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Analysis of Training and Certification of Operations Technicians at Independent Spent Fuel Storage Installations

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Prepared by S. B. Hottman, R. P. Bateman, and D. W. Biers
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NOTICE

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ABSTRACT

This document presents the results of a task analysis and recommendations for the training and certification of operations technicians at independent spent fuel storage installations. Its purpose is to provide a technical basis for initial and continuation training for operations technicians at Independent Spent Fuel Storage Installations (ISFSIs). It also provides guidance for testing operations technicians to ensure that training objectives have been achieved. The recommended testing provides a basis for certification of ISFSI operators. The basis for this handbook was a task analysis conducted at the ISFSI at Morris, Illinois. Supervisors were interviewed and a preliminary job analysis was used to determine required operator skills. Training, safety and operating documents and checklists were reviewed and task inventory forms were developed with the help of ISFSI supervisors. Operations Technicians were then interviewed and the task inventory forms filled out with information on task frequency, difficulty, hazard, time to complete and error potential. These data were analyzed to determine required operator skills and proficiency levels necessary for safe ISFSI operations. The training and testing for certification necessary to verify the skills and proficiency levels were inferred from the data base and the Morris operation records.

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Several individuals at Systems Research Laboratories, Inc. (SRL) participated in this study and report preparation. Darrell E. Wright aided in data collection at the General Electric Morris Operation and in data compilation and review. John C. Simons and Daniel W. Sauer provided input to portions of the recommendations section. Composition and editing tasks were performed by Imogene J. Hoffer, who deserves full credit for meeting the deadlines.

1. INTRODUCTION

Although the 1977 ban on reprocessing spent nuclear fuel was lifted by President Reagan in October 1981, the requirement for large capital investments by the private sector in reprocessing plants and the difficulty in competing with other low-cost fuel sources has continued to deter development of a privately owned reprocessing industry. In addition to this delay in spent fuel reprocessing, Secretary James Edwards has stated that the Department of Energy (DOE) does not plan to provide federal spent fuel storage services at Away From the Reactors (AFR) sites.

The federal government has reduced the interim spent fuel management budget from $23 million in fiscal year 1981 to $7 million in fiscal year 1982. The result of these actions is that despite lifting the ban on reprocessing, there remains an additional step in the nuclear fuel cycle: long-term interim spent fuel storage.

Although at least three dry storage systems have been proposed and are in various stages of development, all require up to two years of cooling of the fuel bundles in conventional wet storage pools. The costs associated with development of dry storage combined with the uncertainties of a new technology make it likely that Independent Spent Fuel Storage Installations (ISFSIs) will be used to store both PWR and BWR fuel. There is an extensive technology base related to water pool storage, a technique that has been used successfully for 30 years (Wargo, 1981). Nevertheless, federal certification and training requirements for ISFSI operators have not yet been developed. The requirements of 10 CFR 72, "Licensing requirements for the storage of spent fuel in an independent spent fuel storage installation," state that the applicant for an ISFSI license must establish a program for training, proficiency testing, and certification of personnel. With no regulatory guide, ISFSIs have established programs that are, at best, very extensive but inefficient, covering far more than should be required in order to ensure that no possible area has been omitted. By adopting such a conservative approach, some ISFSIs would establish large training programs that would be,in the worst case, wasteful and inappropriate. This study was developed to provide a technical basis for a regulatory guide entitled "Training and Certification of Independent Spent Fuel Storage Installation Operators." The purpose of this document is to present the results of a task analysis of operations technicians at an ISFSI and to relate the findings to minimum training and certification requirements for ISFSI operators.

Because ISFSIs currently in use, such as the General Electric installation at Morris, Illinois, were originally designed and staffed as reprocessing facilities, the facility design and technical capability of operations technicians may greatly exceed any reasonable minimum requirements. Many of them hold nuclear operators licenses and have skills and training in total reprocessing operations. This study was designed to answer the following questions:

1. What skills are necessary to be an effective ISFSI operations technician?

2. What areas and levels of technical knowledge are necessary for the operations technician to operate the facility safely?

3. What type of examination/certification procedure would best verify the presence or absence of the skills and knowledge necessary to operate an ISFSI safely?

The basis for this study was a task analysis of the operations technicians' activities at the General Electric Morris Facility. Representative activities were selected to include normal and abnormal conditions, routine and emergency operations. In order to evaluate training and certification adequacy, it was necessary to establish an understanding of the working environment and the purpose of the operation. Operational constraints were evaluated as the operations technicians' tasks were analyzed. It was necessary to determine what was done, how frequently it was done, how long it took and how difficult the selected tasks were. In addition, errors were evaluated in an effort to determine weak areas in the training and certification program.

Following the introduction in Section 1, this document presents the results of the task analysis along with appropriate background information and the recommendations for a training and certification program that should ensure qualified personnel at existing and future ISFSIs. The facility, plant layout and operation are described in Section 2, along with current operations technician qualifications, training and certification, and a discussion of tasks that are accomplished. Section 3 presents the program plan that was developed to guide the task analyses, the supervisor questionnaires that were used to select representative tasks and establish worker qualifications. The task selection process and the Task Inventory method are also described in that section. The data analysis is described in Section 4, along with results, statistical summaries, and tentative analyses of the results. In Section 5, recommendations are made for operations technician qualifications, education, and training for initial certification and for biennial recertification. Answers to pertinent questions are provided and the study is summarized.

2. THE MORRIS ISFSI

2.1 Morris Operation

The Morris Operation is classified as an Independent Spent Fuel Storage Installation (ISFSI). An ISFSI is a facility which receives and stores spent irradiated fuel and, in the case of the Morris Operation, this storage facility is located away from the reactors it services. The Morris Operation is licensed by state and federal agencies for the receipt and storage of irradiated fuel from both Boiling Water Reactor (BWR) and Pressurized Water Reactor (PWR) nuclear power plants. These fuel bundles are received from several locations around the United States.

In producing energy, the fuel bundles undergo changes which alter their ability to produce controlled thermal heating. In this changed state, they are designated as spent fuel, removed from the reactor core, and stored for cooling at the reactor site for at least one year. As stored spent fuel accumulates, contracts may be negotiated to remove some of the bundles for extended interim storage prior to either reprocessing or a more permanent dry storage. Because of legal constraints, the realities of establishing contracts, and problems in physical preparation and shipment, arrival of spent fuel at an ISFSI follows an irregular distribution pattern ranging from zero fuel over a several month period to as many as 100 bundles in one month. An ISFSI must be staffed to safely handle large numbers of arriving bundles, yet have the flexibility to maintain a static storage level for long periods.

At the Morris ISFSI, fuel has arrived in single unit casks designed for truck tractor trailers and in large casks mounted on rail cars. The shipping casks are large metal cylindrical containers. They may have a self-contained cooling system, and are designed to retain their integrity under a variety of extreme impact loads without leaking radiation to the environment. The truck transportable cask currently in use is designed to hold one PWR or two BWR fuel bundles. The cask for rail car transport will hold 7 PWR or 18 BWR fuel bundles. Additional information, sketches, and photographs of these casks are contained in NEDG 21889 (1978).

Upon receipt of the spent fuel, a step-by-step procedure is performed which ultimately results in the spent fuel being located under water in a large specialized basin. The fuel is stored under water for dissipation of heat from the irradiated fuel and for shielding from any radiation hazard to the employees or general public. Once the fuel bundle is stored, basin and system maintenance becomes the primary tasks for the fuel bundle.

A summary of the fuel receipt/storage cycle is as follows: (1) casks are off-loaded from the transport vehicle; (2) cask is placed by crane in the unloading pit; (3) fuel is removed from cask under water and transferred to a storage basket; (4) storage basket is placed in one of the storage basins; (5) cask is removed from the unloading pit; (6) cask is decontaminated and surveyed; (7) cask is loaded onto transport vehicle and shipped off-site. The time required for this entire procedure depends upon several variables including the type of cask, weather, time of day, shift size, and backlog to name a few. Because a majority of the fuel receipt/storage work occurs under water (for radiation protection purposes), the operations technicians may employ various devices to enhance their fuel basket tool manipulation coordination. These devices include underwater TV camera, underwater periscope, and/or binoculars.

Following receipt, unloading, and storage of the spent fuel, operations at an ISFSI center around maintaining the fuel bundles in a safe and secure environment. The basin (or pool) in which the fuel is stored to prevent contamination of the environment must be cooled and the water filtered to remove impurities which may transport radioactive sources. Filter material and other substances that have been exposed to contamination must receive special handling and be stored in a Low Activity Waste (LAW) vault. Installation systems must be checked for proper operation to prevent leaks of contaminated air or water. Fuel accountability checks must be made and radioactivity must be monitored to ensure that the entire system is under control. Once the fuel has been stored, the ISFSI operation becomes more of a process monitoring than a materials handling situation.

2.2 Plant Layout

The Morris Operation is physically located on 815 acres in the Goose Lake Township of Grundy County, Illinois. Primary functional facilities which comprise the fuel receiving/storage operations are housed on 15 of those acres and are enclosed by security fencing. Figure 1 illustrates the primary buildings of interest which are within the 15-acre main area.

Located in approximately the middle of Figure 1 is the Main Building which is a massive reinforced structure that contains the fuel storage facilities. Additional portions of the Main Building are the LAW evaporator, control room, laboratory, change rooms, and office space. Portions of the Main Building which are used by the Fuel Storage facilities are the cask receipt and decontamination area; fuel unloading and storage basins; basin support system; and control room. Supporting systems for fuel receipt and storage in part include the LAW system; ventilation system; basin water cooling and filtration system; cask sampling and flush system; sump monitoring and pump out facilities; and the radiation monitoring equipment. Some of these fuel receipt/storage areas are identified by the letter guide in Figure 1.

An expanded illustration of the receipt/storage areas in the Main Building is presented in Figure 2a. Specifically illustrated are the storage basins and decontamination pad. The lower drawing (Figure 2b) shows the cask unloading and fuel basins water depths. Operations technicians are required to perform operations remotely, on casks, fuel bundles, and storage baskets resting on any of the illustrated shelves and basins.

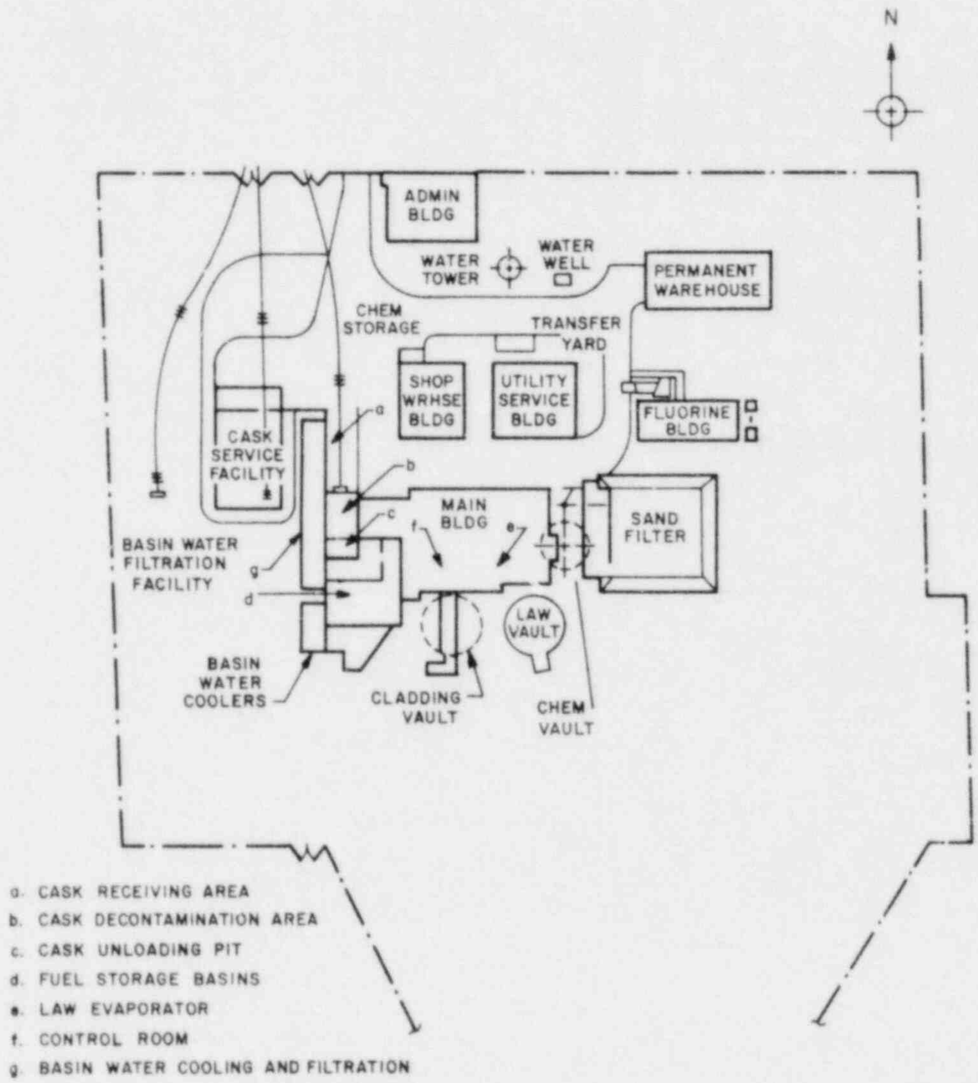

Figure 1. Main Plant Facilities for the Morris Operation (adapted from Astrom and Eger, 1978)

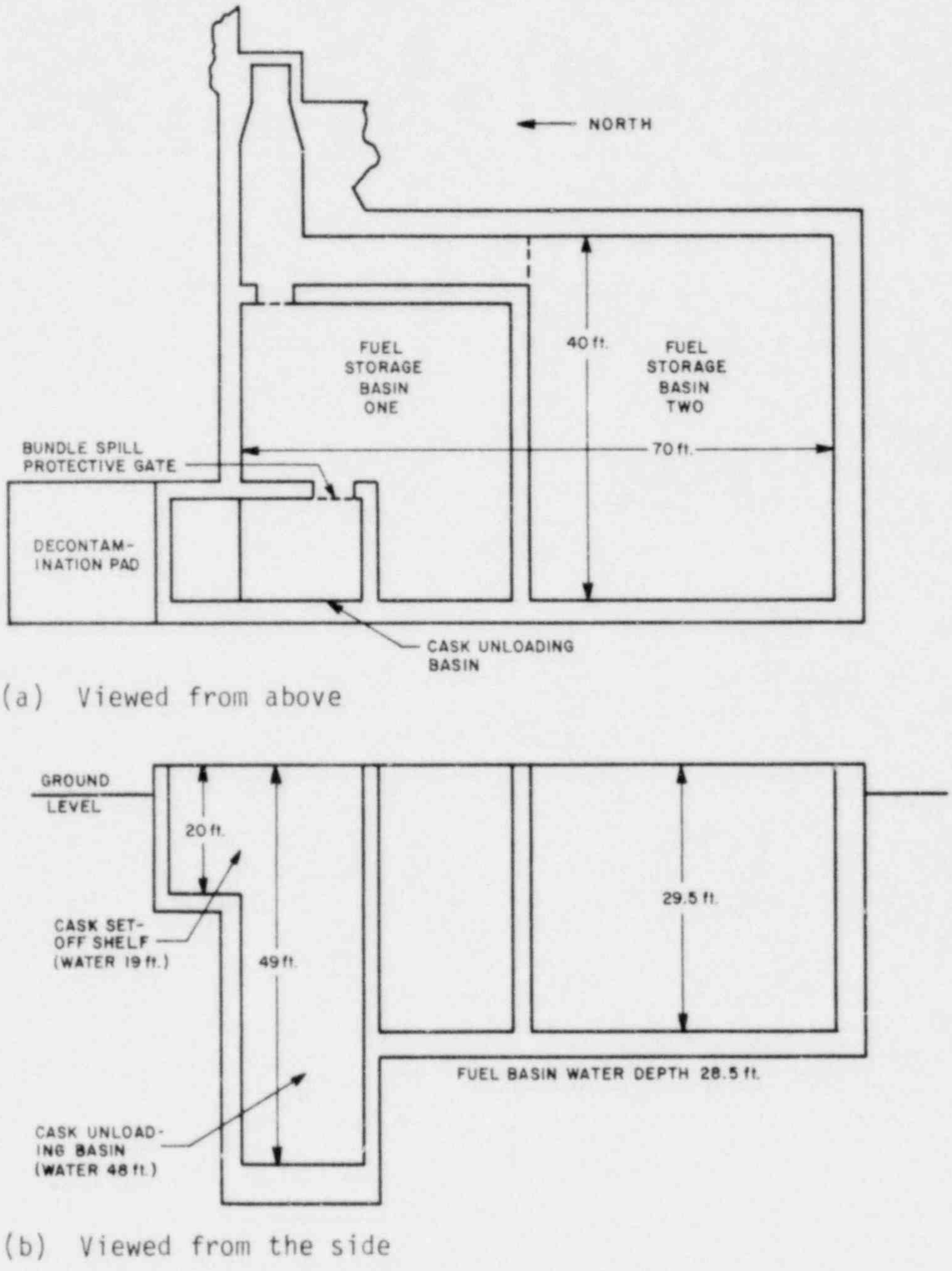

Figure 2. Fuel Receipt and Storage Area
(adapted from Astrom and Eger, 1978)

To illustrate the interrelations of the various systems and subsystems, the Basin Leak Detection System and LAW vault will be briefly discussed. The fuel storage system, a stainless steel lined concrete pool, contains a series of channeling grooves in the concrete that lead to a sump system which collects any water that may have escaped from the stainless steel liner. This sump system collects water that may have originates through the basin liner of the fuel storage basins or by intrusion through the concrete basin walls. The LAW vault, which is a below-ground 600,000-gallon liquid waste holding tank, receives primarily slurries from filter media and waste water from several areas. Areas include basin water treatment system, cask decontamination area, laboratory, basin leak detection system, and from the personnel decontamination shower in the change rooms.

Cranes, a portion of the primary equipment used for fuel receipt/storage, are operated in the areas covering the decontamination pad, cask unloading basin, and fuel storage basins. The largest crane is the cask crane--a 125-ton crane which has access to the cask receiving area, decontamination pad, and unloading pit. Covering the storage basins and unloading pit is the basin crane which has a capacity of 7.5 tons. The smallest crane, the fuel handling crane, has a 5-ton capacity and serves the decontamination pad and unloading pit.

The primary description of the plant layout has involved the Main Building because the primary fuel receipt and storage occur there. This is not to say that the operations technician's entire job is performed there. Performing plant rounds alone, which requires over 125 system inspections at several location throughout the 15-acre primary facility, ensures that the operations technicians are cognizant of all systems and locations throughout the facility.

2.3 ISFSI Operator Qualifications

Personnel at the Morris ISFSI who are operations technicians are well qualified for their positions due to job experience. The average length of working time at the Morris Operation is 7.3 years for operations technicians. The range of the time on the job varies from 1 to 13 years. Two operations technicians have been certified as Reactor Operators. Seven of the 13 operations technicians were certified by the Atomic Energy Commission as Remote Process and Mechanical Cell Operators during the time when the Midwest Fuel Recovery Plant (now Morris ISFSI) was being readied for operation. In addition, two of the four shift supervisors were certified as Senior Reprocessing Operators.

In general, certified operations technicians at the Morris ISFSI are qualified for activities involving operations that are far more complex than the storage of fuel.

2.4 Tasks

Under the General Electric concept of operations of an ISFSI, it is the operations technicians under the operations technicians supervisors who perform the essential ISFSI functions. Supporting personnel provide security, perform equipment maintenance, complete laboratory and radiological safety analyses, and conduct special operations. Management, engineering, training, and administrative support is provided by additional personnel.

The operations technician performs tasks that deal with the receipt and storage of spent fuel, cask handling and decontamination, operation of the filtering and cooling systems for the storage basin, water demineralization, low activity waste vault operations, accountability, monitoring, and electrodecontamination operations. Probably unique to the Morris Operations is the operation of air and water utility systems and the conduct of experiments involving stored fuel. Because of the 7-day, 24-hour operation, the shift supervisor--a certified operations technician--is the de facto on-site manager during evening shifts and on weekends. The control room is, in effect, the ISFSI command post. The operations technicians also participate in the development of training sessions and materials which must be updated to reflect current procedures. During emergencies and abnormal operations on-site, the shift supervisor and operations technicians form the core of the emergency brigade. Special training prepares them to handle unusual situations as they develop. When there is a cask-related mishap away from the installation, a similar special team is formed to deal with problems that arise.

While many events are monitored from the control room, the plant layout requires personnel to travel to different locations within the installation to check on status and operations. These surveillance activities, called "plant rounds," are performed at regular intervals and constitute a substantial part of the duties of an operations technician.

Activities are described in a volume of Standard Operating Procedures (SOPs), and tasks are defined as the elements that constitute an activity. The list of SOPs is shown in Table 1. All of these SOPs were reviewed in order to scope the activities which constitute an operations technician's job. Not all tasks listed in the SOPs are accomplished by the operations technicians. Some activities, such as rounds, are made up of tasks related to a variety of systems and are not formally described in the SOPs.

2.5 Training/Certification/Operator Records

Equipment and controls that are important to safety must be identified in the Safety Analysis Report and in the license application for an ISFSI. Further, in accordance with Title 10, Code of Federal Regulations, Part 72 (10 CFR 72), paragraph 72.91 "Operator Requirements," only trained and certified personnel, or persons being directly supervised by trained and certified personnel, may operate equipment or controls that are important to safety.

Managerial personnel responsible for the supervision of certified personnel must also be certified. Paragraph 72.92 states that an ISFSI license applicant must establish a program for training, testing, and

Table 1. Standard Operating Procedures for the Morris Operations ISFSI

SOP Number	Title
1-3	Receipt and Handling the Loaded IF-300 Cask
1-4	Receipt and Handling the NAC/NFS-4 Type Cask
1-5	Handling the IF-300 Redundant Yoke
1-7	Fuel Removal and Storage
1-8	Accountability System of Fuel Storage Area
1-9	Basket Handling and Installation
1-10	Fuel Grapple Movement Into and Out of Basin
1-11	Hydrostatic Test of IF-300 Cask
1-12	Preparation of IF-300 Off-Site Shipment
1-13	IF-300 Cavity Relief Valve Removal and Reinstallation
1-14	Draining and Filling of the Neutron Shield on IF-300 Cask
1-15	Leak Testing of IF-300 Cask Neutron Shield System Relief Valve
1-16	IF-300 Fuel Basket (Insert) Rotation
1-17	IF-300 Gasket Installation
1-18	IF-300 Cask Reconfiguration
1-20	Basin Filter, F-102, Operations
1-22	Basin Cooler Operations
1-23	Basin Pump Room Sump Jet Operations
1-24	Emergency Action for Morris Operation Basin Coolers
1-26	Operation of Basin Expansion Gate Pump-Out System
1-27	Operation of Basin Leak Detection System
1-28	Operation of Cladding Vault Leak Detection System
1-29	Basin Pump Room Addition Sump (V 107) Pump-Out Procedures
1-30	IF-300 Car Skid LIfting Procedures
1-31	Helium Leak Detector Operations
1-32	Fuel Basket Ventilation Hood Operations
1-33	Operation of Decontamination Scaffolding (Me-193)
1-35	Handling of Casks Which Contain Leaking or Failed Fuel
1-48	Operation of Canyon Crane, Me-130
1-50	Operation of ISCO Shuttle Wagon
1-51	Waste Compacton Operation
1-52	Handling, Packing, Storing and Shipping Regulated Dry Waste
1-54	Graco Pump Operations
4-1	Dry Chemical Vault Intrusion Water Removal
5-2	LAW Evaporator System Operations
5-3	LAW Vault Annulus Jet-Out and Sampling
5-4	LAW Valut (V-570) Sampling and Freeboard Measurements
5-5	LAW Vault Intrusion System Operations
7-1	Operation of Process Cooling Water System
7-2	Operation of Process Steam System
7-3	Routine Checks Associate With Plant Surveillance
7-4	Process Steam Crosstie

Table 1 (continued)

SOP Number	Title
7-5	Process Steam Water Treatment
7-6	Routine Sampling Procedures
7-8	Surveillance and Empty-Out of Sumps During Plant Layaway Status
7-9	Morris Sanitary and Process System Operations
8-1	Air Compressor and Dryer Operations
8-2	Demineralizer Unit Operations
8-3	Utility Boiler Operations
8-4	Utility Boiler Shutdown
8-5	Operation and Sparing of Boiler Feed Water Pumps
8-6	Sparing of Demineralized Water Booster Pumps
8-7	Operation of Utility Cooling Water System
8-8	Operation of Electrical Boiler 13-805
8-10	Operation of Building Ventilation System
8-11	Process Building Ventilation System Emergency Procedure
8-12	Air Outage and Return to Normal
8-13	Heat Pump Operations
8-14	Process Building Heating and Air Condition
9-1	Fire Water Panel Operations
9-2	Use of Well Pump for Fire Fighting
9-3	Water Tower Heating System
9-5	Morris Operation and Winterization
10-1	Electrodecontamination Operations
13-1	Receipt and Storage of 60% Nitric Acid
13-2	Receipt and Storage of Sodium Hydroxide
14-1	Partial Shutdown - Initial Action and Return to Normal
14-2	Total Power Loss - Initial Action and Return to Normal
14-3	Cross-Tie of Incoming Power Busses
14-4	Emergency Diesel Generator Operations
14-5	24 Volt DC Power System Operations
14-6	UPS System Operations
15-1	Bowser Meter Calibration Check and Operations
16-10	Basin Water Analysis Compliance Test
16-11	Basin Leak Detection Compliance Test
16-12	Basin Leak Detection Calibration Compliance Test
16-13	Basin Leak Rate and Operations
16-14	Cladding Vault Leak Detection and Operation Test
16-15	Basin Cooler Leak Detection Compliance Test
16-40	Dry Chemical Vault Intrusion Analysis and Operation Test

Table 1 (continued)

SOP Number	Title
16-51	LAW Vault Leak Detection Compliance Test
16-52	LAW Vault Intrusion Compliance Test
16-80	Emergency Exhaust Blower Operation Test
16-82	Sand Filter Delta-P Operation Test
16-84	Exhaust Sample Analysis Compliance Test
16-85	Exhaust Sample Calibration Compliance Test
16-87	Demineralizer Operation Test
16-90	Emergency Generator Operation Test
16-91	Emergency Generator Sequencing Operation Test
16-93	UPS Load Operation Test
16-95	24 VDC Load Operation Test
16-96	Criticality Detectors Compliance Test
16-97	Criticality Siren Compliance Test
16-98	ARM Calibration and Compliance Test
16-100	Effluent Water Analysis Compliance Test
16-101	Annual Routine Process Steam Samples Operation Test
16-110	Sealed Source Inventory and Leak Check Compliance Test

certification of their operations personnel. This section describes the training, certification, and record keeping of operations personnel at the Morris Operation who are impacted by paragraphs 72.91 and 72.92.

The training and certification program at the Morris Operation is conducted by the following individuals with the indicated assigned duties:

- o Manager Plant Operations - Administrator and Certifying Officer.
- o Manager Quality Assurance and Safeguards - Testing and Certification preparation.
- o Operations Engineer - Program implementation and coordination.
- o Operations Supervisor - Training Officer (orignate and/or rewrite Training Sessions).
- o Operations Technician - Assist in preparation of new Training Sessions or changes.

Figure 3 presents a partial organizational listing at the Morris Operation and, in particular, personnel important to the certification process.

Training for operations technicians which ultimately results in certification is a process that is intended to provide certification within one year. The training program is described in Morris Operating Instruction 606 (MOI-606). General Electric requires training for new employees in the following areas:

- o Orientation and indoctrination.
- o Security.
- o Safety.
- o Emergency Procedures.
- o Quality Assurance.
- o Plant Equipment - Forklift, Pettibone, Four-Wheel Drive Truck, and vehicle for moving railway cars (ISCO).

All Introductory Sessions and Session IV-13 in the Plant Operations Training Program (see Table 2) must be completed before assignment to a rotating shift. Training in the remainder of the sessions in the Plant Operations Training Program must be completed prior to certification. Safety training must be completed by all Morris Operations personnel before any work activity can be accomplished.

The safety and plant operations programs are described in the following paragraphs.

There are three levels of safety training at the Morris ISFSI. The most elementary safety training is designated Class B. The most complete safety training is designated Class A. For individuals who have had previous training is nuclear safety at some other facility, a shorter version of Class A, designated Class A-2, provides instruction in only Morris specific systems.

