CONSTRUCTION OF A NUCLEAR WASTE REPOSITORY IN BASALT AT HANFORD, WASHINGTON

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I. INTRODUCTION

When I first agreed to prepare this paper I was optimistic that I would be able to objectively report on the actual drilling of the Exploratory Shaft (ES) in basalt and on our preparations for starting underground exploration. That is not the case.

The substance of the paper I am about to present has been affected by the fact that drilling of the Exploratory Shaft at Hanford has been delayed from our initially scheduled start of drilling date of February 1983 to our current schedule of March 1985. This delay was dictated by the necessity of complying with programmatic requirements of the Nuclear Waste Policy Act.

This paper then will be directed toward a review of our plans for completion of the Exploratory Shaft and for completing the underground excavation work currently planned for site characterization, ending with an overview of the conceptual design for a nuclear waste repository in basalt.

It should be clearly understood that the work at Hanford is directed toward studying the basalts to determine the feasibility of constructing a nuclear waste repository in basalt. Actual construction of a repository is contingent upon many factors still under study.

1.0 Hanford and the Nuclear Industry

In January 1943, the Hanford Site in Southeastern Washington State was selected by the Manhattan Engineer District of the Corps of Engineers for the construction of facilities to produce plutonium for the world's first nuclear weapons. In March of that year work was begun on three reactors, three chemical processing plants for recovery of plutonium in the fuel, sixty-four storage tanks, fuel fabrication facilities and 4,300 houses in the community of Richland.

In July 1945, Hanford plutonium was used in the world's first nuclear detonation at Alamagordo, New Mexico. The bomb that was dropped on Nagasaki, Japan also contained Hanford-produced plutonium.

During the years following the Manhattan Project's first controlled chain reaction, researchers recognized that radioactive liquid wastes could be stored safely, on an interim basis, in underground tanks. Then, in the early 1960's, nuclear scientists began to emphasize the need for finding acceptable methods of permanent waste disposal. In the mid-1970s, this effort was accelerated.

In February 1976, the National Waste Terminal Storage Program (NWTS) was established by the U. S. Energy and Research Development Administration (ERDA), predecessor of the U. S. Department of Energy (DOE). The program's mission was to provide facilities for commercial nuclear waste disposal in various geologic formations within the United States. The properties of salt, granite, shale, tuff, and basalt were to be investigated. The basalts underlying the Hanford Site in Southeastern Washington State were selected as one of the candidate rock types for evaluation. This, then is the program that gave rise to the current Basalt Waste Isolation Project (BWIP) and led to development of a conceptual design for construction of a nuclear waste repository in basalt (NWRB).

1.1 Hanford Basalts

Much is known and much is being learned about the Columbia Plateau Basalts underlying the Hanford site. The basalts have been, in the past, studied by the Federal government, State agencies, and academic institutions on irrigation projects, dams, nuclear reactors and nuclear processing plants at or near Hanford. This prior knowledge provided a base which has since been greatly expanded by extensive detailed studies and analyses performed by Rockwell's Basalt Waste Isolation Project Staff. These detailed studies are currently ongoing and continue to add to our knowledge of the Columbia Plateau Basalts.

- Columbia Plateau Basalts in the Pasco Basin (SLIDE 1) comprise one of the largest continental basalt provinces in the world, approximately 41,000 cubic miles in volume with an average thickness of 5,000 feet. Most of the basalt was emplaced during volcanic pulses between 6 and 16 million years ago.

- The Hanford Site covers 570 square miles of the Pasco Basin within the Columbia Plateau (SLIDE 2). The Pasco Basin basalts are overlain with glacial sediments resulting from great floods; in fact, some enthusiastic geologists have described them as the greatest floods known to have occurred anywhere in the world. The sediment layers are about 600 feet thick at Hanford's reference repository location (RRL).

II. REPOSITORY EXPLORATION ACTIVITIES

2.0 Exploratory Shaft Construction

The first step toward actual underground exploration of the reference repository location (RRL) will consist of the drilling of an exploratory shaft (ES). This shaft, as currently envisioned, will be drilled and cased through the overlying sediments and basalts to the total depth of 3,960 feet (SLIDE 3 - RRL GEOLOGIC COLUMN).

The exploratory shaft will be drilled with conventional rotary drilling equipment designed and built specifically for large diameter shaft drilling. This particular drilling rig has been used to drill 120-inch diameter shafts to depths in excess of 4,800 feet and was used to drill the deepest oil/gas exploration hole that has been drilled in the western world, an 8.5-inch diameter hole that went to a depth of 31,411 feet. This hole was stopped when the drillers hit molten sulfur.

The rig has a rated hook load capacity of 1,555,000 pounds, the rotary table is powered by three 1,000 HP D.C. electric motors (SLIDES 4 & 5).

Drill cuttings will be removed from the bottom of the bore hole by means of a simple, air assisted, reverse circulation system. Drilling fluid, essentially free-standing in the bore hole, will flow across the face of the drill bit and up the drill pipe to the surface. Compressed air will be injected into the upper portion of the drill pipe to assist the fluid mud flow. The mud will be discharged into surface mud pits to allow drill cuttings to settle out before recirculation into the shaft bore.

The shaft will be completed in two phases. The first phase will consist of drilling, casing, and grouting the upper portion of the shaft - that portion of the shaft that penetrates the glacial sediments overlying the basalts. This portion of the shaft will be drilled to a depth of 640 vertical feet at a diameter of 144 inches with a bit equipped with mill-tooth cutters. The 640 feet of shaft will be cased with a 112 inch diameter casing, run in 40 foot sections. The casing will be open-ended and will be bottomed on a concrete plug placed at the bottom of the shaft bore hole. The casing annulus will be filled with cement grout over the entire vertical length of the casing.

