LARGE DIAMETER SHAFT CONSTRUCTION IN SALT

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ABSTRACT

The U.S. Department of Energy (DOE) has a program to identify and develop potential repository sites in salt formations for storage of commercial high-level nuclear waste. Parsons-Redpath, a Joint Venture of The Ralph M. Parsons Company and the J.S. Redpath Corporation, is the Construction Manager (CM) for the Exploratory Shaft Facility (ESF) in Salt Project. A large diameter vertical shaft will be excavated to provide access to the referenced horizon in a salt formation for in-situ testing and site characterization.

BACKGROUND AND OVERVIEW

Some parts of the ESF-Salt may be subject to licensing consideration by the Nuclear Regulatory Commission (NRC) if it is chosen as the repository site. Because of this, and out of concern for public safety and protection of the environment, the materials used and work accomplished at the ESF will be controlled consistent with "nuclear" requirements, i.e., ANSI/ASME NQA-1, Quality Assurance Program Requirements for Nuclear Facilities, and related documents.

Quality Assurance (QA) is an integral part of the set of management controls that is used to govern Project construction management activities. A popular definition for QA is that it encompasses all those planned and systematic actions necessary to provide adequate confidence that a structure, system or component will perform satisfactorily in service. In different terms, QA is what one does to make sure one gets what one pays for. All discipline managers whose functions affect quality must actively support the Quality Program to assure full compliance with project requirements. Management controls govern all of the significant construction-related activities such as design reviews, procurement actions, design control, fabrication process control, surface construction, drilling and mining, inspections and surveillances, qualification and acceptance testing, operations and maintenance, document control, and records management.

Management controls are described in a set of approved policies and procedures (see Fig. 1). These documents form the basis for ensuring consistency of management and a planned, systematic approach to reach Project goals through a coordinated expenditure of available resource within defined constraints (i.e., schedule, budget, quality level, safety limits, etc.). The ESF-Salt Project uses a Performance Measurement System (PMS) to discretely identify work tasks (in terms of schedule and costs), assign responsibilities and to track progress. Analyses of PMS data provides management visibility of performance and productivity, information needed for effective construction management (see Fig. 2).

In addition to planning for NRC licensing eventualities, consideration must be given to developing Environmental assessments and to obtaining the necessary federal, state and local permits and licenses for constructing the ESF-Salt Maintenance of some permits (e.g., Air Quality) will continue for the life of the Project. The licensing and permit requirements for the ESF-Salt are relatively complex and comprehensive. They certainly distinguish this Construction Project (and similar ones) from most of the other major construction projects in the world. While requirements for construction of nuclear power plants parallel those for a high-level nuclear waste repository, the unique nature of a repository (i.e., very long-term storage) dictates an interpretive application of regulatory provisions to the entire research/development, design, construction, testing and operations process. We anticipate acquiring several major permits and licenses (and numerous lesser licenses/permits) in conjunction with the construction process, and then monitoring selected parameters to maintain designated permits and licenses.

The current planning schedule (see Fig. 3) calls for start of shaft construction by September, 1986 (surface preparation work would start in June, 1986) and completion of the shaft by February, 1988. The underground construction work to mine out up to 1,800 feet of drifts for in-situ tests to support site characterization is scheduled to begin in March, 1988, and should be completed in August, 1988. Surface and underground facilities will then be maintained and operated until testing is completed in about April, 1989. Shortly thereafter, a decision will be made to designate the ESF-Salt as the repository site or to abandon it and reclaim the site.

The site for the ESF-Salt has not yet been designated. Several potential locations in Louisiana, Mississippi, Texas and Utah are being