Class A training is required for all persons whose assigned work area includes work in hazardous areas where protective equipment or clothing

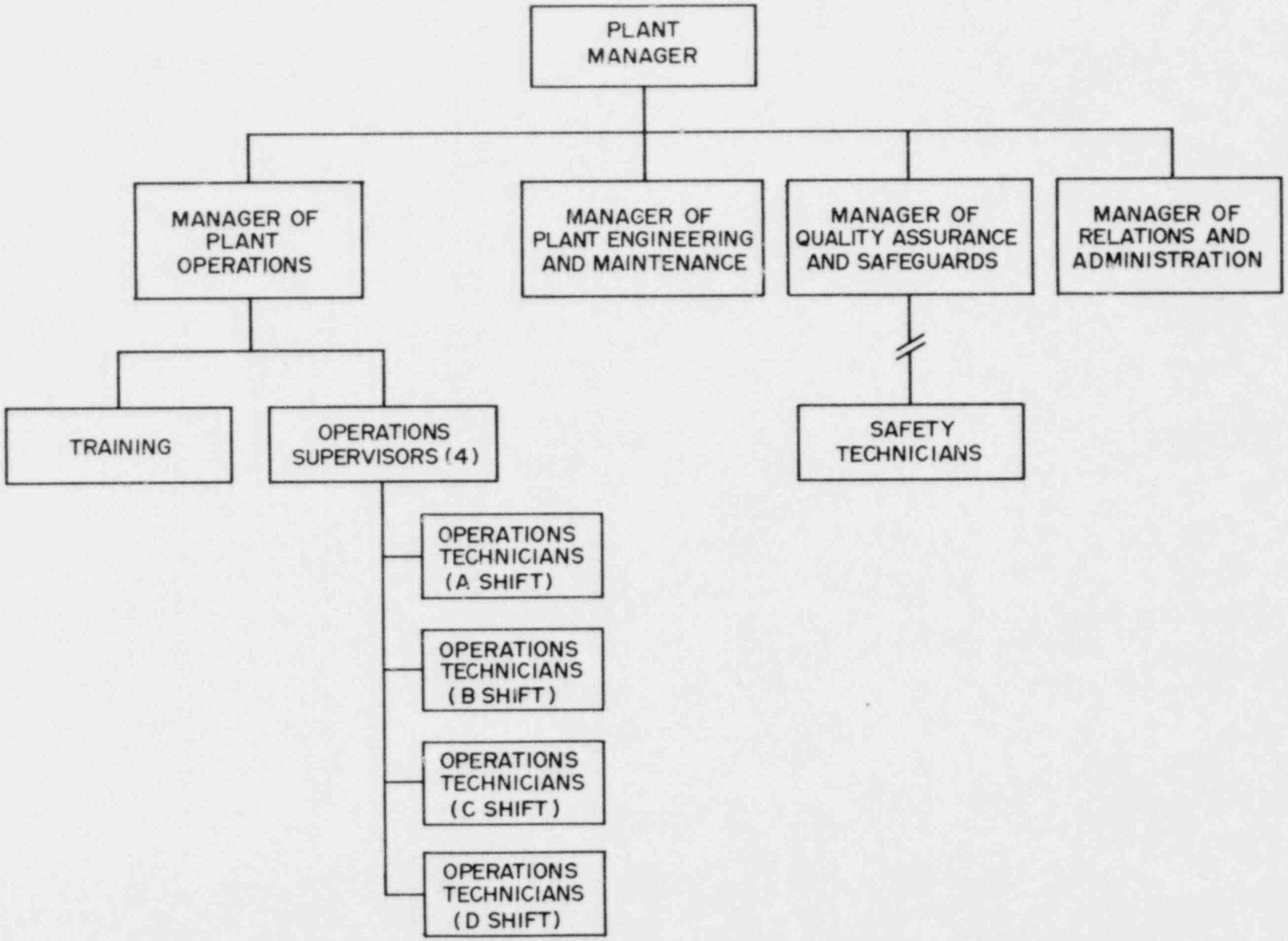

Figure 3. Partial Organizational Structure at the Morris Operation

is required. This training will permit them unescorted entry. The training consists of 16 hours of classroom time which covers the following areas: potential hazards, safety procedures, protective clothing, first aid, and the use of radiation detection equipment.

For a person with previous nuclear safety training, the plant safety officials review the person's documentation to determine compliance with the Morris Operation requirements. A waiver for Class A training will be made if the person's records satisfy Morris requirements and Class A-2 Safety Training will be substituted. Class A-2, a subset of Class A training, consists basically of instruction on Morris Operation specific systems. These systems include instrumentation, emergency procedures, and industrial safety. A walk-through of the plant is also conducted for this training.

Class B training is required for persons at the Morris Operation who are not required to perform some job function in a hazardous area where protective equipment or clothing must be worn. These persons may not enter hazardous areas without being escorted by a Class A certified person. In order to work in a non-hazardous area without an escort, all employees and visitors must complete at least the Class B training. Training for Class B consists of four hours of classroom training which deals mainly with potential hazards and safety procedures. Following the classroom training a site tour is conducted which identifies potentially hazardous areas and the location of various safety equipment. If permanent or semi-permanent job assignment is at the Morris Operation, then a written test is administered to cover the emergency alarm responses.

A written test is required for safety certification. For Class A (including A-2), the certification exam consists of from 20 to 25 questions. For Class B certification, the test is only one third as long. Reexamination and subsequent recertification is required annually for all workers. If individuals with Class A certification fail the annual reexamination, they cannot enter the hazardous areas without a Class A certified person. Persons failing the test must undergo retraining and pass reexamination for subsequent certification.

The Plant Operations Training Program is divided into four separate sections entitled Introductory, Basin Systems, Utilities, and Miscellaneous Sessions. Several sessions comprise the major four sections. The subject matter of the sessions involves the following items: radiation and industrial safety, equipment design, operating characteristics, instrumentation and control, and management systems and procedures. A majority of the sessions have audio-visual materials which include either 35 mm slides, videotape, or viewgraphs which are all used in a classroom training situation. Training is conducted by the Training Officers who present the theory and operations of equipment using the audio-visual material. Following the classroom training, the operations technicians may review the material on an individual basis. This material includes the lesson plan (script), slides, videotape, viewgraphs, discussion questions and quiz questions. Table 2 shows the

Table 2. Plant Operations Training Program

Training Session Number	Training Session Title	Script Pages	Number of Slides	Input Recording Time (minutes)	Discussion Questions	Quiz Questions
I	Introductory Sessions					
I-1	Plant Function	11	20	5	4	3
I-2	Plant Layout	15	99	26	--	6
I-3	General System Description	19	71	20	6	9
I-4	Fuel Storage and Cask Handling	13	49	17	6	4
I-5	Organization and Personnel Duties	8	26	14	--	1
II	Basin Systems - Cask Handling					
II-1a	Miscellaneous Basin Equipment and Systems: Basin Systems	20	60	25	3	5
II-1b	Miscellaneous Basin Equipment and Systems: Cask Handling	16	39	15	4	5
II-2	Fuel Storage	22	27	27	11	11
II-3	Basin Filter	18	15	30	7	8
II-4	Basin Coolers	9	9	15	--	10
II-5	IF-300 Cask	24	64	37	10	8
II-6	NAC/NFS-4 Cask	19	20	17	8	11
II-7	Basin Leak Detection System	12	4	11	3	5
II-8	Basin Accountability System	17	7	18	6	8
III	Utilities					
III-1	Electrical Systems	23	34	29	11	10
III-2	Utility Steam System	29	30	52	8	14
III-3	Demineralizer Water System	20	27	29	7	12
III-4	Process Building Ventilation	24	52	33	6	9
III-5	Low Activity Waste System	32	47	57	8	8
III-6	MO Water Systems	38	32	60	22	16
III-7	Process and Instrument Air Systems	29	36	25	10	16

Table 2 (continued)

Training Session Number	Training Session Title	Script Pages	Number of Slides	Input Recording Time (minutes)	Discussion Questions	Quiz Questions
III-8	Process Steam	22	20	38	5	6
III-9	Aqueous Wastes	7	15	11	--	10
IV	Miscellaneous					
IV-1	Instrumentation	26	35	37	6	8
IV-2	Data Interpretation	14	20	22	5	6
IV-3	Licensing Requirements and Compliance Operability Tests	13	29	17	4	11
IV-4	Radiation Monitors	17	47	24	3	7
IV-5	Criticality Control	10	16	10	6	7
IV-6	Security	13	52	16	--	4
IV-7	Administration Procedures	15	23	15	3	8
IV-8	Bulk Chemical Receipt and Handling	15	39*	15	1	5
IV-9	Sampling	13	18	14	--	5
IV-10	Winterization	21	29	20	7	5
IV-11	Cranes and Rigging	85	43¶	--	--	--
IV-12a	LSA Waste Management - Compactor Operation, Drum Handling, Labeling, and Storage	9	Video	--	--	--
IV-12b	LSA Waste Management - Miscellaneous	6	--	--	--	--
IV-12c	LSA Waste Management - Miscellaneous	3	11	--	--	--
IV-13	Chemistry and Physics	33	43	64	--	13
IV-14	Safety, Chemistry, Plant Manuals	--	--	--	--	--

*Plus video.

¶Viewgraphs

specific quantity of material available for each training session. Once the trainee's review is completed, a walk-through of the studied area/system is conducted by the Training Officer. The trainee uses the appropriate SOP to describe the startup, operation, and shutdown of the system. Particular attention is placed on the trainee's safety focus, knowledge of off-standard conditions, and appropriate knowledge of data collection forms. After each classroom session and walk-through, a quiz is administered covering that session. A score of 80% is required to pass, and this is documented on a record keeping form. If the trainee fails, the deficient areas are identified; the trainee is then retrained and retested. When the trainee has been assigned to a rotating shift, on-the-job training (OJT) begins. This OJT is conducted in conjunction with the Plant Operations Training Program. The trainee observes certified personnel operating the systems and eventually operates the systems under the supervision of certified personnel. When operation of the equipment is not possible (e.g., equipment operated only during off-normal conditions), a walk-through operation of the equipment is conducted by certified personnel. The trainees are rotated throughout the first year of training so that at the end of that time they have been exposed to all the plant systems. Upon completion of all the OJT and the Plant Operations Training Program, the final certification testing occurs.

The final certification testing consists of a comprehensive written test and a walk-through examination. The written examination is divided into five categories, with each category constituting a percentage of the examination as shown below.

Category	Percentage of Final Examination	Average Score Results - 1980
Basin Operations	30	94.98
Cask Handling	20	96.14
Health and Safety	20	93.45
Instrumentation	10	85.19
Utilities	20	92.07

Licensing requirements involve only the first four categories. The "Utilities" category is a unique requirement for the Morris ISFSI where the operations technicians also operate the installation utility systems.

A score of 70% or greater in each of the categories is required for the trainees to pass the exam. The walk-through examination involves going to the actual locations for equipment and controls. When possible, actual operations are performed. When actual operation is not possible, proper control actions are explained. Questions may be asked concerning actions to be taken if indications are other than normal. The following areas are covered during a typical walk-through examination:

- Tour of work area - a description of valves, lines, instrumentation, monitors, and alarms may be required.

- o Ability to respond to simulated emergency conditions is evaluated.
- o Working knowledge of all safety systems.
- o Knowledge of all applicable documents, data sheets, log books, SOPs, and any references to any systems.

If a trainee should fail any portion of the written test or walk-through, accelerated intensive retraining is accomplished followed by retesting. This procedure continues until all criteria for certification are successfully achieved.

Certified personnel also must be recertified periodically. Annually, all certified employees must complete and pass an examination on security, safety, emergency procedures, and quality assurance. Every two years the certified personnel must review the Plant Operations Training Program. They then must pass the same current written test given to trainees but must score a minimum of 80% in all five categories for recertification. Concurrently, certified personnel must pass the same walk-through examination given to trainees. Again as in the case for the trainee, if personnel seeking recertification should fail any portion of the written test or walk-through, then accelerated intensive retraining is accomplished followed by retesting.

Documentation and records of all the certified personnel are maintained on the following forms:

- o Graded session quizzes - kept by the operations supervisor until certification is complete.
- o Plant Operations Training Summary Record - documents employees physical examination, security training, quality assurance, Safety A training, Plant Operations Training (written and walk-through), and the on-the-job performance evaluation. Morris Operations form number MO-383.
- o Training Session Record Program - time spent by personnel in classroom and on-the-job training along with the documented grades. Morris Operations form number MO-384.
- o Final Examination - the graded written and oral examination.
- o Plant Operations Training Program Certification - documents that operations personnel are certified. Morris Operations form number MO-385.
- o Job Performance Statement - time spent on various activities. Morris Operations form number MO-388.

The majority of these records on each employee are maintained for the five previous years.

Operations supervisors are responsible for completing the Job Performance Statement (MO-388) for the personnel assigned to their shifts. Table 3 shows the results for one shift as to the overall percentage of time that various operations technicians spent on various activities. This information is synthesized to produce the data assigned to MO-388. Table 4 presents a summary of the average percentage that various workers spent on various systems.

Table 3. Example of Percentage of Operations Technician's Time on Various Activities

Duty	Percent Time
Housekeeping	10
Physical Inventory	5
Radioactive Nuclear Material (includes fuel handling)	60
Safety	5
Scrap Disposal	5
Training	10
Waste Treatment (includes dry waste)	5

Table 4. Average Percentage of Workers Time on Various Systems (February 1979 to February 1981)

WORKER	SYSTEM/AVERAGE PERCENT TIME					
	Cask Operations	Fuel Handling	Support Systems in the Basin area	Waste	Inspections & Surveillance	Safety and Security
Operations Technicians	7.4	7.6	7.8	8.8	59.4	8.8
New Operations Technicians	9.2	12.9	8.8	5.8	52.1	11.4
Operations Supervisor	4.4	4.1	3.4	4.8	77.2	6.0
Engineers	1.6	2.0	2.7	5.0	85.6	5.4
All Workers	6.5	7.1	6.6	7.2	64.5	8.1

3. METHODOLOGY

3.1 Program Plan

3.1.1 Research Task 1 - Familiarization

The objective of Research Task 1 was to develop this program plan. In order to satisfy this requirement, it was first necessary to visit the Morris ISFSI to arrange for follow-on Systems Research Laboratories, Inc. (SRL) visits, obtain certified safety and security training, determine the availability of GE personnel for interviews, and establish a tentative schedule for visits. Because supervisors were not available for interviews, and documentation was not available for SRL review, a second visit was planned. The requirements for site visits and travel are shown in Table 5, and the Milestone Chart for this program is shown in Figure 4.

There are approximately 97 activities described by SOPs. Additional activities, such as control room duties, are covered by checklists. Monitoring of the facility, referred to as "making the rounds" involves combining several checks of different subsystems into what may be considered a single activity. Based on information obtained on the first visit, the tentative list of ISFSI operations technician functions to be analyzed included the following:

1.	Cask handling	SOP 1-3
2.	Cask testing	SOP 1-11
3.	Cask turnaround	SOP 1-12
4.	Fuel handling	SOP 1-7
5.	Crane operation	SOP 1-48 or 1-9 or 1-10 or 1-50
6.	Basin filter	SOP 1-20
7.	Basin cooling	SOP 1-22
8.	Basin pump	SOP 1-23
9.	Basin leak detection	SOP 1-27
10.	Radioactive wastes	SOP 1-51 or 1-52 or 5-2
11.	Decontamination	SOP 1-33
12.	Alternate cooling methods	SOP 1-24
13.	Casks with leaking fuel	SOP 1-35
14.	Control room operations	No specific SOP
15.	Demineralizer operation	SOP 8-2
	or "Rounds"	No specific SOP

Following additional study and discussion, the list of activities to be analyzed was revised to those listed in Section 3.3

Based upon information from the manager of the Morris ISFSI and SRL's review of the operation and Standard Operating Procedures, the 15 selected activities represented a fair sampling of the range of operations technician activities that relate directly to spent fuel storage. The list was reviewed and revised following supervisor interviews. Each of the selected activities were analyzed to establish the principal tasks that made up the activities. These were used as the basis for Operational Sequence Diagrams (OSDs) and Task Inventories.

Table 5. Requirements for Site Visits and Travel

Depart	Return	Persons	Destination	For
21 Dec	23 Dec	2	Sandia, Albuquerque NM	Kickoff meeting
7 Jan	9 Jan	3	GE, Morris IL	Safety/Security Training
28 Jan	31 Jan	2	GE, Morris IL	Supervisor Interviews, Documentation Review
22 Feb	27 Feb	2	GE, Morris IL	Task Inventory
16 Mar	18 Mar	1	GE, Morris IL	Follow-up Inventory
8 Apr	10 Apr	2	GE, Morris IL	Review Final Report
21 Apr	22 Apr	2	Sandia, Albuquerque NM	Present Final Report

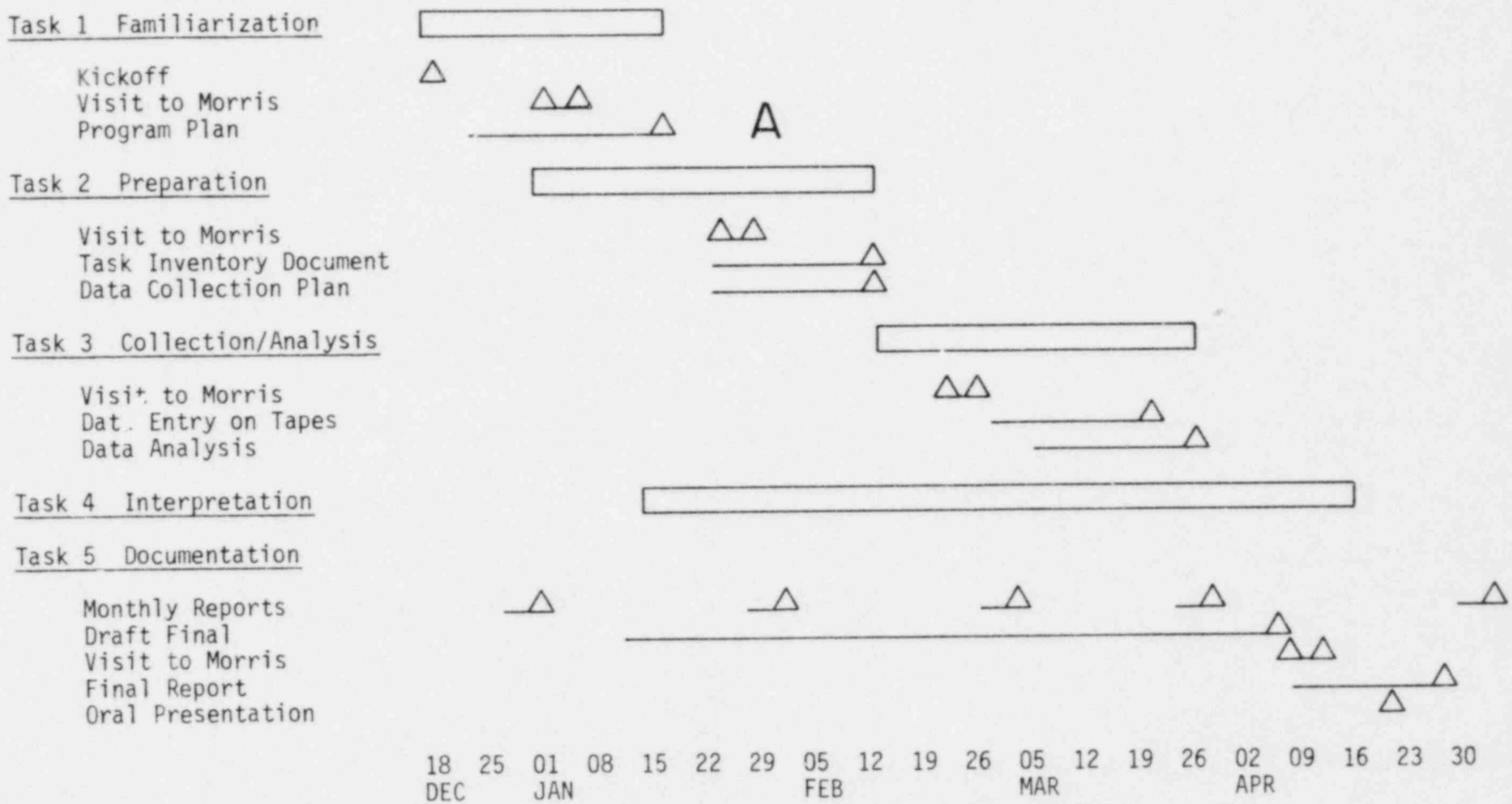

Figure 4. Milestone Chart

Site visit requirements were based upon when the information was needed to support the objectives of the study and upon when the Morris shift schedules made it possible to interview the necessary personnel. To interview supervisors and review documentation, a Thursday through Sunday visit provided the availability of managers, engineers and shift supervisors and time to review documents without interfering with Morris operations. A shift schedule is shown in Table 6 below. Shift schedules for Task inventories are shown under Research Task 3.

TABLE 6. SHIFT SCHEDULE AND SUPERVISOR INTERVIEWS

	THURSDAY	FRIDAY	SATURDAY	SUNDAY
FIRST SHIFT (0000-0850)	C Crew	C Crew	D Crew	D Crew
SECOND SHIFT (0800-1650)	D Crew	A Crew	A Crew	A Crew
THIRD SHIFT (1600-0050)	B Crew	B Crew	B Crew	B Crew

Managers and engineers are available during the second shift on Thursday and Friday.

A lower level of administrative activity on Saturday and Sunday provides time to review documentation.

3.1.2 Research Task 2 - Preparation for Data Collection

The second visit to Morris was used to interview twelve managers, engineers and supervisors and to review documents on Morris operations and training. The supervisor interview consisted of two parts. The first part was a structured interview (see Appendix A) designed to produce information on the following:

1. Allocation of operations technicians' time
2. Similar jobs
3. Required worker characteristics
4. Typical tasks and activities
5. Hazardous tasks and activities
6. Difficult tasks and activities

The remainder of the interview was allocated to establishing the major activity elements, process sequences, and links between elements for the activities to be analyzed. These data were correlated with data obtained from written SOPs and used to develop both OSDs and the Task Inventories. The training program was reviewed based on Morris Operating Instructions and Training guides. In addition, researchers reviewed training records to determine course characteristics and trends in the training efficiency. For some tasks such as "rounds" or control room duty, user checklists were reviewed to establish the task inventory. Researchers also reviewed Emergency and Casualty Procedures and the Evacuation Plan and Procedures.

The results of this task were completed OSDs (see Appendix B) for reference, an understanding of the Morris operation and the current training/certification program, and the development of completed Task Inventories. In reality, the preparation for data collection involved the gathering of a considerable amount of data. The data collection plan is the Task Inventory form. It was administered to 100% of the certified operations technicians and to certified supervisors, engineers, and managers. The schedule and methodology for Task Inventory is included under Research Task 3 below.

3.1.3 Research Task 3 - Data Collection and Analyses

The primary data collection tool proposed for this study was the Task Inventory. It can produce a machine-readable data base that can be updated, edited, expanded, and reproduced and used for computer analysis. From one perspective, the Task Inventory may be viewed as a list of possible tasks, grouped by activity. The Task Inventory method was used to gather data on how much time is spent on each task, task difficulty, task frequency, hazards, and errors. The activities selected for analysis were broken down to their task components. In order to obtain the level of detail necessary to establish training and certification requirements, an average of 13 components of each activity was established, based upon the judgment and experience of the researchers. Subjects were asked to provide responses for tasks which constituted a part of their job. Responses included an estimation of the time to complete the task on a seven point scale. Additional questions are used to determine task frequency, errors, difficulty, and hazard level for each task.

The Task Inventory was developed as the basis for Comprehensive Occupational Data Analysis Program (CODAP). It provides a method of obtaining data from personnel who have experience in task accomplishment without actually having to observe the activity. Early attempts at obtaining subjective data produced meaningful statistical treatment of the data. The Task Inventory provides a vehicle for obtaining subjective data with smaller variations in the data points. Because subjective estimates of time spent on subtasks were variable and unreliable, a seven point floating scale was developed (see Table 7). Rather than use arbitrary anchors at the endpoints of the scale, this floating scale is based on the respondents' subjective interpretations of average. The scales were used to determine the time spent on tasks, task difficulty, and hazard value.

Table 7. Seven Point Rating Scales

	TIME TO DO IT ONCE	FREQUENCY (How Many Times Do You Do It)	DIFFICULTY	HAZARD VALUE (Importance of Doing It Right)
1	Much less than average	Hardly ever	Very easy to do	Not much will happen if done wrong
2	Less than average	Less than average	Easier than average	Less than average
3	Slightly less than average	Slightly less than	Slightly easier than average	Slightly less than average
4	Average	Average	Average	Average
5	Slightly more than average	Slightly more than average	Slightly harder than average	Slightly more than
6	More than average	More than average	Harder than average	More than average
7	Much more than average	Very often	Very hard to do	Doing it wrong will cause a lot of trouble

The Morris 1982 Shift Rotation Schedule was reviewed in order to coordinate trips so that all four shifts would be available for interviews during a visit. By traveling to arrive on a Monday, it was possible to have three opportunities to interview each shift during a 4-1/2 day period. A typical shift schedule is shown in Table 8.

Table 8. Shift Schedule for Task Inventories

DAY / SHIFT	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
FIRST		C Crew	C Crew	C Crew	C Crew
SECOND*		D Crew	D Crew	D Crew	A Crew
THIRD	A Crew	A Crew	B Crew	B Crew	B Crew

*Managers and engineers are available Monday through Friday during the second shift.

All 24 of the GE employees certified to perform operations technicians duties were interviewed. While it was possible to conduct group interviews, the GE Plant Manager indicated that group interviews would not be possible for all subjects. Because the interviews were expected to require two hours, with a maximum limit of three hours, two researchers traveled to Morris for the Task Inventories. This provided for interviews, task observations, and normal waiting time for subject availability.

The data consist of responses from 24 subjects on 217 tasks covering five areas (time spent, frequency, difficulty, hazards and errors). This produced over 23,000 data points for analyses. Data were punched on cards, verified, and transferred to tapes for analyses and subsequent delivery to Sandia National Laboratories.

While the size of the data base did not warrant the use of the CODAP program for analysis, it should be noted that the data base format is CODAP compatible in the event that additional analyses are required at some future time.

The Statistical Package for the Social Sciences (SPSS) analysis program was initially selected for use in reducing the raw data. The primary analysis to have been performed on the Task Inventory seven point scales was the formation of frequency tables developed with SPSS Program FREQUENCIES.

Frequency tables contain:

1. The seven point floating scale code.

2. The raw frequency associated with each value.

3. The relative frequencies with any missing values included in the percentages.

4. Adjusted relative frequencies with missing values excluded from the data base.

5. The cumulative adjusted frequency based on the nonmissing values.

Statistics computed on the frequency data included the mean, minimum, maximum, and standard deviation. After determining that these simple statistical computations were sufficient for task analysis, the plan to use SPSS was discarded, and a more simple program written to compute the desired statistics.

3.1.4 Research Task 4 - Interpretation of Results

The information flow chart for interpretation of the results is shown in Figure 5. Using the data developed from reviews, interviews, inventories and observations, the training program now in effect was analyzed to determine training objectives. These learning outcomes were compared with the results of the task analysis. Difficult and hazardous tasks should receive more attention in any training program. Where an apprentice program involving on-the-job training is used, tasks which are performed frequently require less audio-visual instruction. The researchers suspected that parts of the current training program might be based upon fuel reprocessing. After a careful review of the Morris Operation, it was determined that this suspicion was unfounded. A major purpose of this study was to recommend a minimum training program that will be wholly adequate for certification based upon total safe performance.

From the outset, it should be noted that there are two general types of subtasks: mental (noting limits, reading gages, following checklists) and psychomotor (eye-hand coordination in crane operation). Training in these two areas should be totally different. Psychomotor tasks, such as crane operation, cannot be learned in a classroom. Proficiency requires actual practice. It seems appropriate to require crane operators to operate the equipment at reasonable time intervals to maintain certification and to require practice prior to spent fuel handling if regular operation is not accomplished. The training program was evaluated, based not only on what is taught, but how it is taught.

Where human errors are present in an operation, both the task and the training are suspect. Errors on hazardous tasks are potential indicators of a lack of understanding of the system as well as of

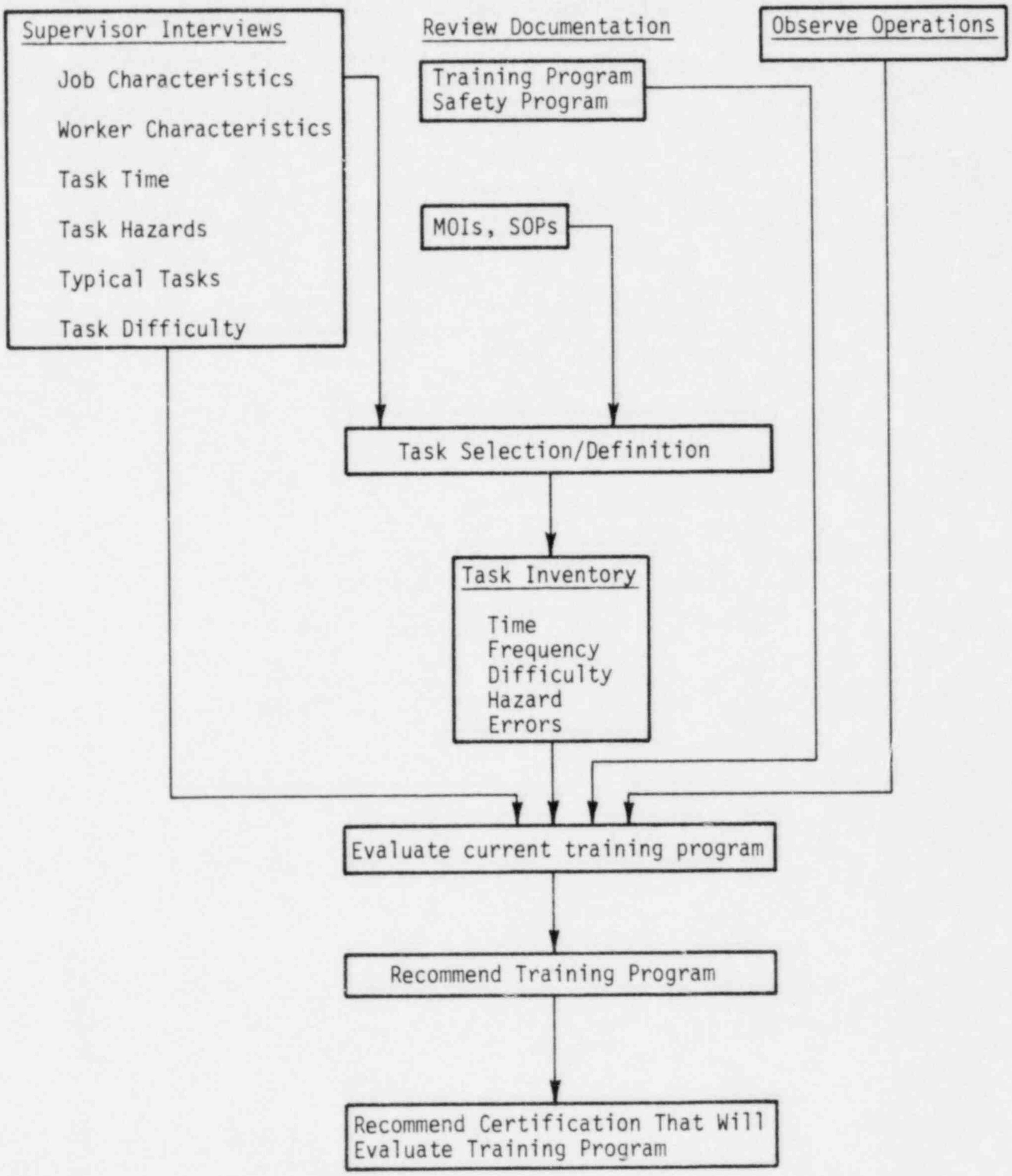

Figure 5. Information Flow Chart for Interpretation of Task Analyses

improper task design. The current training program was analyzed to determine how well it met the needs identified during the task analysis. Changes were recommended only if it was felt that they would more efficiently enable new ISFSI operators to become qualified and certified.

