RESPONSES TO JULY 1986

SCP Q-LIST METHODOLOGY WORKSHOPS

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Q-LIST WORKSHOP RESPONSES

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1. INTRODUCTION

Guidance for Developing the SCP-CDR and SCP Q-List (Q-List Methodology) was transmitted to the project offices on April 25, 1986. Q-List workshops were held at each of the project offices in July 1986 to discuss implementation of the guidance. During these workshops questions arose regarding clarification of the guidance, especially in interface areas such as application of graded QA once an item becomes Q-Listed. HQ agreed to review the open questions and provide appropriate responses. This document contains clarification to the guidance and answers all open questions identified at the workshops.

The workshops provided an excellent opportunity to discuss each project's specific concerns and ideas. As a result, the need for a Design Classification System (DCS) became apparent. This system enables the repository designers to meet system reliability requirements without being forced into a binary system whereby a component is either on the Q-List or it is not. Additionally, the proposed Design Classification System conforms well to the graded QA approach forming a consistent design/QA matrix. Section 2 discusses the proposed DCS.

It became apparent also that separation of special activities, such as site characterization activities, from the Q-List was beneficial from a design and QA implementation viewpoint. The Activities List was created, therefore, to ensure that proper QA is provided for these special activities. Section 2.4 discusses the Activities List.

Section 3.0 discusses responses to the NNWSI Q-List workshop held at Las Vegas, NV on July 15-16, 1986.

Section 4.0 discusses responses to the BWIP Q-List workshop held at Richland, WA on July 18-19, 1986.

Section 5.0 discusses responses to the SRP Q-List workshop held at Columbus, OH on July 28-29, 1986.

Section 6.0 discusses impact of the enclosed clarification on the SCP.

2. PROPOSED DESIGN CLASSIFICATION SYSTEM

2.1 CENTRAL Q-LIST WORKSHOP ISSUES

At each workshop questions arose as to what Q-Listing an item or activity meant from a design and QA standpoint. For example, should activities be Q-Listed and, if so, which parts of the activity should receive QA and should hardware associated with the activity be designed to specific Part 60 criteria. Questions also came up as to whether an item which receives Level 1 QA is also a Q-List item. Systems that have ALARA impact, or are important to DOE from a reliability viewpoint, for example, will need special QA and design requirements. What is their relationship to the Q-List? Additionally, questions arose regarding where to place systems deemed important to "preservation of the retrieval option" since neither the important to safety category nor the important to waste isolation category logically fit. The guidance documents had not clearly addressed all these interfaces and additional clarification was requested by the projects.

2.2 CATEGORIZATION REQUIREMENTS

From a repository designer's perspective combining systems, components, and structures with related activities and licensing requirements into a single list can cause confusion since requirements which are applicable will vary. Codes which are applied to the design are established to consider the relative functional importance of public safety, industrial personnel safety,

and reliability functions of the hardware. In addition, historically, only hardware items are included on Q-Lists since placement on the Q-List brings about special design criteria requirements as well as special QA requirements.

These concepts are graphically expressed in Figure 2.2-1 which shows that repository hardware can be divided into four logical categories, each of which will have special design and QA requirements. These categories are; items important to preservation of the retrieval option, items important to safety, items important to waste isolation, and items important to DOE for operational and reliability reasons. Note that the associated design and QA requirements will likely vary from category to category, but will be more stringent than those associated with standard non-critical hardware.

Both the DOE and the NRC recognize that the mined geologic repository system is unique from a licensing viewpoint in that various features of the geologic system may be depended on for meeting post-closure performance objectives. These geologic features, therefore, cannot be compromised during site characterization or repository construction and activities related to barrier characterization, for example, may need support of QA to ensure that the integrity of the site is not compromised. Additionally, other special activities such as studies or laboratory tests which the DOE may want to use in the LA for licensing purposes will require subpart 'G' QA. Appropriate portions of these special activities should be subject to QA control but it is proposed that any special activity subject to QA control procedures be placed on an Activities List (see Section 2.4) rather than on the Q-List. It is recognized that a methodology is required for defining which related activities and which areas of the related activities should be subject to subpart 'G' QA.

The concept of establishing several hardware categories to capture items with "like" requirements and including only hardware items on the Q-List leads one to consider implementation of a design classification system. Separation of hardware items from special activities is consistent with the NRC's view in 10 CFR 60 subpart G, as well as in NRC's NUREG-0804 discussions.

2.3 DESIGN CLASSIFICATION SYSTEM DESCRIPTION

The proposed Design Classification System is a three-level system which provides a method for correlating and specifying the design and QA requirements for repository hardware. Such requirements ensure that each hardware item will perform with an appropriate degree of reliability under projected normal and abnormal operating conditions, including design basis accidents. The system is analogous to that currently being used on the DOE-WIPP program and in the nuclear power industry.

Table 2.3-1 provides proposed bases and criteria for assigning the appropriate design class to a repository item. Design Class 1 contains items important to public health and safety. Design Class 2 contains items important to DOE from an operational or reliability viewpoint, as well as items important to preservation of the retrieval option. Design Class 3 contains items which do not typically require any special design or QA requirements. This proposed Design Classification System is a strawman for discussion purposes but appears to provide a sound conceptual vehicle for resolving many of the design and QA issues expressed at the workshops.

Table 2.3-2 is a rudimentary tabulation of basic design requirements which may apply to classified items. Table 2.3-3 provides examples of typical hardware design groupings associated with the various hardware sub-categories given in Table 2.3-2.

As indicated in Table 2.3-4, only Design Class 1 items would be placed on the Q-List* and only these items would receive QA Level 1. Note that Design Class 1A is associated with items important to safety, while Design Class 1B is restricted to engineered barriers important to waste isolation. Natural barriers, such as characteristics of the site itself, would be defined via the performance allocation process and activities associated with these natural barriers would be placed on a separate Activities List (see Section 2.4) and would receive Level 1 QA.

Design Class 2 items would receive Level 2 QA but those items placed in Design Class 2A would receive Level 2** QA (equivalent to Level 1) due to their increased reliability needs. Design Class 3 items would received Level 3 QA.

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*Q-List is defined as: "Systems, components, and structures important to safety and engineered barriers important to waste isolation."

2.4 ACTIVITIES LIST

2.4.1 Activities List Definition

The proposed definition of Activities List, i.e. those actions which receive Part 60 subpart G QA is:

> "List of activities which are associated with preserving the integrity of, ensuring the performance of, and assessing the safety of (1) natural system barriers important to waste and (2) Q-Listed items; or, activities whose undertaking could adversely affect the performance of those items and barriers."

2.4.2 Discussion of Related Activities

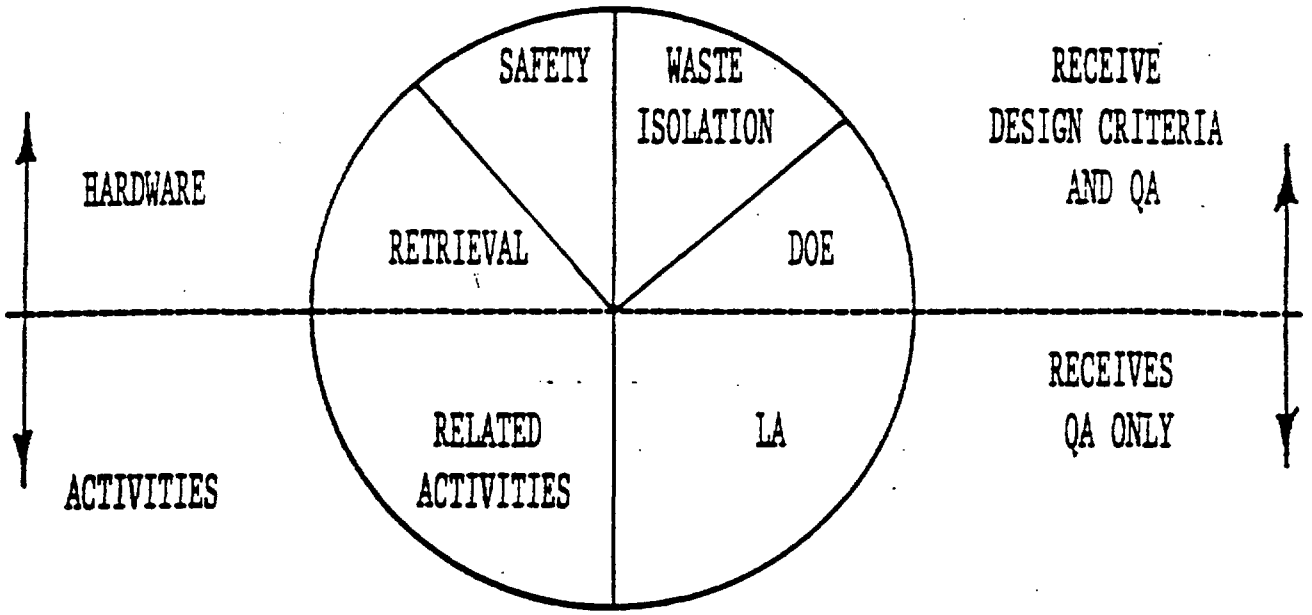
In accordance with 10 CFR 60 Appendix G, activities to be included are site characterization, facility and equipment construction, facility operations, performance confirmation, permanent closure, and decontamination and dismantlying of surface facilities. Specific activities within the 10 CFR Part 60 Subpart G QA program, such as control of design, purchasing fabrication, inspection, and maintenance (10 CFR 50 Appendix B, Introduction) need not be identified on the Activities List. Table 2.4-1 provides a listing of typical major site characterization-related activity categories for consideration. Each major activity will have sub-activities associated with it as illustrated in Table 2.4.2 for the shaft excavation activity. Of course the sub-activities can also be subdivided.

In order for a sub-activity to be placed on the Activity List, selection criteria are required to determine if a portion of the sub-activity needs to be controlled to ensure that Part 60 performance objectives are not compromised. Once identified, the targeted activity can be defined and described in a procedure which will be subjected to one or more review and approval cycles, as specified in the Procedure Review Cycle. The Procedure Review Cycle is a QA Level 1 document which would likely require NRC acceptance. After the sub-activities requiring QA are identified, then different types of QA Level 1 control could result as exemplified in Table 2.4-3 for shaft excavation.

After approval of the activity procedure, execution of the activity would require Level 1 QA and in most cases personnel may require training and certification.

For SCP purposes, it is proposed that a discussion of the methodology to be used to identify activities to be placed on the Activities List be provided, along with a preliminary list of candidate activities for inclusion on the list.

FIGURE 2.2-1. Categorization of QA Items and Activities



CATEGORY	CATEGORY BASIS	REQUIREMENTS* DESIGN	QA
Safety	Important to Safety	X	Level 1
Waste Isolation	Important to Waste Isolation	X	Level 1
Retrieval	Important to Retrieval Option	X	Level 2**
DOE	DOE Preference	DOE only	Levels 1, 2 & 3
Related Activities	Barrier Characterization Activities	—	Level 1
LA	LA-Driven	—	Levels 1 & 2

* Within each category, the graded QA approach should be applied.

** Same requirements as Level 1.

Table 2.3-1. Design Classification System

Design Class	Functional Considerations
1a	Items essential to the preclosure protection of the health and safety of the public, i.e.: -- Prevent from exceeding 0.5 rem -- Mitigates to 0.5 rem*
1b	Items essential to the post-closure protection of the health and safety of the public, i.e.: -- Engineered barriers important to waste isolation
2a	Items not included in Design Class 1 that are relied on for: -- Preservation of retrievability option -- Prevention of major contamination -- Confinement and control of process radioactivity effluent -- Shielding for Waste Handling Building rod consolidation cells -- On-site radioactivity monitors (accidents) -- Surface lag storage -- Emplacement operations -- Support of Design Class 1 items
2b	Items not included in Design Class 2a that are relied on for: -- Important to worker health & safety -- Major impact on facility operations -- Post-accident radiological monitoring -- Potential for minor contamination -- Design or fabrication complexity or uniqueness -- Support of Design Class 2 items
3	All items not included in previous classes

NOTE: Design Class 1 includes systems, structures, and components, including engineered barriers, for surface and subsurface application, but not including natural features such as host rock.

