

The gear they would carry would include breathing apparatus, devices for measuring gamma and beta radiation, air and gas samplers, explosive gas meters, beam flashlights and two-way radios.

The length of time the reentry team could spend in the containment building would depend upon the level of radiation, but could be as long as an hour.

The reentry team would have two basic assignments: to map the radiation levels and "hot spots" in as much of the building as practical under the conditions they find; and to assess the physical condition of the inside of the containment building and its contents.

Bechtel also considers the use of robots if radiation levels are found to be too high for human entry. The report states that robots would be capable of making the entry and performing radiation surveys, dose rate assessment evaluations and observations of the general condition of the containment building at the point of entry. However, a robot would not be as mobile, flexible or "intelligent" as a human team.

GPUSC is also considering the possiblity of sending a specially equipped and trained man into the containment building before remote decontamination or removal of the sump water. This reentry, using essentially the same techinques as proposed by Bechtel, would be made through the same airlock recommended by the Bechtel report. The goal of such an early entry would be to obtain more detailed data on conditions within the building before deciding on the various decontamination techniques or planning subsequent recovery efforts.

DECONTAMINATING THE AIR

The air in the containment building contains high levels of radioactive gases, particulates and iodine that must be reduced to minimize exposure of workers during the decontamination program. The principal contaminants, stemming from the reactor cooling system water that spilled into the containment building, are miscellaneous fission products, noble gases, iodine, cesium and tritium, all of which must be disposed of in a manner that will not jeopardize the public health.

Purging of the containment building atmosphere would be done after the remote decontamination sequence, but before human entry. The basic objectives would be:

* To minimize the impact on public health and safety of containment building clean-up.
* To assure the lowest reasonable possible exposure of workers to radioactivity.
* To assure that there is no danger to the health or safety of the public, by keeping any releases well within all applicable Federal limits.

Several techniques for decontaminating the containment building atmosphere were surveyed by Betchel. One, known as the filtration and purge method, involves circulating the contaminated air through filters to remove radioactive particulate matter and through charcoal to remove iodine. The air would then be exhausted in controlled amounts into the atmosphere through a vent stack after going through a second filter and charcoal sequence. Some radioactive gases, mainly krypton, would be released, but in concentrations within Federal discharge limits.

The Bechtel study indicates this process would take about 51 days, after which the air in the containment building should be breathable in accordance with Federal standards.

Bechtel estimates that at the end of the 51 days, the total off-site dose due to radioactive gases from the filtration and purge process would not exceed 0.14 millirems of gamma radiation and 14.8 millirems of beta radiation at the site boundary and would be less as distance from the site increases. In both cases, the emissions would be within technical specifications, legal limits and Federal guidelines for normal plant operation.

The study also points out that the filtration and purge method can meet any off-site dose objective other than absolute zero. It is simply a matter of reducing the purge rate to comply with the goal. Existing meteorological conditions (wind direction, etc.) would be taken into consideration to further minimize dosages.

Three other methods are also being evaluated:

* Compression and storage of the contaminated air in tanks.
* Cooling the air to very low (cryogenic) temperatures at which the radioactive gases liquify and can be separated from the air and stored.
* Absorption of the radioactive gases as they are passed through a charcoal bed at very low temperatures.

While preliminary evaluations indicate the filtration and purge method is the best all around alternative, GPUSC is conducting further studies to determine the safest and most effective way of handling the contaminated air in the containment building. This work includes:

* A more thorough investigation of the filtration and purge system. Work already completed in this area shows that Bechtel's estimates of the amount of radiation that would be released into the atmosphere

and the resulting dose rates are correct and, therefore, would qualify under Federal regulations.

* The feasibility of each of the alternate methods is being studied in depth.

No final decision has been made at this date as to which of the available methods of disposing of the radioactive gases in the containment building will be used.

DECONTAMINATION BEFORE HUMAN ENTRY

So-called "remote decontamination" of the containment building is planned before entry by workers to complete the job by manual methods. The procedure is intended to reduce human exposure to radiation during initial entry and hands-on decontamination. Bechtel has identified four basic remote decontamination techniques:

1. Flushing with clean water.
2. Use of steam to induce condensation on surface.
3. Flushing with detergent solutions.
4. Flushing with chemical solutions.