The second phase of shaft work will consist of drilling, casing, and grouting the lower portion of the shaft (the portion that penetrates the basalt flows) from a depth of 640 feet to the total shaft depth of 3,960 feet. This portion of the shaft will be drilled a vertical distance of 3,320 feet at a diameter of 110 inches with bits equipped with strawberry cutters with tungsten-carbide (TC) inserts (SLIDES 6 & 7).

The final casing run will consist of 72-inch diameter sections, 80 feet in length, to be run to a depth of 3,900 feet. This will be closed-ended, water tight casing and must be floated into place. Thus, as each 80 foot section of casing is welded to the casing string under the rig, the casing interior will be filled with sufficient water to cause the string to "sink" into the drilling fluid (mud) filling the shaft bore hole. In this manner the casing string, with a dry weight of 5.8 million pounds, will be kept within the hook load capacity of the drill rig until it can be grouted into place.

Once the casing string has been run in the shaft bore hole it will be grouted - that is, the casing annulus will be filled with cement grout over the entire vertical length of the casing (SLIDES 8, 9, and 10).

The grouting procedure for the 72-inch diameter casing will differ from the 112-inch diameter casing grouting procedure in one very significant detail (SLIDE 11).

This detail has to do with placement of chemical seal rings above and below the location selected for making the shaft breakout. This chemical seal will function as a pressure ring to effectively stop the vertical movement of ground water adjacent to the casing, in the event that the grout seal is not one hundred percent tight to the casing. The composition of this chemical seal and the method of placement is a patented process and the patent holder does not, unfortunately, give out a great deal of information on the subject.

Now that we have successfully drilled and cased the Exploratory Shaft we are ready to demobilize the drilling equipment and make haste to get ourselves underground!

2.1 Exploratory Shaft Surface Plant

Construction of surface plant facilities will be started well before completion of shaft drilling operations. Ideally, plant facilities will be at or near completion concurrent with the end of drilling. The uncertainty of drill penetration rates, and therefore determination of the total time required for drilling contrive to make actual scheduling of these activities somewhat uncertain.

The Exploratory Shaft surface plant will consist of those facilities required to support the planned underground exploration and testing activities (SLIDE 12). These include primary and emergency hoisting systems, explosive storage, ntilation air cooling towers, and temporary office b ildings.

When the surface plant is in place and functional a concentrated effort will be made to dewater and equip the shaft to access the basalt flow selected for characterization.

2.2 Underground Excavation, Phase I

A port hole drilling program will be started as soon as the shaft is equipped and otherwise made accessible. This program will require the drilling of a series of holes at different elevations, from the shaft into the various basalt flows penetrated by the shaft bore. The purpose of this drilling will be to determine the effectiveness of the casing grouting in stopping the vertical movement of ground water adjacent to the shaft. If all proves well at the conclusion of this drilling, a shaft breakout will be made at the elevation of the basalt flow selected for characterization.

The initial approach to underground excavation will consist of mining approximately 50 linear feet of drift (SLIDE 11) normal to the shaft from the point of breakout. This work will be done by conventional drill and blast methods. (I might also add that this work will be done very carefully in order to avoid any damage to the shaft.) Hand-held Jackleg type rock drills, powered by compressed air will be used for drilling blast holes and small, compressed air powered, scrapers will be used for removal of blasted rock. Broken rock will be loaded directly into a bucket at the shaft and hoisted to the surface for disposal.

2.3 Underground Excavation, Phase II

The second phase of underground excavation, which will consist entirely of extending the initial 50 feet of drift further into the basalt, will not be started until and/or unless all aspects of Phase I excavation are positive.

Phase II will require the excavation of approximately 5,500 cubic yards of rock and the installation of all utilities and facilities required to perform the mining and to support scheduled follow-on test activities (SLIDE 14). Phase II mining will also be done by conventional drill and blast methods and with conventional mining equipment. However, the volume of excavated rock to be handled and the materials required for ground support and for construction of underground facilities dictate that shaft materials handling facilities be upgraded (SLIDES 15 & 16).

Phase II equipment will consist of an electric/hydraulic two-boom drill jumbo, rubber-tired loader hopper units (similar to the Atlas Copco CAVO machines), shotcrete equipment, and miscellaneous small tools such as pumps, impact wrenches, and hand-held rock drills.

Smooth wall blasting techniques will be used for all Phase I and Phase II excavation.

Ground support will consist of rock bolts in all excavated areas, steel station sets adjacent to the shaft breakout area, and shotcrete (to be applied over the rock bolts) as conditions require.

III. REPOSITORY CONSTRUCTION

3.0 General

The current design for a nuclear waste repository in basalt exists in conceptual form only and, as such, is subject to review and revision on a continuous basis. Because of the fluidity of the design, any discussion runs the risk of presenting outdated information. Further, I am sure that information gained from the Exploratory Shaft program will have a strong impact on the final design of a repository in basalt. At an extreme, such information could indicate that the Columbia Basalts do not present a favorable geological environment and that any design is superfluous.

However, prudence dictates that we not look at only the dark side of any particular situation that has the potential for both positive and negative results. Therefore, we shall discuss the current conceptual design with the admonition that what we see here may not be what will be shown in the future (SLIDES 17 & 18).

The conceptual design is comprised of from 15,000 to 20,000 feet of vertical shaft and over 200 miles of horizontal excavation. The areal extent of the underground workings exceeds 2,300 acres. The repository is laid out in twenty panels, each of which represents one year's accumulation of nuclear waste.

Methods of excavation, ground support requirements and techniques, muck removal--all of these are still open for evaluation and properly so.

This concludes my presentation.