A properly designed training program should totally prepare operators for certification. In this sense, training and certification go together and certification becomes a verification of the training system. Philosophically (and practically), certification need not be a total review of training (such as an eight-hour examination) nor should it be limited to mental examinations when psychomotor skills are required and the mental task is reduced to simply following a set of procedures or selecting the proper checklist. Certifying procedures, based upon current testing theory and the task analysis, are recommended in this report.

3.1.5 Research Task 5 - Documentation

The documentation specified in the program plan established the basis for this report and monthly progress reports. The planned progress is shown on the Milestone Chart (see Figure 4).

3.2 Supervisor Job Analysis

Prior to developing the task inventory, supervisors, engineers, and managers at the Morris Operation were interviewed using a formal questionnaire (see Appendix A). These questionnaires were designed to provide information on the qualifications of an operations technician, the duties of an operations technician as percentage of working time, the relation of other jobs to the operations technician and lists of activities that are typical, that are hazardous and that require training and practice. The questionnaire served as a vehicle to obtain a collection of expert opinions rapidly and provided a means of familiarizing researchers with the operation as viewed by those who knew it best. Results were used directly in selecting activities for the task inventory.

Supervisors were asked to select, from a group of six jobs, what kind of experience background would be most desirable in hiring a new operations technician. Preferences for process controllers, crane operators and nuclear submarine control room work (40, 37 and 35 selections) were expressed. Experience in warehouse operations was rated low (11 selection) along with heavy equipment operations and nuclear power control room operator (20 and 27). It is interesting to note that two of the twelve supervisors rated nuclear power control room experience as most desirable, and two others rated it second most desirable. Those who rated it low claimed overqualification as the reason. These data are summarized in Table 9.

These results helped to clarify perceptions of the activities performed by an operations technician. Although receipt and storage of spent fuel may appear similar to warehouse activities, there is a considerable

Table 9. Rank Order of Six Selected Types of Job Experience for Operations Technicians

Job	Ranking	Times Selected
Process Controller	1	40
Crane Operator	2	37
Nuclear Submarine Engine Operator	3	35
Nuclear Power Control Room Operator	4	27
Heavy Equipment Operator	5	20
Warehouse Experience	6	11

amount of effort devoted to process operations such as basin filtering and cooling, LAW vault evaporation, and demineralization. The use of overhead cranes in handling the fuel bundles, casks, and baskets is also a key task element. Experience with nuclear materials is desirable (ranked third and fourth) but not paramount. One supervisor volunteered the observation that reliability and dependability were far more important than experience when hiring a new employee for an ISFSI. Another supported this concept by adding "maturity" to the list of desirable characteristics.

The importance of these perceptions should not be overlooked. They are the subjective judgments of experienced professionals. There is no doubt that a certified operations technician possesses some character traits that are not trainable. Given the state of the art in psychological testing, these characteristics are probably not testable. The burden of employee selection belongs to the managers and supervisors. Their judgments are often subjective. If reliable tests for employee dependability can be made available to ISFSI managers, they may provide a useful service.

Supervisors were also asked to list the types of work experience (other than ISFSI) that would be most helpful for a newly hired operations technician. The results are shown in Table 10; there is a rather high degree of correspondence between this table and Table 9.

Supervisors were asked to estimate the percentage of time spent by operations technicians on various activities. Using the raw data estimates, one could conclude that an operations technician is busy 200% of the time, but still spends 15% of the time waiting for work assignments (see Table 11). Questions on time spent were purposely separated in the questionnaire to prevent second guessing and balancing the numbers to get 100%. When the data are normalized, the probable

Table 10. Work Experience Most Frequently Rated as Helpful for New Operations Technicians

Work Experience	Number of Supervisors who Listed This Work
Job requiring mechanical skills	6
Process/chemical controller	5
Radiation knowledge	5
Heavy equipment use	4
Crane use	3
Any nuclear experience	3
Instrumentation	3
Procedure/record keeping	2
Nuclear reprocessing	1
Reactor fuel handler	1
Remote handling	1
Laboratory technician	1

division of effort during periods when fuel is being received is as follows:

Cask/fuel operations	24%
Control room, inspection, housekeeping	34%
Training	6%
Utility, basin operation, demineralization	23%
Waste handling	3%
Waiting	9%
Emergencies	1%

When no fuel is arriving, the 24% of the time allocated to cask and fuel operations is distributed among other activities, with training getting the major share.

Based upon the mean number of casks estimated to arrive each year (74) and the mean estimated handling time per cask for fuel storage (13.2 hours), it would appear that only 12% of the time is spent receiving and storing fuel. This result was interpreted to mean that, although the main activity for an operations technician is the receipt and storage of spent fuel, it does not occupy a large amount of the working day. Aircraft pilots work under similar conditions. Although flying typically occupies a third of their working time, there are periods when it may be reduced to 10% of their time (less than 20 hours per month). When this situation exists, the normal result is that additional time is spent in training so that working skills and proficiency are maintained. From a safety point of view, there is a real need to ensure that the training is effective and realistic. Persons engaged in extended training and practice may easily become bored and adopt an attitude of indifference.

Table 11. Estimated Percentage of Time that Operations Technicians Spend on Activities

Job Duty	Minimum (%)	Maximum (%)	Range (%)	Mean (%)	Day Shift (minutes)	Evening Shift (minutes)	Midnight Shift (minutes)
Training	3.0	25	22	11.5	25.6	25.5	25.3
Cask Operations	8.0	80	72	43.8	97.2	97.1	96.7
Inspections	7.0	40	33	20.5	45.5	45.5	45.3
Control Room	5.0	33.3	28.3	20.3	45.0	44.9	44.8
Housekeeping	10.0	50.0	40.0	16.6	36.8	36.7	36.6
Fuel (receive and store)	5.0	60.0	55.0	37.8	83.8	83.7	83.5
Waste Handling	2.0	20.0	18.0	7.5	16.7	16.6	16.5
Waiting (day shift)	2.0	37.5	35.5	15.3	33.9	--	--
Waiting (evening shift)	1.0	50.0	49.0	15.6	--	34.9	--
Waiting (midnight shift)	1.0	50.0	49.0	16.5	--	--	36.5
Demineralizer Operations	1.0	25.0	24.0	6.6	14.7	14.6	14.5
Basin Operations	1.0	40.0	39.0	14.5	32.2	32.1	32.0
Utility Operations	5.0	40.0	35.0	18.4	40.9	40.8	40.6
Abnormal (emergencies)	0.04	12.5	12.46	3.5	7.7	7.7	7.7

*Minutes were obtained by standardizing the mean percentages and then converting to minutes based on an 8-hour shift.

The responses cataloged in Table 11 also provide other information. The range for estimates of percentage of time spent on cask operations represents the actual ranges experienced over an extended period. During a "campaign," when casks are arriving, percentages are very high. For the last year, there have been no new arrivals. The second largest range, "Fuel (received and store)," indicates the same situation. Although it was hypothesized that the waiting time for different shifts might vary, the responses from supervisors did not reflect large differences. One shift supervisor explained that the evening shifts were better able to go about their work without interruptions.

Supervisors were asked questions about qualifications for an ISFSI operations technician. Their responses reflected a very conservative attitude; that is, they stated that they wanted to hire only applicants who were highly qualified. This may be explained in part by the extremely high caliber of the work force and the extensive qualifications of the present employees. Supervisors were asked to rate qualifications on a seven point scale (see Appendix A). The mean values were computed and interpreted. Results are shown in Table 12. A review of these responses indicates that this may well be a supervisor wish list, especially regarding certified personnel. Two to three years OJT seems to be unreasonably long, especially since both skill and intelligence requirements are low and since Morris Operating Instruction specifies a one-year certification program. If a high school graduate can enter the field, there appears to be no real need for college courses prior to certification. Investigators found no evidence that this was an actual requirement. Despite the tendency to specify an ideal employee and job situation, these data do present a reasonable job description that coincides with other evidence that worker dependability and maturity are very important in completing rather average industrial tasks deliberately and accurately. Strength, speed, or uncalled for improvization are not required, or even desirable.

These supervisor analyses were extremely helpful in characterizing the work of an operations technician and in selecting activities for analysis using the task inventory. Activities rated as typical or hazardous or requiring training because of difficulty were evaluated for inclusion in the Task Inventory. The results are shown in Table 13. They were used to select activities for further analysis.

3.3 Task Selection

In order to cover normal, abnormal and emergency activities, it was necessary to select a subset from the list of SOPs for which operations technicians were responsible. Using data gathered during the administration of supervisor questionnaires and understanding of the operations technician's job gained from a review of available documents (listed in Appendix C) and interviews with GE management personnel, a list of activities (Table 14) was prepared for further analysis using the Task Inventory method (Moore, 1976; Christal, 1974; Morsh, 1968).

Table 12. Supervisor Evaluation of Required Qualifications

Characteristic	New Employee Mean Rating	New Employee Interpretation	Certified Operations Technician Mean Rating	Certified Operations Technician Interpretation
Experience	2.5	0 to 1 year related	5.8	2 to 3 years on the job
Skill (dexterim)	2.8	capable but not trained	5.5	some pertinent skills
Knowledge (education)	4.0	high school graduate	4.7	some college work
Mental Ability (intelligence)	2.5	select from standard procedures	4.2	understands and applies principles
Effort (physical	4.5	lifting light loads	4.5	lifting light loads
Initiative	2.7	knows what to do, needs reminders	4.2	does own job, motivates others
Responsible for Loss (errors)	2.2	not responsible, verbal repremand	3.2	responsible, possible suspension
Responsible for Others	2.0	not responsible	4.0	responsible for uncertified worker
Work Conditions (health)	3.9	Moderate hazards	4.9	must be careful to avoid serious hazards
Work Safety (accidents)	3.2	slow work pace minimizes hazards	3.3	slow work pace minimizes hazards

Table 13. Activities Rated Typical or Hazardous or Difficult

Activity	Sum of Times Named	Activity	Sum of Times Named
Cask Operations	33	Training/Paperwork	6
Fuel Handling	31	Control Room	5
Utility Operations	17	Accountability	5
Rounds	16	Equipment Operations	3
Crane Operations	16	Process Control	3
Radiation/Malfunction	10	Basin Operations	3
LAW Vault Operations	9	Compliance Tests	2
Basket Operations	7	Vehicle Operations	1
Decontamination	6	Climbing, Lifting	1

Each required area was represented by at least two activities. Utility operations were eliminated from consideration on the basis that this activity was unique to the GE Morris Operation and not inherently an activity for operations technicians. Training was not analyzed as an activity, but the training program was reviewed in detail. The 16 activities represent a fair sampling of the range of activities which are a part of the operations technician job. Based on time spent, they represent 80% of the work (training, waiting and utilities account for the remaining 20%). They include both routine and abnormal operations. They include hazardous tasks and tasks that are relatively safe. They appear to be representative of the tasks and activities covered in the Morris Plant Operations Training Manual.

3.4 Task Inventory Data Collection Plan

Due to circumstances beyond the control of the investigators, there was no scheduled receipt of fuel during the period of this study nor during any reasonable extension of the effort. Therefore, the more direct methods of task analysis such as observation, time and motion studies, and job sampling were not available. The lack of devices for simulation and training and the dedication of employee time to normal duties effectively prevented analysis of simulated tasks. The best source of data was identified as the workers themselves. Supervisors, engineers, and managers were considered to be highly knowledgeable sources of information on the nature of the tasks, hazards, and the theoretical basis for the work. However, task difficulty and perceived task hazard levels were identified as worker-unique elements of information. A third source of data was the written guidelines for the ISFSI operations technicians' tasks. These guidelines are Morris Operating Instructions (MOIs), Standard Operating Procedures (SOPs), checklists, and plans.

The selected approach involved using all three sources. Initial informal discussions with Morris Operation managerial personnel and a review of literature available in the public domain provided a general

Table 14. Activities Examined for the Task Inventory

Activity	SOP	Cask Ops	Fuel	Basin	Radiation	Facility
Cask Unloading	1-3	X	X			
Crane Operations	1-49	X	X			
Fuel Removal/ Storage	1-7	X	X			
Hydrostatic Testing	1-11	X				
Off-site Shipment	1-12	X				
Basin Cooler	1-22			X		
Water Compliance Test	16-10			X		
Basin Filter	1-20			X		
Demineralizer	8-2			X		
LAW Evaporation	5-2				X	
Electrodecon-tamination	10-1				X	
Leak Detection	1-27			X		
Emergency/Basin Cooler	1-24			X		
Leaking Casks	1-35	X				
Control Room	None					X
Rounds	7-3					X

understanding. Formal interviews with supervisory personnel provided not only the basis for task selection (discussed under Section 3.3 above), but also provided insight into the overall philosophy of work accomplishment at an ISFSI and information on characteristics of the operations technicians. A careful review of the documented activities provided a basis for questions on the tasks themselves. Notes based on the review of SOPs and discussions with supervisors were used to develop a set of OSDs. These OSDs were kept at the task level. The lower elements which would be required for actual job performance were either subsumed under an appropriate task or grouped together to constitute a generic task. The results of this effort are presented in Appendix B. The OSDs show the interactions and outline each activity by task, but more importantly, they provide the framework for the development of a Task Inventory.

The Task Inventory method of data collection for task analysis was developed by the Air Force (Morsh, 1968; Moore, 1976) to use in getting task data from personnel who actually did the work. Previous methods, based on worker estimates of time spent, contained too much variability to be used. Worker estimates of time contained bias due to attitudes and time perception which tended to scatter the data. The basis for the Task Inventory is a seven-point floating scale which relates each task to every other task. To ensure that the "every other task" concept was common, subjects read through the list of tasks before responding. The Task Inventory provides a basis for computer analysis of the data using the Comprehensive Occupational Data Analysis Program (CODAP) developed and reported by Christal (1974). Due to the small data base (100% sampling provided only 24 subjects, including managers), CODAP was not used for data analysis. However, the data have been entered on computer tapes in a CODAP compatible format in case future analyses are required.

The Task Inventory and instructions used in this study are contained in Appendix A. It contains questions on worker qualifications used to establish credibility, and a list of 217 tasks, grouped by activity. The activities are based on the Morris Operation SOPs. They correspond to duties in the Air Force version of a task inventory. The tasks which make up an activity are identifiable things that a worker must do. The tasks were developed from the OSDs, but do not include the "sequence" parameter. For example, the task "initial checklist" may appear several times during an operational sequence. For Task Inventory purposes, it is grouped with similar items, such as "enter gage reading on checklist," and appears on the Task Inventory as "complete checklist and paperwork."

After the subjects read through the list of tasks and were given the opportunity to list additional tasks that they perform during an activity, they were asked to go through the list five separate times. On the first review they were asked to establish frequency of each task, using a seven-point floating scale. The scale actually had a center value which was fixed from the subjects' viewpoints. The value "4" was defined as "about average number of times." Other values were defined above and below average. The subsequent three reviews were used to rate time spent on each task, task difficulty and hazard level for each task.

Each of these evaluations was based on a seven-point floating scale. Definitions for the scale variables can be found in the Task Inventory instructions and rating scale listings located in Appendix A. For the fifth review, subjects were asked to evaluate the potential for errors for each task using a five-point absolute frequency scale. Additional information was requested for tasks that were rated extremely dangerous.

The Task Inventory was administered to individuals or small groups during their normal work shifts. Time to complete the inventory ranged from 2.5 to 6.0 hours, with most subjects requiring about 3.0 hours. The results and analysis are presented in Section 4.

3.5 Review of Other Certification Programs

A facility which closely approximates the Morris Operation's function is Allied General Nuclear Service Barnwell Nuclear Fuel Plant (BNFP). The Morris facility was originally designed for reprocessing fuel but has only been used as an ISFSI. BNFP was designed as a reprocessing facility with a processing capacity of 1600 metric tonnes/year of irradiated uranium fuel. As of this date, BNFP has not received an operating license from the NRC. The personnel selection and training description which follows is the program portion that covers the receipt and storage of the fuel and not the chemical reprocessing portion at BNFP. The description has been adapted from a BFNP Training (1977) description.

BNFP selects operators from one of two general educational areas. Similar to the Morris Operation, the first category is persons with a high school diploma. A stipulation is that mathematics and science courses were a concentrated study area in the high school curriculum. The second educational area that applicants are selected from is a two-year technical college degree. Specific areas of concentration are engineering, chemistry, and nuclear technology for the two-year degree.

All training is administered by the Training Department which reports directly to the vice president and is independent of plant operations management. The training instructors are certified by BNFP and some have college degrees.

Training at BNFP consists of both classroom and on-the-job instruction. Trainees must complete the classroom portion before proceeding to on-the-job training. All trainees enrolled in the Mechanical Operator (receive, handle, and store fuel) curriculum follow the same sequence of training.

All new employees first receive an eight-hour orientation covering general safety (industrial and radiological), quality assurance, and nuclear materials safeguard. Following the orientation, the trainees complete the Radiation, Health, and Safety Basic Training which covers Health Physics areas including radiation exposure and control; and the purposes and use of protective equipment. The remainder of the classroom instruction is listed in Table 15 and is a 120-hour program

Table 15. Cask and Fuel Handlers Course Listing for the Barnwell Nuclear Fuel Plant

Course Description	Class Time (hours)	% Total Course
AGNS ORIENTATION	2	100
a. Company History		
b. Personnel Policies		
c. Insurance & Benefit Package		
d. Form Filling		
BNFP ORIENTATION	1	100
a. Overview of Fuel Cycle		
b. BNFP Purpose		
BASIC RADIATION PROTECTION	1	100
a. Nontechnical		
b. Radioactivity		
c. Radiation Symbol		
d. Radiation Exposure		
GENERAL SAFETY REQUIREMENTS	3/4	100
a. Information for Safe Operation		
b. Portion of BNFP Health & Safety Manual		
GENERAL EMERGENCY PLAN	3/4	100
a. BNFP Emergency Plan		
b. All Employees Involved		
ORIENTATION ON HEALTH & SAFETY MANUAL	1-1/4	100
a. Overall Setup on Manual		
b. In Detail		
c. Part of Policies & Procedures Manual		
QUALITY ASSURANCE INDOCTRINATION	1	100
a. BNFP Q.A. Program		
b. 10 CFR 50, Appendix B		
BASIC RADIOLOGICAL HEALTH	4	100
a. In Depth		
b. Atomic Structure		
c. Radiation & Units		
d. Exposure, Rates, Does Limits		
e. Shielding		
OCCUPATIONAL RADIATION EXPOSURE LIMITS	1/2	100
a. History of Limits		
b. Conservatism & Uncertainties		

Table 15 (continued)

Course Description	Class Time (hours)	% Total Course
BNFP EXPOSURE GUIDES & POLICIES a. Radiation Exposure	1/2	100
BIOLOGICAL EFFECTS OF OCCUPATIONAL RAD. a. Expect in Rad. Exposure Medicine to lecture b. Accute & Chronic Effects c. Medical Treatment	2	100
PERSONNEL MONITORING a. Types & Purposes b. Equipment & Methods c. Records & Reports	1	100
RADIATION MONITORING a. Methods, Procedures & Equipment b. Identifying Rad./Contamination Areas c. Air Sampling	3	100
WORK POLICIES, STANDARDS & PROCEDURES a. 10 CFR 20 b. "Safe Work Permit" System	1	100
RESPIRATORY PROTECTION a. Respirator Usage b. Air-Purifying Equipment c. Airline Devices d. Self-Contained Breathing Apparatus	1	100
INSTRUMENT FAMILIARIZATION a. Radiation Detection/Measurement Instrumentation BNFP b. Demonstration	4	100
PROTECTIVE CLOTHING FAMILIARIZATION a. Anti-Contamination Clothing b. Demonstration c. Change Room Procedures	2	100
SAFETY SUPPORT ORGANIZATION a. AGNS Safety Organization b. Safety Philosophy	2	100
EMERGENCY PROCEDURES a. Emergency Procedures Manual b. Alarm Sounds c. Emphasis on Criticality & Fire Alarms	2	100

Table 15 (continued)

Course Description	Class Time (hours)	% Total Course
WORK EXPERIENCE a. Field Utilization of Instrumentation b. Dose Rate Determinations c. Stay-Time Calculations d. Practice Donning Anti-Contamination Clothing	8	100
GENERAL SAFETY & INDUSTRIAL HYGIENE a. Industrial Safety & Health Practices b. Federal, State & Local Regulations	2	100
OPERATIONAL SAFETY & HEALTH ACT (OSHA) a. OSHA Application to BNFP	1	100
MEDICAL CONSIDERATIONS a. BNFP Medical Program b. Accident & Illness Reporting c. First Aid Responsibilities	1	100
PROCESS FLOW DIAGRAM OVERVIEW a. Live b. Give Trainee Familiarization of Process	8	100
MATH FUNDAMENTALS a. Significant Figures b. Scientific Notation c. Metric System	1	10
USE OF THE CALCULATOR a. Introduction to Calculator Use b. Calculations	1/2	100
GRAPH DEVELOPMENT & INTERPRETATION a. Types of Graph Paper b. Nomographs	1	100
INTRODUCTION TO PHYSICS a. Length, Speed & Velocity b. Mass & Weight c. Force, Volume	2	100
WORK & POWER a. Efficiency b. Units of Power	1-3/4	50

Table 15 (continued)

Course Description	Class Time (hours)	% Total Course
INTRODUCTION TO CHEMISTRY a. Mixtures & Compounds b. Chemical Symbols, Valence c. Writing & Balancing Equations d. Acid-Base Reactions	2	100
SIMPLE CHEMICAL ACTIONS a. Solubility of Substances b. Molarity-Normality	1	30
SURVEY OF ANALYTICAL CHEMISTRY a. Gamma Activity Determination b. Alpha Activity Determination c. Beta Activity Determination	1/2	20
SAFETY ANALYSIS REPORT a. In Depth Discussion b. Portions Pertaining to Fuel Receiving and Storage Stations (FRSS)	2-3/4	25
PRINCIPLES OF MEASUREMENT a. Thermocouples b. Pressure & Differential Pressure c. Flow, Level, Density d. Load Cell e. Transmitters	4	100
BASIC CONTROL SYSTEMS a. Ventilation System b. Emergency Utilities (FRSS) c. Nuclear Safety (FRSS)	3/4	10
FUEL RECEIVING a. Movement of Spent Fuel Trucks and Rail Cars b. Survey of Paperwork c. Preparation of Casks for Unloading d. Cask Crane Operation	4	100
CASK UNLOADING a. Unloading in Test Area b. Sample for Radioactivity c. Unloading Pool Area d. Fuel Assembly Inventory System e. Safety Precautions	4	100

Table 15 (continued)

Course Description	Class Time (hours)	% Total Course
FUEL STORAGE & CASK REMOVAL a. Moving Canisters to Storage Pool b. Accountability of Fuel in Pool c. Cask Decontamination d. Preparation of Cask for Return	4	100
FUEL POOL SUPPORT OPERATIONS a. Pool Filter, Demineralizer b. Pool Gate, Storage Racks c. Leaker Can Assemblies d. Pool Cooling, Water Testing	4	100
FUEL TRANSFER a. Fuel Transfer Conveyor	3	100
VENTILATION a. Operation FRSS Ventilation b. Routine Radiation Checks c. Alarms & Corrective Action	1	20
UTILITIES a. Utility Air Supply b. Instrument & Breathing Air	1/2	20
CONTAMINATION CONTROL a. Practical b. Alpha, Beta Survey Equipment c. Smearable Contamination Samples d. Movement of Contaminated Equipment e. Classification & Posting of Contamination Areas	4	100
RADIATION EXPOSURE CONTROL a. Relates Instrument Reading, Distance and True Does Rate b. Approximate Quantity of Radioactivity from Dose Rate c. Influence on Instrument of Radiation d. Determining Surface Dose Rates	3	100

Table 15 (continued)

Course Description	Class Time (hours)	% Total Course
SELF MONITORING	3	50
a. Safe Work Practices in Rad. Areas		
b. Limitations of Monitoring Devices		
c. Respiratory Protection		
d. Entry & Exist Procedures		
e. Interpretation of Nasal Swabs		
f. Personnel Decontamination		
SHIELDING	1-1/2	10
a. Effects of Time, Distance & Shielding		
b. Practical Experience in Use of Transmission Factors		
FUEL ELEMENT	1/2	50
a. Criticality Control During Shipping		
b. Criticality Control during Storage & Shearing		
GENERAL CONSIDERATIONS	4	100
a. Evacuation & Re-Entry Procedures		
b. Fire Brigade		
c. Review Emergency Plan		
d. Alarm Systems & Location		
EMERGENCY EQUIPMENT	1	100
a. Emergency Power		
b. Emergency Water Supplies		
INSTRUMENT & CONTROLS	2	25
a. FRSS		
b. Ventilation System		
c. Utility Area		
d. Piping and Instrumentation Drawings & Walk-Through		
ACCOUNTABILITY & SAFEGUARDS	3	100
a. Handling Fuel Data		
b. Maintain Current Inventory		
c. Receipt & Storage of Fuel		
d. Leaking Fuel Assemblies		

Table 15 (continued)

Course Description	Class Time (hours)	% Total Course
REGULATORY REQUIREMENTS a. Title 10 CFR 1. Part 20 Standards for Protection Against Radiation 2. Part 50 Licensing of Production in Utilization Facilities 3. Part 55 Operator Licenses 4. Part 70 Special Nuclear Material 5. Part 100 Reactor Site Criteria	4	100
DISSOLUTION a. General Discussion b. Purpose	1/2	10
EVAPORATION a. General Discussion b. Purpose	3/4	20
FLUID TRANSFER a. Pumps, Blowers, Jets, Airlifts b. Attention to FRSS	1	20
INTEGRATED OPERATIONS MECHANICAL a. Live Walk-Through of Operation Procedures b. Attention to FRSS	4	20
WASTE DISPOSAL a. FRSS & Cask Water b. Scrap Metal Waste	3	30

requiring approximately 4 weeks to complete. When the percentage of total course column is less than 100, it means that the cask and fuel handlers attend only a portion of a larger course. The class hours represent that smaller percentage.

Performance during the classroom portion of the training is a closely monitored process. Tests are given at a rate of nearly one per day and these tests are graded overnight and critiqued with the trainee the next day. This procedure allows the Training Instructors to identify trainees needing additional study, tutoring, or special assistance. Once all classroom training is accomplished, the trainee is introduced to the actual job operations.

On-the-job training is administered by the department supervisors and conducted by certified technicians describing and performing the work while the trainee observes. Once the trainee understands the system, the trainee performs the operation under the supervision of certified personnel. The trainee follows a program approved and published in a series of Qualifications Guides and Checklists. Successful completion and adequate performance on all of the Qualifications Guides and Checklists is required before final certification testing.

Final certification evaluation consists of a written test covering the classroom material and an oral walk-through test. The written test is composed of 60% on basic course material and 30% on required synthesis of at least two basic concepts. The final 10% are very difficult questions involving combinations of several concepts and reasoning to select from opposing solutions. A minimum score of 70% is required to pass the examination. The 70% score represents all the basic course material questions being successfully answered, one-third of the synthesis material, and none of the difficult questions. Because of this, a trainee can fail with a grade of slightly greater or less than 70% so a further criteria must be met. Any grade falling in the range of 60 to 80% requires the Training Instructor's written evaluation of why a trainee is designated as passing or failing with a score in that range. Following successful performance on the written certification test, the trainee proceeds to the certification test for the on-the-job training.