Each of these would use the containment building spray system, which was built into the containment building for emergency use to remove iodine from the air in the event of an accident.

The sequence of remote decontamination events as described by Bechtel is as follows:

1. A flush with some 250,000 gallons of clean water.
2. Injection of a small steam flow while draining the flush water from the floor to prevent chemicals now dissolved in the water from precipitaiting and adhering to drained surfaces.
3. Multiple steam cycles to help remove contamination clinging to walls, ceilings and unfloodable surfaces.
4. Evaluation of the effectiveness of the water and multiple steam flushes. If these have been effective, the recommendation is to repeat the water flush. Since the steam flush already will have been repeated several times, it need not be done again. If neither the water nor steam flushes have been effective, the proposal is to proceed to Step 5.

5. A flush with 250,000 gallons of a detergent solution.

6. A flush with 250,000 gallons of clean water.

7. Again evaluate effectiveness of Steps 5 and 6 and repeat if effective or proceed to Step 8.

8. Use of chemicals, beginning with those chemicals least likely to be harmful to equipment within the containment building, proceeding to stronger chemicals as required. The use of chemicals will be followed by a 250,000 gallon flush with clean water. When it is determined that the radiation levels are sufficiently low for human entry, there will follow a 200,000 gallon flush with water containing corrosion inhibitors. This water would remain in the containment building sump during the initial periods of manual decontamination to minimize airborne tritium and help shield workers from radiation caused by contaminants remaining on the floor.

This sequence of flushes should reduce the contamination on those areas and equipment directly contacted by the various sprays to a level one hundredth or less of current levels. However, some areas not directly sprayed will be less thoroughly cleaned and will require greater care during manual clean-up.

Bechtel identified about 10 chemicals that might be used in the remote decontamination process without harming components of the containment building, but these and even stronger chemicals would only be used as a last resort in the event the earlier remote decontamination steps failed to achieve the desired results.

GPUSC agrees that the water and steam flushes should be used and that chemicals would be used only if radioactive levels are found to be too high for safe human entry for manual decontamination, and then only if we are assured that the chemicals will not harm the nuclear steam supply system.

MANUAL DECONTAMINATION

Manual decontamination will be the final step in the TMI-2 clean-up. The plan generally calls for starting the clean-up at the entry hatch and working outward until the entire building has been cleaned.

The job falls roughly in two parts: general overall decontamination and decontamination of specific hard-to-get-at areas that may contain "hot spots."

The overall area decontamination will be accomplished by flushing with water and detergent solutions applied with spray apparatus. Fire hoses and portable tanks with spray attachments will be used.

Steam cleaning will be used on specific area contamination. Hard-to-reach "hot spots" will be scrubbed manually with detergents.

Protection of the technicians working in the containment building will be of paramount importance. Before they begin their job, general area and airborne radiation monitors must be installed to alert the workers when danger of over-exposure exists.

Workers will wear breathing apparatus and anti-contamination clothing while performing manual clean-up work.

Allowable work periods will be dictated by existing radiation levels. In no case will workers be allowed to get radiation doses exceeding legal limits as set forth in Federal standards.

As will be the case in the remote decontamination procedures, special care will be taken in manual decontamination to protect the nuclear steam supply system because of its importance to future operation of the plant.

OPENING OF REACTOR HEAD & REMOVAL OF FUEL CORE

Following decontamination of the containment building, the reactor coolant system will be flushed and remotely decontainmated. The overhead polar crane will be placed into serviceable condition and the refueling cavity around the reactor flooded to cover the reactor vessel and permit the removal of the reactor head with minimal recontamination of the surrounding area.

Because we expect there is significant core damage, the fuel will be removed using specially designed tools and eventually shipped to a processing/storage depository in spent fuel casks. The fuel will be temporarily held in TMI-2's spent fuel pool, which will be modified for the operation. For planning purposes we are assuming that at least half (about 60%) of the fuel assemblies have been damaged.