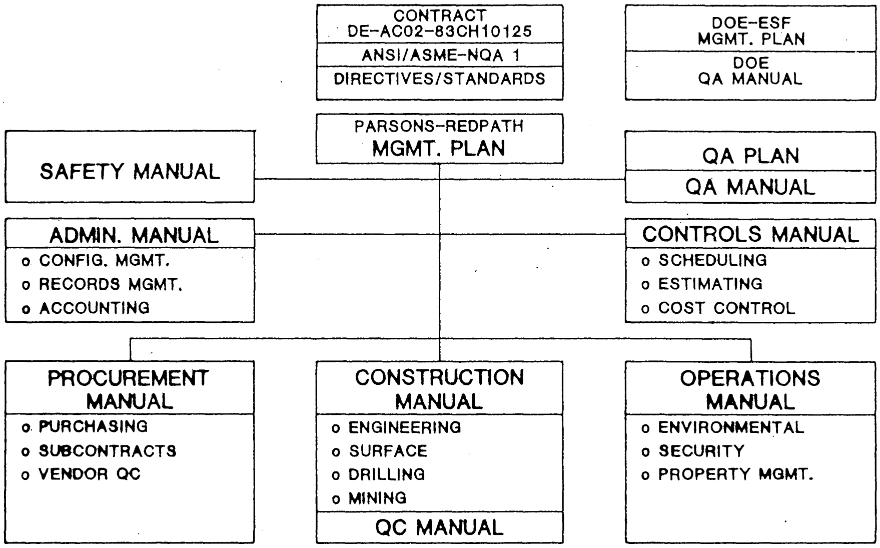

Fig. 1 Management Documents
Exploratory Shaft Facility - Shaft

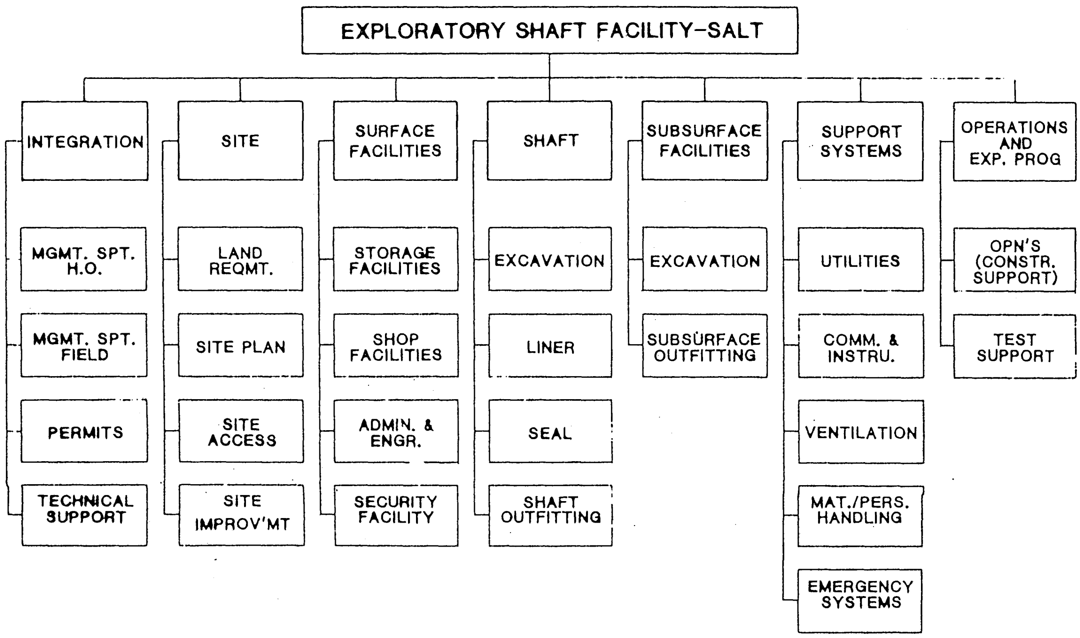

Fig. 2 Performance Measurement System

evaluated for suitability. The salt site will be recommended for Presidential consideration in January, 1985; a Presidential decision on salt-site selection is now planned for March, 1985. Alternative preliminary designs have been done for the prospective sites; these have been supported by construction scheduling and cost estimates to allow an efficient start-up program when the site(s) is selected. All of the prospective sites are technically suitable candidates for an ESF from a construction standpoint. They share some common characteristics and each one has some uniqueness to be considered for construction. Many other factors (such as socio-economic issues) have been factored into the site evlauation and selection process; however, the CM's interest is primarily oriented to construction-related matters.

