ENGINEERS INTERNATIONAL, INC.

P.O. BOX NO. 43817
TUCSON, AZ. 85733-3817
TELEPHONE: 602/884-8818

28 October 1988
Ref. No. 1148-09-05

Waste Management Engineering Branch
Division of Waste Management
U. S. Nuclear Regulatory Commission
Mail Stop 4-H-3
Washington, D.C. 20555

Attention: Mr. John T. Buckley, Project Officer

Subject: Transmittal of a rough draft position paper entitled, "Technical Position on Construction Specifications for the Exploratory Shafts and the Exploratory Shaft Facility", dated 20 October, 1988.

Dear Mr. Buckley,

Enclosed, please find one (1) review copy of the subject technical position paper. We have left it unbound to facilitate your making copies for distribution to interested parties.

We would welcome your comments and questions, which may be directed to the undersigned. Upon your direction, we will forward the number of corrected copies in final form that you specify.

Sincerely,
ENGINEERS INTERNATIONAL, INC.

Robert A. Cummings

Robert A. Cummings
Principal Geological Engineer

enc.

NH14
D1004
WM-11

TABLE OF CONTENTS

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) is required by the Nuclear Waste Policy Act of 1982 and by 10 CFR Part 60 to conduct a program of site characterization before submitting an application for license to construct a repository. "Site characterization" is a program of both testing and exploration.

The repository design, under which the license application would be made, will need to be adequately supported by testing that represents repository conditions and measures resulting rock mass behavior, both in the host rock, and in adjacent strata whose behavior may be important to repository performance. Exploration of rock mass conditions must also be done, to establish the representativeness of the tests and of the performance calculations presented in support of the design.

Some of these tests and measurements will be performed at depth, in an Exploratory Shaft Facility constructed especially for the purposes of testing and exploration of the host rock. Access to the subsurface for purposes of site characterization and at-depth testing will be achieved through one or more Exploratory Shafts (ESs).

The ESs will not merely provide access to the ESF for subsurface testing, however. The construction of the ESs and ESF will yield data about the site geologic conditions, response of the rock mass to excavation, site hydrogeology, and shaft and drift constructability, which will be of use in overall site characterization, repository design, seal design, and performance assessment. Depending on program needs and findings, the ESs and ESF may also permit expanded subsurface exploration, by drilling or by limited lateral excavation from various locations along the shafts.

This construction and testing is not without limitation, however. ES and ESF construction, and related testing and exploration, should not compromise the ability of the site to meet the performance objectives prescribed in 10 CFR 60. Meeting these performance objectives not only means controlling any potentially-adverse effects on the host rock, but it also means controlling any potentially-adverse effects on the ability to effectively seal the repository openings, to safely carry out repository operations, and, should it be necessary, to safely and effectively retrieve the waste. In addition, ES and ESF construction, exploration, and testing methodologies must not compromise the accuracy, generality, or suitability of data to be used in satisfying site characterization, repository design, performance assessments, or other licensing requirements.

The manner of construction of the ES and ESF can materially affect how site characterization is conceived and carried out. The ESF will provide baseline data and continuing information on repository performance over the long term. Because present plans call for the ESs to support repository construction and to play an important role in repository operation to remove ventilation exhaust, ES construction is also tied to repository design, construction, and operation. Repository sealing and decommissioning plans will need to cover all repository components, including the ES and ESF, so as to assure that the performance objectives of 10 CFR 60 will be met. The ESs and ESF will need to be considered in retrieval plans.

In order to simultaneously realize the objectives of adequate site characterization, representativeness of test data, and satisfactory projections of repository performance, both the construction and testing activities of the ESs and ESF need to be stringently controlled. In a day-to-day sense, the plans and specifications will constitute the vehicle for such control. The implementation of the controls called for in the plans and specifications will determine the conformance of the constructed facility, and the data generated from it, with the objectives of the design and of regulatory measures such as 10 CFR 60.

The discussion sections of this paper identify some of the major aspects and considerations for the ESF specifications documents so that the regulatory import of 10 CFR 60 to the construction documents is apparent before the specifications are written. If this import is covered in the construction documents, there will be increased assurance that the constructed facility will be qualified for licensing, and decreased uncertainty in the performance expectations of the repository. A major subject of this paper is to examine the applicability of common specification provisions for shaft and tunnel projects of this magnitude, particularly the use of existing trade specifications, for conformance with the regulatory requirements of this particular application.

Therefore, this Technical Position has been prepared to provide the NRC staff with information on aspects of the construction specifications that are important in forecasting satisfaction of 10 CFR 60 requirements.

2.0 REGULATORY BACKGROUND

The ESs and ESF are to enable the program of site characterization required by 10 CFR 60.10 to occur prior to the submittal of an application for a license to construct a HLW repository. Additionally, to the extent that these exploratory facilities may become integral parts of and affect the performance of the repository, specifications for the construction of the facility must be also be supportive of various sections of 10 CFR 60 dealing with items important to waste isolation, containment, safety, and performance confirmation.

2.1. Regulatory Basis for ESF Impacts on Site Characterization

Regarding site characterization as described in Part 60.10, Paragraph [d] requires the following.

> (1) Investigations to obtain the required information shall be conducted in such a manner as to limit adverse effects on the long-term performance of the geologic repository to the extent practical.
> (3) To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for underground facility construction and operation or where large unexcavated pillars are planned.
> (4) Subsurface exploratory drilling, excavation, and in situ testing before and during construction shall be planned and coordinated with geologic repository area operations design and construction.