* The DOE is currently discussing application of 5 rem limit for design basis accident mitigation with the NRC.

Table 2.3-2. Basic Design Requirements for Classified Items*

	STRUCTURES/ SUPPORTS		VENTILATION, COOLING, AIR HANDLING	MECHANICAL HANDLING SYSTEMS AND EQUIPMENT		UTILITIES, WASTE OTHER SYSTEMS AND OTHER STRUCTURES		INSTRUMENTS CONTROLS AND ELECTRICAL	
	Safety Criteria	Standard Criteria	Industry Standards	Safety Criteria	MFG. Standards	Safety Criteria	MFG. Standards	Safety Criteria	MFG. Standard
Design Class 1a	X		X, (2)	X		X		X	
Design Class 1b	X		X, (2)	X		X		X	
Design Class 2a	(1)	X	X, (2)	X		(1)	X	(1)	X
Design Class 2b	(1)	X	X	(1)	X		X		X
Design Class 3		X	X		X		X		X

Notes (1) Safety criteria requirements on a case-by-case basis.

(2) Except structures and supports that are given safety criteria.

*This table is included as an example and is not for guidance purposes.

Table 2.3-3. Typical Hardware Design Groupings*

STRUCTURES/ SUPPORTS	VENTILATION & AIR HANDLING	MECHANICAL HANDLING - EQUIP. & SYSTEMS	UTILITIES, WASTE & OTHER SYSTEMS & STRUCTURES	INSTRUMENT/ CONTROLS & ELECTRICAL
• Hot Cells • Waste Handling Facility	• Filters (HEPA Exhaust, others) • Ducts, Piping, Dampers, Elect., I&C • Blowers/Fans • Cooling & Heat Removal • Breathing Air • Instruments & Process Air	• Cranes, Hoists • Transporters WH) • Conveyors, Carts • Manipulators • Casks	• Steam • Potable water • Process water • Cooling water • Fire protection • Radwaste -gas -liquid -solids • Admin., Training, Mgmt. • Security • Radintion Monitoring	• Electrical -power supplies -distribution • Radiation Alarms & Controls • Criticality Controls • Alarms • Lighting • Computer Sys. • Backup Inst. & Controls

*This table is included as an example and is not for guidance purposes.

Table 2.3-4. Design Classification System and Q-List/QA Requirements

Design Class	Functional Considerations	Q-Listed	QA-Level
1a	Items essential to the preclosure protection of the health and safety of the public, i.e.; — Prevent from exceeding 0.5 rem — Mitigates to 0.5 rem*	Yes	1
1b	Items essential to the postclosure protection of the health and safety of the public, i.e.; — Engineered barriers important to waste isolation	Yes	1
2a	Items not included in Design Class 1 that that are relied on for: — Preservation of retrievability option — Prevention of major contamination — Confinement & control of process radioactivity — Shielding for Waste Handling Building rod consolidation cells — Surface lag storage — Emplacement operations — Support of Design Class 1 items	No	2**
2b	Items not included in Design class 2a that that are relied on for: — Important to worker health and safety — Major impact on facility operations — Post-accident radiological monitoring — Potential for minor contamination — Design or fabrication complexity or uniqueness — Support of Design Class 2a items	No	2
3	All items not included in previous classes	No	3

Note: Design Class 1 Includes systems, structures, and components, including engineered barriers, for surface and subsurface application, but not including material features such as host rock.

* The DOE is currently discussing application of 5 rem limit for design basis accident mitigation with the NRC.

** QA requirements equivalent to Level 1 will be applied.

Table 2.4-1. Typical Major Site Characterization Activity Categories

- EXCAVATION (shafts and drifts)
- DATA COLLECTION
- BOREHOLE DRILLING
- AQUIFER SEALING
- LINER INSTALLATION
- ROCK SUPPORT INSTALLATION (roof bolts, etc.)
- BLASTING
- EQUIPMENT INSTALLATION
- SURVEY AND ALIGNMENT CONTROL
- WASTE PACKAGE TESTING
- OTHERS

Table 2.4-2. Shaft Excavation Sub-Activities

- DETERMINE SIZE AND LOCATION OF HOLE
- DRILL ENGINEERED DESIGN BOREHOLE (EDBH)
- GROUTING FOR WATER CONTROL (PRE-SINKING)
- DETERMINE EXCAVATION METHOD (including assessment of impact on damaged rock zone and on data gathering capability)
- SPECIFY AND PROCURE EXCAVATION EQUIPMENT
- DEVELOP EXCAVATION PROCEDURES
- PERSONNEL TRAINING
- MOBILIZE AND STAGE SINKING EQUIPMENT AND PERSONNEL
- SITE PREPARATION (grading, access, utilities, etc.)
- REMOVE OVERBURDEN
- INSTALL SHAFT COLLAR TO BEDROCK
- SINK SHAFT (drill/drill and blast) (sink and line concurrently)
- GROUT AQUIFERS (as required)

Table 2.4-3. QA Level 1 Control -
Shaft Excavation Sub-Activities

Sub-Activity	Design Control	Procedure Control	Hardware Control	Operator Certification	Hold Points
Drill EDBH	---	X	---	X	X
Excavation (Drill/Blast)	X	X	X*	X	X
Grouting	X	X	X	X	X

* Controlled blasting - explosive verification.

3. NNWSI WORKSHOP RESPONSES

3.1 IMPORTANT TO WASTE ISOLATION (ITWI)

3.1.1 Items Important to Waste Isolation

Items important to waste isolation are those barriers, structures, systems, and components which are relied on to meet the postclosure performance objectives in 10 CFR 60 subpart E.

Specifically, the following subpart E performance objectives must be met:

Overall System

Overall system performance objective for the geologic repository after permanent closure as provided in 10 CFR 60.112 and in the EPA Standard, 40 CFR Part 191 for both anticipated and unanticipated processes and events.

Engineered Barriers

Containment requirements for the Engineered Barrier System and the waste packages as given in 10 CFR 60.113(a)(1)(i)(A) and 60.113(a)(1)(ii)(A) for anticipated processes and events.

Control of the engineered barrier system release rate as given in 10 CFR 60.113(a)(i)(i)(B) and 60.113(a)(1)(ii)(B) for anticipated processes and events.

Geologic Setting

Pre-Waste Emplacement Groundwater travel time requirement as given in 10 CFR 60.113(a)(2).

3.1.2 Implementation

Barriers, systems, components, and structures important to waste isolation will be identified in the performance allocation process to develop the site characterization program. Performance will be allocated to both engineered barriers (e.g. the waste package) and natural barriers (e.g. the host rock and hydrostratigraphic units). Engineered barriers that will be relied upon to demonstrate that the performance objectives are met will be subject to design criteria and quality assurance requirements. The natural barriers themselves, will, of course, not be subject to design criteria.

However, many of the activities associated with characterization of the natural barriers will be subject to quality assurance. It is expected that reallocation of performance may occur as additional information is acquired in the site characterization program. Therefore, activities associated with those natural barriers relied upon in the present performance allocation should be subject to quality assurance. Furthermore, relevant activities applicable to natural barriers which may be relied upon in future performance allocation should also receive this attention. In view of the lack of

information regarding site characteristics, it is prudent to presume that the testing and analysis of all elements of the geologic setting within the controlled areas will be subject to appropriate quality assurance.

Any engineered barrier determined in the performance allocation process to be important to waste isolation will be placed on the Q list. The item will be placed in Design Class 1b (See Section 2.3) and appropriate design criteria will then be imposed. Activities associated with the barrier such as design, testing, and performance analysis will be placed on the activities list.

Natural barriers will not be placed on the Q list. However, activities that are part of the program to characterize any of these barriers in the geologic setting within the controlled area will be placed on the activities list. These activities include testing and analysis of the site and any activities that may significantly affect the performance of any natural barrier in the site.

3.2 RETRIEVAL REQUIREMENTS

3.2.1 Introduction

It is recognized that the NWPA requires the DOE to maintain an option for retrieval of emplaced waste and 10 CFR 60 establishes certain criteria by which the retrieval option must be implemented.

The emphasis of the NWPA and the NRC's statement of consideration relative to retrieval is on the following:

1. Maintaining the retrieval option at all times during the operations phase and some specified time beyond that, such that the NRC can have a viable option if they are not satisfied with the anticipated performance of the repository at the time the DOE makes an application to amend its license to permit decommissioning and sealing of the repository; and

2. Demonstration of "proof-of-principle" such that, at the time of the License Application, the NRC is satisfied that the technology and operational systems can be put into place, notwithstanding the anticipation of adverse underground conditions.

In a license application, therefore, the DOE would need to address three major requirements, each concerned with demonstrating the adequacy of its plans to implement retrieval if it were required. They are as follows:

1. Preservation of the retrieval option;

2. Protection of public radiological safety during retrieval operations (60.111(a) proposed revision); and

3. Plans for alternate storage of radioactive waste, should retrieval be required (60.21(c)(12)).

These requirements are concerned with different phases of the repository program although there may be some overlap in time. The site characterization phase is primarily concerned with item 1.

3.2.2 MAJOR RETRIEVAL REQUIREMENTS

3.2.2.1 Preservation of the Retrieval Option

The Q-List Methodology primarily addresses preservation of the retrieval option (item 1 above) to ensure that systems, components, or structures required to function in order to preserve the retrieval option are designed to an adequate reliability. As indicated in Section 2.3, these systems would be classified as Design Class 2a, would receive additional design criteria similar to 60.131(b), and would receive the equivalent of Level 1 QA. Based on this evaluation these systems are not required to be placed on the Q-List.

Since this requirement is a fundamental requirement of the NWPA, any system, component, or structure which is required to perform its function such that retrieval is not rendered impossible or impracticable by a result of its failure is of significance to the overall performance of the repository. Unlike item 2 above, the preservation of retrieval option cannot be evaluated on the basis of radiological dose consequences. It will be evaluated on the basis of identifying scenarios leading to subsurface conditions which would render the implementation of retrieval operations to be impossible or impractical. Examples might include:

1. Failure of a shaft liner, or seal, or borehole seal, which allowed large amounts of water to flood the subsurface. This could be caused by inadequate design or external events such as earthquakes, shaft operating accidents, etc.

2. Inadequate consideration given to waste characteristics and emplacement configurations which could lead to a criticality condition.

3. Uncontrolled settlement or convergence of overlying strata following mining activity which severely impeded the ability to re-mine and gain access to the waste.

4. Seismic/tectonic events which would lead to loss of containment from a significant number of waste packages.

3.2.2.2 Protection of Public Radiological Safety During Retrieval Operations

As previously discussed, in a License Application, the DOE will be required to demonstrate a proof-of-principle for retrieval operations, under anticipated conditions. This means that the proposed procedures, as well as operation of equipment (systems, components, and structures) would be subjected to a full safety analysis. Any system, component, or structure which, through its failure, could create a radiological dose rate to the public in excess of .5 rem would be considered important to safety.

This retrieval component needs to be addressed in greater detail later in the design process as it relates to classifying retrieval operational equipment as important to safety based on radiological analyses of retrieval operations.

3.2.2.3 Plans for Storage of Radioactive Waste Should Retrieval be Required

These plans will need to be addressed at the LA stage and described in the LA Safety Analysis Report.

3.2.3 Practicality of Retrieval

3.2.3.1 Background

10 CFR 60 Statements of Consideration include discussion of retrieval requirements. This discussion has raised the need for clarification, particularly with respect to practicality of retrieval.

At issue are the words "The definition indicates that the requirement of retrievability does not imply ready or easy access to emplaced wastes at all times prior to permanent closure. Rather, the Commission recognizes that any actual retrieval operation would be an unusual event and may be an involved and expensive operation. The idea is that it should not be made impossible or impractical to retrieve the wastes if such retrieval turns out to be necessary to protect the public health and safety."

Specifically, the words "or impractical" bring up a need for clarification. The purposes of this discussion is to provide clarification for the term "practical" and to provide a suggested method of quantification of retrieval practicality.

The design and planning of retrieval operations, while considering the anticipated hostile and subsurface conditions which exist must assume that the underground environment can be restored to the point where men and machines can work reasonably efficiently and absolutely safety.