Two basic methods (or a combination thereof) exist for excavating the exploratory shaft in salt:

1. "Drill and Blast" (i.e., freeze and "mine"), and

2. "Blind-Boring" using big-hole drilling and casing techniques.

The ESF-Salt Project is committed to the second method. We intend to use big-hole drilling procedures to sink the exploratory shaft at the salt site (see Fig. 4).

The at-depth shaft will be approximately 14 feet in drilled diameter to a depth of about 3,000 feet; it will be fully lined with a ten-foot nominal inside diameter steel casing and will be cement-sealed to prevent vertical movement of aquifer water within the hole. Surface facilities required to support exploratory shaft underground activities will include a headframe and hoisting system, generator building and transformer yeard, security systems, office facilities, roadways, excavated salt storage areas, etc. The equipment needed for ESF-Salt construction can be categorized to support three basic activities: 1) surface construction, 2) drilling operations, and 3) underground construction and testing.

Surface construction will initially be site preparation work to ready the site for drilling operations and casing fabrication. Site preparation requirements vary considerably for the candidate locations. While some items such as a suitable drill pad, mud pits and a lay-down area are common to all sites, geographic differences will govern other construction items such as roads/access, groundwork/surfacing, power availability, water sources, worker accommodations, etc. Accordingly, our construction planning is coordinated along two basic lines; those services and items common to all sites and those which are site-specific. Procurement packages have been defined in two broad categories also, those that have a site-common relationship and those which are site-specific. Procurement actions have been prioritized and scheduled with emphasis on maximum flexibility and cost efficiency in acquiring equipment and materials. For example, the drill tools needed to bore the exploratory shaft have been broken out into two packages: one that can be used at all of the sites, and one that will be tailored to site-specific requirements when the ESF-Salt site is officially selected. Additionally, the site-common drill tool package identifies the long-lead items such as drill pipe and the mandrel which require longer procurement time than the site-specific components, which will be off-the-shelf components to the extent possible.

This will be one of the largest shaft drilling programs ever undertaken. It will, however, be done using state-of-the-art technology to fabricate the drill tools, the drill rig and support equipment. The basic techniques for big-hole drilling have been adapted from petroleum industry practices. A great deal of the refinement work has been done on the Nevada Test Site in conjunction with emplacement of nuclear devices for underground testing. Drilling industry hardware and techniques have been tailored and "scaled up" for big-hole application. The drill rig we envision for use on this Project will be sized to handle loads of about 2.5 million pounds and will be geometrically capable of handling casing joints which exceed 18 feet in diameter and casing sections (i.e., cans) that exceed standard industry lengths. The drill string will incorporate a stabilized drilling assembly with weights of about 750,000 pounds, using both stabilization and the "pendulum effect" (i.e., Newton's Law of Motion) to ensure hole verticality. Conventional monitoring methods (e.g., inclination surveys, caliper logs, etc.) will be adapted for use on the exploratory shaft to verify design parameters.

For purposes of discussion (with no reason of site preference), drilling operations anticipated for use in the Permian Basin in Texas will be described to illustrate application of techniques (refer to Fig. 5). An initial hole excavated to a diameter of about 25 feet would be lined with conductor casing and cemented to a depth of about 100 feet; excavation would either be done using a clamshell or an auger. A hole about 22'6" in diameter would be drilled through the Ogallala formation to a depth of plus 400 feet and a "surface" casing run; and cemented from that depth to the surface for aquifer isolation. Next a hole of about 18'6" diameter would be drilled through the Dockum formation to a depth of plus 1,100 feet and an "intermediate" casing run and cemented from that depth to the surface for aquifér protection. Finally, a 14' diameter hole would be drilled to the test horizon in the salt formation at about 3,000 feet and a "final" 10' I.D. casing cemented from total depth to the surface. Chemical seals would be strategically emplaced in the cement annular column to further enhance the prevention of vertical migration between aquifers or to the test horizon.