The DOE is also required, by 10 CFR 60.21, to provide a detailed description of subsurface conditions which is to include the following information:

[A] The orientation, distribution, aperture in-filling, and origin of fractures, discontinuities, and heterogeneities;
[B] the presence and characteristics of other potential pathways such as solution features, breccia pipes, or other potentially permeable features;
[C] the geomechanical properties and conditions, including pore pressure and ambient stress conditions;
[D] the hydrogeologic properties and conditions;
[E] the geochemical properties; and
[F] the anticipated response of the geomechanical, hydrogeologic, and and geochemical systems to the maximum design thermal loading, given the pattern of fractures and other discontinuities and the heat transfer properties of the rock mass and groundwater.

The above information will also be needed, along with other information, for investigations of the siting criteria listed in 10 CFR 60.122. Measurements of site characteristics pertaining to these criteria, and analyses derived therefrom, must support the Safety Analysis Report, as required by 10 CFR 60.11.

Opportunities to collect this information will occur during the construction of the ESs and the ESF. Activities to collect this information will impact methods and operations used in construction and in preparations for testing. These methods and operations must allow the information to be fully obtained before critical exposures or regions in the rock become concealed, altered, or inaccessible due to the progress of construction or testing.

2.2. Regulatory Basis for ESF Impacts on Repository Post-Closure Performance

For purposes of this Technical Posaition, the discussion of potential ESF post-closure performance impacts includes aspects of waste isolation, waste containment, and aspects of sealing that could be important to assuring effective containment and isolation.

2.2.1. Definitions

Items important to waste isolation, containment, and the sealing of shafts and boreholes are subject to definitions contained in 10 CFR 60.2.

Part 60.102 further describes physical areas relating to isolation, including the geologic setting and the geologic repository. The geologic setting includes the geologic, hydrologic and geochemical systems of the region in which a geologic repository operations area is or may be located. At the time of license application, the ESs and ESF will exist within these systems, have the potential to modify their behaviors, and have the potential to modify the perception of these systems gained through site characterization.

The geologic repository includes the operations area plus that portion of the geologic setting that provides isolation of the radioactive waste. Present design concepts incorporate the ESs and the ESF into the repository, and they therefore would be included in the definition of the geologic repository operations area. This Part specifically excludes shafts, boreholes, and their seals from the definition of the underground facility, but would not exclude other portions of the ESF from this definition. Therefore portions of the ESF may be considered parts of the engineered barrier system, which should perform in conjunction with the geologic setting to achieve control of radioactive releases.

The requirements of 10 CFR 60 are qualified in many areas as to the degree of assurance and completeness required in forecasting compliance. It is not necessary to prove absolute compliance with the performance measures involving long periods in the future, but instead to offer "reasonable assurance" that the performance objectives will be met. It is also necessary to attain reasonable assurance of "substantially complete" containment under 10 CFR 60.113, subject to the overall system performance requirements.

2.2.2. Importance to Waste Isolation

Items important to waste isolation are subject to regulations contained in 10 CFR Parts 60.112 and 60.113.

Part 60.112, <u>Overall system performance objective for the geologic repository after permanent closure</u>, provides the basis for overall performance criteria after permanent closure:

> The geologic setting shall be selected and the engineered barrier system and the shafts, boreholes and their seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency with respect to both anticipated processes and events and unanticipated processes and events.

Performance criteria for particular barriers after permanent closure are described in 10 CFR Part 60.113. It specifies the containment period that the engineered barrier system must be reasonably assured of achieving, the pre-waste-emplacement groundwater travel time, and the permissible release rates following the containment period. Although anticipated processes and events are to be the basis for the evaluations, the Commission is entitled to consider any particular sources of uncertainty, and this would include those that may be related to the presence of the ES and ESF, or the design of the underground facility. The contribution, if any, of the ES and ESF to the pre-waste-emplacement groundwater travel time must be addressed.

Part 60.133 sets forth criteria that must be implemented by the specifications with respect to various aspects of the underground facility. One of these aspects is flexibility of design: "The underground facility shall be designed with sufficient flexibility to allow adjustments where necessary to accommodate specific site conditions identified through in situ monitoring, testing, or excavation." In addition, 10 CFR 60.133 requires that the layout, orientation, geometry, and depth of the underground facility, and the design of engineered barriers, contribute to containment and isolation; that the design provide for control of water and gas intrusion; that the potential for deleterious fracturing and rock movement be reduced; that the potential for creating preferential pathways be reduced; that engineered barriers be designed to assist in meeting post-closure performance objectives; and that thermal loads be taken into account.

2.2.3. Importance to Containment (Post Closure)

Concepts pertaining to the relative roles of containment and isolation in overall repository performance are found in 10 CFR 60.102(e), which refers to an emphasis on containment during the period immediately following permanent closure. Containment is chiefly provided by the waste package. The requirements for containment are given in 10 CFR 60.113(ii)(A). In analyzing the ability to provide satisfactory containment, the DOE must consider the ESs and the ESF, as they will be constructed, and any potential direct or indirect impacts these facilities may have on the waste package environment or on the waste packages themselves.

2.2.4. Sealing

Part 60.134 sets forth the general criteria for the design of seals in shafts and boreholes. Seals must be designed to eliminate the potential for shafts and boreholes to become preferential pathways that could compromise the ability of the geologic repository to meet the post-closure performance objectives. To the extent that the ESF may be important in post-closure performance, seals will need to be provided in accordance with 10 CFR 60.134.

The standard for seal effectiveness set by 10 CFR 60.134(a) is stringent. A high level of design assurance against the creation of pathways is required, (the design must assure that shafts and boreholes "do not" become pathways). Furthermore, the pathways to be eliminated need only potentially compromise the ability to meet the performance objectives; there need not be a definite deficiency in projected performance to warrant the provision of seals. In 10 CFR 60.134(b), the standard for the implementation of the design in construction (designation of materials and placement methods) is given with respect to two occurrences: potential groundwater preferential pathways and existing radionuclide migration pathways. The standard is not to reduce these to just below some perceived threshold of performance impact, but to reduce them to the extent practicable, through the choice of materials and placement methods. Furthermore, the language in 10 CFR 60.134 (b) says nothing about a potential preferential groundwater pathway having a predicted performance impact, or that there be a prediction that radionuclide migration would actually occur along existing pathways. Sealing must be accomplished irrespective of such predictions.