3.2.3.2 Practicality Issues

The idea of practicality connotes the capability of actually being executed in fact, as opposed to theory or speculation. Practicality also implies a reasonable schedule executed at a reasonable cost. In the repository context, this can be translated into a requirement that the repository design must feature components, systems, and structures that render retrieval achievable using reasonably available technology on a reasonable schedule at a reasonable cost. Additionally, safety or retrieval operations should parallel that of emplacement operations.

Retrieval equipment designs should, then, be subjected to proof-of-principle testing, as well as mock-up testing and dry runs sufficient to demonstrate reasonably available technology. The NRC appears to accept the position that "proof of principle" testing adequately demonstrates hardware practicality. This idea is congruent with the previously published DOE position on retrievability and retrieval (PRR) which states that "All retrieval concepts, methods, and nonstandard equipment necessary for the retrieval of any or all of the emplaced waste shall be:

1. designed and engineered, before license application, so that the retrieval method will successfully operate and function under a range of adverse underground conditions.

2. fabricated for mock-up tests during a proof-of-principle demonstration period before the license application; and

3. further developed and tested, if needed, under selected repository conditions during the review of the license application and repository construction."

3.2.3.3 Factors Affecting Retrieval Practicality

The practicality of waste retrieval is seen to vary with at least three major functions: time since emplacement, accident occurrence since emplacement, and the magnitude of the retrieval operation.

Each major factor is discussed below:

A. Time since emplacement. Retrieval is at its easiest around time of emplacement, when extraction of the just-placed canister from its resting place could use essentially the same machinery used for emplacement. The degree of difficulty of retrieval is likely to increase with time since emplacement. If the surrounding rock strata heats up, for example, a means of cooling would have to be provided. If the drift is backfilled and sealed, opening and remining would have to be performed. A possible complication would exist if the host rock had closed in, gripping or partially crushing the walls of the canister, then extraordinary and complicated means would likely have to be brought into play to accomplish retrieval.

B. Accident occurrence since emplacement. Can abnormal subsurface conditions be restored on a reasonable schedule and at a reasonable cost

to where retrieval procedures can proceed? Retrieval would be further complicated by the occurrence of abnormal or accident situations during the time between emplacement and retrieval. The effects of postulated accidents would likely have to be dealt with prior to the commencement of retrieval operations. This presents the most difficult design regime likely to be encountered. The concern would be that the same accident that gave rise to the need for retrieval also precluded it.

The design and planning of retrieval operations, while considering the anticipated hostile and subsurface conditions which exist must assume that the underground environment can be restored to the point where men and machines can work efficiently and safely.

This means that if excessive heat, flooding, strata collapse, etc. is present, then these conditions must be corrected to the point where the planned retrieval operation can be implemented. It would only be necessary to demonstrate that the retrieval operation can be implemented efficiently for a discrete area of the repository, taking into account anticipated site-specific problems (pinching of the canisters, breach of canisters, creep in salt, heat, etc.) Practicality of retrieval should not be a concern since proof-of-principle testing will show equipment compliance.

The HQ guidance paper on development of a site-specific strategy for implementation of retrieval (April 16, 1986) postulates an "Abnormal Retrieval Condition" where all of the emplaced canisters are to be retrieved and 25% of all canisters are assumed to be failed. The 25% value is arbitrary but the intent of the guidance is to show that one or more failed waste packages can be retrieved under abnormal conditions.

The practicality issue becomes significant when accident scenarios are introduced which lead to severe subsurface conditions such as extensive flooding, extensive strata collapse or instability, etc. Although it may be argued that successful retrieval of waste is only a function of sufficient time and money, this may not, under certain circumstances, be a reasonable or practical approach.

C. Magnitude of the retrieval operation. The above aspects are compounded as the number of canisters to be retrieved increase. However, at some point an economy of scale would probably be realized, and the incremental difficulty would level off and might even decrease.

3.2.3.4 Suggested Quantification Methodology of Retrieval Practicality

Retrieval practicality can be expressed in terms of cost and schedule. As indicated in Subsection 3.2.3.2, safety of retrieval operations is not an issue since it should parallel that of emplacement operations.

Retrieval under normal conditions is not expected to present extraordinary problems and, as such, ought to be performed in about the same time as emplacement and with a comparable degree of difficulty.

Accident conditions may significantly complicate retrieval and probably will delay the commencement of actual retrieval operations until such time as the major damage has been dealt with. Thus, retrieval after an accident should be accomplished in about the same time as emplacement plus the construction time of the GROA. In this manner, the construction period may be used to recover from the accident occurrence.

To affix a dollar ceiling value to the retrieval scenarios, for defining practicality, it is suggested that the cost ceiling methodologies parallel the schedule ceiling methodologies. Therefore, under normal retrieval conditions, the retrieval cost ceiling should approximate the emplacement cost. Accident condition cost ceilings should approximate the sum of normal costs, as figured above, plus the GROA construction cost as a special allowance to cope with the effects of the accident.

3.2.4 Proof of Principle

Can retrieval, under reasonably anticipated conditions, be demonstrated? As stated in Subsection 3.3.2.2, key features of the retrieval hardware design should be fabricated or mocked-up and subjected to testing under conditions approximating those which would likely be encountered in an actual retrieval scenario. Successful demonstration of operability would constitute an acceptable proof of concept.

3.2.5 Safety Analysis for Implementation

Could failure of any system, component, or structure during retrieval operations result in a dose to the public in excess of .5 rem? A safety analysis for the implementation phase of retrieval must be performed late in the design process to show that implementation of the retrieval option would not result in undue risk to the health and safety of the public. If retrieval operations could result in radiological doses in excess of 500 mrem at or beyond the nearest boundary of the unrestricted area, then retrieval equipment would need to be classed as important to safety.

3.3 Q-LIST METHODOLOGY FIGURE 4-1 CLARIFICATION

In Q-List Methodology Figure 4-1, the final step is to place items on important to safety list (box 7) if the projected consequence is greater than 500 mrem and the scenario is credible. In order to clarify the intent of this step an understanding of the difference between preventative and mitigative systems is required. The following definitions as summarized from Section 5.3.1 are presented:

Preventative System*: Any system whose design and function actively or passively stop an event from occurring, or, reduce the probability of occurrence of an event.

Mitigative System*: Any system whose design and function actively or passively reduce the severity or consequences of an event once the event has occurred.

Several examples of preventative and mitigative systems for various hypothetical accidents are given in Table 3.4-1. Equipment redundancy can be used to improve reliability, but this decision should be made on a case-by-case basis.

The following sub-steps to Figure 4-1 of the Q-List methodology should be included in determining systems, components, and structures important to safety:

*System, component, or structure.

7.a If the projected consequences of the scenario are greater than or equal to 500 mrem and the scenario is considered credible then a determination should be made as to which system, component, or structure is the front-line preventative system. This system must be Q-Listed.

7.b. The scenario should then be reanalyzed taking into account the reduced failure probability of the Q-listed preventative system. If the scenario is still considered credible, then additional Q-listed mitigative systems must be provided until the scenario is no longer credible or its consequences are less than the 500 mrem dose criterion.

3.4 Q-LIST METHODOLOGY FIGURE 4-3 CLARIFICATION

Figure 4-3, "Methodology B schematic for preclosure events (operational/retrieval) impacting ability to perform retrieval", and the text of Subsection 4.2.1 have been revised to clarify Q-List requirements and eliminate identification of specific abnormal initiating events. The revised text and figure are presented in Appendix B.

3.5 COMMON INITIATING EVENTS

Table 4-2, "Preclosure Subsurface Facility Initiating Events - Minimum Set -" of the Q-List Methodology has been revised as shown on the attached Table 3.6-1 to delete events 9 (Areal Power Density Overload) and 14 (Coupled Effects), and to revise event 10 (Improper Construction Techniques) to be included under Event 11 (Operator Error).

Various initiating events identified in Table 4-2 of the Q-List Methodology have been reviewed to determine if frequency of occurrence could be estimated on a generic basis for two or more sites. The following discussion indicates for which events this may be possible.

- "Hoist cage drop of waste package" could probably be treated generically for the salt and basalt sites;

- The "underground flooding" initiating event appears to have sufficiently diverse causal mechanisms that it should be treated on a site-specific basis;

- Generic treatment of the "Explosion/Fire" event for all three sites appears feasible from the diesel fuel and explosives aspect, but all three sites differ from the methane gas viewpoint;

- Operator error events are site-specific since the probability per year is dependent on the total number of personnel involved and the total number of waste packages being handled;

- "Shaft Failure" events are site-specific due to different types of liners used and different mechanisms for failure;

- Drift collapse should be treated on a site-specific basis due to the different properties of the media and differences in the probabilities of external events;

- Type I seismic events (those of a less severe nature) appear to have similar occurrence frequencies at the Basalt and Salt sites, and these may be candidates for generic analysis. Caution should be used, however, due to the slightly different accelerations at these two sites and the differing potentials for damage;

  The Tuff site is sufficiently different to preclude its inclusion in a generic treatment; and

- Type II seismic events (those of a more severe nature) again appear to have similar occurrence frequencies at Salt and Basalt as to be candidates for generic treatment, while the Tuff occurrence frequencies should be analyzed separately.

3.6 RADIOLOGICAL SENSITIVITY STUDY

During the Q-list workshop held in Nevada, the NNWSI project participants expressed interest in obtaining a copy of the "Underground Waste Handling Accident Sensitivity Study." A draft of the study dated August 1986 was transmitted to headquarters on September 10, 1986 by WESTON.

3.7 DATA BASES

A detailed listing of availability and risk data sources is given in Appendix A. The appendix lists document number and date, the title of the document, and the author or publisher. The documents listed are not classified, and are available to the public for a nominal fee. The various

NUREG documents are available from either the Government Printing Office or NTIS. NRC documents may be examined at the Public Document Room, which is located in Washington, DC.

A brief discussion of data base development is presented below as an aid to setting up and effectively using the industry information currently available. Much of the material, as well as the first five pages of Appendix A, has been excerpted and condensed from NUREG/CR 2300, the PRA Procedures Guide, and reference thereto is suggested.

3.7.1 Overview

The development of a data base for accident-sequence quantification is a multistep process involving the collection of data, the analysis of data, and the evaluation of appropriate reliability models. It produces results that specify the numerical values to be used for each event in the fault and event trees.

The steps that need to be addressed in developing a data base are discussed in the subsequent sections, in the order the tasks would be accomplished. As in many engineering analyses, the order may be modified as the work progresses, or iteration may be required.

3.7.2 Initiating-Event Models

Initiating events are the occurrences that initiate an accident sequence. The desired measure for such events is frequency. A plant may experience tens of these events per year or only one in 10,000 years.

Initiating events are assumed to occur randomly in time, and they are usually assumed to occur at a constant rate. However, data on events that occur more frequently indicate that the rate of occurrence may be higher during the plant's first years than during subsequent years. there are insufficient data to predict whether or not the frequency of these initiators might increase in later life.

The Underground Safety Assessment Report gives suggested accident models. However, prior to their use, the models should be evaluated for site specific accuracy and applicability.

It should be noted that in most PRAs initiating events are treated as single events. However, the initiating event can be quantified by combining several events. This combination can be accomplished through a fault tree, an event tree, or a similar tool. While this may not affect the underlying event modeling and data analysis, it may require quantification tools that differ from those used to evaluate system/sequence frequency-weighted unavailability via fault trees, event trees, etc. That is, it may be necessary to quantify the synthesized initiating event as a frequency, rather than a probability.

3.7.3 Data Gathering

Before collecting and analyzing data, it is important to know what kind of data are needed. In a PRA the events of interest are modeled as events that occur randomly. In general, they occur either randomly in time or randomly at each challenge. Thus, for each classification of events, data will be either x events in time T or x events in n trials (or demands). In addition, if it is necessary to test the components-reliability models, the

actual time history of the failures is needed. More specifically, if the failure of motor-operated valves to open when needed is a class of events to be evaluated, it will be necessary to search data sources to determine the number of occurrences for this event, either the number of demands or the time over which these events occurred, and when each failure to open occurred. It will also be useful to examine other data bases for information about the event of interest.