The big-hole drilling method for sinking the exploratory shaft is the preferred excavation method, particularly in locations with producing/prolific aquifers. It optimizes the ability to isolate and protect the aquifers and preclude water migration into the salt formation test horizon. Protecting the aquifers is necessary from environmental and socio-economic standpoints to ensure high-quality water availability for consumption. Preventing aquifer penetration to the salt test horizon eliminates the potential for erosion/leaching and migration of any contaminants back to the aquifers. The plasticity or self-healing characteristic of salt enhances its desirability as a deep storage medium for nuclear

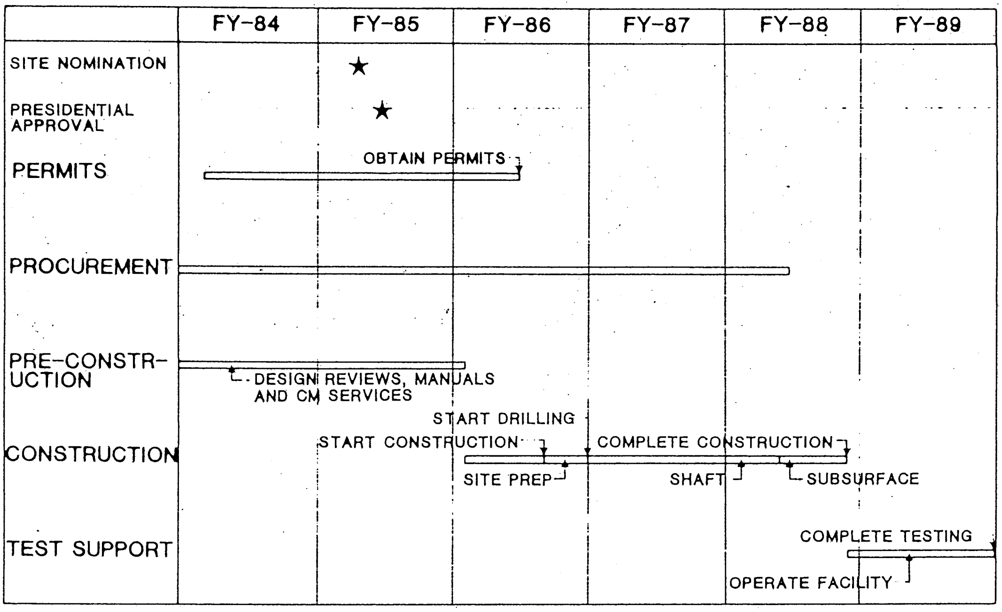

Fig. 3 Current Planning Schedule
Exploratory Shaft Facility - Salt

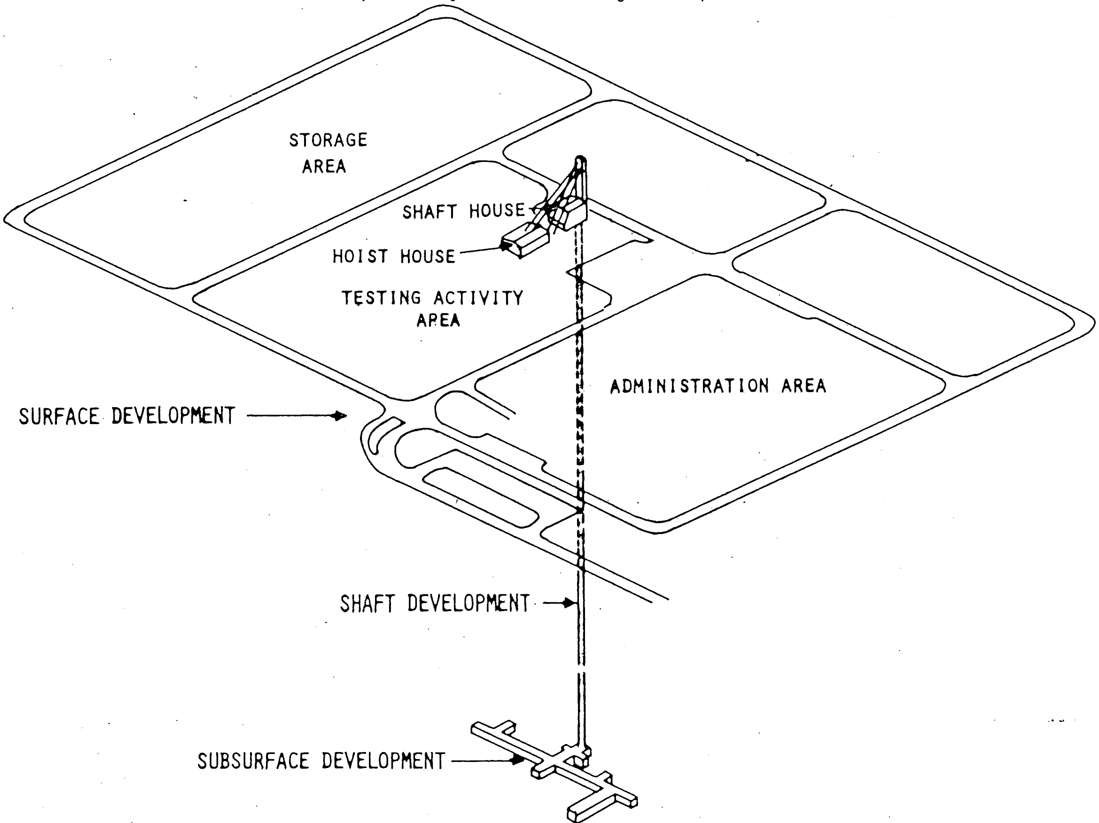

Fig. 4 Schematic Layout of Exploratory Shaft Facility - Salt Permian Basin