2.3. Other ESF Regulatory Impacts

The ESs and ESF, being incorporated into the repository and being involved in the collection of data that will be used in the design of retrieval systems and in the setting of baselines for performance evaluations, will be subject to various other regulatory provisions.

2.3.1. Pre-Closure Safety and Containment

Present repository operational concepts intend for the ESs to be used only for development ventilation exhaust. The portions of the ESF in the underground facility are not projected to be directly involved in waste emplacement operations, in the sense that waste is not intended to be transported through or emplaced in the ESF openings, and ESF openings are intended to be kept separate from emplacement-side ventilation and utilities.

This does not mean that the construction of the ESs and ESF will necessarily be irrelevant to safety and operational issues during the preclosure period, however. In underground work, space and access are difficult to attain. There has already been recognition of this fact in the conceptual design, which assumes that the ESF and the shafts will support repository construction. A potential also exists for the ESF openings and shafts to be supportive of emplacement operations in ways not presently envisioned at the present conceptual stage of the repository design.

Examples are auxiliary ventilation during transitional periods (particularly early in repository operations when the extent of subsurface workings is limited) or as a result of off-normal events, including retrieval; for routing of cables for critical data transmission, monitoring, or communications; as a part of the escapeway for personnel in the event of an accident, fire, or flood; or for subsurface lag storage of waste during potential retrieval operations.

The ESF subsurface workings are also near the planned location of a performance confirmation area. This area will be a site of waste emplacement and will be ventilated and maintained in accordance with practices intended for other emplacement activities, yet may experience higher levels of personnel activity than emplacement panels without special performance confirmation designation. As the design is refined, direct or indirect interactions of this area with the adjacent ESF should be considered as to ways that could impact safety or containment.

The provisions of 10 CFR 60.131 are for general design of the repository operations area. As mentioned previously, the ESF must be included in the definition of the repository operations area, so the provisions of Part 60.131 may apply. In considering the applicability of Part 60.131, even if they are not considered to be systems, structures, and components important to safety, the ESs and ESF must be considered as potential direct or indirect sources of disruptive events such as those listed (fires, equipment failures, need for monitoring and instrumentation equipment, emergency capability, and so on) against which systems, structures, and components important to safety must be designed.

Additional design criteria covered under 10 CFR 60.133 may impact preclosure containment and the overall safety of operations. These apply to the underground facility irrespective of predictions of importance to safety, containment, or isolation.

2.3.2. Retrievability

Present retrieval concepts do not identify any planned role for the ESs or the ESF. However, these concepts are very preliminary and there remains a potential for these facilities to become involved under some retrieval scenarios. Requirements for retrieval are covered under 10 CFR Parts 60.133(c) and 111(b).

2.3.3. Quality Assurance

Subpart G of 10 CFR 60 deals with Quality Assurance. Part 60.151 "Applicability," states that site characterization efforts and performance confirmation data collection shall be included in the Quality Assurance program. Many activities within the ESs and ESF will be critical to collection of site characterization or performance baseline data, or may affect the quality of those data. Therefore, a QA program is needed for the ESs and the ESF irrespective of any further need for a QA program on the grounds of perceived importance to safety, or to design and characterization of barriers important to isolation.

The NRC established its technical position and identified various information needs, with respect to QA for License Application and Site Characterization, in a technical position document, NUREG-1318. This staff technical position indicates the manner in which QA grading procedures for nuclear facilities as set forth by NQA-1 (ANSI/ASME, 1986), Appendix 4A-1, Section 5.0 have been modified for use in the repository program. The grading, in general, is to be in accordance with the complexity, impact of malfunctions, level of special surveillance needed, quality history and degree of standardization involved with the item or activity, and other criteria. Grading of QA would apply to the construction and design aspects of the ESF related to site characterization and to some aspects of those items related to performance assessment. However, NUREG-1318 also states, on page 15, that items and activities related to waste isolation should not be significantly graded, and that "a conservative level of QA should be assigned to the testing and design of barriers in the event that subsequent data analyses show them to be important in meeting the isolation and containment requirements of 10 CFR Part 60."

With respect to identifying importance to safety and/or waste isolation, the NRC staff makes clear in NUREG-1318 that probabilistic risk analysis (PRA) of the type used in reactor construction and design is an acceptable approach for assessing the design and construction requirements of a nuclear waste repository, but anticipates that the DOE could identify events of high potential dose consequence that should be considered for Q-list designation despite a low probability of occurrence (NUREG-1318, p. 4). The NRC staff would expect to see a preliminary Q-list in the SCP based on assessments of importance to safety or waste isolation based on conservative analyses to be sure all potential items are identified at the major component or system level.

However, the NRC staff should also expect that the construction of the ESs and ESF as well as other major site characterization activities would also be included on the preliminary Q-list. On page 13, NUREG-1318 states, "During the early phase of characterization ... most data collection activities should be controlled under Subpart G" and goes on to say that where it is known that data will not be needed for performance assessments or will be duplicated under Subpart G, those data would not need to be covered under Subpart G. The construction of the ESs and ESF will precede practically all subsurface data collection and will not be duplicated. Therefore it is doubtful that the conditions of Subpart G for most of the construction activities of the ESs or the ESF could be justifiably disregarded.

A Generic Technical Position was issued in 1987 by the NRC describing requirements and procedures for determining how data may be qualified for licensing that were not obtained under an approved QA program.