In general, for events involving components in safety systems, the quantity of interest is the probability that the component cannot perform its intended function when the initiating event occurs.

Thus, the objective of the data-gathering task is to obtain the raw information needed for estimating the event-model parameters identified in the preceding section: (1) the number of failures in time or the number of demands for reliability models and (2) the frequency of initiating events. The data may also be used to test the applicability of the event model; in this case, it is necessary to have the time of each failure. The sources of data may include plant records, existing data reports, and previous PRAs. This section describes various sources of available data and their attributes; it then discusses the process of data collection. It is strongly recommended that representative existing data sources be closely examined to establish clearly the type of data needed before beginning the collection of plant data.

3.7.3.1 Existing Data Sources

As the data analyst proceeds to determine the appropriate reliability data, he finds a spectrum of available resources. In some cases a clearly appropriate source is available. In other instances, however, there are few

sources of data whose content and format allow unambiguous selection. The data analyst must decide on the appropriateness of the data he examines. The data source does not always specify what failure modes or mode is represented; whether, for example, the pump driver is included in all pump failures; what environment is applicable; or what the total population is. Often, additional research may be needed to discover the information not available in the reported data. Discussed below are the following sources that may be useful in building a data base for a PRA:

1. A report (EPRI, 1982b) on the loss of offsite power at nuclear power plants.

2. A report (McClymont and McLagan, 1982) on diesel-generator reliability at nuclear power plants.

3. Data summaries of the licensee event reports submitted to the Nuclear Regulatory commission.

4. The reactor Safety Study (USNRC, 1975).

5. An IEEE data manual on electronic, electrical, and sensing components.

6. The Nuclear Plant Reliability Data System.

7. The National Electric Reliability Council.

A substantial number of other sources are also available; GIDEP, SRENCO, SRI, Farada, etc.

3.7.3.1.1 *Loss of Off-Site Power at Nuclear Power Plants: Data and Analysis, EPRI NP 2301*

This 1982 report presents data on the frequency of loss and subsequent recovery of offsite power at nuclear power plants. The data were collected from the sites of 47 plants. Results are presented as events per site and by National Electric Reliability Council region. Data analysis includes point estimates for frequency with confidence limits, assuming a constant rate of occurrence. Recovery time is analyzed with a log normal distribution for the time to recover. All raw data are reported to allow the user to perform his own analysis. This document is the most comprehensive source of data on the loss of offsite power for PRA usage.

3.7.3.1.2 *Diesel Generator Reliability at Nuclear Power Plants: Data and Preliminary Analysis, EPRI NP-2433*

(McClymont and McLagan, 1982). This report presents data related to the reliability of emergency diesel generators. The sources include plant records, utility records, and licensee event reports submitted to the Nuclear Regulatory Commission. The data include both raw information and estimates of event-model parameters. The report details failure to start, failure to continue running, and repair times..

3.7.3.1.3 *Data Summaries of Licensee Event Reports at U.S. Nuclear Power Plants*

Published by the Nuclear Regulatory Commission, these data summaries are available as six separate reports:

1. Diesel Generators (NUREG/CR-1362; EG&G-EA-5092)

2. Pumps (NUREG/CR-1205; EG&G-EA-5044)

3. Valves (NUREG/CR-1363; EG&G-EA-5125)

4. Selected Instrumentation and Control Components (NUREG/CR-1740; EG&G-EA-5385)

5. Primary Containment Penetrations (NUREG/CR-1730; EG&G-EA-5185)

6. Control Rods and Drive Mechanisms (NUREG/CR-1331; EG&G-EA-5079)

They describe the results of analyses of component failures reported to the Nuclear Regulatory Commission in licensee event reports. Component failures are reported for individual plants, by reactor vendor, by failure mode, and for all plants considered together. Included are failure rates, failures on demand, and some information on repair times. The estimates of event-model parameters, however, are based on estimates of population, demands, and exposure time. Hence, the statistical analysis includes estimated information together with actual plant data.

3.7.3.1.4 *Reactor Safety Study, WASH-1400, Nuclear Regulatory Commission, 1975*

Appendix III of this report, "Failure Data," contains the failure data used in the study, including raw data from 1972, notes on test time, notes on maintenance time and frequency, the results of a human-reliability analysis, aircraft-crash probabilities, estimates of the frequency of initiating events,

and some information on common-cause failures. From the assembled information, this appendix also defines the "assessed range" for each failure rate. The authors state, however, that "this data may not be sufficiently detailed, general, or accurate enough for use in other quantitative reliability models or in applications involving greater specificity."

3.7.3.1.5 *IEEE Project 500 Data Manual, Institute of Electrical and Electronics Engineers, Inc.*

This document contains data for electronic, electrical, and sensing components. The reported values are mainly synthesized from the opinions of some 200 experts. Each expert has submitted a low, a recommended, and a high value for the failure rate under normal conditions and a maximum value that would be applicable under all conditions (including abnormal ones). The pooling of estimates was done by geometric averaging, a method judged to be a better representation of expert estimates, which are often given as negative powers of 10. While some estimates include hard data, the reader is not made aware of which estimates are based only on opinion, on hard data, or a combination of both.

3.7.3.1.6 *Nuclear Plant Reliability Data System (NPRDS), Southwest Research Institute*

The NPRDS collects failure data on safety-related systems and components. At present, 61 plants are reporting data. The data are compiled and disseminated in periodic reports to the participants of the program and

other potential users. In addition, special searches of the data base may be requested by the participants and others, or the users can access the data through their computer terminals. Typical information that NPRDS provides includes the following:

1. The plan operating mode (i.e., operating, standby, and shutdown).

2. The calculated in-service hours of the system.

3. Outage times.

4. Number of failures per million in-service hours.

5. Number of applicable tests.

6. Number of actuations for standby equipment.

7. Component failure modes and effects.

The main disadvantage is the dependence of the NPRDS on regular participant reporting. If no report is received from a participant in a reporting period, it is assumed that no failures have occurred. In the near future, data from plants with irregular reporting will be filtered from the data base to avoid this disadvantage.

3.7.3.1.8 *National Electric Reliability Council (NERC)*

On January 1, 1979, the Edison Electric Institute (EEI) transferred to NERC the responsibility for operating its equipment-availability data system--the prime utility-industry source for the collection, processing, analysis, and reporting of information on power-plant outages and overall performance. The Unit Year Summary computer program produces a report for each individual unit, including statistics for the latest year and cumulative statistics for the life of the unit. In addition, the Equipment Availability Task Force produces annually a report on equipment availability for a 10-year period. Finally, the EEI has established a procedure for processing special requests for the analysis of reliability data.

3.7.4 Component-Data Collection From Nuclear Power Plants

At present, no nuclear plant keeps records of component reliability for the specific purpose of using them as data for risk assessments. The PRAs that have been conducted to date have had to depend on other sources for plant-specific data. These sources include many plant records and procedures that may be available to the PRA analysts. The usefulness of a particular source depends on the reliability models chosen to represent components in system fault trees. On the other hand, the availability (or the absence) of various data sources may affect the choice of models by a system analyst. Table 3.8-1 lists the most common parameters used to represent components, the data required to derive estimates of the parameters, and the potential sources of such data as plants. How these sources can be used on extract needed information is briefly explained below.

3.7.4.1 Periodic Test Reports and Procedures

Periodic test reports and procedures are a potential source of data on failures, demands, and operating time for components that are tested periodically. Test reports for key components or systems typically contain a description of the test procedure and a checklist to be filled out by the test as the steps are performed. For example, in an operating test of an emergency diesel generator, the procedure may call for starting the diesel and running it for an hour. The record of a specific test would report whether or not the diesel started and whether it ran successfully for the entire hour. Another example is a test of emergency system performance, in which the procedure calls for the tester to give an emergency signal that should oOpen certain flow paths by moving some motor-operated valves and starting one or more pumps. The position of the valves and the operation of the pump are then verified, giving records of whether the valves and pumps responded successfully to the demands. As shown by these examples, records of periodic tests provide a self-contained tally of demands on some components, as well as the failure (and success) of the component given these demands.

3.7.4.2 Maintenance Reports

Reports of maintenance on components are potential sources of data on failures, repair tims after failure, and other unavailability due to maintenance. These reports typically include the following:

1. A plant identification number for the component undergoing maintenance and a description of the component.

2. A description of the reason for maintenance.

3. A description of the work performed.

4. An indication of the time required for the work or the duration of the component's unavailability.

The report may indicate that maintenance was needed because the component failured to operate adequately or was completely inoperable. Such an event may then be added to the count of component failures. The maintenance report often gives information about the failure mode and mechanism as well as the amount of time spent on repair after the failure was discovered. Such information must be interpreted carefully, because the actual repair time may cover only a fraction of the time the component was unavailable between the detection of the failure and the completion of repairs. In addition, the repair time is often given in terms of man-hours, which means that the actual time spent on repair could be shorter, depending on the size of the work crew; the use of recorded man-hours would therefore lead to a conservative estimate of repair time. The complete out-of-service time for the component can, however, be derived, because the maintenance record often states the date on which the failure was discovered and the date on which the component was made available after repair.

Maintenance reports that record preventive maintenance can be used to estimate the contributions of these actions to component unavailability. Again, the report may show that a component was taken out of service on a certain date at restored some time later, giving a sample of the duration of maintenance. The frequency of these events can be derived from the number of preventive-maintenance reports in the calendar time considered.

3.7.4.3 Operating Procedures

Operating procedures can be used to estimate the number of demands on certain components in addition to demands occurring during periodic tests. This estimate is obtained by multiplying the number of demands imposed on a component during a procedure by the number of times the procedure was carried out during the calendar time of interest. Unfortunately, the latter number is not always easily obtained. For procedures followed during plant startup or shutdown, the number of times the procedure was performed should be readily obtainable, but for procedures followed during operation, this information will be available only from the control-room log.

3.7.5 Expert Opinion

Expert opinion is often used when other information is inadequate. If neither physical nor theoretical models are available and relative frequency is unavailable as well, subjective assessment is the only alternative for obtaining a probability. The practical feasibility of this alternative is supported not only by theoretical foundations that show judgments about uncertain events can be expressed as probabilities but also by practical assessment procedures. The following is a summary of assessment procedures. After this summary, well-known cautions and guidelines for interpreting and reviewing expert opinions are presented to highlight the care and caveats that must accompany the quantitative assessment. The user should be aware that the subjective estimates frequently used in PRAs can have large biases and errors.

3.7.5.1 Assessment Procedures

Two approaches to subjective probability assessment are in practical use, either the direct approach or the indirect approach. The direct approach will be addressed here. With the direct approach, the expert is asked to declare the probability number associated with the feeling of uncertainty for the occurrence of an event.

The well-known difficulties in obtaining useful subjective probability assessments are summarized below in the section entitled "Validity of Expert Opinion." These difficulties are magnified by by inexperienced, unaided direct assessments.

The direct approach has the expert state a number that represents the assessment of the probability. Some studies have shown it possible for people to become better at assessing their own feelings of uncertainty as probabilities. This improvement in direct assessment comes from specific training and guided practiced discipline rather than by trail and error. A good direct assessment comes from one who is both an experienced expert in what is known about a technical area (as well as how much is not known) and an experienced expert on how to express that judgment with little cognitive bias. This is an uncommon combination of expertise.

3.7.5.2 Assessment Models

The representation used to model the uncertain event, either intuitively or formally, is a significant part of obtaining a good assessment. How the expert thinks about the problem of giving a judgment on the event likelihood should be recorded (see the discussion on "Recording Expert Opinion.") It is

this representation that fashions the eventual probability that is assessed. If disputes or questions arise in reviewing the quality of the expert opinion, a brief description of the thought model can focus the issue to a particular facet of that judgment.

Often, the expert is better able to provide a judgment by refining the event description into underlying events or factors. This formal assessment model can be subdivided until the expert finds it easy to examine each part, provide an opinion conditioned on each one, and review the formally computed probability of the original event for completeness and accuracy. This aid to assessment relieves an expert from making logical, or procedural, errors in combining the underlying knowledge. Reducing this source of error with the use of assessment models allows the assessor to focus on revealing a more subtle bias in the judgment.