Following removal of the fuel assemblies, the balance of the reactor coolant system will be decontaminated. GPUSC assumes that some fuel pellets and other core debris have been distributed to other parts of the system. Because of this, it will be necessary to remove the reactor vessel's lower internal parts and cleanup the bottom, remove the pumps, inspect and repair if necessary the steam generator tubing, and chemically decontaminate the Reactor Coolant System.

REMOVAL AND TRANSPORTATION OF RADIOACTIVE WASTE

FROM THREE MILE ISLAND

The removal and transportation of radioactive wastes from Unit 2 at Three Mile Island has begun, with refuse moving by tractor-trailer units to the Hanford Reservation in the state of Washington.

The Auxiliary Building clean-up and decontamination of water will result in about 250 shipments over a four year period. Bechtel has projected that decontamination of the Containment Building and Reactor Cooling System may require in the range of 2,000 to 2,500 shipments.

For protection of the public health and safety, a series of routine but rigorous inspections precedes dispatch of each shipment. Teams from two federal agencies, one Pennsylvania state agency, and numerous operating units of Metropolitan Edison Company are involved in the process of checking and certifying a shipment in compliance with standards for radiation control and physical condition of the vehicle and its cargo.

Current shipments consist of 150 to 160 steel, 55-gallon drums containing dry, compacted solid refuse from Unit 2 clean-up operations. Included are radioactively contaminated work clothing, shoe covers, small tools, rags, paper, and other debris. Some 600 drumloads has accumulated when shipments began on August 7, 1979. In addition, there are a number of wooden boxes, about four by four by eight feet, containing non-compactible debris.

To some segments of the public, waste from Three Mile Island has a special stigma, regardless of the routine level of radiation. Accordingly, TMI management has undertaken a special public affairs program. State officials along the shipping itineraries were individually briefed, and company representatives are accompanying the initial shipments to handle any inquiries.

Maximum permitted radiation levels on the exterior of the shipment are considered conservative. Radiation readings for the first shipment were substantially lower than the permissible maximums. For example, readings six feet from the trailer were 1.5 millirems per hour in contrast with a permitted level of 10.0.

When each shipment is dispatched, designated officials in states along the itinerary are notified of the route, contents and estimated time of arrival in that state.

Shipments of somewhat higher level radioactive wastes will begin. Some of these may require somewhat lengthier routing because of the extra weight of containers used. Routing is a result of piecing together in sequence, states in which necessary permits for overweight shipments can be procured.

The heavy casks to be used for these shipments will contain a dewatered resin used in a chemical process for absorbing radioactive materials now dispersed in the water held captive since the accident in March.

After the reactor vessel is opened and the fuel removed, GPUSC expects to ship the fuel to a depository off-site in spent fuel casks specifically designed for such purposes.

The number and type of shipments required to remove contaminated materials from the Island will depend on the nature of the decontamination system used at each stage and the amount of radioactive materials. An estimate of such shipments will be made prior to the initiation of each decontamination effort.

CALCULATING RADIATION LEVELS

IN THE CONTAINMENT BUILDING

One of the first steps that must be taken before re-entry and decontamination work can begin is to determine how much radioactivity exists in the containment building. While levels cannot be determined exactly until re-entry has been accomplished, Bechtel has made a range of calculations based on existing data. What is presently known is derived from samples of the reactor cooling water, samples of air from the containment building and radiation measurements made by detectors both inside and outside the building.

Four major sources of radiation are involved:

* General area levels from radioactivity deposited on walls and floors.
* Airborne sources.
* Concentrations in the sump water, which is about seven feet deep on the building's floor.
* Local areas of heavy contamination known as "hot spots".

Using available measurements from these sources, Bechtel estimates a range of three probable radiation levels--the lowest, the median and the highest.

Bechtel's airborne radiation estimates range from 0.73 to 1.3 microcuries per cubic centimeter. A microcurie is a measure of the rate of disintegration of radioactive material. The major contributor to this airborne radiation is krypton 85, one of the radioactive gaseous fission products.

Radioactive content of the sump water ranges from 222 to 961 microcuries per cubic centimeter, largely due to barium 137m and cesium 137 in the water. Bechtel estimates that the sump water also contains 0.5 to 1.5 microcuries per cubic centimeter of tritium, a radioactive form of hydrogen that cannot be readily removed from the water by commercially available techniques. Tritium has a relatively small biological effect which can be further reduced by dilution.