2.3.4. Performance Confirmation

General requirements for performance confirmation are described in Subpart F and include provisions for continued in situ monitoring until permanent closure. Performance confirmation will begin during site characterization, which as mentioned above, will involve the ESF, and will pose special QA requirements. Data collected during the site characterization phase will be used as baselines against which repository performance will be measured and therefore must not be inaccurate or ambiguous. Performance confirmation as presently conceived will involve waste emplacement and removal in areas near the ESF.

3.0 TECHNICAL POSITIONS

3.1. Importance of ES/ESF Specifications to Site Characterization and Performance Confirmation

The Specifications must be supportive of collection of data collected during and following construction, that will be used to characterize the site and support the design. These data may be obtained by geologic mapping of the excavations; by monitoring the response of the host rock to drilling, excavation, and support; by monitoring the behavior of the support systems themselves; by exploration from the subsurface such as by drilling or geophysical testing; by the availability of samples for petrologic, geomechanical, hydrogeologic, geochemical and geologic testing and analysis; by making available sites for in-place hydrogeologic, geomechanical, thermal, thermomechanical, geochemical, and coupled-effects tests; and by permitting surface-to-subsurface tests such as to determine seismic wave attenuation characteristics. As these data are collected and analyzed, additional types, numbers, locations, or extents of tests or maping may be identified.

Insofar as the testing is needed to characterize the site presented to the NRC for licensing, the plans and specifications for construction should be written so as to permit flexibility in the data gathering approach and a suitable, stable environment for collecting and storing appropriately-qualified data. At the same time the specifications should discourage activities that disrupt, interfere with, limit, or alter the data or the ability to obtain the data needed for site characterization.

If changes on the design, materials or construction methods are proposed, the potential impacts of such changes on the collection of all site characterization and performance confirmation data shall be assessed and a decision whether or not to implement the proposed change shall be made accordingly, before the data collected can be affected.

Also during site characterization some data will be collected for performance confirmation purposes. These data will be used as the basis of comparison by which the performance of the repository will be judged. Two broad categories of data are included: those data indicating whether the repository is performing as expected, and those data indicating whether assumptions upon which the license was based (design and performance assumptions) are, in fact, the case (10 CFR 60.140(a) (1) and 60.140(a)(2). In order to provide a valid basis for comparison, plans and specifications shall insure that the performance confirmation data will be accurate, repeatable, and unambiguous. The specified construction controls shall result in data that are as independent as possible of the effects of construction methods, and irregularities connected with construction shall be controlled to the extent practicable. All factors influencing the data collected should be fully-identifiable through a clear and rigorously-implemented Quality Assurance program required as part of the specifications for construction.

3.2. Relationship of ES ESF Specifications to Items Important to Safety and Containment (Pre-Closure)

If the ESs or ESF could be involved in such a way that the facility or any part of it could be important to safety as defined in 10 CFR 60.2, then the Specifications should provide for the appropriate levels of sealing, safeguards against disruptive events, and quality control and Quality Assurance.

The DOE shall, prior to preparing the Specifications, consider all the roles the ES or ESF will or could potentially play in repository operations and retrieval under normal or off-normal conditions, when determining whether or not the ES, ESF, or any part of these, might be important to safety. Direct or indirect impacts on safety, or on systems, structures, and conponents important to safety apart from the ESF, should be identified. If it is determined that neither the ES, ESF, nor any part thereof is or could potentially be important to safety, this determination shall be supported by appropriate tests and analyses.

The Specifications should not contain provisions that, whether explicitly or implicitly, could violate the assumptions upon which a determination of unimportance to safety is based. The Specifications should provide that evaluation of any proposed changes consider the impact on importances to safety or containment, before the proposed change could be implemented.

3.3 Importance of the ES/ESF Construction Specifications to Waste Isolation (Post-Closure)

Designs are prepared on the basis of certain data, assumptions, and analyses. Among these will be performance analyses addressing the effects, if any, that the ES and ESF may have on the ability of the site to isolate the waste in accordance with the performance objectives. These performance analyses will, in turn, be dependent on data and assumptions having to do with the ES, the ESF, the site characteristics, and their interface with the repository.

The ES/ESF Construction Specifications shall accommodate these assumptions, data, and analyses by ensuring that the provisions for construction that they represent will be realized. Further, the Specifications shall accommodate the full identification and quantification of features or conditions contrary to these assumptions, data, or analyses and shall permit the necessary adjustments to be made in the construction procedures or design to assure that the overall performance objectives will be met. If adjustments to the design or permitted construction methods are made for reasons other than ensuring performance, these shall be assessed as to their effects on waste isolation and the assumptions, data, and analyses pertaining to waste isolation. Any decision to implement or not to implement any proposed change shall be made subsequent to an analysis of the potential effect on waste isolation.

To facilitate this, the Specifications should identify in advance the assumptions, data, and analyses used in the determination of importance to waste isolation and should indicate in what areas and to what degrees these may be affected by variations in site conditions or construction procedures.

3.4 Importance of the ES/ESF Specifications to Retrievability

At the present time, retrieval provisions are only conceptually-developed, particularly where off-normal retrieval conditions are to be accommodated. The current DOE position is that, to support license application (LA), detailed designs and proof-of-principle demonstrations would be provided as necessary to establish the feasibility of the retrieval concept for normal and expected off-normal conditions. The full range of off-normal conditions has not been analyzed and may still not yet be fully-analyzed by the time site characterization begins. Therefore it is not known with certainty to what extent, if any, the ESs or the ESF may be involved in retrieval activities. The DOE should consider a full range of normal and off-normal retrieval conditions and determine, among other things, what role, if any, the ES or ESF would or may potentially play in retrieval. If, prior to the initiation of site characterization, it has not been determined that neither the ES, nor the ESF, nor any part thereof, would or would potentially affect retrievability or the retrieval process, then the construction of the ES and/or ESF should be supportive of the role it will or potentially will have in retrieval. Should a potential exist for these facilities to be involved in retrieval, the conduct of the construction and the Specifications pertaining thereto shall not preclude the utility of the facilities in retrieval.