BLIND HOLE DRILLING

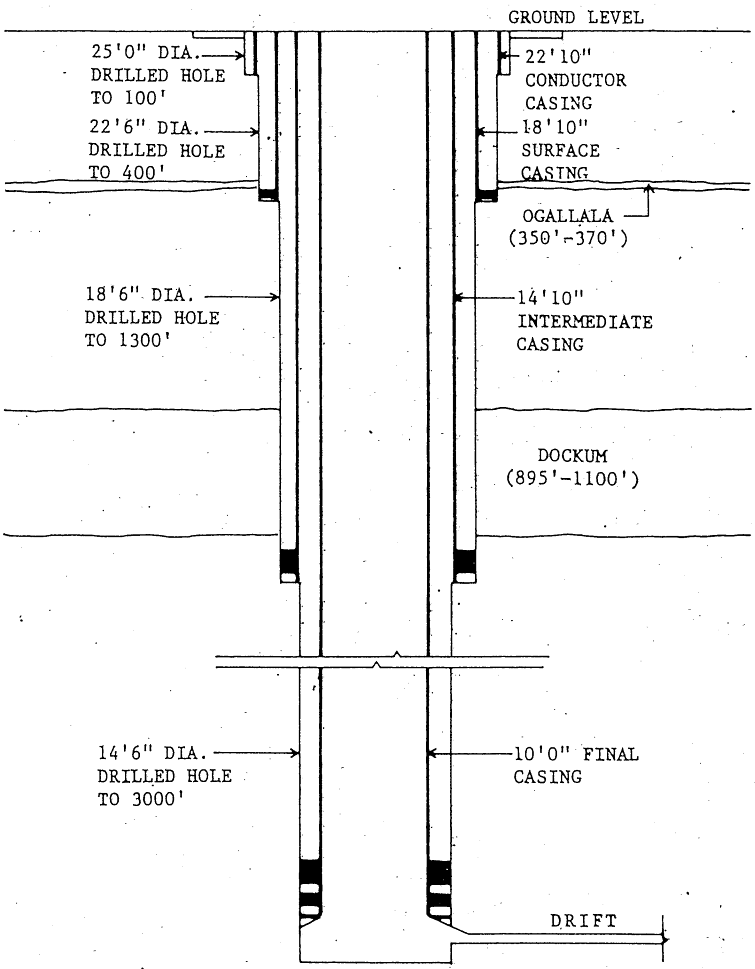

Fig. 5 Preliminary Sketch of Shaft Construction Method -- Permian Basin

materials. Under the conditions of conservative design that exist with multiple physical barriers being envisioned between the nuclear material and the accessible environment, the practical possibility of waste migration appears to be nonexistent. Additionally, using the big-hole drilling method for this project will enhance the safety aspects of the job by eliminating the need for having people "down hole" until after it is fully lined and sealed. It should also be much more schedule-efficient than the drill and blast method to the extent that it will be more cost effective on an overall basis, although big-hole drilling entails the use of considerably more capital equipment from an initial investment standpoint than mining techniques do.