The certification examination for the on-the-job training consists of a walk-through examination in the following six knowledge areas: equipment design, operations, interlocks, special precautions, emergency procedures, and administrative limits. An examiner grades the trainee with a code letter in each of the six knowledge areas for a given facility, location, process, or piece of equipment. The code letters are as follows:

E - excellent; superior
G - good ; average, some weak points
F - fair; sufficient to pass, no strong points
P - poor; insufficient knowledge to perform job

and represent the level of proficiency of the trainee. Failure in any area must be explained in writing by the examiner. Provisions are inherent in the certification program for any additional training that a trainee may require to pass all the certification testing.

A passing score on both the written and walk-through certification examination results in the employee's receiving certification from the BFNP management.

Retraining is patterned after 10 CFR 55 and consists of three cycles within a biennial cycle. The three cycles are as follows:

- o Four-month cycle - Within this time period, all licensed operators must perform all job-related activities and have their competence evaluated. Failure to perform the activities or incompetence results in internal removal of their certification. Successful completion of a walk-through examination recertifies the operator.

- o One-year cycle - Twelve monthly lectures are given. At the end of the year a recertification examination is given which provides feedback on competence.

- o Two-year cycle - Walk-through examination in the area of the operator's license.

Other than the BNFP, there are no operating AFR ISFSI type facilities to describe that are similar to the Morris Operation. An installation located in New York at West Valley is an ISFSI type facility containing its full capacity of 1600 tons of industrial fuel, but no plans exist for further fuel receipt so training at that facility was not investigated. However, BNFP facilities certification examination is patterned after the NRC examinations administered at West Valley, New York Nuclear Fuel Services facility, and as such the two training programs are inherently similar.

American National Standards Institute, Inc. (ANSI) 3.1-1981 describes the training program for personnel at nuclear power plants. The program lasts approximately 19 months and includes simulator and control room operation. This program includes fuel handling systems and other subsystems some of which are similar to the Morris Operation, but the intensity of the required training for the more complex nuclear power plant is not applicable to an ISFSI.

4. RESULTS OF TASK INVENTORY

Appendix D presents the biographical and Morris Operation information for the 13 operations technicians (from the Task Inventory biographical section). The operations technicians average 41 years of age and all have achieved minimally a 12-grade education. They have spent an average of 7.3 years in their present job and 9.9 years in nuclear related jobs. They find their job fairly interesting and feel their job uses their talents very well. Moreover, they rate their training as being excellently tailored to their job. In terms of their job activities, the 13 operations technicians indicated that they spend slightly above an average amount of time on Rounds, Fuel Handling/ Storage, Crane Operations, and Routine Housekeeping and slightly below an average amount of time on Basin Cooler Operations, Hydrostatic Cask Testing, Basin Leak Detection, Electrodecontamination, Dealing with Leaking Fuel Casks, Working with Basin Pumps, and accountability. The remainder of this section will discuss the results of the Task Inventory (at the task level) for all certified personnel at the Morris Operation.

4.1 Data Reduction

SRL was tasked with sampling the entire population of certified personnel at the Morris Operation facility. Since each individual answered the task analysis from the perspective of the operations technician, it was first necessary to determine the extent to which the other certified personnel (engineers, supervisors, managers, former operations technicians) responded in a fashion similar to the current operations technicians. Such a determination is crucial in deciding whether the data can be combined into one data base or whether the data must be treated separately for the various categories of certified personnel.

A FORTRAN program was written to compute the minimum, maximum, mean and standard deviation for each of five variables (Frequency, Time Spent, Difficulty, Hazard, Error) for each of the 217 tasks. For the sixth variable, Predicted Errors for Novice Personnel (Error-New-Person), the calculations include the total number of individuals selecting the task as one in which an error was likely for novice personnel.* The program generated statistics for the following categories and combinations of certified personnel:

- o Operating Technicians (OT)
- o Supervisors (S)
- o Engineers (E)
- o OT + Former Operating Technicians (FOT)
- o OT + S
- o OT + S + FOT
- o OT + S + E
- o OT + S + E + Managers (M)
- o Other (non-operations technicians) (S + E + FOT + M)
- o All (OT + S + E + FOT + M)

*Novice personnel are those with less than six months in the job following qualification or certification (Reference NUREG/CR-1278).

Visual inspection of the output revealed for each variable, a fairly high degree of correspondence in the rank-ordering of the means for the 217 tasks across the various categories and combinations of certified personnel. In general, for each variable, tasks rated high by one category of personnel were also among the highest rated tasks by the other categories of personnel.

To check on the correspondence in the rank-ordering of the mean ratings on the 217 tasks statistically, Pearson product moment correlations were computed between the mean task ratings for current operations technicians and supervisors, between current operations technicians and engineers, and between current operations technicians and all other certified personnel. A high correlation indicates close correspondence between the rank-orderings based on mean ratings on the 217 tasks. Table 16 presents the results of the correlational analysis.

Inspection of Table 16 reveals a high degree of correspondence between the rank ordering of the tasks between the current operations technicians and personnel in other categories, with the highest correlations being between the current operations technicians and all other certified personnel. The correlations tend to be lower for engineers and supervisors, and for the variable, Error New Person, because of the fairly large number of tasks with equal mean (total) ratings (tied scores tend to reduce the magnitude of the correlation).

Table 16. Pearson Correlation Coefficients of Operations Technicians vs Other Morris Operations Personnel on Each Task Inventory Variable

Personnel					Task Inventory Variable
Operations Technicians	vs	Supervisor	Engineer	Other Personnel	
		0.81	0.79	0.87	Frequency
		0.63	0.70	0.78	Time Spent
		0.82	0.74	0.86	Difficulty
		0.88	0.84	0.93	Hazard
		0.70	0.55	0.73	Errors
		0.50	0.52	0.66	Errors for Novice Personnel

All correlations are significant at the α = .001 level.

Given that all certified personnel are in general responding in the same fashion, the decision was made to combine all the data into one data base. The mean, standard deviation, and minimum and maximum score for each of the 217 tasks on each of the six variables based upon all 24 respondents can be found in Appendix E. When the number of respondents (N) is less than 24, it means that some subjects did not respond to that item.

All subsequent data reported herein use the entire data base and are based upon the mean task rating for the first five variables and upon the total number of nominations for the sixth variable (Error-New-Person).

4.2 Rating on Individual Variables

To facilitate presentation and discussion of the results, tasks were grouped into categories based upon the correspondence between the mean rating and the original scale descriptors (c.f., Table 17). Groups or intervals of rating scale values were formed by establishing upper and lower limits around the original rating scale value. The midpoints of the intervals between the original rating scale values served as the interval boundaries. Given that verbal descriptors were associated with each rating category, any task whose mean fell into the range of scale values bounded by the upper and lower limit could be described by that verbal label. For example, as shown in Table 17, any task with a mean rating between 3.5 and 4.5 on all five scales would be considered to occur with average frequency, represent average time spent, be of average difficulty, represent a typical hazard, and to have an error frequency of perhaps as often as once per year.

For the variable, Error New Person, the standard deviation (SD) was used to classify the tasks. Any task which was +1 SD above the mean or greater (total greater than 9 respondents selecting the task) was classified with category "Error likely by new person." Any task which was -1 SD below the mean or greater (total less than 2 respondents selecting the tasks) was classified into the category "Error less likely by new persons." Tasks falling between 9 and 2 were considered to have an average likelihood of error by novice personnel.

Table 17. Upper and Lower Limits and Varable Descriptors for Each of Five Rating Scales

Rating Scale Value	Upper/Lower Limits	Frequency	Time Spent	Difficulty	Hazard	Error
7	7.5 - 6.5	Well Above Average	Well Above Average	Extremely Difficult	Absolutely Dangerous	
6	6.5 - 5.5	Above Average	Above Average	Very Difficult	Very Dangerous	
5	5.5 - 4.5	Slightly Above Average	Slightly Above Average	Fairly Difficult	Somewhat More Dangerous	Less Than One Per Year
4	4.5 - 3.5	Average	Average	Average	Typical Hazard	Pernaps as Often as Once per Year
3	3.5 - 2.5	Slightly Below Average	Slightly Below Average	Fairly Easy	Fairly Safe	Probably More Often Than Once a Year
2	2.5 - 1.5	Below Average	Below Average	Very Easy	Very Safe	Perhaps as Often as 2-3 Per Year
1	1.5 - 0.5	Well Below Average	Well Below Average	Extremely Easy	Absolutely Safe	More Than 2-3 Per Year

4.2.1 Frequency

Table 18 presents the means and standard deviations for each variable for each activity based on the averages of the tasks within an activity. The average task has a mean frequency rating of 3.2 indicating that, in general, tasks are rated as occurring with slightly less than average frequency. From an inspection of the raw data, this appears to be due to supervisors and engineers rating relative frequency at lower levels than operations technicians.

Plant Rounds and Control Room duties are the most frequently occurring activities, followed next by Crane Operation, Demineralizer Operations, and Fuel Removal and Storage. These first five activities are rated as occurring with average frequency. The least frequently occurring activity is Cask Handling with Failed or Leaking Fuel, rated as occurring at below average frequency. All other activities were rated as occurring with slightly below average frequency.

Using the criteria established earlier, 3 tasks were rated as occurring with slightly above average frequency, 88 with average frequency, 83 with slightly less than average frequency, 37 with below average frequency, and 6 with well below average frequency.

Table 19 lists the 54 most frequently performed tasks. The catchall task, "Accomplish Other Tasks (if any)," was intentionally omitted.

As indicated in Table 19, the most frequent operations technician activity is Plant Rounds, checking the status and condition of components of the ISFSI. Of the 41 Plant Rounds tasks, 28 are included in the 54 most frequently performed tasks. Other Plant Rounds tasks, such as vehicle checks, are accomplished on a less than daily basis. Other frequently performed tasks include cask decontamination, basin water analysis log, paperwork completion for the demineralizer, and control room operations such as receiving and transmitting calls, performing rounds check, responding to alarms, and monitoring the LAW evaporator. Paperwork, checklists and log keeping are other frequent activities for operations technicians.

The list of the 42 tasks which occurred with below average or less frequency is shown in Table 20. It also excludes the catchall "Accomplish Other Tasks, if any." This list includes 8 of the 9 tasks dealing with Cask Handling of Failed or Leaking Fuel, 9 of the 21 Emergency Actions for Basin Coolers, 6 of the 12 Basin Filter Operating tasks and 5 of the 12 Basin Cooler Operating tasks. As can be seen, most of the least frequently performed tasks by the operations technician are called for by rare events such as emergency situations or casks with failed or leaking fuel.

Table 18. Activity Statistics for the Six Variables

Activity	Tasks		Frequency	Time Spent	Difficulty	Hazard	Error	Predicted Errors
Cask Unloading	19	Mean	3.4	3.2	3.5	3.3	4.4	7.7
		SD	.4	.4	.7	.5	.3	3.6
Crane Operations	11	Mean	3.6	3.2	3.2	3.1	4.4	4.7
		SD	.2	.2	.2	.6	.2	2.6
Fuel Removal and Storage	11	Mean	3.5	3.2	3.8	3.2	4.7	8.0
		SD	.6	.4	.6	.7	.4	4.4
Hydrostatic Testing	14	Mean	2.9	3.0	3.1	2.9	4.6	3.3
		SD	.3	.4	.3	.6	.2	2.5
Off-Site Shipment	12	Mean	3.2	3.2	3.3	3.0	4.6	5.4
		SD	.7	.9	.7	.9	.3	4.3
Basin Cooler Operation	13	Mean	2.9	2.6	2.8	2.4	4.6	4.6
		SD	.9	.6	.8	.7	.2	3.3
Basin Water Analyses (Compliance Test)	6	Mean	3.2	2.5	2.9	1.8	4.3	6.8
		SD	.8	.5	.7	.7	.3	2.9
Basin Filter Operation	12	Mean	2.7	2.6	3.0	2.7	4.6	6.8
		SD	.9	.6	1.3	1.2	.3	3.7
Demineralizer Operation	7	Mean	3.5	3.1	2.7	2.0	4.0	6.8
		SD	.9	.6	.4	.6	.3	3.7
LAW Evaporator System Operation	12	Mean	3.1	3.0	3.4	3.0	4.3	8.5
		SD	.6	.4	.5	.8	.2	3.8

Table 18 (continued)

Activity	Tasks		Frequency	Time Spent	Difficulty	Hazard	Error	Predicted Errors
Electrodecontamination	8	Mean	3.2	3.2	3.3	2.8	4.0	6.1
		SD	.4	.3	.4	1.1	.5	2.8
Basin Leak Detection	10	Mean	2.7	2.4	2.4	2.4	4.7	2.9
		SD	.3	.4	.4	6	.2	2.4
Emergency Action for Basin Coolers	22	Mean	2.5	2.5	2.9	2.6	4.7	4.1
		SD	.7	.4	1.0	.9	.2	2.8
Cask Handling with Failed or Leaking Fuel	10	Mean	2.0	2.4	2.8	3.1	4.8	3.3
		SD	.4	.4	.3	.7	.1	2.4
Control Room Duties	8	Mean	3.9	3.4	2.9	1.8	3.9	7.2
		SD	.3	.5	.2	.2	.3	4.5
Plant Rounds	42	Mean	3.9	3.0	2.6	2.8	4.2	4.1
		SD	.4	.5	.4	.3	.3	3.9
All Tasks Combined	217	Mean	3.2	3.0	3.0	2.8	4.4	5.4
		SD	.8	.6	.7	.8	.4	3.8

Table 19. Ranking of Task on Frequency for Operations Technicians

Activity	Task	Rank	Mean
Plant Rounds	Check the Heat Pump System and Indicators	1	4.6
LAW Evaporator System Operation	Monitor Operation from Control Room, Log Data Every 2 Hours	2.5	4.5
Demineralizer Operations	Check During Rounds	2.5	4.5
Plant Rounds	Complete Shift Rounds Data Sheet	4	4.4
Plant Rounds	Inspect the Compressor Room and Indicators	8.5	4.3
Demineralizer Operations	Complete Paperwork, Checklist	8.5	4.3
Control Room Duties	Complete Logs and Other Forms	8.5	4.3
Plant Rounds	Check the Demineralizer System	8.5	4.3
Plant Rounds	Inspect the Emergency Equipment Building	8.5	4.3
Plant Rounds	Inspect the Generator Room and Indicators	8.5	4.3
Plant Rounds	Inspect the Basin Areas	8.5	4.3
Plant Rounds	Inspect the Basin Filter and Indicators	8.5	4.3
Control Room Duties	Receive and Transmit Calls	17	4.2
Plant Rounds	Inspect the Utility Building and Indicators	17	4.2
Plant Rounds	Check the Basin Coolers and Indicators	17	4.2

Table 19 (continued)

Activity	Task	Rank	Mean
Off-Site Shipment Preparation	Decontaminate Cask	17	4.2
Basin Water Analysis (Compliance Test)	Log and Initial Data on Samples and Results	17	4.2
Plant Rounds	Check the Utility Boiler Systems	17	4.2
Plant Rounds	Inspect the Water Tower and Indicators	17	4.2
Plant Rounds	Inspect the Exhaust Blower Room	17	4.2
Cask Unloading	Decontaminate Head, Cask, and Trunnion	17	4.2
Control Room Duties	Perform Rounds Check	22.5	4.1
Fuel Removal and Storage	Complete Paperwork, Checklists, and Logs	22.5	4.1
Basin Filter Operations	Monitor Water Flow Rates	29	4.0
Plant Rounds	Inspect the Well House and Indicators	29	4.0
Plant Rounds	Inspect the Basin Cooler Area	29	4.0
Plant Rounds	Inspect the Cask Receiving Area and Indicator	29	4.0
Fuel Removal and Storage	Operate Crane for Basket Moving	29	4.0
Plant Rounds	Check the Process Building and Indicators	29	4.0
Plant Rounds	Inspect the Emergency Electrical Room and Indicators	29	4.0

Table 19 (continued)

Activity	Task	Rank	Mean
Basic Cooler Operation	Check for Leaks	29	4.0
Cask Unloading	Complete IF-300 Checklist (initials and date)	29	4.0
Plant Rounds	Check the Utility Cooling Tower and Indicators	29	4.0
Plant Rounds	Inspect the Ventilation Supply Room and Indicators	29	4.0
Fuel Removal and Storage	Identify Fuel Bundles	36.5	3.9
Basin Water Analysis (Compliance Test)	Take Water Samples from Basin	36.5	3.9
Plant Rounds	Inspect the Chemical Storage Area and Indicators	36.5	3.9
Crane Operations	Check Operations	36.5	3.9
Basin Filter Operations	Verify Basin Level > = 58%	43	3.8
Plant Rounds	Check the Accumulator (V-806) Indicators	43	3.8
Basic Cooler Operation	Complete Paperwork, Logs	43	3.8
Control Room Duties	Respond to Alarms	43	3.8
Plant Rounds	Check the Phosphate Tank Indicators	43	3.8
Plant Rounds	Check the Hydrazine Tank Indicators	43	3.8
Plant Rounds	Check the Deaerator (V-801) Indicators	43	3.8

Table 19 (continued)

Activity	Task	Rank	Mean
Plant Rounds	Check the Degasifier Indicators	43	3.8
Plant Rounds	Monitor the Process Steam Room Indicators when in service	43	3.8
Off-Site Shipment Preparation	Complete Check Sheets, Paperwork	51	3.7
Plant Rounds	Inspect the Warm Warehouse	51	3.7
Crane Operations	Move the Load from Location to Location	51	3.7
Plant Rounds	Inspect the Mockup Tower and Indicators	51	3.7
Plant Rounds	Inspect the Cask Service Facility	51	3.7
Cask Unloading	Remove Road Grime	51	3.7
Plant Rounds	Monitor the Process Cooling Waters Indicators when in service	51	3.7

Table 20. Ranking of Tasks on Lowest Frequency for Operations Technicians

Activity	Task	Mean
Basin Filter Operations	Verify Vacuum Head Below Water	2.4
Emergency Action for Basin Coolers	Open Valve to Discharge Header	2.4
Off-Site Shipment Preparation	Refuel Engine	2.4
Basin Filter Operations	Open Filter Outlet Valve	2.4
Off-Site Shipment Preparation	Prepare Tool Box and Spare Parts Box	2.4
Basin Cooler Operation	Prime Pump	2.3
Basin Water Analysis (Compliance Test)	Determine Actions Required	2.3
Basin Leak Detection	Clean Sample Box	2.3
Emergency Action for Basin Coolers	Turn Cooler Pumps Off	2.3
LAW Evaporator System Operation	Sample Density	2.3
Basin Filter Operations	Open Vacuum Sweeper to Filter System Valve	2.3
Emergency Action for Basin Coolers	Turn Basin Pumps and Fans Off	2.3
Electrodecontamination Operation	Calculate Surface Area, Current, Cathodes	2.3
Cask Unloading	Survey Radiation of Car, Cask, and Head	2.3
Basin Cooler Operation	Throttle Valve, Checking Pressure	2.3
Basin Leak Detection	Attach Tubing to Basin System	2.2

Table 20 (continued)

Activity	Task	Mean
Cask Handling with Failed or Leaking Fuel	Monitor Temperature of Cask	2.2
Cask Handling with Failed or Leaking Fuel	Vent Cask to LAW Vault	2.2
Cask Handling with Failed or Leaking Fuel	Flush Cask	2.2
Cask Handling with Failed or Leaking Fuel	Fill Cask with Water	2.2
Basin Water Analysis (Compliance Test)	Plot Data on Analysis Results	2.2
Emergency Action for Basin Coolers	Close Valve 3/4 Turn	2.2
Hydrostatic Testing	Drain Cask to LAW Vault Using Air Pressure	2.2
Cask Handling with Failed or Leaking Fuel	Obtain Coolant Sample	2.2
Cask Handling with Failed or Leaking Fuel	Take Sample from Cesium Analysis	2.1
Basin Filter Operations	Close Vacuum Sweeper to Filter System Valve	2.1
Fuel Removal and Storage	Disengage Fuel Grapple Manually	2.0
Emergency Action for Basin Coolers	Turn Breakers Off	1.9
Demineralizer Operations	Set Timers	1.9
Off-Site Shipment Preparation	Assist Train Crew	1.8
Basin Cooler Operation	Install Chicago Coupling	1.7
Emergency Action for Basin Coolers	Monitor Area for Heating	1.7

Table 20 (continued)

Activity	Task	Mean
Basin Filter Operations	Remove Sweeper Head and Attach Cleaning Tool	1.6
Basin Cooler Operation	Turn Pump on to Increase Demin Pressure	1.6
Emergency Action for Basin Coolers	Adjust the Regulator	1.6
Emergency Action for Basin Coolers	Start Emergency Power Manually	1.5
Basin Cooler Operation	Remove Pump Discharge Pressure Indicator	1.3
Cask Handling with Failed or Leaking Fuel	Contact Personnel if Cesium Measure is High	1.2
Basin Filter Operations	Clean Cask Interior	1.2
Cask Handling with Failed or Leaking Fuel	Evacuate Personnel from Hazardous Areas	1.2
Emergency Action for Basin Coolers	Cover Coolers with Tarps and Fan Openings with Plastic	1.1
Emergency Action for Basin Coolers	Light Space Heaters to Heat Area	1.0

4.2.2 Time Spent

As can be seen in Table 18, the average task required slightly less than average time spent (M = 3.0). Operations technicians spent the most time on Control Room Duties, Crane Operations, Fuel Removal and Storage, and Cask Unloading, all of which require slightly below the average time to accomplish. The least amount of time (below average) is spent on Cask Handling with Failed or Leaking Fuel and on Basin Leak Detection.

As the tasks were classified, only cask decontamination during unloading and during preparation for off-site shipment are rated as requiring more than the average amount of time to accomplish. Twenty-seven tasks are rated as average, 139 as slightly below average, and 49 as below average.

Table 21 lists all those tasks (n = 29) in which operations technicians spend an average or greater amount of time. Of the tasks included in Table 21, the greatest number came from Plant Rounds (n = 8), Cask Unloading (n = 5), and Control Room Duties (n = 4). Interestingly, these four control room tasks represent 50% of the Control Room Duties, and the Control Room Duties activity was ranked highest in time spent (Table 18). In addition, 5 of the tasks rated high on time spent include "Accomplish Other Tasks, if any" in the areas of Demineralizer Operations, Control Room Duties, Off-Site Shipment Preparation, and Cask Unloading, and Plant Rounds. Given that most respondents did not write in the specific tasks, we are unable to identify the nature of these other task activities in these areas. The 49 tasks rated as below average in time spent (a rating less than 2.5) include 11 of the 21 Emergency Actions for Basin Coolers, 7 of the 9 Basic Leak Detection tasks, 6 of the 9 tasks dealing with Cask Handling of Failed or Leaking Fuels, 5 of the 12 Basin Filter Operating tasks and 5 of the 12 Basin Cooler Operation tasks (see Table 22). As with ratings of frequency, the tasks rated below average in time spent may be characterized as involving rare events.

Table 21. Ranking of Tasks: Most Time Spent

Activity	Task	Rank	Mean
Off-Site Shipment Preparation	Decontaminate Cask	1	5.2
Cask Unloading	Decontaminate Head, Cask, and Trunnion	2	4.7
Plant Rounds	Complete Shift Rounds Data Sheet	3	4.2
Control Room Duties	Perform Rounds Check	5.5	4.0
LAW Evaporator System Operation	Monitor Operation from Control Room, Log Data Every 2 Hours	5.5	4.0
Basin Filter Operations	Clean Basin Floor	5.5	4.0
Demineralizer Operations	Accomplish Other Tasks (if any)	5.5	4.0
Control Room Duties	Complete Logs and Other Forms	9	3.9
Cask Unloading	Unbolt and Remove Cask Head	9	3.9
Plant Rounds	Accomplish Other Task (if any)	10	3.9
Demineralizer Operations	Check During Rounds	12.5	3.8
Plant Rounds	Inspect the Utility Building and Indicators	12.5	3.8
Plant Rounds	Check the Heat Pump System and Indicators	12.5	3.8
Control Room Duties	Accomplish Other Task (if any)	12.5	3.8

Table 21 (continued)

Activity	Task	Rank	Mean
Fuel Removal and Storage	Complete Paperwork, Checklists, and Logs	16.5	3.7
Cask Unloading	Complete IF-300 Checklist (initials and date)	16.5	3.7
Off-Site Shipment Preparation	Complete Check Sheets, Paperwork	16.5	3.7
Plant Rounds	Check the Utility Boiler Systems	16.5	3.7
Cask Unloading	Install Cask Head	20.5	3.6
Crane Operations	Move the Load from Location to Location	20.5	3.6
Hydrostatic Testing	Pressurize Cask	20.5	3.6
Off-Site Shipment Preparation	Accomplish Other Tasks (if any)	20.5	3.6
Plant Rounds	Check the Demineralizer System	26	3.5
Fuel Removal and Storage	Operate Crane for Basket Moving	26	3.5
Hydrostatic Testing	Complete Checklist, Paperwork	26	3.5
Control Room Duties	Receive and Transmit Calls	26	3.5
Plant Rounds	Perform Vehicle Checks	26	3.5
Cask Unloading	Accomplish Other Tasks (if any)	26	3.5
Plant Rounds	Inspect the Basin Areas	26	3.5

Table 22. Ranking of Tasks: Least Time Spent

Activity	Task	Mean
Basin Leak Detection	Put Sample in Container	2.4
Basin Leak Detection	Clean Sample Box	2.4
Cask Unloading	Survey Radiation of Car, Cask, and Head	2.4
Plant Rounds	Inspect the Analytic Lab	2.4
LAW Evaporator System Operation	Reduce Steam, Jet Off-Gas Cell Sump	2.4
Emergency Action for Basin Coolers	Check Basin Level	2.4
Emergency Action for Basin Coolers	Open Valve to Discharge Header	2.4
Cask Unloading	Operate Rail Car Brakes, Chocks, and Couplings	2.4
Off-Site Shipment Preparation	Refuel Engine	2.4
Basin Leak Detection	Open Jet Suck Valve to Collect Sample	2.3
Cask Handling with Failed or Leaking Fuel	Monitor Temperature of Cask	2.3
Emergency Action for Basin Coolers	Shut Down Cooler Fan	2.3
Basin Filter Operations	Verify Basin Level > = 58%	2.3
Basin Cooler Operation	Turn Fans On	2.3
Hydrostatic Testing	Vent Valve Operation	2.3

Table 22 (continued)

Activity	Task	Mean
Hydrostatic Testing	Check LAW Vault	2.3
Cask Handling with Failed or Leaking Fuel	Obtain Coolant Sample	2.2
Emergency Action for Basin Coolers	Monitor Area for Heating	2.2
Plant Rounds	Inspect the F(2) Disposal Area and Indicators	2.2
Basin Filter Operations	Open Vacuum Sweeper to Filter System Valve	2.2
Cask Handling with Failed or Leaking Fuel	Take Sample from Cesium Analysis	2.2
Emergency Action for Basin Coolers	Restart Fans	2.2
Emergency Action for Basin Coolers	Turn Basin Pumps and Fans Off	2.2
Demineralizer Operations	Set Timers	2.1
Basin Filter Operations	Close Vaccuum Sweeper to Filter System Valve	2.1
Basin Cooler Operation	Notify Personnel - Pump on Line	2.1
Cask Unloading	Position Rail Switches and Gates	2.1
Emergency Action for Basin Coolers	Turn Cooler Pumps Off	2.1
Emergency Action for Basin Coolers	Turn Breakers Off	2.1
Basin Leak Detection	Place Steam Supply Valve to Jet	2.0

Table 22 (continued)

Activity	Task	Mean
Basin Leak Detection	Attach Tubing to Basin System	2.0
Off-Site Shipment Preparation	Prepare Tool Box and Spare Parts Box	2.0
Emergency Action for Basin Coolers	Close Valve 3/4 Turn	2.0
Basin Filter Operations	Verify Vacuum Head Below Water	2.0
Basin Filter Operations	Place Filter/Hold Switch in Hold	2.0
Basin Water Analysis (Compliance Test)	Determine Actions Required	2.0
Basin Filter Operations	Open Filter Outlet Valve	2.0
Emergency Action for Basin Coolers	Start Emergency Power Manually	2.0
Basin Leak Detection	Turn Level Controller Switch to Hand Position	1.9
Emergency Action for Basin Coolers	Adjust the Regulator	1.9
Basin Leak Detection	Turn On Power Switch	1.9
Cask Handling with Failed or Leaking Fuel	Contact Personnel if Cesium Measure is High	1.8
Basin Water Analysis (Compliance Test)	Plot Data on Analysis Results	1.8
Basin Cooler Operation	Turn Pump On to Increase Demineralization Pressure	1.8
Basin Cooler Operation	Install Chicago Coupling	1.8

Table 22 (continued)

Activity	Task	Mean
Cask Handling with Failed or Leaking Fuel	Evacuate Personnel from Hazardous Areas	1.7
Off-Site Shipment Preparation	Assist Train Crew	1.7
Basin Cooler Operation	Remove Pump Discharge Pressure Indicator	1.6

4.2.3 Difficulty

In the Task Inventory instructions, "Difficulty" was not defined, except for the request to "indicate how hard it is to perform each task." The rating scale for difficulty went from "extremely easy" through "average" to "extremely difficult" (see Table 17). Judging from the responses, the subjects interpreted difficult to include both complex tasks and tedious tasks.

The average task was rated as fairly easy (M = 3.0). The two activities at the top of the difficulty list, Fuel Handling and Storage and Cask Unloading, both fell within the average difficulty category. The two activities which are, in general, the easiest are Basin Leak Detection (very easy) and Plant Rounds (fairly easy). On an individual task level, 10 tasks are rated as fairly difficulty, 29 as average, 130 as fairly easy, and 48 as very easy.