3.7.5.3 Validity of Expert Opinion

The validity of a subjective assessment comes from the knowledge content provided by the expert. The content factor is evaluated from the credentials provided by the expert. Identifying who knows what and how much is a routine task for a professional community. Even for a recognized expert, a peer review can use the assessment model to judge whether or not all the significant factors were included in the expert's opinion. Inaccuracies, disputes, omissions, and limits to knowledge can then be examined to improve the accuracy of the substantive, or content, portion of the probability assessment.

It is well known that various biases may accompany the subjectively quantified assessments of an expert. Experts often overestimate the degree of certainty of their estimates and claim too high a level of assurance. Interval estimates for which 98-percent assurance was claimed tended in reality to have an assurance of about 70 percent (i.e., to include the correct value 70 percent of the time). Alternatively stated, interval estimates are often too narrow for the assurance level that is claimed. Tversky and Kahneman (1974) attribute such bias in part to the phenomenon of "anchoring": the expert tends to focus, or "anchor," on an initial guess and is reluctant to deviate too far from the guess in accounting for possible misjudgment. The results of such studies suggest that the assurance associated with expert-supplied interval estimates should be reduced from that claimed. For example, if a 90-percent interval estimate is solicited, then the interval could perhaps be considered to be an actual 70-percent interval in fitting a prior.

It is also well known that the manner chosen to encode (solicit) the subjective probabilities held by the expert is crucial and may significantly affect the quality of the information.

3.7.5.4 Recording Expert Opinion

The procedure used for assessing expert opinion and the assessment model used by the expert to construct the judgment should be described in a record of the expert opinion.

A subjective probability is an evaluation. The important procedural and substantive factors in that evaluation should be recorded, like any other engineering analysis, to permit a peer review to determine the quality of that result.

This record does not have a standard format; however, with time and experience, one may evolve. Nevertheless, the probability number can be meaningless without a description of how it was obtained and what its principal foundations were.

3.7.6 Documentation of the Data Base

An important aspect of developing the data for accident-sequence evaluation is to document the various steps of the process. This includes not only the final numbers but also the various assumptions and sources of information. The reader should be able to trace each data item from the fault tree or event tree back to the source, with each assumption and calculation apparent.

Documentation should include the output of the data process (i.e., the numbers used in quantification) and the general data base used in the PRA.

3.7.7 Assurance of Technical Quality

The term "assurance of technical quality," as used here, refers only to the quality of the data base that results from the procedures given in this chapter. Many factors affect the quality of the data base, including the

overall programming, planning, and scheduling, as well as budget limitations. The objective of this section is to address the items that will enhance the data quality within the program constraints.

The most beneficial activities to maximize quality are reviews and checks. As each data quantity is produced, it should be checked against other data bases. Major discrepancies should be justified. Other staff members should review the event quantifications for their models and cross-compart with others with the same type of events. Finally, the team leader should review the data, using his experience to look for unusual results. Of course, outside peer review is an important part of the review process, though feedback for revision via this path usually takes longer than does feedback within the study.

Documentation is the key to the quality of the data base. The data analyst should keep a notebook to document his decisions and assumptions. THis notebook will make final documentation easier and make the data traceable from event results back to the source. It is also important to carefully document computer runs so that, if necessary, the runs producing particular results can be found. Often a keypunch error can result in an incorrect result.

3.8 OFF-THE-SHELF EQUIPMENT

Guidance regarding failure rate data for equipment (i.e., should the equipment be assumed to be off-the-shelf or safety-grade prior to determination of Q-List requirements) is presented below.

Generally, prior to determining that a given piece of equipment belongs on the Q-list it should be assumed that it is normal commercial grade.

For certain equipment, such as the main line production mechanisms in hot cells which are likely to be of higher quality, a greater level of reliability should be assumed. This might also apply to cranes and certain waste form handling equipment.

Table 3.4-1. Examples of Preventative and Mitigative Systems and Features

Event	Preventative Systems	Mitigative Systems
Hoist Cask Drop	Hoist	Emergency Ventilation Cask Impact Limiters Crash Beams Crush Materials
Underground Fire or Explosion	Methane Monitors Ventilation	Fire Detection Fire Suppression
Underground Flood	Shaft Liner Aquifer Seals	Dewatering Pumps Bulkheads
Seismic	None*	None**

* Prevention of adverse consequences is accomplished through proper design.

** No mitigative systems are provided specifically for the seismic event. However, consequences with this event can be mitigated by systems such as emergency ventilation.

Table 3.6-1

Revised Table 4-2. Preclosure Subsurface Facility Initiating Events - Minimum Set -

Event*	Basalt	Salt	Tuff
1. Hoist cage drop of waste package	X	X	-
2. Hoist cage overtravel at headframe during retrieval of waste package	X	X	-
3. Transporter crash on ramp, with fire	-	-	X
4. Underground explosion via commercial explosives	X	X	X
5. Underground explosion via methane	X	X	-
6. Seismic event	X	-	X
7. Underground flood (or groundwater intrusion	X	X	X
8. Fire	X	X	X
9. Operator error-- installation/ pre-closure operations (including improper construction techniques)	X	X	X
10. Shaft failure--			
common mode	X	X	-
single	X	X	-
11. Drift collapse	X	X	X

* Events 1 through 11, as applicable, should be assessed for emplacement as well as retrieval operations. For retrieval operations, consideration should be given to the possibility of damaged waste packages.

Table 3.8-1. Sources of Plant Data

Parameter	Data Requirements	Potential Sources
1. Probability of failure on demand	a. Number of failures	Periodic test reports, maintenance reports, control-room log
	b. Number of demands	Periodic test reports, periodic test procedures, operating procedures, control-room log
2. Standby failure rate	a. Number of failures b. Time in standby	See 1a above Control-room log
3. Operating failure rate	a. Number of failures b. Time in operation	See 1a above Control-room log, periodic test reports, periodic test procedures
4. Repair-time distribution parameters	Repair times	Maintenance reports, control-room log
5. Unavailability due to maintenance and testing	Frequency and length of test and maintenance	Maintenance reports, control-room log, periodic test procedures
6. Recovery	Length of time to recover	Maintenance reports, control-room log
7. Human errors	a. Number of errors b. Opportunities	Maintenance reports, control-room log, periodic test procedures, operating procedures

4. BWIP WORKSHOP RESPONSES

4.1 ITWI CLARIFICATION

See Sections 2.4 and 3.1 for clarification of the important to waste isolation and related activities questions.

4.2 RETRIEVAL REQUIREMENTS CLARIFICATION

See Section 3.2.

5. SRP WORKSHOP RESPONSES

5.1 ITWI DEFINITION

See Sections 2.4 and 3.1 for clarification of the important to waste isolation and related activities questions.

5.2 RETRIEVAL REQUIREMENTS CLARIFICATION

Please refer to section 3.2, Retrieval Requirements for discussion of this issue.

5.3 Q-LIST CLARIFICATION

5.3.1 Preventative/Mitigative Determination

5.3.1.1 Preventative System

Preventative means to keep from happening or to avert some occurrence from taking place. Hence, a preventive system is one which anticipates some undesirable occurrence or process and counters it in advance of its actual occurrence. This may be accomplished by either impeding the development of a process leading to an undesirable occurrence, or by keeping one or more of the necessary elements of an equation leading to an accident in abeyance. A preventative system is defined as any system whose design and function actively or passively stop an event from occurring, or, reduce the probability of occurrence of an event.

5.3.1.2 Mitigative System

Mitigate means to make or become less severe or intense; to moderate, the severity of an outcome. Hence, a mitigative system is one which exerts its influence after-the-fact of an undesirable occurrence and acts to lessen its severity. All systems which act upon the existing circumstances are mitigative in nature. A mitigative system is defined as any system whose design and function actively or passively reduce the severity or consequences of an event once the event has occurred.

5.3.1.3 Clarifying Remarks and Examples

The above definitions allow a given system to be at once preventive as well as mitigative. They do not, however, allow this situation to exist for a common occurrence. For example, a fire door may be preventive with respect to the spreading of a fire beyond its boundary, and it may be mitigative with respect to lessening the severity of the overall fire damage. Some systems are generally preventive, and some are mitigative most of the time. The situation to avoid is one of attempting to generalize certain systems as always preventive, and others as always mitigative. In order to precisely determine whether a particular system is preventive or mitigative, a specific event must be examined.

Additional illustrative examples and discussion of the Q-Listing of preventive and mitigative systems are presented in Section 3.3, Q-List Methodology Figure 4-1 Clarification.

5.3.2 Q-List Methodology Section 4.1.8 Clarification

This section states that, "If the consequence is clearly less than the criterion, the scenario is eliminated." Since the criterion is 500 mrem, a value "clearly less" than that must be established by each project to ensure adequate calculational margin.

5.4 DATA BASES

Please refer to Section 3.8 Data Bases for a comprehensive discussion of this issue. Information and data sources are listed in Appendix A.

6. SCP IMPACT

The clarifications provided in this document impact the SCP chapter requirements as indicated in the following sections.

6.1 SCP CHAPTER 6.0

Q-List items will be listed in Chapter 6 and will not address related activities. Items important to the preservation of the retrieval option will be placed in Design Class 2a and will receive the equivalent of Level 1 QA but will not be on the Q-List.

6.2 SCP CHAPTER 8.0

A list of natural system barriers considered important to waste isolation will be identified in Section 8.6. Activities related to items important to waste isolation will be identified on the Activities List as study plans are completed. This is a necessary pre-requisite since, in order to define specifically which activities are related to items important to waste isolation, it is necessary to clearly understand what work at the study plan level will be performed. In lieu of a list of activities, the projects should identify in 8.6 what criteria will be applied to activities to determine if they are related to items 'important to waste isolation'. An example of such criteria is presented below.

Activities Related to Items Important to Waste Isolation

In order to demonstrate the qualities of the natural system which are important to waste isolation, the activities that affect those qualities must be identified so that they can be controlled and documented in accordance with appropriate quality program requirements. Activities related to the natural system important to waste isolation fall into three general categories. They are:

1. Activities that alter the natural system barriers considered important to waste isolation, such as drilling and excavating in the system, and withdrawing water from and injecting water into the system.

2. Data collection activities that provide measurements of the natural system barriers considered important to waste isolation. These are the basis for understanding the relevant characteristics of the barriers.

3. The activities of assessing the description, or model, of the barriers against the performance requirements of 10 CFR 60.112 and 60.113.

All activities, including those conducted outside of the natural system important to waste isolation, must be evaluated for their effects related to the natural system.