Conventional (i.e., existing) drill rig designs will be adequate for our purposes. Some physical scaling-up of the mast may be needed for some designs to provide the required working load capacity with an acceptable safety margin, and to be geometrically capable of handling the large diameter joints of pipe when running the casing "down hole." Existing materials and fabrication techniques can be used for the rig work.

Casing material and fabrication process control will be consistent with the basic requirements of ANSI/ASME NQA-1, Quality Assurance Program Requirements for Nuclear Facilities, as will the control of lining/sealing materials. As mentioned previously, this is necessary because the shaft and lining (i.e., casing, cement and seals) will be subject to NRC licensing if the ESF-Salt is chosen as the site for the repository. These licensing considerations dictate development and implementation of formal document control and records management systems (among others) to ensure an adequate paper trail exists to verify material characteristics and application of fabrication processes. Documentation requirements for this Project will be considerably more than those normally needed for a construction job although the conceptual approach is the same. In other words, the same tasks need to be done on the ESF-Salt Project that would be done on a conventional job, but qualification, certification and verification of those tasks need increased management attention and documentation. Formal definition of system controls is mandatory to demonstrate their existence. These documented controls (i.e., written procedures) must be subjected to appropriate reviews for assessment of adequacy. Then, a continuing program must be implemented to verify that personnel satisfactorily comply with the approved procedures and that specified results of activities are recorded properly. The necessary management system is not really too much different from that required for a well-run construction project. It does require formalization through written policies and procedures along with comprehensive documentation to record specified aspects of the various activities.

Casing segments (i.e., plate steel) or completed casing sections (i.e., "cans") will be transported to the site consistent with transportation constraints. Final welding of the larger sections of casing will be done on-site using qualified welders and welding procedures. The sections of casing will be assembled into the different strings "over the hole", again using qualified welders and welding procedures. All structural welds will be subjected to nondestructive examination (NDE), i.e., radiography and ultrasonic, to ensure their quality. Close coordination is required during the design phase between the CM and the architect-engineer (A/E) to assure that constructibility, inspectibility and operability features are incorporated in the design. For example, inspection ports must be provided in each casing section "can" to allow insertion of a radiographic source after circumferential welds are accomplished "over the hole".

All strings of casing will be cemented in place from the bottom of each string to the surface Volumetric monitoring material's balance and cement bond logs will be used to determine the competency of the "cement job". Chemical seals will be emplaced both remotely and manually above the repository horizon to prevent water migration and resulting damage to the salt formation.

SUMMARY

An emphasis on preventive rather than reactive management is key to an efficient construction management program. Development of contingency plans to deal with unexpected events, e.g., unforseen hole conditions during drilling operations, demonstrations and/or riots, severe weather, fires, etc., are an integral part of the management program to ensure project safety, quality, cost, schedule and environmental objectives are met. A well defined set of management controls for governing important activities is essential to the success of a complex Project, particularly one that requires comprehensive documentation coverage for potential licensing by the NRC. Work tasks must be individually identified, scheduled and tracked to completion to ensure the job is efficiently done. ESF-Salt Project requirements mandate formalization of the Construction Management System, implementation of practical working procedures and good records-keeping to making sure evidence exists that tasks were satisfactorily accomplished in a timely and cost effective manner. Extensive paperwork is a tedious but necessary part of the ESF-Salt Project to prove the adequacy of the job to the most critical of observers.

REFERENCES

1. 10 CFR 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.

2. 10 CFR 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories; Proposed Licensing Procedures.

3. ANSI/ASME NQA-1-1983, Quality Assurance Program Requirements for Nuclear Facilities.

4. Parsons-Redpath Project Construction Management Plan for ESF-Salt, *issued 6/17/83*.

5. Parsons-Redpath Quality Assurance Manual for ESF-Salt, issued 9/30/83.