The low overall difficulty ratings are interpreted to mean that the tasks are not hard for the personnel at the Morris ISFSI. It has already been noted that the experience level for these personnel is much higher than might be found across the industry. This difference will become greater if the need for additional ISFSIs causes expansion over the next few years.

Table 23 presents the mean task difficulty for the 39 most difficult tasks. The 39 most difficult tasks include 9 of the 18 Cask Unloading Operations, 7 of the 10 Fuel Removal and Storage tasks, 6 of the 11 Off-Site Shipment Preparation tasks, 6 of the 11 LAW Evaporator System Operations, and 4 of the 12 Basin Filter Operations. Interestingly, the following three emergency actions for Basin Cooler are included on the list:

	Rank
Cover coolers with tarps and fan openings with plastic	1
Light space heaters to heat area*	2
Monitor area for heating	34

Of more interest is the fact that 29 of the 39 most difficult tasks shown in Table 23 involve psychomotor skills. One requires visual skill (identify fuel bundles) and the other nine tasks are primarily mental.

The list of 48 very easy tasks include 9 of the 21 emergency actions for Basin Coolers, 18 of the 41 Plant Rounds, 5 of the 9 Basin Leak Detection tasks, 6 of the 12 Basin Filter Operations, and 4 of the 12 Basin Cooler operations. The least difficult tasks, in general, involve simple mental tasks such as checking, verifying, inspecting, monitoring, recording and simple motor tasks such as turning, restarting and shutting down.

In comparing easy and difficult tasks, an interesting finding emerges. Ten of the 12 Basin Filter Operations appear, 4 on the most difficult list and 6 on the least difficult list. It appears then that Basin Filter Operations vary widely in difficulty.

*No longer in service at the Morris Operation.

Table 23. Ranking of Tasks on Difficulty for Operations Technicians

Activity	Task	Rank	Mean
Emergency Action for Basin Coolers	Cover Coolers with Tarps and Fan Openings with Plastic	1	5.9
Emergency Action for Basin Coolers	Light Space Heaters to Heat Area	2	5.6
Basin Filter Operations	Clean Cask Interior	3	5.5
Basin Filter Operations	Clean Basin Floor	4.5	5.1
Fuel Removal and Storage	Disengage Fuel Grapple Manually	4.5	5.1
Cask Unloading	Install Cask Head	6.5	4.8
Off-Site Shipment Preparation	Decontaminate Cask	6.5	4.8
Basin Cooler Operation	Prime Pump	8.5	4.7
Cask Unloading	Unbolt and Remove Cask Head	8.5	4.7
Cask Unloading	Decontaminate Head, Cas, and Trunnion	10	4.6
LAW Evaporator System Operation	Sample Density	11.5	4.2
Basin Filter Operations	Remove Sweeper Head and Attach Cleaning Tool	11.5	4.2
Electrodecontamination Operation	Calculate Surface Area, Current, Cathodes	13	4.1
Fuel Removal and Storage	Place Fuel in Basket	15.5	4.0

Table 23 (continued)

Activity	Task	Rank	Mean
Cask Unloading	Remove Cask from Basin with Crane	15.5	4.0
Fuel Removal and Storage	Engage Fuel Grapple	15.5	4.0
Fuel Removal and Storage	Identify Fuel Bundles	15.5	4.0
LAW Evaporator System Operation	Adjust Valves and Pumps	19.5	3.9
Basin Water Analysis (Compliance Test)	Determine Actions Required	19.5	3.9
Fuel Removal and Storage	Remove Fuel from Basket	19.5	3.9
Cask Unloading	Lift and Move Cask to Basin	19.5	3.9
Fuel Removal and Storage	Place Basket in Storage Grid Location	23	3.8
Off-Site Shipment Preparation	Connect Cask to Rail Car	23	3.8
Cask Unloading	Dismantle IF-300 to Access Cask	23	3.8
Off-Site Shipment Preparation	Operate Crane to Place Cask on Rail Car	27.5	3.7
Cask Unloading	Operate ISCO to Move Rail Car	27.5	3.7
LAW Evaporator System Operation	Prepare Extended Shutdown, Add Demineralized Water with Chemical Dolly	27.5	3.7
Off-Site Shipment Preparation	Replace Box Covers, Ducts	27.5	3.7

Table 23 (continued)

Activity	Task	Rank	Mean
Hydrostatic Testing	Attach Hydrostatics Pump; Pressurize; Disconnect	27.5	3.7
Basin Filter Operations	Verify All Valves and Switches are in Correct Position	27.5	3.7
Fuel Removal and Storage	Operate Crane for Basket Moving	32.5	3.6
Cask Unloading	Operate Crane and Trunnion	32.5	3.6
Cask Unloading	Survey Radiation of Car, Cask, and Head	32.5	3.6
Emergency Action for Basin Coolers	Monitor Area for Heating	32.5	3.6
Off-Site Shipment Preparation	Move Rail Car with ISCO	37	3.5
LAW Evaporator System Operation	Configure Valve and Pump in Accordance with Checklist	37	3.5
LAW Evaporator System Operation	Monitor Operation Visually, Check for Leaks	37	3.5
Basin Water Analysis (Compliance Test)	Plot Data on Analysis Results	37	3.5
Crane Operations	Change Hooks and Slings	37	3.5

4.2.4 Hazard

The 217 tasks, in general, are not perceived as being very hazardous, the average task hazard rating (M = 2.8) being fairly safe. The two most hazardous activities, Cask Unloading and Fuel Removal and Storage, are rated as fairly safe. Control Room Duties, the least hazardous activity, is rated as very safe (Table 18).

On an individual task level, 3 tasks are rated as somewhat more dangerous than average, 34 as representing the typical hazard, 109 as fairly safe, 63 as very safe, and 8 as absolutely safe.

The list of the 37 most dangerous tasks are presented in Table 24. The 37 most dangerous tasks include 8 of the 18 Cask Unloading tasks, 5 of the 11 Off-Site Shipment Preparation tasks, 4 of the 9 tasks dealing with Cask Handling of Failed or Leaking Fuel, and 4 of the 11 LAW Evaportor System Operating tasks. Obviously, working with the casks is perceived as the most hazardous part of an operations technician's job.

Eleven tasks shown in Table 24 received a mean rating of 4.0 or higher on hazards. Of these 11 tasks, 3 of the most hazardous tasks involve basin filter operations, specifically:

2	clean cask interior	5.0
8	remove sweeper head and attach cleaning tool	4.3
9	Clean basin floor	4.3

A fourth task, manually disengage fuel grapple, appears to share radiation hazards with the basin operations task. Two of the hazardous tasks involve placing items in and removing them from an acid bath. The use of protective gear may both protect from the hazard and make accidents more likely here. Another hazardous task involves lighting space heaters, a standard hazard for any worker. Removing and replacing components on the IF-300 cask account for two more hazardous tasks. These seem to involve mechanical hazards. Potential exposure to energy in lines (both pressure and radiation) is associated with adjusting valves and pumps for LAW evaporator system operation. For this hazard, subjects are concerned with the possibility of spraying a radioactive mist into the air. The most serious hazard perceived by the subjects was in placing tarpaulins and fan covers on basin coolers during emergency activities. This hazard comprises a possible exposure to radiation, a danger of falling from a height, and possibly falling onto sharp metallic objects.

Among the 70 least hazardous tasks (excluding Accomplish Other Tasks, if any) are all of the Control Room Duties, all of the Demineralizer Operations, all of the Basin Water Analysis (Compliance Test) tasks, 10 of the 21 Emergency Actions for Basin Coolers, 7 of the 12 Basin Filter Operating tasks, and 6 of the 12 Basin Cooler Operations.

Table 24. Ranking of Tasks on Hazard for Operations Technicians

Activity	Task	Rank	Mean
Emergency Action for Basin Coolers	Cover Coolers with Tarps and Fan Openings with Plastic	1	5.1
Basin Filter Operations	Clean Cask Interior	2	5.0
Emergency Action for Basin Coolers	Light Space Heaters to Heat Area	3	4.7
LAW Evaporator System Operation	Adjust Valves and Pumps	4	4.4
Electrodecontamination Operation	Place Item in Acid	7	4.3
Electrodecontamination Operation	Remove and Rinse Them	7	4.3
Fuel Removal and Storage	Disengage Fuel Grapple Manually	7	4.3
Basin Filter Operations	Remove Sweeper Head and Attach Cleaning Tool	7	4.3
Basin Filter Operations	Clean Basin Floor	7	4.3
Off-Site Shipment Preparation	Replace Box Covers, Ducts	10.5	4.0
Cask Unloading	Dismantle IF-300 to Access Cask	10.5	4.0
Off-Site Shipment Preparation	Connect Cask to Rail Car	13	3.9
Off-Site Shipment Preparation	Decontaminate Cask	13	3.9
Cask Unloading	Operate Crane and Trunnion	13	3.9

Table 24 (continued)

Activity	Task	Rank	Mean
Cask Unloading	Unbolt and Remove Cask Head	15	3.8
Fuel Removal and Storage	Remove Fuel from Basket	19	3.7
Fuel Removal and Storage	Place Fuel in Basket	19	3.7
LAW Evaporator System Operation	Monitor Operation Visually, Check for Leaks	19	3.7
Cask Handling with Failed or Leaking Fuel	Flush Cask	19	3.7
Cask Handling with Failed or Leaking Fuel	Obtain Coolant Sample	19	3.7
Cask Handling with Failed or Leaking Fuel	Take Sample from Cesium Analysis	19	3.7
Off-Site Shipment Preparation	Operate Crane to Place Cask on Rail Car	19	3.7
LAW Evaporator System Operation	Sample Density	26.5	3.6
Hydrostatic Testing	Attach Hydrostatics Pump; Pressurize; Disconnect	26.5	3.6
Cask Unloading	Operate Rail Car Brakes, Chocks, and Couplings	26.5	3.6
Crane Operations	Move the Load from Location to Location	26.5	3.6
Basin Cooler Operation	Remove Pump Discharge Pressure Indicator	26.5	3.6

Table 24 (continued)

Activity	Task	Rank	Mean
Cask Unloading	Lift and Move Cask to Basin	26.5	3.6
Crane Operations	Place the Load in Wanted Area	26.5	3.6
Cask Unloading	Remove Cask from Basin with Crane	26.5	3.6
Cask Unloading	Install Cask Head	34	3.5
Cask Handling with Failed or Leaking Fuel	Fill Cask with Water	34	3.5
Hydrostatic Testing	Move Cask with Crane (to and from rail car)	34	3.5
Crane Operations	Lift Load Vertically	34	3.5
Cask Unloading	Decontaminate Head, Cask, and Trunnion	34	3.5
Off-Site Shipment Preparation	Move Rail Car with ISCO	34	3.5
LAW Evaporator System Operation	Prepare Extended Shutdown, Add Demineralized water with Chemical Dolly	34	3.5

4.2.5 Error

As might be expected in an operation involving detailed planning, deliberate operation, and extensive documentation, there are not a lot of errors recorded during operation at the Morris ISFSI. According to the task inventory, unrecovered errors occur infrequently, with the average task (M = 4.4) having an estimated error occurrence of perhaps as often as once per year. The highest rated error prone activities are Control Room Duties (M = 3.9) and Demineralizer Operations (M = 4.0), both having an average error frequency perhaps as often as once per year. The least error-prone activity is Cask Handling of Failed or Leaking Fuels, and it occurs with an average error frequency of less than once per year. This statistic is attributable to the fact that, in ten years of operation, there have been no casks received with confirmed leaking fuel bundles. Other activities in which the average error frequency is less than once per year include Hydrostatic testing, Off-Site Shipment Preparation, Basin Cooler Operations, Basin Filter Operation, and Basin Leak Detection (see Table 18).

On an individual task level, there is relatively little variability in the mean task rating for errors. Only three of the tasks have a mean error rating falling into the category "probably more often than once a year." Of the remaining tasks, 103 are rated as having errors perhaps as often as once per year and 111 are rated as having errors less than one per year.

Table 25 presents a list of the 25 most error-prone tasks (M < 4.0) (Accomplish Other Tasks, if any, is included). As can be seen in Table 25, the most error-prone tasks include 5 of the 7 Control Room Duties, 3 of the 7 Demineralizer Operating tasks (including Accomplish Other Tasks, if any), 3 of the 8 Electrodecontamination tasks, and 8 of the 42 Plant Rounds (including Accomplish Other Tasks, if any).

According to the task inventory responses, most errors (around one per year) occur in performing vehicle checks. This is especially noteworthy when one observes that the vehicles are the one item that is most familiar to employees. Four of the 10 most error-prone tasks involve completion of logs and data sheets. From this statistic, it might be inferred that operations technicians are better at performing a task than in logging it. There is a distinct possibility that forms and checklists are too unwieldy or too complex to be completed while an actual task is in progress.

Activities producing errors are demineralizer and electrodecontamination operations, both of which are supporting activities for the ISFSI. Calculations and checking contamination levels are suspected as sources of error during decontamination. Demineralizer valve operation and system checking are considered to be error likely tasks.

Log entry and checklist completion is considered to be the major error source for such complex activities as fuel removal and storage, cask unloading, basin filter operations, basin water analysis compliance

Table 25. Ranking of Tasks on Errors for Operations Technicians

Activity	Task	Rank	Mean
Plant Rounds	Perform Vehicle Checks	1	3.2
Electrodecontamination Operation	Complete Logs	2.5	3.3
Plant Rounds	Complete Shift Rounds Data Sheet	2.5	3.3
Plant Rounds	Accomplish Other Tasks (if any)	7.5	3.5
Plant Rounds	Check the Demineralizer System	7.5	3.5
Control Room Duties	Complete Logs and Other Forms	7.5	3.5
Electrodecontamination Operation	Check Contamination Levels of Tools/Equipment	7.5	3.5
Electrodecontamination Operation	Calculate Surface Area, Current, Cathodes	7.5	3.5
Demineralizer Operations	Complete Paperwork, Checklist	7.5	3.5
Demineralizer Operations	Adjust Valves	7.5	3.5
Fuel Removal and Storage	Complete Paperwork, Checklists, and Logs	7.5	3.5
Plant Rounds	Check the Utility Boiler Systems	12.5	3.6
Cask Unloading	Complete IF-300 Checklist (initials and date)	12.5	3.6

Table 25 (continued)

Activity	Task	Rank	Mean
Basin Filter Operations	Record Readings in Basin Filter Log	12.5	3.7
Basin Water Analysis (Compliance Test)	Log and Initial Data on Samples and Results	16.5	3.7
LAW Evaporator System Operation	Monitor Operation from Control Room, Log Data Every 2 Hours	16.5	3.7
Plant Rounds	Inspect the Compressor Room and Indicators	16.5	3.7
Control Room Duties	Start and/or Stop Equipment	16.5	3.7
Control Room Duties	Perform Rounds Check	16.5	3.7
Plant Rounds	Inspect the Utility Building and Indicators	20.5	3.8
Demineralizer Operations	Accomplish Other Tasks (if any)	20.5	3.8
Control Room Duties	Respond to Alarms	23.5	3.9
Plant Rounds	Inspect the Ventilation Supply Room and Indicators	23.5	3.9
Off-Site Shipment Preparation	Complete Check Sheets, Paperwork	23.5	3.9
Control Room Duties	Initiate Scheduled Tests	23.5	3.9

test, LAW evaporator system operation, off-site shipment preparation, and crane operation.

Interestingly, "Accomplish Other Tasks, if any," in the areas of Plant Rounds and Demineralizer Operations were rated as error-prone. Since respondents did not write in specific tasks, it is impossible to identify the nature of the task activity.

The 27 least error-prone tasks ($M \geq 4.8$) (including Accomplish Other Tasks, if any) include 9 of the 21 Emergency Actions for Basin Coolers, 4 of the 9 Basin Leak Detection tasks, and 4 of the 9 tasks involving Cask Handling of Failed or Leaking Fuel. Again, most of the least error-prone tasks involve rare events.

Appendix F lists Error Narrative information derived from the three error questions responded to by certified personnel (see end of Appendix A)

4.2.6 Errors Predicted for Novice Personnel

For novice personnel, those who have been certified less than six months or who are not yet certified, the error evaluation was somewhat different. The basic unit of analysis was the number of respondents who considered the task as one in which an error was likely by novice personnel. The mean number of times a task was nominated as an "Error-New-Person" was 5.4. The activities which had the highest number of nominations for Error-New-Person include Cask Unloading, Fuel Removal and Storage, LAW Evaporator System Operation, and Control Room Duties. The least error-prone activity was Basin Leak Detection (see Table 18).

At the individual task level, any task which was nominated by 10 or more respondents (+1 SD) as likely to produce an error by a new person was included in the list of error-prone tasks whereas any task nominated by one or none of the respondents (-1 SD) was included in the list of error-free tasks for new personnel.

Table 26 presents the 35 most error prone tasks for novice personnel. The list includes 7 of the 18 Cask Unloading tasks, 5 of the 10 Fuel Removal and Storage tasks, 5 of the 11 LAW Evaporator System tasks, and 3 of the 7 Control Room Duties.

After the subjects had rated all of the tasks for error frequency, they were asked to indicate which tasks were more likely to have errors made by new personnel. There are no new personnel at the Morris ISFSI. Responses concerning "Error-New-Person" were interpreted as perceived errors, possibly based on personnel recollections.

Some of the tasks judged likely to produce errors for new personnel involve crane operation, a precise psychomotor skill involving judgment and eye-hand coordination. These include:

- Lift and move the cask to the basin
- Operate the crane to place cask on the rail car

Table 26. Ranking of Tasks on Errors Predicted for Novice Personnel

Activity	Task	Rank	Mean
Basin Filter Operations	Verify All Valves and Switches are in Correct Position	1	15.0
Control Room Duties	Respond to Alarms	2.5	14.0
Plant Rounds	Check the Demineralizer System	2.5	14.0
Fuel Removal and Storage	Remove Fuel from Basket	7	13.0
Fuel Removal and Storage	Complete Paperwork, Checklists, and Logs	7	13.0
Off-Site Shipment Preparation	Operate Crane to Place Cask on Railcar	7	13.0
LAW Evaporator System Operation	Check System Operations: Blowers, Vents, Instruments	7	13.0
LAW Evaporator System Operation	Configure Valve and Pump in Accordance with Checklist	7	13.0
Plant Rounds	Check the Utility Boiler Systems	7	13.0
Cask Unloading	Operate ISCO to Move Railcar	7	13.0
Fuel Removal and Storage	Place Fuel in Basket	13.5	12.0
Cask Unloading	Lift and Move Cask to Basin	13.5	12.0
LAW Evaporator System Operation	Adjust Valves and Pumps	13.5	12.0

Table 26 (continued)

Activity	Task	Rank	Mean
LAW Evaporator System Operation	Prepare Extended Shutdown, Add Demineralized Water with Chemical Dolly	13.5	12.0
Cask Unloading	Operate Railcar Brakes, Chocks, and Couplings	13.5	12.0
Plant Rounds	Inspect the Compressor Room and indicators	13.5	12.0
Off-Site Shipment Preparation	Move Rail Car with ISCO	19.5	11.0
Basin Cooler Operation	Prime Pump	19.5	11.0
Demineralizer Operations	Adjust Valves	19.5	11.0
Demineralizer Operations	Set Timers	19.5	11.0
Cask Unloading	Install Cask Head	19.5	11.0
Plant Rounds	Inspect the Basin Filter and Indicators	19.5	11.0
Plant Rounds	Check the Basin Coolers and Indicators	29	10.0
Cask Unloading	Survey Radiation of Car, Cask, and Head	29	10.0
Fuel Removal and Storage	Disengage Fuel Grapple Manually	29	10.0
Fuel Removal and Storage	Place Basket in Storage Grid Location	29	10.0
Basin Cooler Operation	Complete Valve Check Off Lists	29	10.0

Table 26 (continued)

Activity	Task	Rank	Mean
Basin Filter Operations	Record Readings in Basin Filter Log	29	10.0
Cask Unloading	Unbolt and Remove Cask Head	29	10.0
LAW Evaporator System Operation	Shutdown, Valves and Pumps Adjusted to Flush	29	10.0
Crane Operations	Hook Load	29	10.0
Cask Unloading	Remove Cask from Basin with Crane	29	10.0
Emergency Action for Basin Coolers	Check Valving	29	10.0
Control Room Duties	Initial Scheduled Tests	29	10.0
Control Room Duties	Complete Logs and Other Forms	29	10.0

- Remove fuel from the basket
- Place fuel in the basket
- Remove cask from basin with crane

Another group of tasks, judged by at least ten subjects to be more likely to have errors committed by novice personnel, include:

- Verify basin filter valve and switch positions
- Respond to control room alarms
- Check LAW evaporator system operation
- Configure LAW evaporator valves and pumps
- Adjust LAW evaporator valves or pumps
- Initiate scheduled control room tests
- Complete control room logs and other forms
- Emergency action - check valving
- LAW evaporation systems shutdown
- Demineralizer operation - adjust valves
- Demineralizer operation - set timers

These tasks appear to be process oriented. They require system understanding and interpretation followed by a series of actions in a complex pattern. The pattern may involve instrument or valve arrangements, and the arrangements may adversely affect sequential operations.

The remaining tasks on which new personnel are considered to be error-likely involve rail car operation and movement and use of a chemical dolly. The problem here may be one of unfamiliarity with a system. New personnel are not likely to have experience with railroad operations or chemical dollies. When this is the case, there is a requirement for sufficient specific training to make the new employee familiar with the system and competent in the psychomotor skills required for system operation. The importance of training increases when frequency of the task is low.

The list of 30 relatively error-free tasks for new personnel (excluding Accomplish Other Tasks, if any) include 13 of the 41 Plant Rounds, 4 of the 9 Basin Leak Detection tasks, and 4 of the 21 Emergency Actions for Basin Coolers. Most of these error-free tasks involve simple mental activities (e.g., inspect, notify, verify), simple motor actions (e.g., put, remove, turn), or tasks which represent rare events.

4.3 Correspondence Between Variables

Table 27 presents the correlation between the means of the 217 tasks for each of the six variables. All correlations except two (the correlation between Frequency and Error-New-Person and the correlation between Difficulty and Errors) are significant at minimally the .05 level. Note that the sign of the correlation with error are opposite that of the true relationship because of the reverse polarity of scale--low rating corresponds to high error rate.

Table 27. Correlations of the Mean Ratings on 217 Tasks for Each of Six Variables

	Time Spent	Difficulty	Hazard	Error	Error New Person
Frequency	0.66***	-0.19**	-0.20**	-0.57***	0.11
Time Spent		0.44***	0.20**	-0.52***	0.31***
Difficulty			0.65***	-0.03	0.45***
Hazard				0.23***	0.17*
Error					-0.38***

Significant correlations: * α = .05
** α = .01
*** α = .001

After identifying the tasks which are rated high in difficulty, hazard, or likelihood of error, it was noted that these variables, evaluated singly, did not provide information concerning possible corrective action. That is, there is no indication as to whether task difficulty should be reduced by training changes, or by task modification, or by changing the equipment. However, when a task is performed frequently and already requires a considerable portion of a worker's time, it seems unlikely that difficulty, hazards, or errors can be reduced by spending additional time practicing the task or training. For tasks which are accomplished frequently and are rated as difficult, hazardous, or error-likely, it seems reasonable to attribute the problem to either the equipment or the design of the task itself.

In analyzing the relations between variables, several general principles evolved. These were used to identify the preferred corrective actions. Figure 6 summarizes the principles. It should be noted that specific changes in training, task design or equipment can not be recommended without a task analysis that is based on the individual steps and actions that make up a subtask.

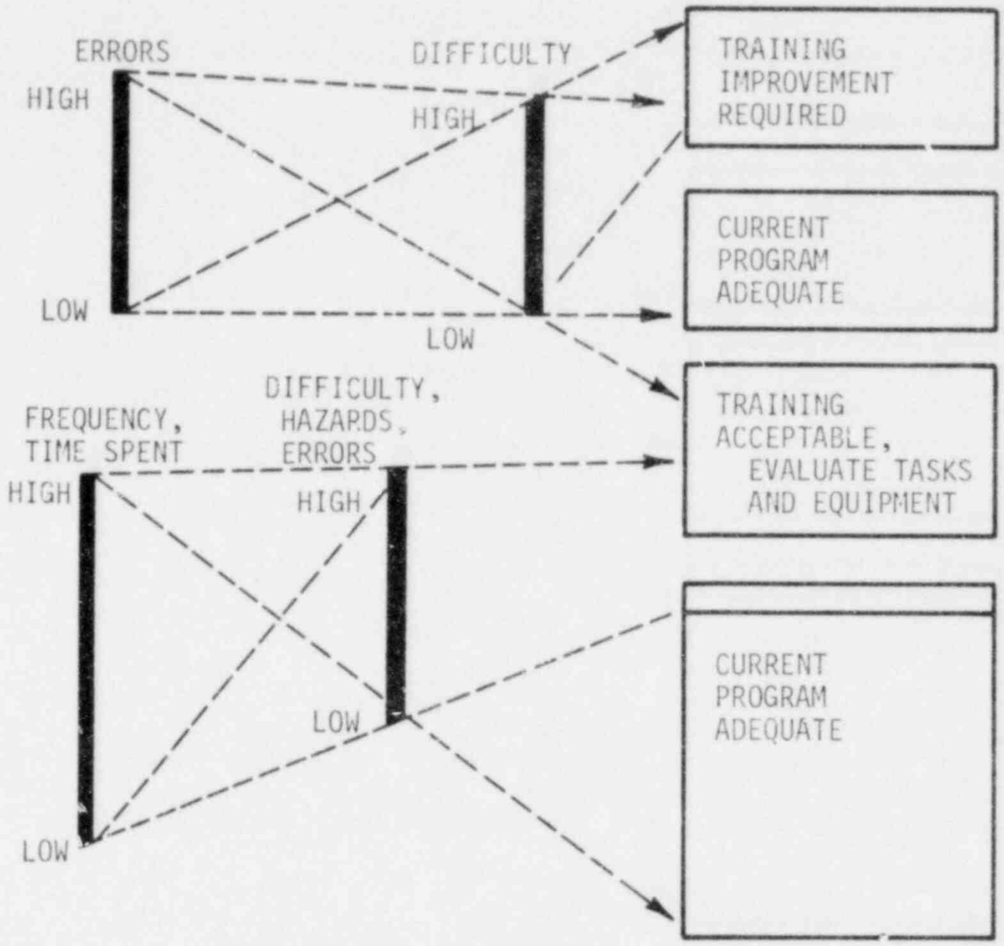

Figure 6. Relations Between Analysis Variables and Recommended Changes in Training, Equipment, and Task Design

4.3.1 Correspondence Between Frequency and Other Variables

Ratings of Frequency are correlated fairly strongly with Time Spent and Errors. The greater the frequency with which operations technicians engage in a task, the greater the time spent and the more likely an error is to be made.

The correspondence between Frequency and Time Spent can be seen in that four of the six highest rated activities for both variables (Control Room Duties, Cask Unloading, Crane Operations, Fuel Removal and Storage) and the lowest rated activity for both variables (Cask Handling of Failed or Leaking Fuels) are the same. On an individual task level, 33% (n = 18) of the tasks occurring most frequently are also on the list of those tasks involving the greatest time spent. On only one occasion did a task rated high in Frequency get rated low in Time Spent (Basin Filter Operations: Verify basin $\geq$ 58%). Of the 42 least frequently occurring tasks, 69% (n = 29) are also on the list of tasks in which the operations technicians spent the least time. There are no occurrences of a task rated low in Frequency but high in Time Spent.

The correspondence between Frequency and Error is perfectly understandable--the more frequently one engages in a task, the more opportunity there is for errors and the more likely an error is to be made. This relationship is reflected in the fact that Control Room Duties and Demineralizer Operations are rated high in Frequency and also high in being error-prone whereas Cask Handling of Failed or Leaking Fuels is rated low in both Frequency and Error.

The correlation between Frequency and Error, although perfectly understandable, must be interpreted with care. Just because a task is rated low in Frequency does not imply that the task is not error-prone. If the tasks had been engaged in more frequently, more errors might occur. Given the criticality of some of the least frequently occurring tasks (Cask Handling of Failed or Leaking Fuels and the Emergency Actions for Basin Coolers), one would not want to make errors on these tasks.

On the individual task level, the following 14 tasks were rated high in frequency and as being error-prone:

- Complete IF-300 checklist
- Complete paperwork, checklists, logs for Fuel Removal and Storage
- Complete check sheets, paperwork for Off-Site Shipment preparation
- Log and initial data with sample and results (Basin Water Analysis)
- Complete paperwork, checklists for Demineralizer Operations
- Monitor operation LAW Evaporator System from control room, log data every 2 hours
- Perform rounds check (Control Room Duties)
- Respond to control room alarms
- Complete control room logs and other forms
- Inspect utility building and indicators
- Check utility boiler system
- Check the demineralizer system
- Inspect vent supply room and indicators
- Complete shift round data sheet

It can be seen that these tasks involve either completion of paperwork, checklists, logs, etc. or plant rounds. When high frequency tasks are judged to be error likely, additional training will probably not reduce the number of errors. Errors in high frequency tasks are usually caused by careless behavior or lack of motivation. This is especially true for the 14 tasks involving paperwork or checklists. The tasks are not difficult. The operations technicians know what is expected. Training will not improve the situation. If the checklists were computerized, so that illogical answers could be rejected and continued use was impossible unless proper entries were made, the number of errors could probably be reduced.