APPENDIX A

Data Base Reference Information

Availability and risk data: source index

Document number and date	Document title	Author or publisher
WASH-1400 (NUREG-75/104), 1975	Reactor Safety Study--An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, Appendix III, "Failure Data"; Appendix IV, "Common Mode Failures"	U.S. Nuclear Regulatory Commission
IEEE-STD-500, 1977	IEEE Guide to the Selection and Presentation of Electrical, Electronic and Sensing Component Reliability Data for Nuclear Power Generating Stations	Working Group SC5.3 of Reliability Subcommittee, Nuclear Power Engineering Committee, Institute of Electrical and Electronics Engineers
IEEE-STD-493, 1980	IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems	Working Group of Reliability Subcommittee, Power Systems Support Committee, Industrial Power Systems Department, Institute of Electrical and Electronics Engineers
NUREG/CR-1635, 1980	Nuclear Plant Reliability Data System 1979, Annual Reports of Cumulative System and Component Reliability	Southwest Research Institute for Subcommittee 58.20 of the American Nuclear Society
GADS, 1981	Ten Year Review, 1970-1979, "Report on Equipment Availability"	National Electric Reliability Council
GADS, 1981	Ten Year Review, 1970-1979, "Component Cause Code Summary Report"	National Electric Reliability Council
ORNL/ENG/TM-2, 1976	Nuclear Reliability Assurance Data Source Guide	Oak Ridge National Laboratory
GA-A14839/UC-77	GCR Reliability Data Bank Status Report	General Atomic Company
MIL-HBK-217C, 1979	Military Standardization Handbook: Reliability Prediction of Electronic Equipment	U.S. Department of Defense
NUREG/CR-1278, 1980	Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications	A. D. Swain and H. E. Guttmann, Sandia National Laboratories
EPRI NP-1064, 1979	Analysis of Utility Industry Data Systems	Stone & Webster Engineering Corporation for the Electric Power Research Institute
EPRI NP-1191	Nuclear and Large Fossil Unit Operating Experience	B. M. Stoller Corporation for the Electric Power Research Institute

Availability and risk data: source index

Document number and date	Document title	Author or publisher
NUREG/CR-1331, 1980	Data Summaries of Licensee Event Reports of Control Rods and Drive Mechanisms at U.S. Commercial Nuclear Power Plants	EG&G Idaho, Inc., for the U.S. Nuclear Regulatory Commission
EPRI NP-443	Characteristics of Instrumentation and Control System Failures in Light-Water Reactors	S. L. Dasin, E. T. Burns, V. Cini, and W. S. Loell, Electric Power Research Institute
EPRI NP-1675, 1981	Assessment of Exposure Fire Hazards to Cable Trays	J. S. Newman and J. P. Hill, Factory Mutual Research Corporation, Electric Power Research Institute
CONF-800403, 1980	"The Frequency of Fires in Light-Water Reactor Compartments," in Proceedings ANS/ENS Topical Meeting, April 6-9, 1980, Knoxville, Tennessee	G. Apostolakis and M. Kazarians
Nuclear Safety, Vol. 20, No. 3, May-June 1979	"Nuclear Plant Fire Incident Data File"	A. G. Sideris, R. W. Hockenbury, M. L. Yeater, and W. E. Vesely
Nuclear Safety, Vol. 20, No. 3, May-June 1979	"Review of Fire Protection in Nuclear Facilities of the Atomic Energy Commission, 1947-1975"	W. W. Maybee
IAEA-SM-210/11, 1978	Reliability of Piping in Light Water Reactors	S. H. Bush, International Atomic Energy Agency
EPRI NP-438, 1977	Characteristics of Pipe System Failure in Light Water Reactors	S. L. Dasin and E. T. Burns, Electric Power Research Institute
NUREG/CR-1730	Data Summaries of Licensee Event Reports of Primary Containment Penetrations at U.S. Commercial Nuclear Power Plants	EG&G Idaho, Inc., for the U.S. Nuclear Regulatory Commission
NUREG/CR-1740	Data Summaries of Licensee Event Reports of Selected Instrumentation and Control Components at U.S. Commercial Nuclear Power Plants	EG&G Idaho, Inc., for the U.S. Nuclear Regulatory Commission

Availability and risk data: source index

Document number and date	Document title	Author or publisher
NUREG/CR-1464, 1980	Review of Nuclear Power Plant Off-Site Power Source Reliability and Related Recommended Changes to NRC Rules and Regulations	R. E. Battle et al., Oak Ridge National Laboratory
EPRI NP-2230, 1982	ATWS: A Reappraisal, Part III, "Frequency of Anticipated Transients"	F. L. Leverenz, Jr., et al., Science Applications, Inc., for the Electric Power Research Institute
EPRI NP-2301, 1982	Loss of Off-Site Power at Nuclear Power Plants: Data and Analysis	Electric Power Research Institute
Nuclear Safety, Vol. 19, No. 1, January-February 1978	"A Review of Safety-Related Occurrences in Nuclear Power Plants as Reported in 1976"	R. L. Scott and R. W. Gallaher, Nuclear Safety Information Center
Nuclear Safety, Vol. 20, No. 6, November-December 1979	"Assessment of the Frequency of Failure to Scram in Light-Water Reactors"	G. Apostolakis, S. Kaplan, B. J. Garrick, and W. Dickter
Nuclear Safety, Vol. 19, No. 6, November-December 1978	"Application of Reactor Scram Experience in Reliability Analysis of Shutdown Systems"	G. E. Edison and M. T. Geretner
ALO-78/SAI-154-79-PA, 1980	Component Failures That Lead to Reactor Scrams	E. T. Burns, R. J. Wilson, and E. Y. Lirn, Science Applications, Inc.
ALO-79/SAI-180-80-PA, 1980	Component Failures That Lead to Financial Shutdowns	Science Applications, Inc.
Nuclear Safety, Vol. 22, No. 2, March-April 1981	"Anticipated Transients Without Scram for Light-Water Reactors: Unresolved Safety Issue TAP A-9"	E. W. Hagen, Oak Ridge National Laboratory

Availability and risk data: source index for pumps

Document number and date	Document title	Author or publisher
NUREG/CR-1205, 1980	Data Summaries of Licensee Event Reports of Pumps at U.S. Commercial Nuclear Power Plants	EG&G Idaho, Inc., for the U.S. Nuclear Regulatory Commission
EPRI-FP-754, 1978	Survey of Feed Pump Outages	Electric Power Research Institute
EPRI NP-351, 1977	Recirculating Pump Seal Investigation	MPR Associates, Inc., for the Electric Power Research Institute
PVP-PB-032, 1978	Pump Reliability Data Derived from Electricité de France Operating Experience	J. Dorey and B. Gachot, American Society of Mechanical Engineers
EPRI NP-1194	Operation and Design Evaluation of Main Coolant Pumps for PWR and BWR Service	E. Makoy and M. L. Adams, Energy Research and Consultants Corporation, for the Electric Power Research Institute

Availability and risk data: source index for valves

Document number and date	Document title	Author or publisher
NUREG/CR-1363, 1980	Data Summaries of Licensee Event Reports of Valves at U.S. Commercial Nuclear Power Plants	EG&G Idaho, Inc., for the U.S. Nuclear Regulatory Commission
EPRI NP-241, 1976	Assessment of Industry Valve Problems	MPR Associates, Inc., for the Electric Power Research Institute
ALO-73, 1980	Study of Valve Failure Problems in LWR Power Plants	Burns & Roe, Inc., for Sandia National Laboratories
ALO-75, 1980	Pilot Program To Identify Valve Failures Which Impact the Safety and Operation of Light Water Nuclear Power Plants	Teledyne Engineering Services for Sandia National Laboratories
Nuclear Safety, Vol. 22, No. 2, March-April 1981	Valve Failure Problems in LWR Power Plants	R. J. Reyer and J. W. Riddington, Burns & Roe, Inc.

Availability and risk data: source index for diesel generators

Document number and date	Document title	Author or publisher
NUREG/CR-1362, 1979	Data Summaries of Licensee Event Reports of Diesel Generators at U.S. Commercial Nuclear Power Plants	EG&G Idaho, Inc., for the U.S. Nuclear Regulatory Commission
NUREG/CR-0660, 1979	Enhancement of On-Site Emergency Diesel Generator Reliability	G. L. Boner and N. W. Hammers
ODE-ES-002, 1974	Diesel Generator Experience at Nuclear Power Plants	J. L. Crooks and G. S. Vissing, U.S. Atomic Energy Commission
Nuclear Safety, Vol. 16, No. 2, March-April 1975	"Standby Emergency Power Systems," Part 2, "Later Plants," pp. 162-179	E. W. Hagen
Nuclear Safety, Vol. 14, No. 3, May-June 1973	"Standby Emergency Power Systems," Part 1, "The Early Plants," pp. 206-219	E. W. Hagen
Nuclear Safety, Vol. 20, No. 2, March-April 1979	"Technical Note: Performance of Diesel Generator Units in U.S. Nuclear Power Stations"	E. W. Hagen

Table 7-1
INITIATING EVENT FREQUENCY DATA

	Initiating Event	Frequency	Reference	Comments
1.	Train collision/derailment	12.6-6[a] per train mile	Bechtel, 1981	
	Severe with fire	1.5-9 per mile	DOE, 1979	
	Moderate with fire	8.0-8 per mile	DOE, 1979	
2.	Truck accident	1.44-4 per mile	Bechtel, 1981	
	Severe with fire	8.2-9 per mile	DOE, 1979	
	Moderate with fire	3.1-7 per mile	DOE, 1979	
3.	Radiation Monitoring System	1.1-4 per hour	SRENCO, 1978	
	a) Sensor/detector/indicator Sensor/detector/indicator	6.81-5 per hour 1.098-5 per hour	SRI, 1981 IEEE, 1984	
	b) Alarms	2.33-6 per hour	IEEE, 1984	
4.	Aircraft crash			
	a) Fatal accidents	6.17-8 per mile	FAA, 1981	These values will be used to determine aircraft crash frequency following model described in (Pepping, 1981).
	b) Aircraft movements (Spokane, Wash)	18,339 per year	FAA, 1981	
5.	Earthquake	1.0-6 per year	Stottlemyre, 1979	For a moderately sized earthquake (~6.7 Richter scale) in any 100 km^2 area - Hanford.

[a] 12.6-6 = 12.6×10^{-6}

Table 7-1 (Continued)

	Initiating Event	Frequency	Reference	Comments
6.	Tornado activity	6.824-6 per year[b]	Stone, 1983	Within 100 miles of Hanford site.
		1.0-6 per year	Davis, 1983	Within 100 miles of Hanford site
7.	Fire in rail switching and truck warehousing depots	-	-	Data may be available from the National Fire Protection Agency, New York
8.	Explosion in rail switching and truck warehousing depots	-	-	Same
9.	Radwaste sampling line rupture/burst	3.973-6 per hour	FARADA, 1972	Corrugated stainless steel wire braid 400 psig
	(Stainless steel flex line mechanical failure)	3.940-6 per hour[b]	Bhaskaran, 1979	Flex metal hose including pipe connection.
10.	Hot cell collar seal failures			
	a) Rotating lip gasket and seal	<2.23-7 per hour	GIDEP, 1981	
	b) Pressure door (hydraulic)	3.765-5 per hour	FARADA, 1972	

[b] Recommended value.

Table 7-1
(Continued)

Initiating Event	Frequency	Reference	Comments
11. Vehicle hydraulic clamping/locking system failure			
a) Interlock system	1.2-3 per year	Bechtel, 1981	
b) Hydraulic piston	5.508-6 per hour	Bhaskaran, 1979	
c) Orientation control system	2.080-5 per hour	Bhaskaran, 1979	
d) Hydraulic piping system	3.4095-5 per hour	Bhaskaran, 1979	
e) Mechanical pin connections	3.250-6 per hour	Bhaskaran, 1979	
f) Pneumatic actuator	2.010-6 per hour	IEEE, 1984	
g) Magnetic jack latch drive mechanism	7.80-7 per hour	IEEE, 1984	
h) Hydraulic actuator	2.90-7 per hour	RAC, 1978	
12. Hot cell shield door seal (pneumatic seals)			
a) Pressure door (hydraulic)	3.765-5 per hour	FARADA, 1972	
b) Electromagnetic radiation shields	5.0847-5 per hour	GIDEP, 1975	
c) Pressure door (mechanical)	4.455-5 per hour	FARADA, 1972	
13. Hot cell crane drop			
a) Cranes (bridge, composite)	1.001-4 per hour	IEEE, 1984	
b) Cranes	5.00-5 per hour	Bechtel, 1981	
c) Structural failure of cranes	1.00-5 per hour	SRENCO, 1978	
d) Crane brake fails	3.00-4 per hour	SRENCO, 1978	

TABLE 7-1
(Continued)

Initiating Event	Frequency	Reference	Comments
14. Canisters punctured during handling			
Hydraulic manipulator (actuator)	2.90-7 per hour	RAC, 1978	
Sufficient stress to breach canister (cask lid falls)	1.00-4 per year	SRENCO, 1978	
15. Radwaste piping rupture	1.00-8 per year	SRENCO, 1978	
16. Transfer cask crane fails to hold position			
Crane brake fails	3.00-4 per year	SRENCO, 1978	
Crane cable fails	1.00-5 per year	SRENCO, 1978	
Crane (composite)	1.001-4 per hour	IEEE, 1984	
17. Transfer cask crane mechanical failure resulting in cask drop or canister puncture by sharp object	Same as 16.	Same as 16.	
18. Waste transport cage mechanical failure			
Chain - door interlock fails (relays)	1.00-4 per year	SRENCO, 1978	
Cage catch gear fails	1.00-2 per year	SRENCO, 1978	
Cage structural degradation	1.00-7 per year	SRENCO, 1978	
Tie-down fails (structural)	1.00-5 per year	SRENCO, 1978	
Cable-to-cage attachment fails	1.00-5 per year	SRENCO, 1978	
19. a) Transporter mechanical failure during transport results in transporter collision with moving or fixed objects			
Collision with moving object	1.00-4 per hour	Bechtel, 1981	
Collision with fixed object	4.80-5 per hour	Bechtel, 1981	