4.0 DISCUSSION

4.1 Use of Trade Specifications

Many generic or standard trade specifications (ACI, ASTM, AWS, etc.) were written and are used for work on the surface and do not consider the underground environment, nor do they consider the special performance and data collection requirements of the ESs and the ESF. These reference specifications need to be supplemented in certain areas if they are to be used for ESF or ESs. Specifications for the ESF should reflect the highest quality and most advanced technology that is currently available, and this technology should be shown to be applicable to the ESF.

We have presented some discussion on items that may be of particular importance in the ESF construction specifications. There is a large number of existing generic specifications that may or may not come into play in ESF construction documents. Those that do appear in the construction documents, or that form the bases for assumptions of design fulfillment or construction methodology, should be assessed on a case-by-case basis with reference to the regulatory provisions outlined in Chapter 2 of this report.

4.1.1. Concrete

Design Basis   Shaft concrete is usually designed using ACI 318-(83) "Building Code Requirements for Reinforced Concrete" as a basis. Since it is known that the ESF will be connected to the repository, it may be more appropriate to use ACI 349-85 "Code Requirements for Nuclear Safety Related Structures." It would be preferable to specify a concrete that has been (or can be) tested and proven specifically for the ESs and ESF and covers the requirements for longevity, thermal response, sealing, strength, durability, workability, curing characteristics, and permeability that may be specific to these facilities.

Slip Forming ESF specifications should address the possibility of slip forming of concrete linings. This would leave no cold joints and is an existing technology. Slipformed linings are poured in long stages after excavation is complete and the potential for disturbance of green concrete by blasting is therefore minimized. The rock walls are exposed for longer periods, which offers a greater opportunity for inspection, mapping, and measurements. To avoid detrimental rock mass dilation prior to lining, provision must be made to assure stability prior to liner placement, but this is desirable whatever the lining method, since loading of green concrete should be discouraged. At Yucca Mountain, available data suggest the rock mass and groundwater conditions may permit slipforming.

ACI has a standard for slip forming that could probably be adapted for use in the ES. Quality control procedures appropriate to the application should be developed.

Repair of Concrete The shaft concrete will almost certainly be subject to chipping and damage due to movement of equipment and working room limitations in the shafts and shaft stations. There are many new epoxy patching compounds that may be very suitable. The ESF specifications should outline the criteria for repair versus replacement, specify how repairs are to be made, and specify the materials that will be used for repairs.

Temperature Control and Curing Consideration of rock temperature needs to be included, and provisions made, in the concrete specification to require appropriate temporary air conditioning or use of admixtures to ensure proper curing. The curing method to be used in the facility should be specified. Water curing will probably not be a viable method because water use in the geologic setting will be monitored and restricted.

Lining cycle The construction documents should specify an acceptable lining cycle or require the Contractor to obtain approval of the proposed lining sequence so that measurements, testing, and instrumentation for site characterization can be interfaced properly, and any performance or sealing implications can be addressed. The sequence used for lining may be dependent on ground conditions in the shaft and therefore may need to be changed during the construction period. This will require flexibility in the specifications and a methodology for accomplishing the reviews efficiently and effectively. This is an item that really has no standard specification and should be specially adapted for the ESF if delays, adverse impacts to ground control, and adverse effects on data collection are to be avoided.

Specifications for shotcrete, concrete, lagging, or any other provision that removes the rock mass from direct access for observation or testing should allow for appropriate mapping, testing, and instrumentation to be completed (consistent with the need to control adverse rock mass movements) before the support is installed.

Handling of water Specifications should make the Contractor responsible for handling and controlling water from all sources, and require temporary berms, dams, or pumps as needed to adequately control water in areas to be concreted. Extreme measures such as grouting could be required if heavy inflows are encountered. Routine contact grouting may be specified behind linings. If any grouting is needed, consideration should be given to eliminating water take tests in the development of the grouting program. A water inventory should be specified and maintained that has sufficient detail to evaluate any effects that water encountered or released during construction may have on the data collected.

Voids and Overbreak Definite procedures for handling unexpected voids or areas where large overbreaks occur should be established with physical limits for each procedure to be used shown on the drawings. These procedures will be critical in avoiding the possibility of preferential pathways in lined areas. All loose or drummy rock should be removed or restrained to preclude damage to test equipment or support equipment from falling rock or extensive cleanup operations. Procedures that may be necessary include installing grout pipes in the liner, backfilling and extra rockbolting. Supplemental suipport or the incidence of overbreak itself should be entered in the data base in such a way that their effects on the collected data can be evaluated.

Testing of Concrete Testing procedures and applicable tests should be specified for each type of concrete to be used at the ESF. Most concrete specifications list a large number of ASTM tests that could apply, and do not specifically identify test methods that are needed for each concrete type and application. A problem that can occur with this method of specifying tests is that occasionally some types of concrete are not included in the test methods listed. For example, ASTM C-39, compressive strength, does not apply to concrete outside of the 2,000 to 6,000 psi range. A definite criterion should also be established in the ESF specification for the frequency of tests, for the handling and curing of test specimens, for sampling procedures, and for the treatment and transmittal of test data.