Those tasks rated low in Frequency but high in Error present a different problem. In spite of the fact they are accomplished infrequently, they are error-prone. These tasks include:

- o Verify vacuum head below water (Basin Filter Operation)
- o Calculate surface area, current, cathodes (Electrodecontamination)

It is possible to attempt to reduce the error rates on these tasks by altering the training program to provide more practice. It may be more cost effective to change the nature of the tasks. For instance, it is not easy to calculate the surface area of irregular objects. It may be sufficient to estimate the surface area, using a rectangular grid and determine acceptable current level and number of cathodes from a look-up table. Before a training program is changed, a subject matter expert should study the task, observe several different individuals doing the task, and determine if there are alternative methods of completing the task. Training should be directed at obtaining a precise result in terms of observable behavior.

The correlations between Frequency and Difficulty and between Frequency and Hazard, despite being significant, are relatively low. In both cases, the correlation is negative. The more frequently operations technicians engage in a task, the less difficult and less hazardous it is rated, in general. It appears that familiar tasks are perceived as being less hazardous.

Of particular interest are those tasks rated high in both Frequency and Difficulty and low in Frequency but high in Difficulty. In the former case, the tasks are difficult despite being performed frequently whereas, in the latter case, these tasks may be difficult because they are performed less frequently.

Tasks rated high in both Frequency and Difficulty include:

- o Unbolt and remove cask head
- o Decontaminate head, cask, and trunnion
- o Operate crane for basket moving
- o Identify fuel bundles
- o Decontaminate cask

Tasks performed frequently yet judged to be difficult are not likely to benefit from practice. Such tasks contain steps which are physically or mentally difficult. Training is not likely to produce positive results unless a better method of doing the task can be developed. For high frequency/high difficulty tasks, training officers should carefully evaluate the steps to determine if task improvement is possible. Unless a better method is discovered, training is not likely to produce changes in perceived difficulty.

There are 12 tasks rated low in Frequency and high in Difficulty. These are:

- o Survey radiation of car, cask, and head
- o Disengage fuel grapple manually
- o Prime pump
- o Determine action required from basin water analyzer
- o Plot data on analysis of Basin Water Analysis results
- o Remove sweeper head and attach cleaning tool
- o Clean cask interior
- o Sample density of LAW Evaporator System
- o Calculate surface area, current, cathodes for Electrodecontamination
- o Cover coolers with tarps and fan openings with plastic
- o Light space heaters to heat Basin Cooler area
- o Monitor Basin Cooler area for heating

Practice should help to reduce perceived difficulty for tasks whose difficulty is related to a lack of familiarity. This may be the situation for half of the tasks on this list. By providing feedback on performance, training can improve on the quality of practice. It is up to the training officer and plant engineers to review these tasks that are perceived as difficult to determine if the tasks should be changed or if the training should be improved.

The most frequently occurring tasks involve Plant Rounds. Considered singly, the tasks associated with Plant Rounds are not difficult. Nevertheless, supervisors identified the "rounds" activity as difficult and requiring considerable time to learn. It appears that, when these tasks are viewed collectively, the "rounds" activity is difficult because of the length of the inspection checklist and the number of different checks done on a variety of different systems.

Considering the relationship between frequency and hazard, two tasks are viewed as being high in Frequency and high in Hazard. These involve moving the load from location to location with the crane and decontaminating the cask. Follow-up interviews with certified personnel confirm that the principal hazards are the danger of falling during decontamination and dropping the cask while moving it. These are standard industrial safety problems, and should be handled according to industrial safety procedures.

Eleven tasks with a low frequency of occurrence are rated as being hazardous. These tasks are:

- o Disengage fuel grapple manually
- o Remove pump discharge pressure indicator
- o Remove sweeper head and attach cleaning tool
- o Clean cask interior
- o Sample density of LAW Evaporator System
- o Cover coolers with tarp and fan openings with plastic
- o Light space heaters to heat Basin Cooler area

- o Flush cask
- o Obtain sample coolant from failed or leaking cask
- o Fill failed or leaking cask with water
- o Take sample from cask with failed or leaking fuel for Cesium analysis

Six of these 11 hazardous tasks were also judged to be difficult to accomplish. The remaining five involve cask operations, with the hazards of three tasks related directly to leaking or failed fuel bundles. It is not prudent to practice hazardous operations because the hazards will be present during practice and increased exposure may increase the probability of a mishap. For training to be of value for hazardous tasks, the hazards must be reduced or eliminated. This is accomplished by developing simulators so that the consequences of errors may be reduced.

Although Frequency was not significantly related to Error-New-Person, there are some interesting relationships. The following seven tasks frequently performed by the operations technicians are rated as likely to produce an error for a new person:

- o Complete paperwork, checklists and logs for Fuel Removal and Storage
- o Respond to alarm in the Control Room
- o Complete Control Room logs and other forms
- o Check the Utlity Boiler system
- o Check the Demineralizer system
- o Inspect the Compressor Room and indicators
- o Inspect the Basin Filter and indicators
- o Check the Basin Coolers and indicators

These represent tasks involving a sequence of mental actions and the interpretation of instruments. They involve information processing and a complete understanding of the systems. A well developed training program should help newly assigned personnel to acquire the necessary understanding and improve the performance of senior personnel as well.

Four tasks, although on the list of most infrequently performed tasks by operations technicians, are rated as likely to produce an error for new personnel.

- o Survey radiation of car, cask, and head
- o Disengage fuel grapple manually
- o Prime pump
- o Set demineralizer timers

As can be seen, most of these tasks involve radiation hazards or are difficult to perform.

4.3.2 Correspondence Between Time Spent and Other Variables

Ratings of Time Spent are moderately correlated with ratings of Difficulty. Generally, the greater the difficulty, the greater the time spent in accomplishing the task. This relationship can be seen in the fact that the two activities in which the greatest time is spent (Cask Unloading and Fuel Removal and Storage) are also among the most difficult and the activity in which the least time is spent (Cask Handling of Failed or Leaking Fuel) is the least difficult. This may be somewhat misleading. Not much time has been spent with casks with leaking fuel because there has never been one confirmed at the Morris ISFSI. The actions are not difficult because the correct procedure is to stop all actions.

For training purposes, it may be important to disaggregate the difficult tasks into those on which operations technicians spend a lot of time and those on which they spend little time. Tasks rated high in both Time Spent and Difficulty include:

- o Unbolt and remove cask head
- o Install cask head
- o Decontaminate head, cask, and trunnion
- o Operate crane for basket moving
- o Decontaminate cask
- o Clean basin floor

Four of these six tasks were rated high in frequency, and have been previously discussed. The remaining two tasks, Install Cask Head and Clean Basin Floor, are not done frequently, but do take a lot of time. They are more likely to benefit from training than the high frequency difficult tasks.

The tasks rated low in Time Spent but high in Difficulty are:

- o Survey radiation of car, cask, and head
- o Determine action required from basin water analysis
- o Plot data on basin water analysis results
- o Monitor basin cooler area for heating

All four of these tasks were rated low in frequency. For monitoring and surveying of radiation, training and practice should increase familiarity and reduce perceived difficulty. In actual cask operations, the safety technicians often do the radiation surveys, "because they are better at it." It is possible that this task should be officially assigned to the safety technicians. Some operations technicians find it difficult to plot data neatly. A better approach might be to assign the plotting task to a single person who has the required ability. Quality of the plots should increase, and the redistribution of a difficult task should increase overall morale. Operations technicians rarely determine required actions following basin water analysis. Information on unusual data is provided to engineers who make the decisions. This task is perceived as difficult because it extends beyond the capability of operations technicians.

The highest correlation with Time Spent is that with Error. The greater the time spent, the more likely an error is made. In general, activities in which the greatest time is spent (e.g., Control Room Duties) were also the most error-prone and activities in which the least time was spent (e.g., Cask Handling of Failed or Leaking Fuels and Basin Leak Detection) are also the least error-prone.

It is unlikely that training will change this situation, especially when errors are made on simple and common functions such as initialing checklists or recording instrumentation readings. To reduce this type of error, there must be a procedural change.

On an individual task level, it is important to distinguish between those error-prone tasks in which a great amount of time is spent and those in which little time is spent. Error-prone tasks in which operations technicians spend a great deal of time include:

- Complete IF-300 checklist (initial and date)
- Complete paperwork checklists and logs for Fuel Removal and Storage
- Complete check sheets, paperwork for Off-Site Shipment Preparation
- Monitor LAW Evaporator System Operation from control room, log data every 2 hours
- Perform rounds check (Control Room Duties)
- Complete control room logs and other forms
- Inspect the Utility Building and indicators
- Check the Utility Boiler Systems
- Check the Demineralizer system
- Perform vehicle checks
- Complete shift rounds data sheet

As with high frequency tasks, these error-prone tasks include primarily plant rounds and the completion of paperwork, logs, and checklists. For these tasks, the comments made for high frequency, error likely tasks apply. In fact, ten of the eleven difficult, high time tasks are also high frequency tasks. There is an opportunity for training to reduce errors on some of these tasks. When the task involves checking a system, errors are more likely when the checker does not fully understand the system. Special training programs, aimed at understanding systems and interpreting data from system inspection could help to reduce errors in some areas. In particular, the following systems should be considered: demineralizer, utility boiler, LAW evaporator and motor vehicles.

Only one task in which operations technicians spend little time was rated as error likely: verify vacuum head below water. However, as with Frequency, the fact that tasks rated low in Time Spent are not rated high in Error may be misleading. If more time were spent on these tasks, more errors might be made. Since the tasks in which little time is spent include activities which represent rare events (Cask Handling of Failed or Leaking Fuels and Emergency Actions for Basin Coolers), there should be little opportunity for errors to occur. One task, which requires only a small amount of time, has been identified as error likely. This task should be carefully examined to determine if it should be changed or if additional training is needed.

The correlations between Time Spent and Hazard and between Time Spent and Error-New-Person, although significant, are relatively low. In both cases, the correlation is positive. The greater the time spent, the more hazardous the task is rated and the more likely an error is to be made by novice personnel.

The tasks rated high in Time Spent and also rated high in Hazard are:

- o Unbolt and remove cask head
- o Install cask head
- o Decontaminate head, cask, and trunnion
- o Move the load from location to location using the crane
- o Decontaminate cask
- o Clean basin floor

The first tasks involve industrial safety hazards, including the danger of falling and the hazards of moving a heavy object with a crane. As mentioned previously, these problems should be handled by standard industrial safety techniques. The use of better platforms and safety belts should be considered. Power tools could be used to reduce the manual forces required.

The cask decontamination and basin floor cleaning tasks involve possible radiation hazards. Practicing hazardous tasks is, in itself, hazardous, and increases exposure to accidents. While the use of a simulator could allow training with reduced exposure to hazards, it could also cause trainees to forget the hazards of the actual task. It should be noted that, in general, the training program and safety records at the Morris ISFSI have been reviewed and judged as satisfactory. Changes should be made with caution, and should be developed to remedy specific shortcomings.

Four tasks on which relatively little time is spent are rated as being hazardous. These include:

- o Operate rail car brakes, chocks, and couplings
- o Remove pump discharge pressure indicator
- o Obtain sample coolant from failed or leaking casks
- o Take sample from failed or leaking cask for Cesium analysis

Training can be expected to produce the most performance improvement on tasks that occur infrequently and require little time. Simulators may be used to permit training and practice in an environment that is relatively hazard-free. If actual systems are adjusted to reduce physical hazards (by reducing operating pressures and temperatures), they may also be used to provide training and practice without excessive risk of injury or system damage. If a worker practices an operation, such as sample-taking, with materials that are not radioactive, proficiency may be expected to increase. The additional training and practice, conducted in a relatively safe environment, will provide increased psychomotor proficiency and reduced the perceived hazard level.

For rail car operations, training officers must balance the hazards of actual operation with the benefits of practice. A training program for rail car operations must include safeguards and close supervision. With experience, the perceived hazards should be reduced.

The correlation between Time Spent and Error-New-Person, although relatively low, is significant. Tasks on which operations technicians spend more time will probably be rated as likely to produce an error when performed by a new person. The following tasks were identified as those on which operations technicians spend the most time and on which new personnel are likely to make an error:

- o Unbolt and remove cask head
- o Install cask head
- o Complete paperwork, checklists, and logs for Fuel Removal and Storage
- o Complete the Control Room Logs and other forms
- o Check the Utility Boiler system
- o Check the Demineralizer system

Two of the tasks require a complete understanding of a system and the ability to interpret system indications. Two of the tasks require completion of paperwork which is based on understanding a process or combination of systems. All four of these tasks could benefit from improved training for new personnel. In identifying these tasks as error-likely for novice personnel, certified workers expressed their belief that experience in system operation is needed in order to reduce the likelihood of errors. Because a lot of time is spent on these tasks, it is possible to provide experience through carefully supervised OJT. Cask head operations are also good candidates for OJT.

Three tasks are infrequently performed by operations technicians but likely to be a source of error for novice personnel:

- o Operate rail car brakes, chocks, and couplings
- o Survey radiation of car, cask, and head
- o Set Demineralizer timers

Recommendations for the first two tasks have already been stated. It appears that personnel at the Morris ISFSI also believe that additional training on demineralization is needed. Because the demineralizer operation is now automated, there may be a lack of experience in manual settings. Novice personnel are likely to rely on the automatic features and not attend to the details of the manual system.

4.3.3 Correspondence Between Difficulty and Other Variables

Ratings of Difficulty and Hazard have a fairly strong positive correlation. As difficulty of a task increases, it is more likely to be rated as hazardous. That this is the case can be seen from the fact that activities such as Cask Unloading and Fuel Removal and Storage are rated high on both Difficulty and Hazard whereas activities such as Basin Leak Detection are low on both. On an individual task level, 64% (n = 25) of the tasks rated high on Difficulty are also rated high on Hazard. At the other extreme, 58% (n = 28) of the easy tasks were rated as less hazardous. Interestingly, none of the easy tasks are on the list of most hazardous tasks.

From a training and certification perspective, tasks which are both difficult and hazardous assume great importance. The following 25 tasks appear on both the list of most difficult and most hazardous tasks:

- Dismantle IF-300 to access cask
- Operate crane and trunnion
- Lift and move cask to basin
- Remove cask from basin with crane
- Unbolt and remove cask head
- Install cask head
- Decontaminate head, cask, and trunnion
- Remove fuel from basket
- Disengage fuel grapple manually
- Attach hydrostatic pump
- Operate crane to place cask on rail car
- Connect cask to rail car
- Decontaminate cask
- Replace box covers, ducts
- Move rail car with ISCO
- Remove sweeper head and attach cleaning tool
- Clean cask interior
- Clean basin floor
- Adjust LAW Evaporator System valves and pumps
- Monitor LAW Evaporator System Operation, visually check for leaks
- Sample density for LAW Evaporator System
- Prepare for extended Basin Cooler shutdown, add demineralized water with chemical dolly
- Cover coolers with tarps and fan openings with plastic
- Light space heaters to heat Basin Cooler area

Ratings of Difficulty and Error were surprisingly unrelated. This may be attributed to the large number of errors made on tasks which were judged relatively simple (checklists, logs and paperwork). It may also be attributed to the fact that tedious tasks (rated difficult) are not necessarily error-likely. Nevertheless, there was one noteworthy relationship: Calculating the surface area, current, and cathodes for the electrodecontamination operation was high in difficulty and rated as error-likely. This deserves special attention to change the procedures and improve on training.

Despite Difficulty and Error not being significantly correlated (see Table 27), Difficulty and Error-New-Person are moderately correlated ($r = 0.45$). As one would expect, as the difficulty increases, the estimated likelihood of an error by new personnel increases. Twenty-four percent (n = 17) of the most difficult tasks are on the list of tasks most likely to result in an error by novice personnel. Conversely, 49% (n = 17) of the tasks estimated most likely to produce error by new personnel are rated as difficult. This relationship suggests that the difficulty of the task is primarily responsible for it being identified as error-likely for novice personnel.

The following is a list of the 17 tasks rated high on both Difficulty and Error-New-Person:

- Operate ISCO to move rail car
- Survey radiation of car, cask, and head
- Lift and move cask to basin
- Remove cask from basin with crane
- Unbolt and remove cask head
- Install cask head
- Remove fuel from basket
- Place fuel in basket
- Disengage fuel grapple manually
- Place basket in storage grid location
- Operate crane to place cask in rail car
- Move rail car with ISCO
- Prime pump
- Verify all basin filter valves and switches in proper position
- Adjust LAW Evaporator system valves and pumps
- Prepare extended Basin Cooler shutdown, add demineralized water with chemical dolly
- Configure LAW Evaporator system valve and pump in accordance with checklist

These tasks identify areas in which training is needed. Eleven of the tasks involve psychomotor skills. These skills are developed only with practice. These responses are interpreted as requests for more opportunities for practice during initial training. Simulated fuel bundles and casks could be used to provide training and practice. The same equipment could be used to sharpen skills following extended periods of inactivity. There also appears to be a need for practice with rail car operations. A second area involves system operations and the positioning of valves and switches. Performance in this area may be improved by improving academic training. Course revisions should be developed to present sample cases in interpretation of system status and the effects of valve, pump, and switch changes. Because several of the systems are remnants of the spent fuel reprocessing system, they may be unnecessarily complicated with respect to the present operation. A system reconfiguration and re-numbering could greatly simplify the system. In conjunction with the reconfiguration, it should be possible to remove valves, gauges, and connections which are not required. Such actions would reduce the possibility of error and improve overall operations. The simpler system would reduce training requirements and could eliminate hazards.

4.3.4 Correspondence Between Hazard and Other Variables

The correlation between ratings of Hazard and Error, although significant, was low and in the direction opposite to expectation. Generally, the more hazardous the task, the less likely errors are to be made by certified operations technicians. A possible explanation for this apparent contradiction is that operating technicians, realizing the hazard potential, spend more time on the task, and thereby make fewer errors. None of the tasks rated high in Hazard were rated as being high in Error. Considering the nature of the ISFSI operation, one might conclude that the system was designed intentionally to prevent errors in hazardous tasks. Operations technicians are encouraged to be more careful when a hazard is perceived. The correlation between Hazard and Error-New-Person was also low but it was in the expected direction. The more hazardous the task, the more likely it was to be rated as error-likely for new personnel. It might be postulated that novice personnel do not fully appreciate the hazards. Twelve tasks rated as involving the most hazard for operations technicians are also rated as error-likely for novice personnel. These tasks are:

- Operate rail car brakes, chocks, and couplings
- Lift and move cask to basin
- Remove cask from basin with crane
- Unbolt and remove cask head
- Install cask head
- Remove fuel from basket
- Place fuel in basket
- Disengage fuel grapple manually
- Operate crane to place cask in rail car
- Move rail car with ISCO
- Adjust LAW Evaporator valves and pumps
- Prepare extended Basin Cooler shutdown, add demineralized water with chemical dolly

Except for the first task (Operate rail car brakes, chocks, and couplings), all of these tasks are included on the Difficult/Error-New-Person list discussed above. Obviously, the experienced personnel who completed the Task Inventory linked difficulty and hazards in analyzing tasks performed by novice personnel.

4.3.5 Correspondence Between Error and Error-New-Person

Error and Error-New-Person are moderately correlated. Generally, the more likely operations technicians are to make an error on a given task, the more likely that task is rated an error-prone for new uncertified personnel.

Nine tasks are rated as likely to produce errors for operating technicians and as being even more likely to produce errors for novice personnel. These include:

- Complete paperwork, checklists, logs for Fuel Removal and Storage

- Record readings in Basin Filter Log
- Adjust Demineralizer valves
- Initiate scheduled Control Room tests
- Respond to Control Room alarms
- Complete Control Room logs and other forms
- Check Utility Boiler system
- Check Demineralizer system
- Check the Compressor Room and indicators

Three of the nine tasks involve paperwork. Apparently, novice personnel are unlikely to complete the paperwork without errors, and they do not improve very much with practice. Training is unlikely to reduce errors in this area. Operations of the demineralizer and utility boiler systems call for tasks involving systems checks which are error-likely. When system checking is not understood, practice does not improve performance. These areas should be subject to improved performance with training. It is possible that control room tests and alarms tasks can be improved by changing the control room layout from its current fuel reprocessing configuration to one more compatible with fuel storage. The compressor room may have similar problems. These tasks should be analyzed in greater detail to identify the subtasks and steps which produce error behavior.

One task (Verify vacuum head below water) is rated as error-likely for operations technicians but not more likely for novice personnel to make errors. Errors during this task do not improve with experience. Training will not be effective in reducing errors on this task. The task must be modified if errors are to be reduced. In order to determine the nature of the required modification, the task must be analyzed in greater detail.

Three tasks, while not identified as error-likely, were selected as possible sources of error for novice personnel. These tasks may present minor problems, and should be identified as lower priority than other tasks which are error-likely. The problem is one of training new personnel in psychomotor skills, and in providing practice in these operations. They are: moving the cask to and from the basin and manually disengaging the fuel grapple. They have been discussed under other paragraphs.

5. RECOMMENDATIONS

The operations technicians play a vital role in the operation of the ISFSI. This is apparent from the analyses of the tasks and activities performed by the operations technicians. They constantly monitor crucial systems, work closely with hazardous substances, and respond quickly and appropriately to abnormal and emergency conditions. The performance of operations technicians directly affects the safe operation of the ISFSI and the safety of plant personnel.

More importantly, the public perception of the reliability of the personnel directly influences attitudes towards the ISFSI. The entire operation must not only be safe, it must appear to be safe. The loss of public confidence in the safety of any nuclear facility, or in the competence of the personnel working there, can adversely affect the entire industry.

Given the importance of the job, it follows that individuals assigned to this job must demonstrate that they possess the knowledge, skills, and abilities necessary to perform as operations technicians. This is accomplished through a certification program which is designed to ensure that individuals meet the minimum qualifications for job performance.

It must be emphasized that certification is not simply demonstrating qualifications on a single certification test. The certification test should be a major milestone in a larger program starting with personnel selection and including initial training and practice prior to certification. It would also include proficiency training to assure compliance with performance standards and update technicians on new procedures and techniques.

The recommendations presented below are based on the results of the task and activities analyses, the analyses of supervisor's surveys and the review of the training and certification program in effect at the Morris ISFSI. Recommendations are grouped according to the concept of a comprehensive certification program which includes personnel selection, training, practice, testing and certification, and recertification.

5.1 Personnel Selection

The selection of personnel for the job of operations technicians is the starting point of the certification process. Personnel selection involves considerable expense and always involves risk. There is no technique to guarantee that the applicant will successfully complete training or perform satisfactorily on the job. A thorough understanding of the job tasks and the skills and knowledges required by operations technicians enables a manager to make better selection decisions. Applicants possessing more of the skills and knowledges required of a job should perform better in that job.

The task analyses and interview data from supervisors and operations technicians provide the kind of job task information which can be used to improve the chances of making sound personnel selection decisions.

Based on interview data and the task data, it is possible to recommend minimum levels of education and experience for applicants for the job of operations technician. A high school education or GED certification is recommended. The job does not require an education level beyond high school. Applicants with higher education credentials may not be sufficiently challenged by the tasks and may experience boredom or overconfidence. Recommended high school courses include mathematics up to and including algebra and basic science. Courses in chemistry and physics would be desirable.

Based on the survey data, we found that supervisors felt that previous job experience was not critical. The general consensus was that no nuclear-related experience was required and that this could possibly be a first job. Six jobs which represented a cross section of related jobs were selected by the researchers. Supervisors were asked to make pair-wise choices among these six jobs, selecting the type of previous job experience that would be preferred in selecting a new employee. The results of these questions are presented in Table 9 (duplicated below).

Table 9. Rank Order of Six Selected Types of Job Experience for Operations Technicians

Job	Ranking	Times Selected
Process Controller	1	40
Crane Operator	2	37
Nuclear Submarine Engine Operator	3	35
Nuclear Power Control Room Operator	4	27
Heavy Equipment Operator	5	20
Warehouse Experience	6	11

5.2 Training

In July 1981, NUREG 0709 reported on the results of a safety evaluation of the ISFSI at Morris, Illinois. In concluding that the operator training and certification plan meets the requirements of 10 CFR 72.92, the report did little more than acknowledge that there was an established training program which included some proficiency testing and that there was an established certification procedure. In a rather brief description of the comprehensive training program established by GE, it is noted that the certification program is inspected by the NRC Office of Inspection and Enforcement as to the quality of the examination and the reasonableness of the grades required for passing.

During this study, the training program for operations technicians was reviewed in detail (see section 2.5). Slides and videotapes were reviewed, lesson plans were read, and the overall training plan was studied. In discussions with Morris personnel, the method of developing training materials was reviewed. Members of the research team who visited the facility actually received the indoctrination training for safety and security. It is our conclusion that the academic training program now in existence is well conceived and carried out. The two-year cycle appears to be adequate as long as special training is conducted on changes in systems or regulations as they occur. Furthermore, it is our recommendation that companies that operate ISFSIs continue to design and conduct their own training programs. The approaches, time spent, and media used can be expected to vary according to operator preferences and the skills available among employees.

Should an ISFSI operator request advice on program contents, it is recommended that NRC provide topical outlines based upon material submitted with applications for licensing under 10 CFR 72.92. Proposed training programs may be evaluated according to their content and as to whether or not they are written on a high school reading level. The training program should be evaluated for adequacy of content before evaluating it for adequacy of coverage of the included topics. A reasonable program should include training on:

- Overview, plant function and layout
- Industrial safety, respiratory protection, OSHA
- Radiation theory, monitoring, and safety
- Security
- Cask handling and turnaround
- Fuel handling and accountability
- Basin operations, cooling, and filtering
- Compliance testing, inspections, and checks
- Waste handling and storage
- Emergency plans and actions
- Relevant installation systems operation
- Basic mathematics, chemistry, and physics
- Utilities (if applicable)

Once the operations technicians have completed the training, the program may be reevaluated with respect to course content and adequacy of training in terms of their performance on certification examinations and tests. Again, it is our recommendation that the company that operates the ISFSI be fully responsible for the content and conduct of training so long as the technicians continue to obtain satisfactory grades on examinations that are standard with respect to the ISFSI industry. The operator should retain control of training time, sequence, and schedules in order to manage the installation resources efficiently. The operator should also retain full responsibility for plant specific utility training and certification. By evaluating the results of the program rather than the program itself, the NRC should be able to exercise sufficient control of the process to guarantee safety without getting directly involved in the management of individual operations by the independent corporations.

5.2.1 Practice

While the academic portion of training at Morris is generally well thought out by the engineers and managers who are responsible for it, training in psychomotor skills does not benefit from the same expertise. This may be a result of engineers' being very familiar with mental training because of their own experiences. Training in physical skills is usually left to athletic coaches. It is well understood that one must practice flying to be a pilot and practice driving to be a taxicab driver. It is less well understood that such psychomotor tasks as crane operation, fuel bundle latching, and basket loading also require practice.

Without an a priori understanding of this need, accompanied by a realization that it may not be prudent to practice the handling of hazardous materials, it is unlikely that anyone will develop simulated systems to be used during initial training or as warm-up tools following extended periods of inactivity. Nevertheless, this is exactly what is required. It may be contended that the "walk-around" examination currently in use does provide the opportunity for a training supervisor or examiner to verify an operations technician's ability to perform a task. This is only partially true. Some equipment is operated. Some operations are only explained. In recommending actual practice, the objective is actually to perform all of the psychomotor tasks and demonstrate the physical skills that are required to do the job safely and effectively.

It is recommended that simulated BWR and PWR fuel bundles, with mass, center of gravity, and moments of inertia the same as actual bundles, be developed for use in initial checkout and practice sessions following extended inactivity. It is further recommended that a simulated IF-300 cask be maintained at the ISFSI for use during practice periods. It is important to note that, while practice is strongly recommended for initial checkout and considered to be valuable for use by certified operations technicians who have not had the opportunity to practice psychomotor skills for periods of six months or longer, practice is not considered appropriate for personnel who have the opportunity to perform actual tasks on a regular basis, unless a problem in a psychomotor skill is observed.

The use of simulated fuel bundles for certification and re-certification testing is described below. It may be possible to use simulated fuel bundles to resolve material handling problems, although such a recommendation extends beyond the scope of this study. Through the use of inert fuel bundles, operations technicians should be able to practice abnormal and emergency tasks. Because some emergency conditions, such as dropping a fuel bundle and having to re-grapple it, are extremely unlikely, practice with an inert bundle may prove valuable only on rare occasions. Nevertheless, it is recommended that training programs be developed for both normal and abnormal conditions, using inert bundles to practice the psychomotor skills involved. Conduct of practice, like other training, should remain as the companies' responsibility.

5.2.2 Testing and Certification

5.2.2.1 Testing

Following a careful review of the Morris ISFSI operation, including the training and certification, we have concluded that although the training is conducted on a professional level and the experience level of the operations technicians is exceptionally high, the written testing conducted at this facility does not adequately measure whether the operations technicians have the knowledge required to perform their assigned tasks. The tests stress theoretical and academic work rather than practical knowledge. The tests we examined do not evaluate whether or not the operations technicians can do their job safely and effectively. Some questions were judged exceptionally easy, others were too hard. Many were inappropriate, that is, not related to the tasks to be performed. In general, the testing process took too long, especially considering the objectives and the personnel involved. It is our professional opinion that this situation is not unique to the Morris Operation. Rather, it will prove to be typical of any testing program developed by personnel who lack training and experience in the science of tests and measurements.