TABLE 7-1
(Continued)

Initiating Event	Frequency	Reference	Comments
b) Operator inadvertently moves underground transporter	1.00-3 per year	SRENCO, 1978	
c) Power steering assembly fails	1.044-4 per hour	Bhaskaran, 1979	
20. Borehole shield door failure during installation of canister			
a) Hatch closure latch fails	1.00-5 per year	SRENCO, 1978	
b) Interlock failure	1.20-4 per operation	Bechtel, 1981	
21. Transport dolly failure			
Relay failure	3.00-7 per hour	Bechtel, 1981	
Relay failure	2.16-6 per hour	SRI, 1981	
22. Power/control cable failure			
Power cable	4.84-6 per hour	IEEE, 1984	
Control cable	4.79-6 per hour	IEEE, 1984	
23. Borehole/cask mechanical lock (interlock) fails	1.20-4 per operation	Bechtel, 1981	
24. Borehole shield door jams hydraulic pressure door	3.24-5 per hour	FARADA, 1972	
Mechanical door - personnel, cargo	1.62-5 per hour	FARADA, 1972	
Door mechanism fails	1.00-6 per year	SRENCO, 1978	
25. Storage plug/retainer ring fails			
a) Fasteners, clip, or clamp	<5.54-5 per hour	GIDEP, 1975	
b) Retaining rings (safety coupling)	1.145-6 per hour	FARADA, 1972	

TABLE 7-1
(Continued)

Initiating Event	Frequency	Reference	Comments
26. Inadvertent cask movement during canister insertion			
a) Accidental transporter motion			
Relay failure	3.00-7 per hour	Bechtel, 1981	
Relays/circuits fail	2.16-6 per hour	SRI, 1981	
b) Hydraulic autopositioner inadvertent movement			
Servo controls (alignment)	6.87-4 per hour	GIDEP, 1981	
Position/angle indicator (motion)	7.00-5 per hour	GIDEP, 1981	
Automatic guidance control system	2.088-6 per hour	Bhaskaran, 1979	
Sleeve engagement mechanism (oper.)	1.308-4 per hour	Bhaskaran, 1979	
Sleeve engagement mechanism (static)	7.688-5 per hour	Bhaskaran, 1979	
27. a) Overspeeding of hydraulic ram ejector unit			
Sleeve engagement mechanism (oper.)	1.308-4 per hour	Bhaskaran, 1979	
Brakes fail	1.00-5 per year	SRENCO, 1978	
Speed control device fails	1.00-4 per year	SRENCO, 1978	
b) Overspeed of placement dolly			
Brake mechanism fails	1.00-5 per year	SRENCO, 1978	
Speed control device fails	1.00-4 per year	SRENCO, 1978	

TABLE 7-2
INTERMEDIATE EVENTS FAILURE DATA

Intermediate Event	Failure Rate or Probability of Occurrence	Reference	Comments
1. Receiving area airlock door failure	2.90 - 4 per hour[a]	Graham, 1971	
2. Receiving area radiation monitoring system failure	1.10 -4 per hour	SRENCO, 1978	
3. Explosion given derailment or truck/rail collision in switchyard activities (excluding shipment of explosives)	TBD[b]		Data may be available from the National Fire Protection Agency in New York.
4. Fire given derailment or truck/rail collision in switchyard	.016	Clarke, 1976	
5. Cask remains intack given fire or explosion	.999	SRENCO, 1978	
6. Explosion given aircraft crash	.5[c]	Engineering judgment	Assumes aircraft explodes upon impact.
7. Fire given aircraft crash	.34	Clarke, 1976	
8. Explosion given earthquake	.01[c]	Engineering judjment	

[a] 2.90-4 = 2.90 x $10^{-\$}$

[b] TBD = To be determined.

[c] The probability distribution to be developed for these values will reflect the uncertainty in assigning the most reasonable value in lieu of the absence of more specific data.

TABLE 7-2 (Continued)

Intermediate Event	Failure Rate or Probability of Occurrence	Reference	Comments
9. Fire given earthquake	.10[c]	Engineering judgment	Assumes earthquake severe enough to damage power lines, resulting in fire.
10. Explosion given windstorm	.01[c]	Engineering judgment	
11. Fire given windstorm	.10[c]	Engineering judgment	Assumes wind velocity strong enough to damage power lines, resulting in fire.
12. Explosion given fire in switch yard area	TBD		Data may be available from the National Fire Protection Agency in New York.
13. Cask preparation area airlock door failure	2.90-4 per hour	Graham, 1971	
14. Unload area airlock door	2.90-4 per hour	Graham, 1971	
15. Hot cell port seal (pneumatic seal) failure	1.0-5 per year	SRENCO, 1978	
16. Radiation monitoring alarm for secondary confinement exhaust system failure	1.10-4 per hour	SRENCO, 1978	

[c] The probability distribution to be developed for these values will reflect the uncertainty in assigning the most reasonable value in lieu of the absence of more specific data.

TABLE 7-2 (Continued)

Intermediate Event	Failure Rate or Probability of Occurrence	Reference	Comments
17. Cask to borehole seal intact given canister breach due to cask motion	TBD		Need more design information to predict seal failure given this condition.
18. Personnel access shaft cage failure	1.0-5 per year	NRC, 1975	Structural failure
19. Waste transport shaft cage failure	1.0-5 per year	NRC, 1975	Structural failure

TABLE 7-3
BASIC EVENT FAILURE DATA

Event ID	Event Description	Failure Rate H (D)[a] Mean	Failure Rate H (D)[a] Variance	Repair Time H Mean	Repair Time H Variance	Reference
A7,A10,A43, A48,C7,C16, D10,D11,D39, D45,D51,D52, D58,D64,D69, D70,D102,D103, D135,D136	Exhaust blower motor (300-500 HP)	1.689-5[b]	1.603-10	2.100+1	7.100+2	NCSR, 1979 (failure rate) GIDEP, 1984 (repair)
B5,B9,B13, B18,B51	Exhaust blower motor (3000 HP)	3.001-5	5.490-9	1.070+2	7.170+2	SRI, 1981 and Westinghouse, 1978 (failure rate)[c] SRI, 1978 (repair)
D24,D25,D26, D27,D78,D79, D86,D87,D111, D112,D119,D120, D144,D145,D152, D153,D169,D170, D177,D178	Damper motor (<1HP)	4.242-6	1.011-11	4.0	9.0	SRI, 1981 and RAC, 1978 (failure rate)[c] SRI, 1980 (repair)

[a] H = hrs D = Demand

[b] 1.689-5 = 1.689×10^{-5}

[c] Composite data derived from the sources listed.

TABLE 7-3 (Continued)

Event ID	Event Description	Failure Rate H (D)[a] Mean	Failure Rate H (D)[a] Variance	Repair Time H Mean	Repair Time H Variance	Reference
A3,A5,A35, A38,B4,B8, B12,B16,B50, C3,C6,D4,D5, D38,D44,D50, D57,D67,D68, D100,D101, D133,D134	Exhaust blower fan	5.361-5	1.615-9	1.800+1	6.300+1	GD, 1963; Graham, 1971; NCSR, 1979; EPRI, 1982; EPRI. 1981; SRI, 1981 (failure rate)[c] EPRI. 1982; EPRI, 1981 (repair)[c]
A24,A49,A51, B7,B10,B14,B21, B53,C26,C27, D28,D30,D32, D34,D40,D46, D52,D59,D65, D72,D73,D80	Instrumentation and controls circuit failure	4.234-6	1.007-11	8.00	3.600+1	SRI, 1981 (failure rate) Engineering judgment (repair)
A11,A16,A22, A29,B14,B40, B47, D7,D93, D126,D159, D184,C11,C15, A17,A25,B36, B42,B48,C18, C22,D17,D95, D128,D161,D186, A20,A28,B37, B43,B49,C20, C24,D19,D97, D130,D163,D188	Air filters (NBS, HEPA, charcoal) primary failure (rupture, out of limits)	3.154-6	6.740-11	0.3	0.144	GIDEP, 1981; IEEE, 1984; EPRI. 1982; SRI, 1981 (failure rate)[c] GIDEP, 1983 (repair)

[a] H = hrs D = Demand

[c] Composite data derived from the sources listed.

TABLE 7-3 (Continued)

Event ID	Event Description	Failure Rate H (D)[a] Mean	Failure Rate H (D)[a] Variance	Repair Time H Mean	Repair Time H Variance	Reference
A12,A15,A18, A26,C17,C21, D16,D94,D127, D160,D185,A19, A27,C19,C23, D18,D96,D129, D162,D187,A21, A30,A41,A47, B25,B31,B35, B41,B46,D6,D92, D125,D158,D183, A40,A45,B23,B29, C10,C14	Air filters (NBS, HEPA, charcoal) Mechanical failure (collapse)	3.505-7	7.488-12	0.3	0.144	Same as above
A1,A34,A37,B2, B17,B26,C2, D36,D42,D48, D55,D61	Tornado dampers fail closed	4.260-6	2.910-11	8.00	56.2	Duphily, 1982 (failure rate and repair)
D12,D13,D14, D15,D76,D77, D84,D85,D109, D110,D117,D118, D142,D143,D150, D151,D167,D168, D175,D176	Filter dampers fail	5.590-6	1.756-11	13.0	32.0	EPRI, 1981 (failure rate) Duphily, 1982 (repair)

(a) H = hrs D = Demand

TABLE 7-3 (Continued)

Event ID	Event Description	Failure Rate H (D)[a] Mean	Failure Rate H (D)[a] Variance	Repair Time H Mean	Repair Time H Variance	Reference
A2,B1,C1,D1	Loss of integrity of exhust duct	2.660-6	4.320-11	12.5	87.8	Duphily, 1982 (failure rate and repair)
A33,A36,B19, B27	Heating/cooling coils collapse and block flow	1.900-5	2.202-9	8.0	36.0	EPRI, 1981 (failure rate) Engineering judgment (repair)
A8,A14,B33, B39,B45,C9, C13,D8,D98, D131,D164, D189	Moisture Separator primary failure	4.748-4	1.408-7	1.0	1.60	FARADA, 1973 (failure rate) Engineering judgment (repair)
A9,A13,B32, B38,B44,C8, C12,D9,D99, D132,D165, D190	Moisture separator collapse - mech. failure	5.276-5	1.564-8	1.0	1.60	FARADA, 1973 (failure rate) Engineering judgment (repair)
E4,E13,E14	Primary cable fault	3.220-6[d]	5.828-12	22.5	285	IEEE, 1984 (failure rate) Duphily, 1982 (repair)
E8,E10	Diesel generator fails to start on demand	(4.000-2)	1.000-3	--	--	NRC, 1975
E7,E10	Diesel generator fails while running (primary failure)	8.000-3	3.890-4	26.0	387.0	NRC, 1975

[a] H = hrs D = Demand

[d] Per 1000 circuit feet

TABLE 7-3 (Continued)

Event ID	Event Description	Failure Rate H (D)[a] Mean	Failure Rate H (D)[a] Variance	Repair Time H Mean	Repair Time H Variance	Reference
E11,E16	Accumulator tank rupture	9.259-6	4.819-11	85.0	452.0	SRI, 1981 (failure rate and repair)
E12,E15	Compressor - primary failure	2.490-5	3.508-10	1.0	1.60	SRI, 1981 (failure rate) Engineering judgment (repair)
E1	Loss of normal commercial power	1.594-5	1.429-10	1.0	1.60	EPRI, 1982 (failure rate and repair)
E2	138 KV/13.8 KV transformer fails	6.900-7	8.820-14	61.2	2110.0	IEEE, 1984 (failure rate and repair)
E3	138 KV oil circuit breaker fails to open	1.776-7	1.922-13	10.0	19.4	IEEE, 1984 (failure rate and repair)
E5,E17,E19	MOC relay fails to energize	(1.250-4) 3.749-7	8.760-9 7.891-14	-- 0.41	-- 0.094	NRC, 1975 (failure rate) NRC, 1975 (failure rate) IEEE, 1984 (repair)
E6,E18,E20	Load center switch-gear failure	2.752-6	4.615-11	66.0	846.0	IEEE, 1974 and SRI, 1981 (failure rate)[c] IEEE, 1974 (repair)

[a] H = hrs D = Demand

[c] Composite data derived from the sources listed.