Some provision for allowing the use of slicklines could be included with the provision that the Contractor test and prove the remix system at the placement area. An effctive remix system is essential to reducing honeycombing and segregation, which are the principal concerns of the use of slicklines, particularly in shaft work. The concrete mixes must be adapted if slicklines are used, because there may be a need for undesirably-low slumps to assure pumpability. If they can be made feasible, the use of slicklines could reduce the net cycle time, reduce costs and underground traffic, be less restrictive to the contractor's operations, and make possible an extension of the available time for mapping in the excavation and lining cycle. It may be necessary to limit slickline distances and provide for extra measures of control of spillage and slickline separation.

If an on-site testing laboratory is to be established or if the Contractor will be required to do some of the testing, the ESF specification should make these points clear and list the equipment and facilities that will be required, and the quality control provisions that will be applicable.

Shotcrete The most-common trade specification (ACI) is applicable to underground use and provisions for qualifying nozzlemen for underground work are included in it. The fact that the underground portions of the specifications will apply should be brought out in the ESF specification. The type of shotcrete (wet or dry) application and special provisions such as fiber reinforcement will also have to be resolved by the specifications.

Shotcrete testing should be provided in the specifications and include mix and additive testing in addition to coring of placed shotcrete. Test panels should be required for each new mix design. Provisions for handling rebound and overshoot should be provided if nearby test equipment, conduits, utilities, or instrumentation could be affected. Some accelerators could be corrosive to delicate data acquisition equipment and instruments.

The timing of shotcrete installation should be coordinated with the overall exploration and testing purpose of the facility.

4.1.2. Structural Steel

Wherever structural steel sets are to be used in underground portions of the ESF, the specification provisions regarding them should be adapted to structural steel underground, rather than relying on standard specifications that may be geared towards surface structures. Major differences in the applications (surface vs. underground) such as blocking, coatings, footblocks, and cribbing, will have to be addressed in the ESF specification.

Particular attention to what is to be done with areas incorporating structural steel for ground support during closure operations will be necessary in the design report. If steel is to be removed, the ground movement associated with a passive support system will be a definite consideration over a 50-year period.

Placement of structural steel members should provide for measurement and quality control of bolted connections, welds, blocking, and footblocks, and for measurement of the loads taken by the steel sets.

4.1.3. Rockbolts and Wire Mesh

The trade specifications (CSI, etc.) cover rockbolting in some detail, but will require some modifications so that bolt types and lengths remain flexible to match pull test results.

A provision for the interfacing of data collection needs with rockbolting patterns and operations should be a part of the ESF specification.

Checking and/or tightening bolts, rebolting and pull testing are other topics that need to be outlined in the specification and will probably have to be written specifically for ESF applications, so as to accommodate the interface with testing and data collection.

Wire mesh may be disadvantageous in some respects for the ESF, and should not be specified or allowed indiscriminately. Proper installation is difficult to accomplish and control, and usually requires large numbers of short bolts to attain effective contact with the rock surface, which would need to be taken into account for certain analyses. The wire may interfere with the placement of instrumentation and could reduce flexibility if moving instrumentation becomes necessary. It may also interfere with electronic data collection. and is not well-suited to applications where extended periods of time are involved. Spalls create bulges with loose rock retained by the strength of the wire; if the mesh fails, it is difficult to clean up the muck and make repairs, and the wire may not prove to be durable enough over extended periods of time if even small amounts of water are encountered.

However, wire mesh does offer the opportinity to view the rock surface over an extended period, and offers a slightly enhanced level of protection for sensitive instrumentation, testing areas, transmission cables, and critical utilities.

4.1.4. Control of Water and Dust

Specifications usually contain provisions for the Contractor to be responsible for control of all dust and water created by construction operations and for Contractor replacement of instrumentation damaged by his operations. In this case, however, the usual controls may not be sufficient to preclude damage or complications to critical experiments and instrumentation. The contractor should be required to submit a plan for water and dust control before construction begins for review and approval by the construction manager. Consideration should be given to preventing large clouds of dust that could damage instruments and test equipment, considering the likely limitations on the use of water underground that are expected. Acceptable limits should be determined and specified with an outline of how monitoring will be implemented.

Standard tunnelling specifications have water control sections, but they will not be adequate for the ESF due to instrumentation and water usage monitoring requirements.

4.1.5 Electrical Systems and Utilities

Specifying "permissible" equipment may not be necessary if explosive gases are not encountered. "Permissible" equipment is very expensive, but if underground storage of fuels is planned, permissible equipment will be advisable.

Standard electrical specifications do not cover electronic data collection systems. ESF specifications need an instrumentation section that includes placing, handling and damage responsibilities for instruments and data collection devices. The data collection system will require a dedicated section. Consideration should be given to the fact that, once data are lost due to accident or natural causes, they cannot be readily recovered.

Conduit for electrical systems and instrumentation will have to be accorded protection in the shaft linings, yet remain accessible for repairs. Conduit may require sealing.

Provisions need to be made for uninterrupted electrical supply to equipment involved in collecting site characterization or performance confirmation data.

The Specifications should provide for lockouts, circuit breakers, and so on to prevent interference of construction electrical use with the transmission and collection of data. Similarly, water piping, valves and nipples should not be located at points where failure, leakage, or condensation could affect data collection, storage, or transmission. Compressed air lines should be robust and protected from separation or damage that could affect site data gathering. Electrical and communications conduits used only for construction should be clearly distinguished from those used for the collection and transmission of data.

4.1.6. Surface Construction

Specifications for surface construction in the shaft areas will have to consider breaches in berms, channels, or pipelines as potential hazards and provide emergency procedures to keep unexpected inflows out of the shafts. This could involve decreasing permeabilities of soil, fill, or fractured rock around the shafts.

If blasting will be required to construct the surface facilities around the shafts, a specification for this type of work will have to incorporate measures to prevent damage to the surrounding rock mass by limiting particle velocities and other means, such as identifying specific powder factors.