To be sure, the tests we reviewed are related to the tasks performed by operations technicians. They are fairly conceived and fairly administered. Unfortunately, they lack validity: they do not measure what they are supposed to measure. They do not measure the ability to perform a group of tasks nor do they measure the specific elements of knowledge required to be able to perform a task. They do measure what all tests measure, the subject's ability to take a test. They measure learning of a set of academic principles, and are extensive enough and difficult enough to create a situation in which not all subjects passed all tests. However, it is possible that a highly qualified operations technician could fail them (some did). It is also likely that an engineer, with only an elementary knowledge of fuel handling and no psychomotor skills, could pass them.

The tests currently in use at the Morris ISFSI were developed to test a general body of knowledge. They may be entirely appropriate for this purpose. They should have been developed to measure whether operations technicians know the items required to perform their job. They do not measure this specific knowledge. Tests for certification of operations technicians should measure the knowledge required to perform the job, not intelligence or ability to memorize things or academic powers. It is therefore important that the test questions be written at a high school level. This is especially important because the reading level of a high school graduate is seldom much higher than an "eighth grade" level. It is recommended that actual questions should be developed by individuals who have been trained in human measurement and have accumulated sufficient expertise to develop not only the questions but the analytic method to interpret the test results. Such individuals should be familiar with ISFSI operations, although not experts in this area.

It is recommended that an NRC test data bank be developed in a format similar to the Federal Aviation Administration (FAA) private pilots' written examination (Trollip and Anderson, 1981). The questions should be based upon material provided by the ISFSI operators and the NRC, and should be updated periodically.

The decision to recommend an NRC test data bank was made after careful consideration of the following points:

1. The current testing program is inappropriate. Although it has evolved over ten years of operational experience, it does not in all cases measure pertinent knowledge.

2. The high caliber of professional operations technicians employed at the Morris ISFSI probably do not have to be tested at all. Their level of expertise is a result of extensive training and is totally independent of testing.

3. There is no way of guaranteeing that personnel at other ISFSIs will be as highly qualified as those at Morris, nor is there any guarantee that the Morris ISFSI will be able to maintain its level of expertise in the future.

4. It is not economically feasible for each ISFSI to employ an expert in tests and measurement full time. A part time expert for each ISFSI would not have sufficient understanding of the tasks to develop adequate questions. The variability of tests among the ISFSIs would make evaluation of actual proficiency difficult.

5. Establishment of a common testing organization, jointly supported by all ISFSIs, merely creates an intermediate organization which must eventually be evaluated by the NRC or an NRC contractor.

6. By controlling the data bank, NRC retains its ability to ensure quality and performs a service for the individual ISFSIs by improving questions submitted by each ISFSI and reporting on test results to all ISFSIs.

7. The ISFSIs retain basic control over the details of the written test and retain certification authority.

We recommend a four-step proficiency test development program that includes an analysis of test questions to improve test reliability and validity with successive test administrations. Developed by a Tests and Measurement expert with heavy input from ISFSI training supervisors, the program would be conducted as shown in Figure 7.

Tied tightly to the task analyses contained in this study, with more detailed analyses of the subtasks, the test should measure only the knowledge that is required to do the job. There must be additional

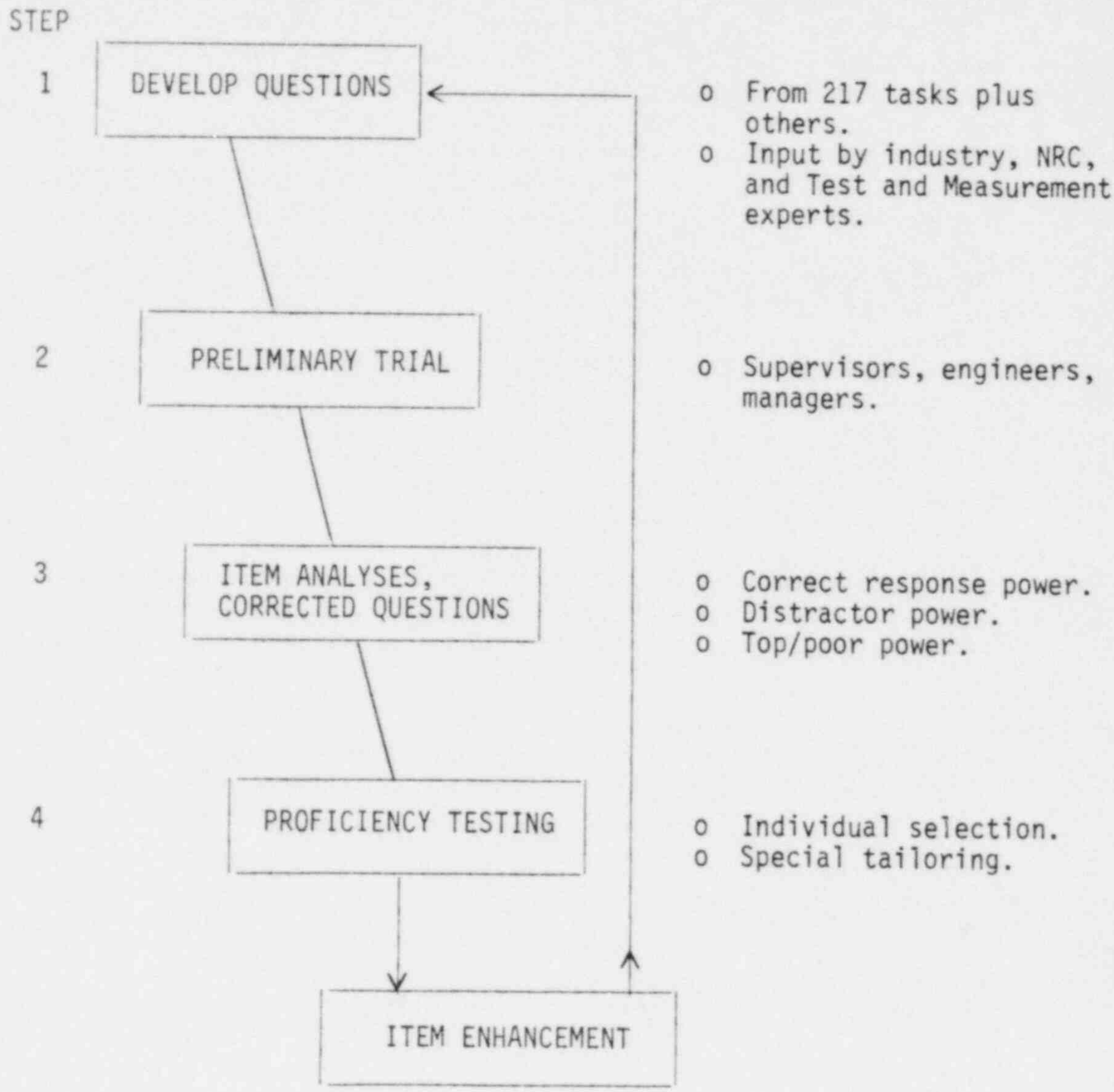

Figure 7. Development of ISFSI Proficiency Tests

input from the ISFSI training supervisors to develop valid tests. The following approach should ensure the development of up-to-date tests that measure the knowledge required to accomplish the tasks.

Step 1: Develop Questions

ISFSI training supervisors, Test and Measurement experts, and NRC personnel would independently develop one question for each selected task as shown in Figure 8. This single archive of questions would be used to develop the proficiency tests for use in Step 4. The questions would be enhanced by Test and Measurements experts to ensure that they actually tested knowledge pertinent to task accomplishment.

27. A fuel basket is held in the basin by

(a) a supporting grid
(b) water pressure
(c) nuclear (atomic) weight
(d) the overhead crane

Figure 8. Sample Question

Step 2: Preliminary Trial

In order to evaluate the questions, supervisors, engineers, and managers at the several ISFSIs would be administered the test questions. Comments on ambiguous or misleading questions would be solicited at this time. These examinations would be scored by recording the number of persons who selected each possible answer. In a multiple choice question, one answer is correct and the other answers are called distractors.

Step 3: Item Analyses, Correct Responses

The responses will be tabulated as shown in Figure 9. Typically, responses will vary for different groups because of experience levels and current knowledge of each task. In the example in Figure 9, managers were unsure of all of the choices. Distractors (c) and (d) did not adequately "pull" the engineers. It appears that the supervisors were less acquainted with the details of the tasks since (c) answer was believed to be correct and (d) was obviously false.

The objective is to develop correct responses and distractors that will differentiate between top level and poor performers. Additionally, for each group and question, group performance baselines are established to which individual performance can be related. For example, a supervisor answering (b) on question number 27 (Figure 9) has responded below the 70th percentile. Training plans and remedies for wrong answers can be related to each question's responses. Because the supervisor background is closer to the operations technician, item analysis for this group is of major interest in developing correct and incorrect responses.

Item analysis, question 27: Percent of group selecting each answer

Answers	Managers	Engineers	Supervisors
(a) Correct	23	75	30
(b) Distractor	27	25	10
(c) Distractor	25	0	60
(d) Distractor	25	0	0

Figure 9. Sample Question Analysis

Step 4: Proficiency Testing

Based on the item analyses, surviving questions would be assigned (and tailored if required) for the proficiency testing. For each task to be tested, there should be several test questions. When the tests are administered to the operations technicians, each person will be required to answer only one specific question. Tailoring is accomplished by having the original developers of the tests (Step 1) examine the item analysis and select wrong answers that are more acceptable. When no one misses a question, a replacement should be considered. To establish test validity, it could be administered to non-certified personnel, and responses compared to the group of certified operations technicians.

Item enhancement should occur periodically to reflect changed procedures and eliminate non-pulling responses that only occupy everyone's time. Until one item enhancement loop is performed and the Step 1 products are adjusted, the proficiency tests will not be tuned for adequate use. When differences are noted between different ISFSIs, the training programs should be analyzed for possible improvements.

This four-step program using ISFSI personnel to generate and improve upon an archive questions that can be administered on the job and in the classroom will assure an operationally-oriented, dynamic test program focused at the task level, yet controlled by Test and Measurement experts who are independent of the operation and of the inspection processes.

It is recommended that the tests be administered biennially by the ISFSI training supervisor and returned to the NRC controlling agency for grading. After grading and analysis of the results, individual scores and an analysis of the facility training program should be provided to the ISFSI. When less than satisfactory performance by individuals or groups is noted, or when weaknesses in an area of training are noted, recommendations for correction should be included.

When problem areas are uncovered, information may be disseminated to other ISFSIs so that problems could be resolved more quickly. Security and training newsletters published by NRC are acceptable means of informing ISFSI operators of potential problem areas. It is further recommended that the results of biennial testing be used as a guideline for conducting NRC facility inspections so that potential problem areas could be given closer attention.

Because of differences in the design of ISFSIs and in the tasks assigned to the operations technicians by different operators, the written examination should have a general section (common to all ISFSIs) and a special section which pertains only to their installation. A third group of test questions may be added by the operator to cover areas that are unique to that organization.

The principles are:

1. Areas to be tested (duties, theories, procedures) are the business of the ISFSI, subject to guidance by NRC.

2. The job of measuring human performance and ability is the business of psychologists, educators, and human factors specialists.

5.2.2.2 Certification

Current certification procedures at the Morris ISFSI include not only a written examination, such as that discussed above, but also oral examinations, "walk-throughs," and a periodic supervisor evaluation of employee safety performance. Participation in training programs, periodic safety meetings and the daily operations of the facility are all a part of certification, informally if not formally. Judging by the training and certification program established at the Morris ISFSI, and a limited review of the Barnwell Nuclear Fuel Plant program, the industry has done very well in developing these programs. It is strongly recommended that this procedure be retained. Certification should remain in the hands of the ISFSI operator. The NRC is not in a position to observe daily performance of the operations technicians. It would not be efficient for the NRC to conduct quarterly safety and security training for each ISFSI. The NRC can conduct spot checks and walk-through examinations for a limited sample of operations technicians. With inputs from industry, the NRC can develop valid written examinations and control their administration. It can monitor and evaluate 100% of the test scores. By monitoring the results of standardized, controlled, written examinations and by conducting random walk-through evaluations, the NRC should be able to ensure that the ISFSIs conduct adequate training programs that guarantee the safety of the public.

While it is understood that actual task performance is observed by supervisors during initial training, actual task performance has not formally been included in a certification examination. It is recommended that evaluation of operations technicians during "walk-throughs" be expanded to require satisfactory performance of all tasks (normal, abnormal, and emergency) prior to initial certification. This performance may be actual or simulated as discussed in section 5.2.1 above. The key point to be made is that the examiner is <u>not</u> the OJT trainer, normally an operations supervisor, but a training supervisor.

5.2.2.3 Recertification

Once an operations technician has received the initial certification, it is only necessary to retain the acquired skills and knowledge. For example, once an individual has completed a driver's training course, complete with academic instruction and practice driving, and has passed the written and driving examinations, that person does not return to school when it is renewal time. The same situation exists for pilots. Although there are periodic medical, academic, and flight proficiency examinations, they do not repeat a 13-month training process every time it is necessary to review their certifications. It should be noted that some study may be required before annual retesting.

When certified operators repeat the entire training course at periodic intervals, it is the course which establishes qualifications and testing becomes superfluous. Certainly, a review of the material is required to ensure a satisfactory performance record. In order to establish minimum training requirements, it is recommended that a "Pre-Test" be given to certified employees. Those who received excellent scores and have special instructing abilities may be used as instructors. Other technicians would receive refresher training as needed to pass the examinations.

There is a reason to be cautious about this approach. In transferring the validation of training from the training course to the tests, it is absolutely essential to have test instruments that are both valid and reliable. The saving in time spent re-hashing old academic courses must be spent in developing adequate tests. The current program at the Morris ISFSI, which is effective although time-consuming, evolved because, given the level of test and measurement expertise available in an ISFSI, a comprehensive academic program was the only way to ensure an adequately trained operations technician.

A pre-test, followed by refresher training based upon the establishment of required learning objectives, followed in turn by the certifying examination is the recommended procedure for academic recertification.

The pre-test may be developed and administered by the ISFSI training supervisor, using old examinations and old test questions. The certifying examination should be the same as is used for initial certification (see section 5.2.1 above), and it should be graded and analyzed as previously discussed.

As with the initial certification, a large portion of the decision to recertify will be based on supervisor evaluations of daily performance. Participation in emergency brigade training and safety/security training will also be considered. It is recommended that only 20% of the performance tasks be formally evaluated every two years, because these tasks involve motor skills which have very high retention rates. This is especially true when these tasks are being performed on a regular basis. This implies that, in ten years, all tasks will have been formally evaluated for each certified employee. This is in contrast to the 100 percent performance evaluation required for initial certification. As with initial certification, some tasks may be simulated.

5.3 Summary

This report has presented a description of the Morris ISFSI and the operations involved in storing spent nuclear fuel. It describes the review of documents and discussions with supervisors, engineers, and managers that led to the selection of 16 activities and 217 tasks for analysis. These activities and tasks were selected primarily to represent tasks that are typical of spent fuel storage operations. Some activities were included to represent abnormal and emergency operations. Operational Sequence Diagrams were prepared to ensure that the tasks that made up each activity were understood. The Task Inventory method of task analysis was selected as a tool for obtaining information from subject matter experts. It was developed for use in task analysis when actual task performance could not be observed. The results of the Task Inventory provided data on time spent on tasks, frequency of task performance, task hazards, task difficulty, and likelihood of errors.

From the results of the Task Inventory, there emerged a list of 63 tasks, approximately 30% of the tasks selected for analysis, which merit additional attention. For a task to be included on this list, it had to meet the criterion of being rated above average in at least one of the following areas: Difficulty, Hazard, and error-likelihood. Twenty-five of the tasks were judged to be both difficult and hazardous. One was judged to be both difficult and error-likely. Ten tasks were rated difficult, seven were rated hazardous, and twenty were identified as error-likely. The 63 tasks are presented in Table 28.

This information was analyzed along with data on frequency and time spent in order to make recommendations on training and certification procedures. The existing training program at the Morris ISFSI was analyzed in detail to obtain baseline data on the training of operations technicians. Training documents were studied, actual training materials were reviewed, and training and testing records were examined to determine what was being done. For comparison, material from the training

Table 28. Tasks that Require Additional Training Time

Task	Difficulty	Hazard	Error
Dismantle IF-300 to access cask for unloading	X	X	
Operate crane and trunnion for cask unloading	X	X	
Lift and move cask to basin	X	X	
Remove cask from basin with crane	X	X	
Unbolt and remove cask head	X	X	
Install cask head	X	X	
Decontaminate head, cask, and trunnion	X	X	
Remove fuel from basket	X	X	
Place fuel in basket for storage	X	X	
Disengage fuel grapple manually during fuel removal and storage	X	X	
Attach hydrostatic pump, pressurize, and disconnect during testing	X	X	
Operate crane to place cask on rail car for off-site shipment	X	X	
Connect cask to rail car	X	X	
Decontaminate cask for off-site shipment	X	X	
Replace box covers and ducts during off-site shipment preparation	X	X	
Move rail car with ISCO	X	X	
Remove sweeper head and attach cleaning tool	X	X	
Clean cask interior	X	X	
Clean basin floor with cleaning tool	X	X	
Adjust valves and pumps (LAW system)	X	X	

Table 28 (continued)

Task	Difficulty	Hazard	Error
Monitor operation visually, check for leaks (LAW system)	X	X	
Sample density of the LAW system	X	X	
Prepare extended shutdown, add demineralized water with chemical dolly	X	X	
Cover coolers with tarps and fan openings with plastic	X	X	
Light space heaters to heat area (Basin Coolers)	X	X	
Calculate surface area, current, and cathodes for electrodecontamination	X		X
Operate ISCO to move rail car for cask unloading	X		
Survey radiation of car, cask, and head	X		
Operate crane for basket moving	X		
Identify fuel bundles	X		
Prime pump (Basin Coolers)	X		
Determine action required for basin water compliance test	X		
Plot data on analysis results of basin water compliance test	X		
Verify all valves and switches are in the correct position (Basin Filter)	X		
Configure valve and pump in accordance with checklist for the LAW system)	X		
Monitor the Basin Coolers area for heating	X		
Operate rail car brakes, chocks, and couplings		X	

Table 28 (continued)

Task	Difficulty	Hazard	Error
Move the load from location to location using the crane		X	
Remove the pump discharge pressure indicator on the Basin Cooler system		X	
Flush cask during failed fuel operation		X	
Obtain sample coolant from a failed fuel cask		X	
Fill cask with water (Failed fuel cask handling)		X	
Take sample for Cesium analysis (Failed fuel cask handling)		X	
Complete IF-300 checklist for cask unloading			X
Complete paperwork, checklists, and logs for fuel removal and storage			X
Complete check sheets and paperwork for off-site shipment preparation			X
Log and initial data on sample and results for basin water analyses			X
Verify vacuum head is below water			X
Record readings in basin filter log			X
Adjust valves on demineralizer			X
Complete paperwork and checklists for the demineralizer			X
Monitor the LAW system from the Control Room and log data every 2 hours			X
Initiate scheduled tests from the Control Room			X
Perform rounds checks in the Control Room			X

Table 28 (continued)

Task	Difficulty	Hazard	Error
Respond to alarms in the Control Room			X
Complete logs and other forms in the Control Room			X
Inspect the Utility Building and indicators			X
Check the Utility Boiler system			X
Check the Demineralizer system			X
Inspect the Compressor Room and indicators			X
Inspect the Ventilation Supply Room and indicators			X
Perform vehicle checks			X
Complete Shift Rounds Data Sheet			X

program at the Barnwell Nuclear Fuel Plant was reviewed. In general, the existing training program at the Morris ISFSI was found to be satisfactory. The certified operations technicians are highly qualified and fully competent in the handling and storage of spent nuclear fuel.

Considering this conclusion, recommendations concerning improvements in the training program should be accepted with caution. The program is basically good without changes. Presented in greater detail in Section 4, the recommendations include the use of inert fuel bundles and simulators to provide hands-on training in psychomotor skills. There are recommendations to simplify procedures, streamline designs of controls and displays, and reassign some tasks.

It was concluded that a person needed only a high school education and normal psychomotor skills to qualify as an operations technician. Far more important than knowledge or dexterity are the character traits of reliability, carefulness, and dependability. In the process of earning certification, novice personnel acquire skills in crane operations, process control, rail car operations, radiation monitoring, and log keeping. The job requires familiarity with a number of utility systems and processes such as demineralization and electrodecontamination.

While the existing training program was judged to be effective in preparing operations technicians to perform their tasks safely and efficiently, the certification examinations presently in use were judged inappropriate. A valid certification program requires observation and evaluation of actual performance. The certification program at the Morris ISFSI is especially strong in this area. A minor recommendation is that the "walk-through" examination be expanded to require more actual operation of equipment. In some cases, the use of simulated equipment is recommended.

The written examinations used for certification were designed to measure general intelligence level and general academic background. It is recommended that examinations be developed to measure specific knowledge required to perform the tasks. It is further recommended that these tests be standardized and maintained at NRC. In this way, NRC will have the ability to measure the required knowledge level of all ISFSI operations technicians and the ability to evaluate a random sampling of technicians during on-site "walk-through" examinations. This combination permits the individual ISFSIs to control the certification of their employees, yet provides the NRC with a reliable procedure to verify the presence or absence of the skills and the knowledge necessary to operate an ISFSI safely.

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APPENDIX A

SUPERVISOR QUESTIONNAIRE AND TASK INVENTORY FORM

This appendix includes the Supervisor Questionnaire and the Task Inventory Form. Both of the forms were self-administered to the certified personnel. Oral instructions (instruction text precedes the Supervisor Questionnaire) were given for the managerial/supervisory personnel which involved the purpose of the questionnaire and the mechanics for answering the questions. The scales used for responding to the qualifications for new and certified personnel on the Supervisors Questionnaire are listed at the end of that form. Oral instructions were also given for the Task Inventory to the certified personnel. These instructions were read from the "Instructions" sheet which precedes the Task Inventory. Further written instructions are included within the Task Inventory. The scales for the variables of interest in the Task Inventory are listed at the end of that form.

SUPERVISOR QUESTIONNAIRE INSTRUCTIONS

The questionnaire which you are to complete will help us learn more about the operations technician job. You are to respond to all questions (except the background information) on your perception of Morris Operation activities and in particular requirements for the operations technicians job activities.

The scales to be used when responding to the qualifications for an operations technician are attached to the back of the questionnaire. To answer the rest of the questions either fill in the blanks where appropriate or in the case of paired job selections, circle your choice. Are there any questions?

SUPERVISOR QUESTIONNAIRE WORKSHEET

Name ____________________ Education ____________________

Position ____________________

Years experience in this position ______

Years experience in nuclear industry ____

List Certifications ____________________

List other positions in the nuclear industry ____________________

Consider the qualifications of an ISFSI operator. In each factor listed, give the degree of that factor required.

	For a new employee (Trainee) Minimum Requirement	For a certified operator Fully Qualified
EXPERIENCE	____________	____________
SKILL (DEXTERITY)	____________	____________
KNOWLEDGE (EDUCATION)	____________	____________
MENTAL ABILITY (INTELLIGENCE)	____________	____________
EFFORT (PHYSICAL)	____________	____________
INITIATIVE	____________	____________
RESPONSIBILITY FOR LOSS (ERRORS)	____________	____________
RESPONSIBILITY FOR OTHERS	____________	____________
WORK CONDITIONS (HEALTH)	____________	____________
WORK SAFETY (ACCIDENTS)	____________	____________

Given a new employee, with minimum degrees as listed above:

How long before that employee can be fully certified? ________

How much training must be given in that time? ________

Once an ISFSI operator is certified, what percentage of time is spent in continuation training, practice and studying during working hours? ________

Given a choice, would you hire a heavy equipment operator or a nuclear power control room operator?

What percentage of time does a certified ISFSI operator spend doing cask operations? ________

Given a choice, would you hire a new employee with warehouse experience or nuclear submarine engine experience?

Given a choice, would you hire a crane operator or a worker with experience as a process controller?

What percentage of time does an ISFSI operator spend performing inspections and walk-through checks? ________

How many cask deliveries do you anticipate during a "normal" year (average of next 10 years)? ________

From cask arrival to storage of spent fuel, how many hours are spent in receiving and storage of the baskets (clock hours)? Assume 4-person shift. ________

Given a choice, would you hire a nuclear power control room operator or a worker with nuclear submarine engine room experience?

Given a choice, would you hire a worker with experience in process control experience or warehouse experience?

What percentage of time does a certified ISFSI operator spend doing control room operations? ________

Given a choice, would you hire a worker with heavy equipment experience or a crane operator?

What percentage of time does a certified ISFSI operator spend doing routine housekeeping of the facility and equipment? ________

What percentage of time does a certified ISFSI operator spend receiving and storing spent fuel (normal situation)? ________

Given a choice, would you hire
a worker with warehouse experience or a heavy equipment operator?

What percentage of time does a certified ISFSI operator spend in waste handling? ________

Given a choice, would you hire
a crane operator or a nuclear power control room operator?

Given a choice, would you hire
a nuclear submarine engine operator or a process controller?

Approximately what percentage of time does an ISFSI operator spend waiting for jobs and on breaks during the

day shift? ________

evening shift? ________

midnight shift? ________

Given a choice, would you hire
a process controller or a heavy equipment operator?

What percentage of time does a certified ISFSI operator spend with demineralizer operations? ________

Given a choice, would you hire
a worker with warehouse experience or a nuclear power control room operator?

Given a choice, would you hire
a worker with nuclear submarine engine experience or a crane operator?

What percentage of time does a certified ISFSI operator spend doing basin operations? ________

What 5 jobs (or tasks) best describe what a certified ISFSI operator does?

____

____

____

____

____

What are the 5 most hazardous jobs (or tasks) performed by certified ISFSI operators (must be done without error)? ______

______

______

______

______

What 5 ISFSI tasks require the most training and practice? ______

______

______

______

______

What percentage of time does a certified ISFSI operator spend in utility operations? ______

Given a choice, would you hire a worker with warehouse experience or a crane operator?

Given a choice, would you hire a nuclear submarine engine operator or a heavy equipment operator?

What percentage of time does a certified ISFSI operator spend in dealing with abnormal operations (emergencies)? ______

Given a choice, would you hire a nuclear power control room operator or a process controller?

What work experience (other than ISFSI operator) would be most helpful for a new employee?

______

______

______

______

______

SUPERVISOR ANALYSIS

(Degrees for Each Job Factor)

EXPERIENCE:

1. None. First job. Less than one year.
2. Not related. Shoe salesman; taxi driver; schoolteacher.
3. One year on similar job. Nuclear operations; heavy equipment ops; warehousing.
4. One year on this job.
5. Over two years on similar job.
6. Over two years on this job.
7. Over three years experience (at least one in same).

SKILL:

1. None required. Ditch digging, sweeping floor.
2. Novice. Capable, but not yet trained.
3. Apprentice. Welders helper, setup man, in-training, plumber's helper.
4. Semi-skilled. Assembly line work, painter's helper.
5. Some skills. Painter, mechanic, stockroom, maintenance.
6. Skilled. Decorator, welder, lathe operator, truck driver, master plumber. Certified.
7. High degree of skill. Artist, silver filagree, gem cutter, fine needle point, pilot, Indy driver.

KNOWLEDGE:

1. Not able to read.
2. Less than 8th grade education. Able to read and follow simple instructions.
3. 8 to 11th grade. Able to read and follow instructions.
4. High school graduate. Able to read and explain instructions.
5. Some college work. Able to read and follow technical instructions.
6. Associate degree. Able to read and follow complex technical instructions.
7. Bachelor's degree. Able to read and explain complex technical instructions.

MENTAL ABILITY:

1. Simple mental tasks, repeated. Follows instructions.
2. Decides which instruction to follow, procedures are standardized.
3. Selects from standard procedures, occasionally employs novel approach.
4. Understands principles and applies them in solving a variety of problems.
5. Uses policy and procedural guides to develop principles and new methods.
6. Works independently; difficult problems solvable using known methods.
7. Makes decisions for which there is no precedent; complex changing problems.

PHYSICAL EFFORT:

1. Job involves little or no physical work (walk to desk or chair).
2. Sitting posture for work, light assembly, soldering.
3. Standing required. Bank teller, grocery cashier, ticket taker, teacher.
4. Walking, standing, some lifting. Shelf stocker, welder, crane operator.
5. Some lifting, light loads. Assembly line.
6. Some lifting, moderate loads. Welder's helper, hod carrier, ditch digger.
7. Considerable physical strength/endurance required. Heavy Lifting, running, NFL air hammer operator.

INITIATIVE:

1. None. If left alone, falls asleep.
2. Must be told what to do. Knows how. Needs reminders.
3. Knows what to do. Does it without supervision.
4. Does own job. Able to motivate others to do job.
5. Finds better ways to do job, motivates others.
6. Finds new things for self and others to do, more than just the job.
7. Discovers new areas in which new things may be done, an innovator.

RESPONSIBILITY FOR LOSS:

1. Makes so many errors, others expect them and allow for them.
2. Not responsible, but expected to do job, will be chewed out for loss.
3. Responsible for loss, may be suspended or retrained after a loss.
4. Will be held financially responsible for own errors.
5. Will be fired if directly responsible for loss.
6. Will be fired for negligent loss (indirectly responsible).
7. Bonded against loss.