The Bechtel report has estimated general area radiation levels for December 1979 and assumes that the water on the floor of the building has been removed, but that no attempt at remotely decontaminating the building has been made. On this basis, general area radiation level estimates within the containment building, measured in terms of gamma dose rates, range from 6.7 rems per hour at a floor 23 feet above the bottom of the containment of 2400 rems per hour at a higher floor (about 66 feet above the bottom of the containment). Rems are a measure of the biological effect of radiation dose absorbed in human tissue.

Due to the location of the existing airlocks, reentry is planned at a floor 23 feet above the bottom of the containment, where the radiation dose rate estimates prior to cleanup range from 6.7 to 46 rems per hour.

The Bechtel radiation estimates are believed to be the best currently available and are based on sophisticated techniques for calculating radiation levels with the presently available data.

Final decisions await direct measurements that can be made by inserting probes into the containment building atmosphere and by obtaining samples of sump water from the floor of the building. Engineers are now working on procedures to execute these measurements.

NEW AND MODIFIED FACILITIES PLANNED

FOR SAFE AND EFFECTIVE DECONTAMINATION

Contemplated by Bechtel, before re-entry and decontamination of the containment building, will be installation of a number of new facilities, equipment and systems, as well as modifications to existing facilities.

The largest single addition recommended by Bechtel is a containment service building and associated facilities to be erected outside but contiguous with the containment building.

This building will be designed to limit the escape of radioactivity during the decontamination process.

The service building also will:

* Provide personnel access to and from the containment building during all phases of decontamination.
* Allow passage of large pieces of equipment and removal of bulk radioactive waste without opening the containment building directly to the atmosphere.
* Serve as a staging area to decontaminate and package contaminated equipment removed from the containment building.
* Serve as an area for holding of high-level radioactive waste for shipment to off-site storage.
* Provide space for a dry cleaning facility for contaminated clothing.

Since as many as 100 people per shift may be working on the decontamination project, the service facility will house a "health physics" office, which will serve as a control point for personnel entry and processing of radiation work permits.

The service building will be equipped with radiation monitors and alarms as a further protection for workers and the general public. The service building will also be equipped to filter all incoming air to remove dust and outgoing air to remove particulate radioactive material.

Other new equipment to be provided for the decontamination project will include temporary lighting and power for the containment building and breathing air systems for workers inside the building. The latter will consist of self-contained breathing apparatus carried by the workers and air from compressed air tanks provided through hoses to masks worn by the operators.

A visual communications system will be available to allow workers to see the actual work area and existing conditions before entering for their assignments.

This system along with a two-way audio control will augment supervision and monitoring of work inside the containment building.

Other new equipment will include a commercial steam generator capable of providing steam at 300 pounds per square inch for decontamination purposes, a water supply and water recycling system, and several large industrial strength vacuum cleaners.

Use of steam is expected to be one of the major tools in reducing contamination within the containment building. The water treatment system will decontaminate water already in the containment building for re-use in the decontamination process, supply and purify any new water that may be required and continually recycle the water used in the decontamination effort. This procedure will greatly reduce the amount of water used in the clean-up.

Key facilities for decontamination of the containment building before human entry will be the existing spray and ventilation systems. The use of these two systems is discussed elsewhere in this report.

EMPLOYMENT AND OTHER LOCAL IMPACTS

The decontamination and reconstruction effort for the TMI-2 reactor containment building (RCB) will require slightly over 4,000,000 work hours. About 25% will be for craft labor, services and site supervision and 25% for engineering and technical services.

Total payroll for this effort is estimated at about $109 million. To the extent feasible, craft and other labor will be drawn from local labor pools or from Met-Ed and other GPU System companies.

Employment levels will range from about 1,000 to 1,400 during the four-year effort. There are currently about 1,400 people working on-site. Normal employment level for TMI is about 600 employees including contractors on-site.

While no effort has been made to gauge the projected dollar value of local purchases, Met-Ed will continue its policy of giving first consideration to local suppliers and contractors, consistant with quality control and materials purchasing needs.

Expenditures to date in conjunction with the Recovery Effort have been about $50 million.