Designated Contractor Use Areas for construction purposes will have to be shown on the plans and located such that the storage of materials and equipment, maintenance and washdown of equipment, and so forth do not interfere with testing programs, the instrumentation/data collection effort, or construction operations.

A secure, temporary structure will be necessary for the storage of instruments and data acquisition during the shaft sinking and underground construction operations.

4.1.7. Equipment

Specialized equipment specifications will need to be developed to incorporate the various features planned. Some of the major items are discussed below.

Hoists Sizing of hoists and choice of an appropriate hoisting rope may be best handled by the supplier. A supplier's submital with sizing and equipment details could be made a part of the specification. ESF specifications should give the design and performance parameters and let the supplier dedicate himself to achieving them.

Emergency hoisting and egress must be considered in the design, but could be made the Contractor's responsibility during the construction phase through the specifications. After construction there will be 2 shafts, 2 hoists and 2 headframes.

Sinking Equipment The specifications should require the contractor's plans for his sinking stage and muck disposal equipment to be reviewed by the construction manager to ensure that it will not interfere with or possibly damage installed instrumentation, and is adequate otherwise. Clearance may be critical. The specifications will need to state that the Contractor's plant (compressors, generator, etc) must be confined to specific areas to ensure that construction equipment and utilities do not interfere with instrumentation and test equipment. There are no trade specifications for these items.

Guides and Shaft Appliances The anchoring of guides or other installations (pipes, etc.) will have to consider instrumentation locations and lining thickness. The long design life of the ESF will be major factor in the selection of materials. The plans and specifications should indicate anchor types and the specific locations for shaft appliances. Temporary construction appliances and equipment must be removed with no damage to the linings or other ground support systems.

It may be necessary to provide continued access for maintenance of shaft instrumentation after shaft outfitting has been removed.

Instrumentation and Observations A section dealing with instrumentation in the ESF specifications is essential. It will have to include various materials specifications, installation procedures, testing procedures for installed instruments, interfacing with construction activities, and assign responsibilities for damage and safety to the various participants to be involved in the work. It will be necessary to identify who is to install what instrumentation, what Contractor performance criteria might indicate a certain amount of Contractor-installed instrumentation, and how the relationship between the construction and instrumentation contractors is to function. A criterion for maximum allowable blast vibrations should be esstablished and included in the ESF specifications.

The Specifications will have to include provisions that preclude disruptive conflict between the progress of construction, and the needs for instrumentation and observations.

"Test site preparation" will have to be specifically outlined and must describe tolerances and acceptable methods of excavation so that instrumentation will perform properly. The installations should be shown on the drawings in detail. There are no trade specifications that would cover the instrumentation at the ESF in adequate detail.

4.1.8. Other

Testing ESF Specifications need to adress construction testing and designate specifically:

- which tests are involved,
- who will perform the testing,
- when test results are to be submitted,
- where specific tests will be conducted, and
- how many tests are required as a minimum.

The testing firm selected should be required to have underground experience. If necessary, standard tests that are not applicable or require special procedures to be performed for underground applications should be modified to provide definite procedures to be used at the ESF.

Other types of Ground Support The ESF specifications should address the fact that ground conditions are not well defined and that ground support may have to be modified during the construction period. An alternative design should be included for worst case, unexpected conditions so that if such conditions are encountered, a change to the alternative method can easily be made.

Blasting A test blasting program should be mandatory before any excavation in a new stratum is begun. Parameters such as particle velocities, frequency distributions associated with displacements, stand up times, types of explosives, drill patterns, powder factors, and suitable rockbolt lengths and types should all be optimized before excavation is begun. Backfilling or filling with concrete can be done at the test sites if required.

Shaft Boring Commonly-used raiseboring specifications can be modified to match ESF requirements, if appropriate.

Smooth Blasting Smooth blasting should be specified for all drill-and-blast excavation. The contractor should be required to have years of experience in smooth blasting to design and implement a smooth blasting program. The specifications will also have to provide for the review of blast plans by the construction manager or his representative.

4.2. Implementation and Enforcement of ESF Specifications

The administration of the construction contract can affect the implementation of change control reviews which in turn affects the consideration of performance and site characterization aspects in changes made; the thoroughness with which the rock mass is investigated during construction; the level of detail in the inspection and reporting of construction that will affect the interpretation of data; and the application of the Quality Assurance and quality control programs.

4.2.1. Type of contract

A unit price/lump sum contract may nonetheless require that items such as changes in the ground support system and installing or altering instrumentation be accomplished on a time and materials basis. A time and materials rate would be most appropriate where instrumentation and observations could impact the work and where an exceptionally high quality of work is required and quantities are vague.

4.2.2. Authority of Construction Manager

Stop Work The resident engineering entity will need authority to stop the work whenever there is just cause if the desired results are to be obtained. In a regulatory sense, "just cause" may arise due to the occurrence or perception of a threat to the acquisition of necessary site characterization or performance confirmation data, a threat to the isolation integrity of the site, or a violation of any of the major design assumptions, whether as a result of Contractor actions or encountered conditions. The determination of a just cause may necessitate scientific or engineering study.

Inplementation of this may entail outlining a review process by a higher authority for immediate action in the ESF specifications. A direct chain of authority should be established in the specifications so that authority and procedures for enforcing the specifications are made clear to all parties concerned.

The authority to order more construction testing or reference testing should be established at the field level, and the responsibilities for the costs of such actions assigned in the specifications.

Change Orders and Claims An ultimate authority for review and final decisions on change orders or claims has to be established amongst the various agencies involved, and established in the ESF specifications. Another important issue that must be resolved in the specifications is the right of the construction manager to order force account work. The issue of who will do the force account work will have to be resolved as well.