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APPENDIX B

Revised Section 4.2.1

4.2.1 Methodology B - Preclosure Events (Operational/Retrieval) Impacting Ability to Perform Retrieval

Figure 4-3 presents a schematic diagram relating to Methodology B. It is incumbent upon DOE to evaluate initiating events which may credibly lead to a local or global retrieval mandate by the NRC and determine which retrieval equipment, if any, need be Q-Listed and which systems, components, or structures need to properly function in order for DOE to show capability to retrieve.

Regardless of the cause, once retrieval is set in motion, the Act and 10 CFR 60 mandate that the action be successfully carried out. Time allowance for retrieval operations is flexible, and not restriction are specifically imposed regarding retrieval costs. NRC does indicate, however, that retrieval must not be impossible or impractical.

Identification of an event which could result in the failure of a system, component, or structure such that the ability to retrieve is made impossible or impractical, would require the casual system, component, or structure (and/or the resulting mitigative item) to be placed in Design Class 2A and receive additional design criteria and QA. Note that NRC mandated retrieval of waste packages on a localized or specific basis, as a result of an abnormal event or accident, is not considered to be under the umbrella of 10 CFR 60.143 (monitoring and testing waste packages of Subpart F-Performance Confirmation Program). Therefore, retrieval equipment need not be constructed prior to establishment of the retrieval mandate and Q-List requirements on retrieval equipment would be limited to the application of Level 1 QA to the design and prototype testing programs.

In assessing whether retrieval equipment must be Q-Listed based on important to safety considerations in the SCP-CDR, or whether repository or ESF subsurface systems, components, or structures must be placed in Design Class 2A and their design criteria modified, a risk assessment methodology similar to Methodology A is applied.

All evaluations performed will be preliminary and based on best available data as augmented by engineering judgment where required. The methodology and results shall be documented appropriately for reference in the SCP-CDR. The following sub-sections describe in more detail the methodology depicted in Figure 4-3, and provide examples, where appropriate.

4.2.1.1 Repository Design Data Base

Reference the repository SCP-CDR design configuration. Document design data and applicable assumptions required for performing this evaluation, such as, exhaust ventilation flow rates and configurations, waste emplacement mode(s) included in the evaluation, waste package design utilized, anticipated specifications for water control systems, etc.

4.2.1.2 Initiating Event Identification and Screening

An assessment of each candidate event must be made as to its frequency of occurrence probability. A screening criterion of 10^{-5}/yr shall be used as a lower bound credible occurrence frequency rate. Initiating events surviving this initial screening process are considered credible on a preliminary basis and will then be developed into accident scenarios.

4.2.1.3 Approximate Event Progression

For the events where retrieval is local, normal retrieval operations are likely, and no abnormal events need be assumed due to the limited time frame. Event progressions for the accident scenarios are then developed similar to Methodology A (See Subsection 4.1.5) and event tree logic models are utilized.

4.2.1.4 Technical Judgment on Sequence Probability

For all event trees, system failure rate probabilities shall be estimated based on performance data base information developed for Methodology A. For identified systems not described in sufficient detail at this state of design, a failure probability based on performance of similar systems or based on conservative bounding assumptions must be assigned.

4.2.1.5 Accident Scenario Screening

The accident scenarios are screened against the 10^{-5}/yr screening criterion plus a potential additional factor to account for technical and regulatory uncertainty. Scenarios with probabilities lower than the criterion are considered incredible and should be eliminated from further consideration.

4.2.1.6 Determination of Q-List Requirements

An assessment should then be made, using Table 4-4 for guidance, as to retrieval equipment Q-List status. In this table, the severity of event impact on the waste package and underground environment is related in a matrix to potential Q-List status for retrieval equipment. Consideration of Q-Listing specific pieces of retrieval equipment requires event and

site-specific technical judgment. The matrix specified in the table is based on projected accident radiological releases from a single waste package, as analyzed in the WESTON Preliminary Repository Underground Design Safety Assessment Report, November 1985, as well as on engineering judgment regarding potential event impacts on the underground environment. When, based on technical judgment, the retrieval equipment Q-List status determination is made it must be determined whether there is reasonable assurance that the retrieval equipment will be able to properly operate in the underground environment and perform the retrieval function. If retrieval is considered possible then the design meets preclosure performance requirements specified in 10 CFR 60.111.

If retrieval is considered impossible or impractical, then the causal and/or resulting mitigative system or major component or structure is placed in Design Class 2A and the appropriate design criteria are adjusted to either reduce the probability of scenario occurrence or to mitigate the consequences. The scenario is then reassessed to ensure that the retrieval option is preserved.

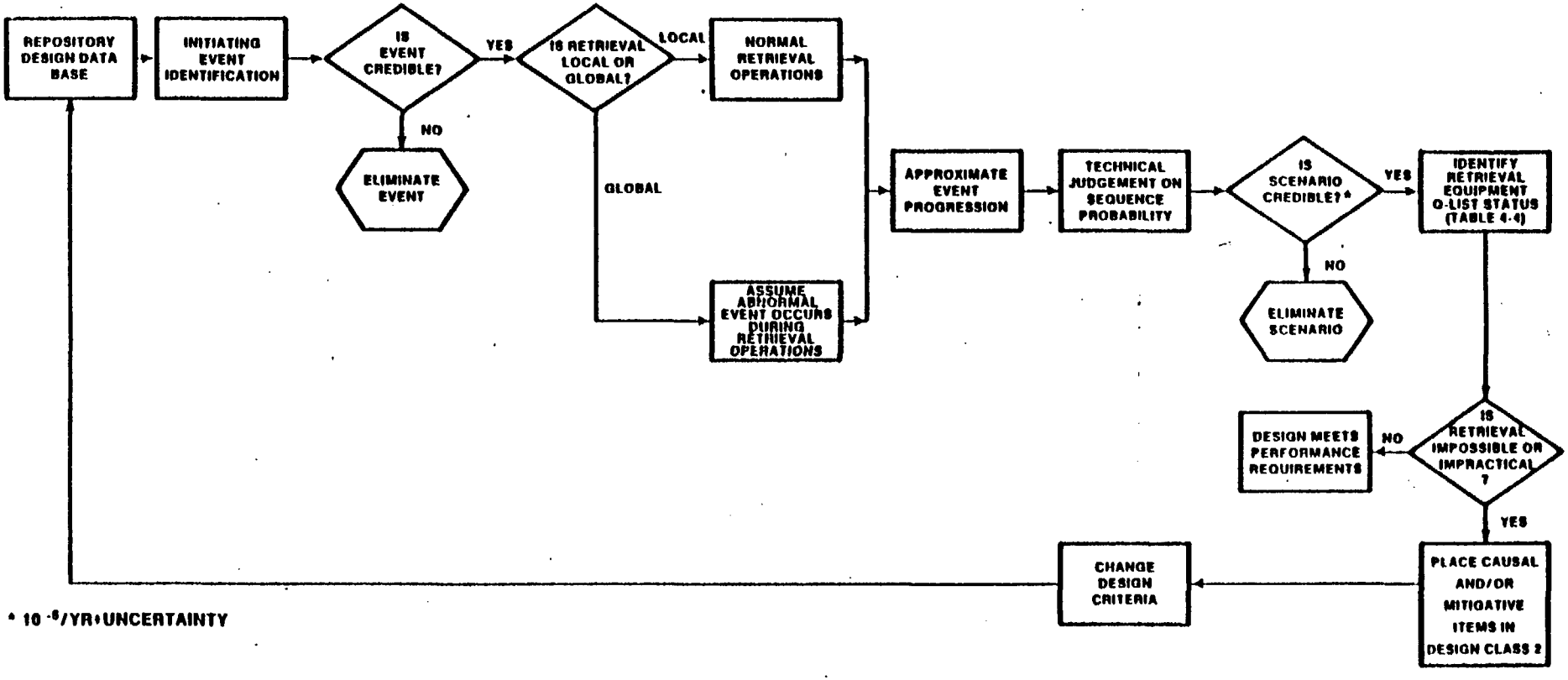

Figure 4-3. Methodology B schematic for preclosure events (operational/retrieval) impacting ability to perform retrieval.

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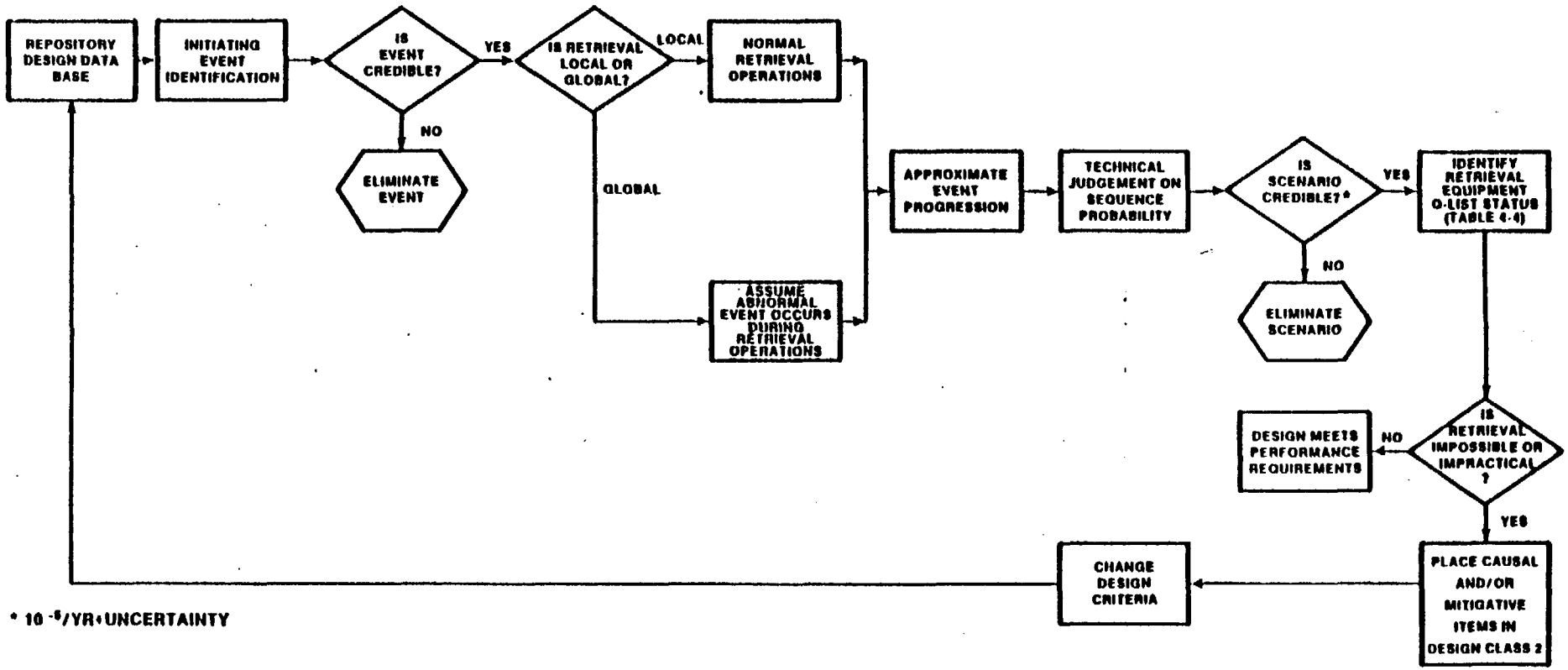

Figure 4-3. Methodology B schematic for preclosure events (operational/retrieval) impacting ability to perform retrieval.

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