4.2.3. Management Structure

Agency (Federal, State and Local) participation, including NRC oversight, will have to be decided upon and appropriate provisions included in the specifications for office space, and levels of participation. The specifications will have to provide for the approval and control of subcontractors, and establish minimum qualifications for subcontractors. If some items of work are to be subcontracted on a separate basis by the DOE, the ESF specification will have to make it known that other construction contractors will be working on the site at the same time as the prime contractor, and the subject of coordination between contractors must be resolved (in the specifications).

The prime contractor and all subcontractors should be prequalified for this particular type of construction.

4.2.4. Contractor Submittals

Required Submittals It is likely that contractor submittals will be needed since the specific capabilities of any given contractor will vary. It would be desirable to limit contractor design as much as possible because submittal reviews will probably be complex and very time consuming, and because construction contractors will have a limited point of view of the requirements for the facility. A review by the construction manager of submittals, with recommendations to the owner (or an approval authority), needs to be done in a reasonable amount of time and must take into account the regulatory needs for the construction measures, such as those identified in this paper. The ESF specification should outline the review procedure to be used and indicate the time required for reviews. A schedule of required submittals should be provided in the specifications.

Value Engineering Many Federal contracts include provisions for value engineering in order to conserve public funds. However, in this case major regulatory issues may be involved that have taken years of intensive technical study to define. Reviewing a value engineering proposal on this project would be a complex process and would require input from the various agencies involved with the work. If a change were to be incorporated, it may be very difficult to put a dollar amount on the worth of the change.

4.3. Surface Preparation

4.3.1. Sequencing of Work

The construction manager will have to review the proposed sequence for surface preparation so that there is not a conflict between surface and shaft construction schedules, and to ensure that the shaft areas are protected from water inflows at all times during the surface preparation period.

The ESF specification needs to make a statement about surface preparations at shaft locations to the effect that fracturing or any type of rock damage is not acceptable in this area and rock excavation for surface construction will have to be done with controlled blasting or mechanical means. Rock damage, should it occur, would have to be repaired by grouting or other appropriate measures and would be the contractor's responsibility. It may be necessary for the specification to provide for grouting after surface preparation in any event, depending on permeabilities encountered around shaft areas. The specifications will need to provide an acceptability standard for rock damage.

The specifications will have to have a provision for monitoring the contractor's water use during sinking and excavation operations.

4.5. Rock Excavation

Rock damage and increased permeability from blasting will need to be measured. Although this will be difficult, if the blasting and surface preparation specifications are written carefully, damage can probably be limited to a fraction of what might occur with no controls. A test blasting program could be invaluable in determining an efficient way to monitor inflows, assess rock damage and determine which measurable parameters are the best indicators of rock damage due to blasting. Maximum allowable particle velocities are not direct measures of rock damage, so if an acceptance criterion for damage is developed on the basis of peak particle velocity, a correlation to rock damage must be demonstrrated.

The limiting of blasting during the sinking operations may be possible by sinking small diameter holes with drill and blast methods and reaming to the finished diameter.

4.6. Tests and Instrumentation Interfacing

The ESF specification should have a section dealing with instrumentation and special testing. Rock excavation methods and coordination of construction operations with the installation of instrumentation should be outlined and include information concerned with how operations may be affected by the testing program.

A description of the testing program should include references to "detail" drawings that show the installations on the plans. If the contractor is not made fully aware that instrumentation is a prime objective, there will be difficulties stemming from the accumulation of standby time and loss of production, which will not serve the objective of quality in site characterization. Test site tolerances and QA/QC procedures for instrumentation should also be addressed in this section of the specifications.

Whatever method of ground support is used will limit the flexibility of the instrumentation program, and complicate the design of the installation. Therefore, designs of instrumentation installations in the drifts (or shafts) will have to incorporate provisions for access through the ground support system so that maintenance and inspection of instruments can be performed. At the same time, the design must provide protection to the instruments.

4.7. Seals

Seals should be designed and constructed using specifications for nuclear construction. Operational seals should be included in the ESF design to prove the constructability of the seals, and to provide redundant barriers to potentially-disruptive effects on performance confirmation data collection planned for the ESF.

4.8. Instrumentation

The underground environment is a hostile one, and instruments will need protection from it. They will probably require constant maintenance on a regular basis. The ESF specifications will have to include maintenance and establish acceptable performance criteria as provisions of the instrumentation contractor's work.

The designs of instrumentation installations should be reviewed by all parties concerned. Delicate instruments cannot be expected to perform without maintenance or replacement over long periods of time. Conduit and data collection systems will have to be protected and integrated into the design and specifications for the facility.

The locations of seismic instruments will be critical. With hoisting in the shaft, equipment running in the drifts, drilling, blasting, and so on, seismic measurements will be constantly subject to interference. This will require special consideration in the ESF specification.

4.9. Special activities

4.9.1. Dust

Dust will be a major problem throughout the life of the facility, especially for instrumentation. Provision for dust control should begin during construction. It may be posssible and necessary to include dust proof casings in the design of instrumentation installations. After construction there will still be concern for dust due to movement through the shafts and drifts, and the use of the ESF to support initial repository construction may generate sufficient additional dust so as to disrupt the ongoing collection of performance confirmation data. Measurement of dust levels is difficult and time consuming and prevention requires extreme diligence. Dust pallatives such as water and chemicals must not be incompatible with the intent of site characterization, performance confirmation, and waste isolation. The ESF specification will have to provide the best possible means of dealing with these problems.

Ventilation in heated test areas will have to be controlled and test sites involving heat will have to be carefully selected. The design and the specifications of the facility will have to address temporary ventilation stoppings, etc. to perform heated tests.

Quality Assurance will be a prime factor in creating a facility that will produce the desired results and at the same time conform to all regulations as per 10 CFR 60.