RESPONSIBILITY FOR OTHERS:

1. Not responsible for own actions.
2. Not responsible for others.
3. Responsible for checking work of others (read checklist).
4. Responsible for work of non-certified technician.
5. Responsible for inspecting work of others.
6. Responsible for actions of others.
7. Responsible for training/certifying others.

CONDITIONS: (Health)

1. There are no health hazards in the working environment.
2. Even continuous exposure to health hazards will have little or no effect on health.
3. Continuous exposure may result in some physical impairment.
4. Moderate hazards require action by employuee to avoid.
5. If careless, may be lightly exposed to serious hazards.
6. If not careful, may be exposed to hazardous conditions.
7. Exposed against will to light (welder) sound (aircraft engine) radiation or chemicals that will cause permanent injury or death.

ACCIDENT HAZARDS:

1. There is no history of personnel injury on this job.
2. No accident hazards of serious nature - office.
3. Slow work pace, deliberate tasks, few hazards - light assembly.
4. Average accident record compared to industry in general.
5. Job pressures, speed of work, presence of hazards, result in above average accident rate.
6. Machinery, weather, energy, heat make accidents likely and common.
7. Job is equivalent to roughnecking in oil field, bomb squads, skydiving.

TASK INVENTORY INSTRUCTIONS

"You are here today to take part in a task inventory. The Nuclear Regulatory Commission needs accurate information about the work done by Morris Operations Technicians. The task inventory is the means by which you supply this information. It consists of some background questions, followed by lists of task grouped under larger divisions of work, called activities. The task inventory is not a test, and the results will not be used to evaluate you, your supervisors or this facility.

In filling out the inventory, you are responsible for giving correct information about the work you do. Eventually, this information may be used to select or train other workers who may enter this field. It may lead to more appropriate evaluations and certifications. The procedure we are using today is based upon a technique developed by the U.S. Air Force. It assumes that the person who knows the most about a job is the person who does the work. It is designed to permit you to describe your work in simple terms so that we can understand you.

Now I will tell you how to complete the inventory. First, fill in the background information pages. Then proceed to the activity pages. Read through all of the tasks under all of the activities before marking any marks in this section. At the end of each activity, a special item "Accomplish other tasks" is listed. You may use it to evaluate any tasks which you do under that activity that are not listed. We have not listed all of the activities you do, because this is a sample of your complex job area. The activities selected were based upon interviews with supervisors and a review or Morris Operation documents. If an activity is not listed, it was left out on purpose. After reading through all of the activities and adding any tasks you feel are appropriate, turn back to the first activity and begin filling in the frequency column. "FREQUENCY" refers to how often you do this task compared to all of the tasks you do. Use the numbers from 1 to 7 according to the scale provided. The number "4" is average. When you have finished all of the "FREQUENCY" ratings, turn back to the first activity again and mark ratings in the second column, "TIME SPENT." "TIME SPENT" means the total time you spend doing that task, compared with the time you spend doing other tasks. (That's why you have to read through the whole inventory before marking it: I want to be sure that you and I have the same idea of what a task is.) The seven point TIME SPENT scale will be provided when you finish column one. A "1" means you spend very much less time on that task than on other tasks. A "7" means you spend very much more time on that task. Notice that you are to report total time spent. A 10-minute task, done six times should have the same rating as a 60-minute task done once.

After completing the "TIME SPENT" column, return to the first activity page again and complete the third column, "DIFFICULTY." The rules are the same: judge the difficulty of each task compared with the other tasks you do. Use the seven point scale provided. Mark each task with a number from 1 to 7.

Some of the work you do is hazardous. The fourth column is your opportunity to evaluate how dangerous different tasks are. Once again, use the seven point scale provided to indicate how the hazards involved in each task compare with other tasks that you do.

For the fifth column "ERRORS" we would like you to provide an estimate of the number of times an error may be made when performing that task. Use the provided five point scale to indicate your estimate of the amount of errors.

After completing the fifth column on "ERRORS," we will ask a few short questions on the most hazardous task for each activity. These questions will be provided to you and answered at the end of each of the 16 activity listing.

The questionnaire may appear long, but we have kept your answers short so that it can be completed quickly. Remember to complete column one on all pages before going to column two. Respond to all boxes in all columns; leave no blank boxes, unless you have never done that task. Are there any questions? (Reference Morsh and Archer, 1967)

BACKGROUND INFORMATION

Name ____
Last First Middle

Age in years ____ Sex ______ Today's date ______________
Year Month Date

Circle the highest high school grade or college/university year you have completed:

Elementary School	High School	College
1 2 3 4 5 6 7 8	9 10 11 12	13 14 15 16 17 18

Certification ____

Previous certifications or licenses ______________________________

____

Present Job Title ______________________________

Time in present job ______________
Years Months

Time in nuclear related jobs ______________
Years Months

1. What do you think of your job?

1 Extremely Dull		5 Fairly interesting
2 Very Dull	4 So-So	6 Very interesting
3 Fairly Dull		7 Extremely interesting

2. How does your job use your talents?

1 Not at all		5 Very well
2 Very Little	4 Quite well	6 Excellently
3 Fairly well		7 Perfectly

3. How well does your training fit your job?

1 Not at all		5 Very well
2 Very little	4 Quite well	6 Excellently
3 Fairly well		7 Perfectly

4. How much time do you spend performing the activities listed below? (If you do not perform the activity, do not respond)

Scale

1 Well below average		5 Slightly above average
2 Below average	4 About average	6 Above average
3 Slightly below average		7 Well above average

A. Rounds ____
B. Cask preparation for shipment (IF-300) ____
C. Demineralizer operations ____
D. Cask unloading (IF-300) ____
E. Fuel handling/storage ____
F. Basin cooling operations ____
G. Hydrostatic cask testing ____
H. Crane operations ____
I. Basin filter operations ____
J. LAW vault evaporation ____
K. Control room operations ____
L. Basin leak detection ____
M. Electrodecontamination ____
N. Dealing with leaking casks (IF-300) ____
O. Basin Water Analysis Compliance Test ____
P. Emergency cooling ____
Q. Training, Studying, Practicing ____
R. Routine housekeeping ____
S. Helping with experiments ____
T. Accountability ____
U. Writing SOP's or training material ____
V. Handling solid wastes (barrels) ____
W. Taking breaks or waiting for tasks ____
X. Working with basin pumps ____
Y. Operating utilities (air, water) ____
Z. Filling out forms, checklists ____

This completes the background information.

STOP

PUT YOUR PENCIL DOWN. READ THIS PAGE BEFORE GOING FURTHER.

To complete the task inventory, you must first read all of the tasks under each of the activities on the following pages. If a task that you do is not listed under an activity, you may add it to the list in the space provided.

DO NOT COMPLETE ANY OF THE COLUMN ENTRIES AT THIS TIME.

Additional instructions will be given after you read the tasks.

ACTIVITY: CASK UNLOADING

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Position rail switches and gates					
Operate railcar brakes, chocks, and couplings					
Operate ISCO to move railcar					
Survey radiation of car, cask, and head					
Dismantle IF-300 to access cask					
Operate crane and trunnion					
Lift and move cask to basin					
Remove cask from basin with crane					
Sample coolant					
Check pressures and temperature of cask					
Flush cask, venting to LAW vault					
Remove road grime					
Unbolt and remove cask head					
Install cask head					
Decontaminate head, cask, and trunnion					
Perform pressurization check					

ACTIVITY: CASK UNLOADING (cont'd)

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Install lock wires					
Complete IF-300 checklist (initials and date)					
Accomplish other tasks (if any)					

ACTIVITY: CRANE OPERATIONS

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Check operations					
Hook load					
Lift load vertically					
Move the load from location to location					
Place the load in wanted area					
Unhook load from crane					
Perform small movements					
Inspect the conditions of cables and welds					
Change hooks and slings					
Complete forms					
Accomplish other tasks (if any)					

ACTIVITY: FUEL REMOVAL AND STORAGE

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Operate crane for basket moving					
Engage fuel grapple					
Remove fuel from basket					
Place fuel in basket					
Disengage fuel grapple (normal operation)					
Disengage fuel grapple manually					
Identify fuel bundles					
Lower and raise pit guard					
Place basket in storage grid location					
Complete paperwork, checklists, and logs					
Accomplish other tasks (if any)					

ACTIVITY: HYDROSTATIC TESTING

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Add demineralized water to cask					
Pressurize cask					
Inspect for leaks, pressures, temperatures					
Attach hydrostatic pump; pressurize; disconnect					
Obtain QA releases					
Check LAW vault					
Vent valve operation					
Move cask with crane (to and from railcar)					
Drain cask to LAW vault using air pressure					
Vent cask to LAW vault					
Coordinate with maintenance for relief valve/gage changes					
Connect hose, make quick disconnects					
Complete checklist, paperwork					
Accomplish other tasks (if any)					

ACTIVITY: OFF SITE SHIPMENT PREPARATION

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Operate crane to place cask on railcar					
Connect cask to railcar					
Decontaminate cask					
Replace box covers, ducts					
Prepare tool box and spare parts box					
Inspect cask and railcar					
Coordinate with control room and safety					
Move railcar with ISCO					
Refuel engine					
Assist train crew					
Complete check sheets, paperwork					
Accomplish other tasks (if any)					

ACTIVITY: BASIN COOLER OPERATION

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Verify water level					
Complete valve check off lists					
Monitor pressure against Table I					
Check for leaks					
Remove pump discharge pressure indicator					
Install Chicago coupling					
Turn pump on to increase Demin pressure					
Prime pump					
Throttle valve, checking pressure					
Notify personnel - pump on line					
Turn fans on					
Complete paperwork, logs					
Accomplish other tasks (if any)					

ACTIVITY: BASIN WATER ANALYSES (COMPLIANCE TEST)

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Take water samples from basin					
Log and initial data on sample and results					
Evaluate results of sample analysis					
Determine Action required					
Notify appropriate people					
Plot data on analysis results					

ACTIVITY: BASIN FILTER OPERATIONS

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Place Filter/Hold switch in Hold					
Verify all valves and switches are in the correct position					
Verify Basin level $\geq$ 58%					
Open Filter outlet valve					
Verify Basin level $\geq$ 58%					
Close vacuum sweeper to filter system valve					
Remove sweeper head and attach cleaning tool					
Verify vacuum head below water					
Open vacuum sweeper to Filter System valve					
Clean cask interior					
Clean basin floor					
Monitor water flow rates					
Record readings in Basin Filter Log					

ACTIVITY: DEMINERALIZER OPERATIONS

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Adjust valves					
Set timers					
Coordinate with control room					
Check during rounds					
Select operating unit (A or B)					
Complete paperwork, checklist					
Accomplish other tasks (if any)					

ACTIVITY: LAW EVAPORATOR SYSTEM OPERATION

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Check system operation: blowers, vents, instruments					
Don radiation protection garments					
Operate canyon crane					
Adjust valves and pumps					
Monitor operation visually, check for leaks					
Monitor operation from control room, log data every 2 hours					
Sample density					
Reduce steam, jet off-gas cell sump					
Shutdown, valves and pumps adjusted to flush					
Prepare extended shutdown, add demineralized water with chemical dolly					
Configure valve and pump in accordance with checklist					
Accomplish other tasks (if any)					

ACTIVITY: ELECTRO-DECONTAMINATION OPERATION

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Check contamination levels of tools/equipment					
Calculate surface area, current, cathodes					
Operate electro-decontamination controls					
Place item in acid					
Remove and rinse item					
Complete logs					
Obtain release from plant safety					
Accomplish other tasks (if any)					

ACTIVITY: BASIN LEAK DETECTION

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Turn level controller switch to Hand position					
Place steam supply valve to jet					
Turn on power switch					
Attach tubing to Basin system					
Open Jet Suck valve to collect sample					
Collect sample					
Put sample in container					
Clean sample box					
Log sample check and complete paperwork					
Accomplish other tasks (if any)					

ACTIVITY: EMERGENCY ACTION FOR BASIN COOLERS

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Start emergency power manually					
Turn cooler pumps off					
Turn breakers off					
Close valve 3/4 turn					
Adjust the regulator					
Open valve to discharge header					
Inspect for water leakage					
Check pump pressure and valving					
Check Basin level					
Check cooler temperature					
Respond to alarm					
Shut down cooler fan					
Check valving					
Check pump readings					
Restart fans					
Turn Basin pumps and fans off					

ACTIVITY: EMERGENCY ACTION FOR BASIN COOLERS (cont'd)

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Cover coolers with tarps and fan openings with plastic					
Light space heaters to heat area					
Monitor area for heating					
Log controls appropriately					
Complete checklists and forms					
Accomplish other tasks (if any)					

ACTIVITY: CASK HANDLING WITH FAILED OR LEAKING FUEL

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Evacuate personnel from hazardous areas					
Flush cask					
Obtain coolant sample					
Fill cask with water					
Vent cask to LAW vault					
Monitor temperature of cask					
Take sample for Cesium analyses					
Contact personnel if Cesium measure is high					
Complete checklists and forms					
Accomplish other tasks (if any)					

ACTIVITY: CONTROL ROOM DUTIES

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Start and/or stop equipment					
Perform scheduled security checks					
Receive and transmit calls					
Initiate scheduled tests					
Perform rounds check					
Respond to alarms					
Complete logs and other forms					
Accomplish other tasks (if any)					

ACTIVITY: PLANT ROUNDS

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Inspect the Utility Building and indicators					
Check the Utility Boiler systems					
Check the Demineralizer system					
Check the Phosphate Tank indicators					
Check the Hydrozone Tank indicators					
Check the Deaerator (V-801) indicators					
Check the Accumulator (V-806) indicators					
Check the Degasifier indicators					
Inspect the Chemical Storage Area and indicators					
Inspect the Water Tower and indicators					
Inspect the Well House and indicators					
Inspect the Cold Warehouse					
Inspect Building F and the indicators					
Inspect the Emergency Equipment Building					
Inspect the Generator Room and indicators					
Inspect the Exhaust Blower Room					

ACTIVITY: PLANT ROUNDS (cont'd)

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Inspect the Compressor Room and indicators					
Check the Utility Cooling Tower and indicators					
Inspect the Warm Warehouse					
Inspect the Mockup Tower and indicators					
Inspect the Cask Service Facility					
Inspect the Basin Cooler Area					
Inspect the Cask Receiving Area and indicator					
Inspector the Basin Areas					
Inspect the Basin Filter and indicators					
Check the Basin Coolers and indicators					
Check the Heat Pump System and indicators					
Check the Expansion Gate and indicators					
Check the Process Building and indicators					
Inspect the F_2 Disposal Area and indicators					
Monitor the Process Steam Room indicators when in service					
Inspect the South Plug Gallery					

ACTIVITY: PLANT ROUNDS (cont'd)

TASKS	FREQUENCY	TIME SPENT	DIFFICULTY	HAZARD	ERRORS
Inspect the Analytic Lab					
Inspect the North Plug Gallery					
Monitor the Process Cooling Waters indicators when in service					
Inspect the North Instrument Gallery and indicator					
Inspect the South Instrument Gallery					
Inspect the Ventilation Supply Room and indicators					
Inspect the Emergency Electrical Room and indicators					
Perform Vehicle checks					
Complete Shift Rounds Data Sheet					
Accomplish other tasks (if any)					
	GO TO (B)	GO TO (C)	GO TO (D)	GO TO (E)	GO TO (F)

(A) That completes the tasks for the activities that are being inventoried. We realize that, as a certified operations technician, you are involved in many more activities in your daily work. This sample was selected after a careful review of the Morris Operation.

Now you are to rate the relative frequency of tasks you perform, that is, compared to other tasks, how many times do you do each task in this list. The rating scale goes from 1 to 7 with 4 representing an average number of times. Ask for the FREQUENCY rating scale (on a separate sheet of paper) at this time. Enter a number from the rating scale (1 through 7) in column one for each task.

GO BACK TO PAGE 4 AND COMPLETE COLUMN ONE.

(B) After completing column one for every task you do, read the following instructions:

Column two is provided for you to rate the amount of time you spend doing a task, compared to other tasks you do. Ask for the TIME SPENT rating scale at this time.

GO BACK TO PAGE 4 AND COMPLETE COLUMN TWO.

(C) After completing column two for every task you do, read the following instructions:

In column three, enter a value from the DIFFICULTY rating scale to indicate how hard it is to perform each task. Ask for the DIFFICULTY rating scale at this time.

GO BACK TO PAGE 4 AND COMPLETE COLUMN THREE.

(D) After completing column three for every task you do, read the following:

Rate each task you do according to how hazardous it is compared to other tasks. Enter the hazard value in column four. Ask for the HAZARD rating scale at this time.

GO BACK TO PAGE 4 AND COMPLETE COLUMN FOUR.

(E) After completing column four for every task you do, read the following:

Rate each task according to how frequently errors are made. For tasks on which errors are more likely to be made by new personnel (uncertified) place an N next to your rating of error frequency. Ask for the rating scale for error frequencies at this time.

GO BACK TO PAGE 4 AND COMPLETE COLUMN FIVE.

(F) After completing column five for every task you do, read the following:

You are to answer three questions concerning all the tasks for each activity that you rated as 7 in column four. If no tasks for that activity had a hazard rating of 7, respond to the <u>one</u> most hazardous task that had the next highest hazard rating. That is, for a case where more than one task has the next highest hazard rating, choose one task in that rating group that you consider most hazardous. Ask for the error questions at this time.

GO BACK TO PAGE 4 AND ANSWER THE ERROR QUESTIONS IN THE SPACE AT THE END OF EACH ACTIVITY.

FREQUENCY RATING SCALE

1 WELL BELOW AVERAGE; SELDOM DONE

2 BELOW AVERAGE

3 SLIGHTLY BELOW AVERAGE

4 ABOUT AVERAGE NUMBER OF TIMES

5 SLIGHTLY ABOVE AVERAGE

6 ABOVE AVERAGE

7 WELL ABOVE AVERAGE; MORE OFTEN THAN OTHERS

TIME SPENT RATING SCALE

1 WELL BELOW AVERAGE

2 BELOW AVERAGE

3 SLIGHTLY BELOW AVERAGE

4 ABOUT AVERAGE AMOUNT OF TIME

5 SLIGHTLY ABOVE AVERAGE

6 ABOVE AVERAGE

7 WELL ABOVE AVERAGE

DIFFICULTY RATING SCALE

1 EXTREMELY EASY

2 VERY EASY

3 FAIRLY EASY

4 AVERAGE

5 FAIRLY DIFFICULT

6 VERY DIFFICULT

7 EXTREMELY DIFFICULT

HAZARD RATING SCALE

1 ABSOLUTELY SAFE

2 VERY SAFE

3 FAIRLY SAFE

4 TYPICAL HAZARD FOR THIS JOB

5 SOMEWHAT MORE DANGEROUS

6 VERY DANGEROUS

7 EXTREMELY DANGEROUS

ERROR FREQUENCY SCALE

1 More than 2 or 3 times a year

2 Perhaps as often as 2 or 3 times a year

3 Probably more often than once a year

4 Perhaps as often as once a year

5 Less than once a year

ERROR QUESTIONS

1. What is the most serious error(s) that could be performed in doing this task?

2. What feature of the task or the environment in which it is performed contributed to the likelihood of the occurrence?

3. Are there any factors in this task that make it possible to recover from the error without penalty? (or, Can the error be made but corrected immediately so that its consequences are avoided?) Explain your answer.

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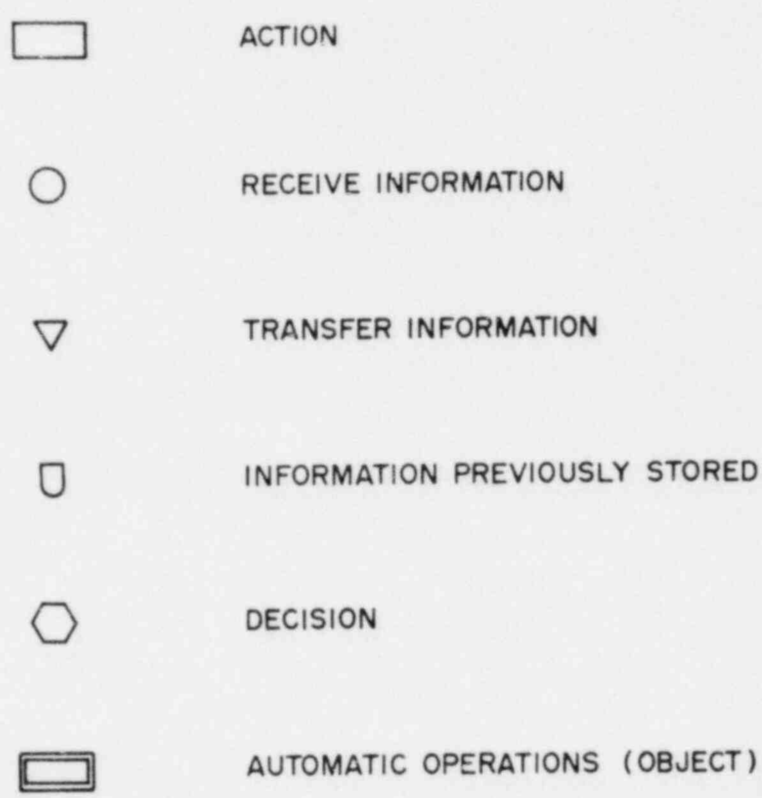
APPENDIX B
OPERATIONAL SEQUENCE DIAGRAMS

Part of the purpose of the task analysis that was conducted at the Morris Operation was to distinguish the allocation of tasks between humans and machines. This allocation was to be accomplished in particular for the following seven functions: handling casks, handling fuel, fuel unloading and cask turnaround, basin cooling, water purification, normal operations, and infrequent or abnormal operations at the Morris Operation.

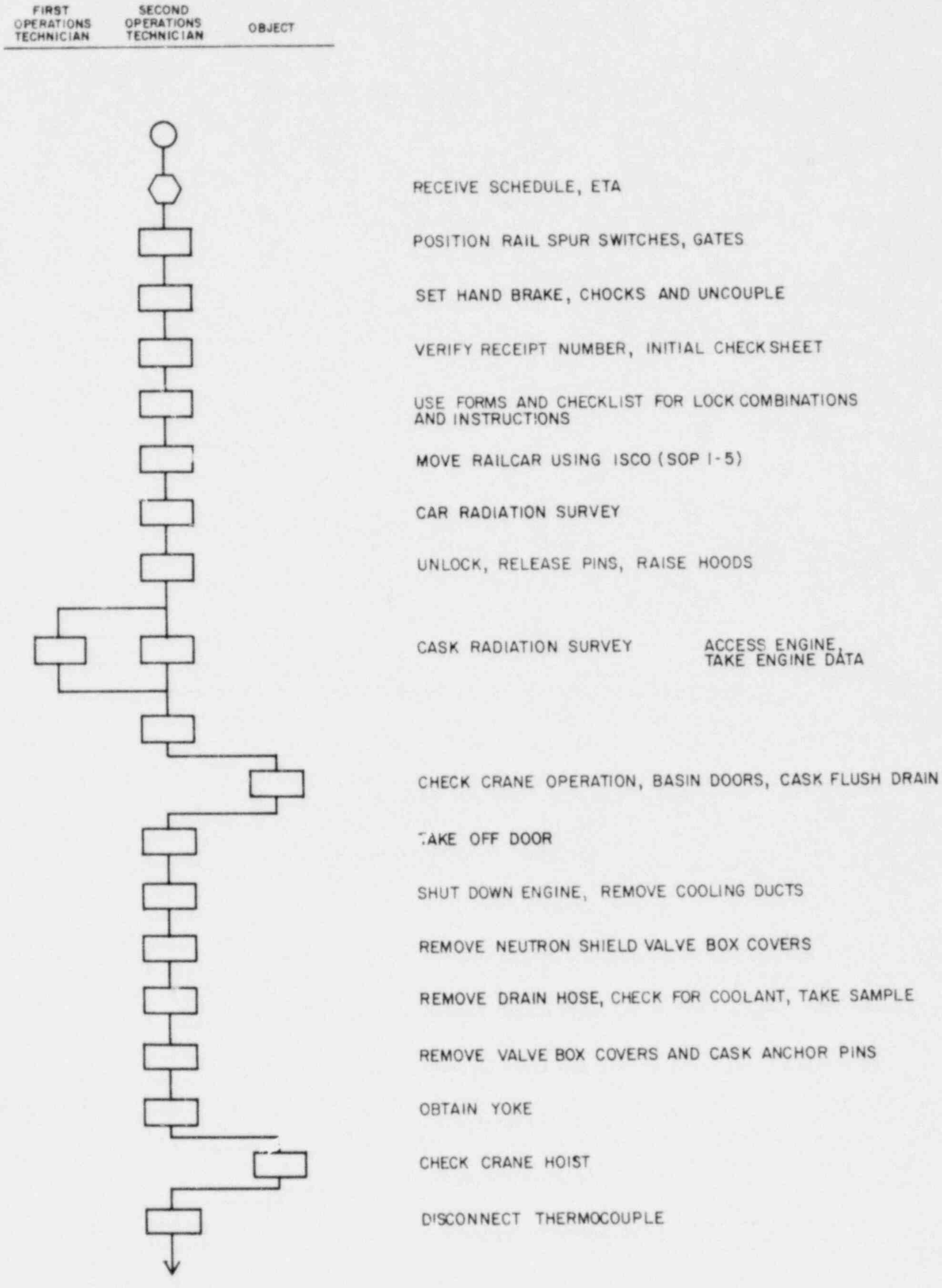
The methodology employed to describe the human/machine task allocation was the construction of Operational Sequence Diagrams (OSD). An OSD is a symbolic flow diagram which indicates the task allocation between the human and machine. Also the OSD's present interactions between the human and machine and it indicates interfaces to other humans and machines in the system. The OSDs in this appendix use the following symbology (from Van Cott and Kindade, 1972):

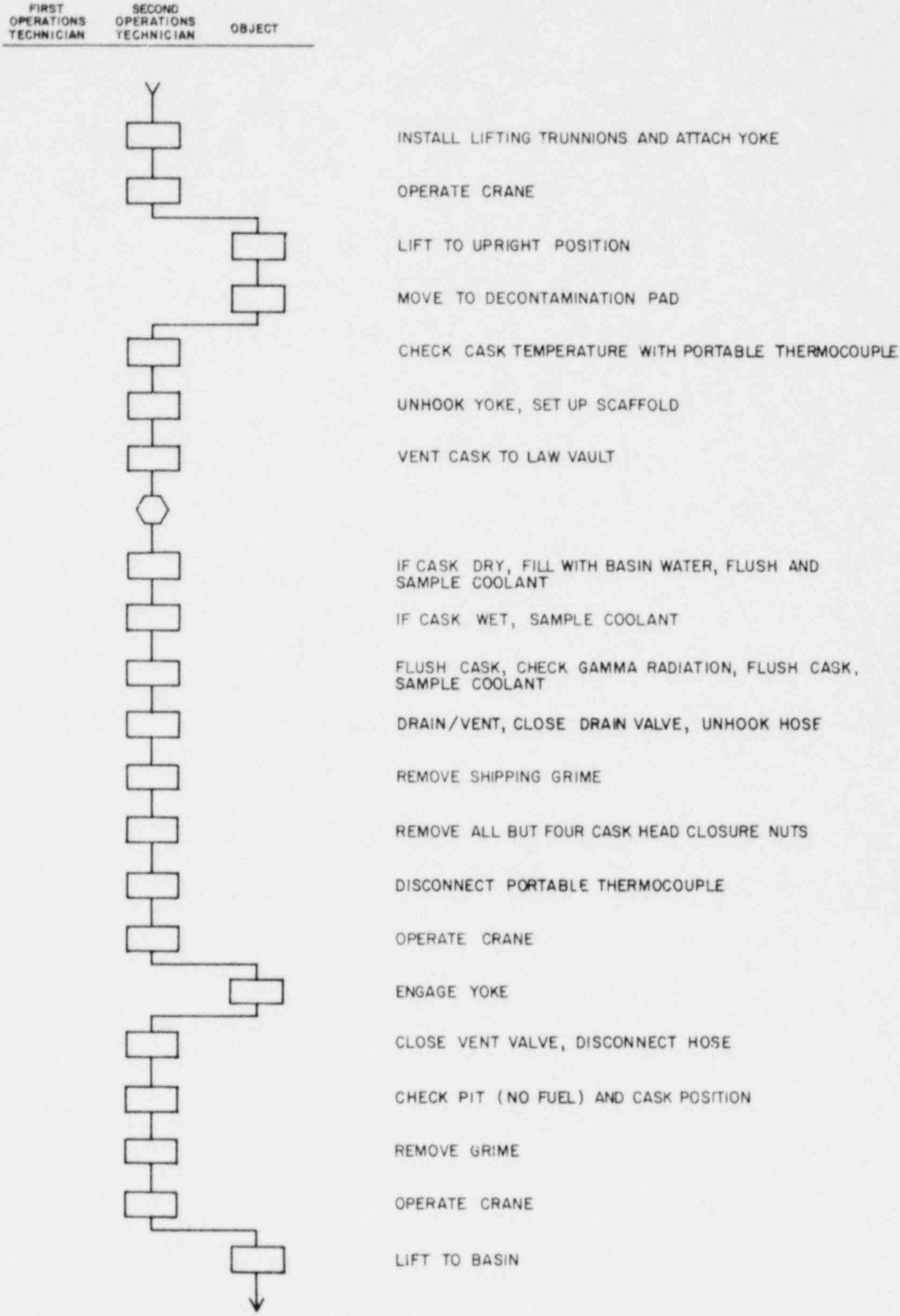


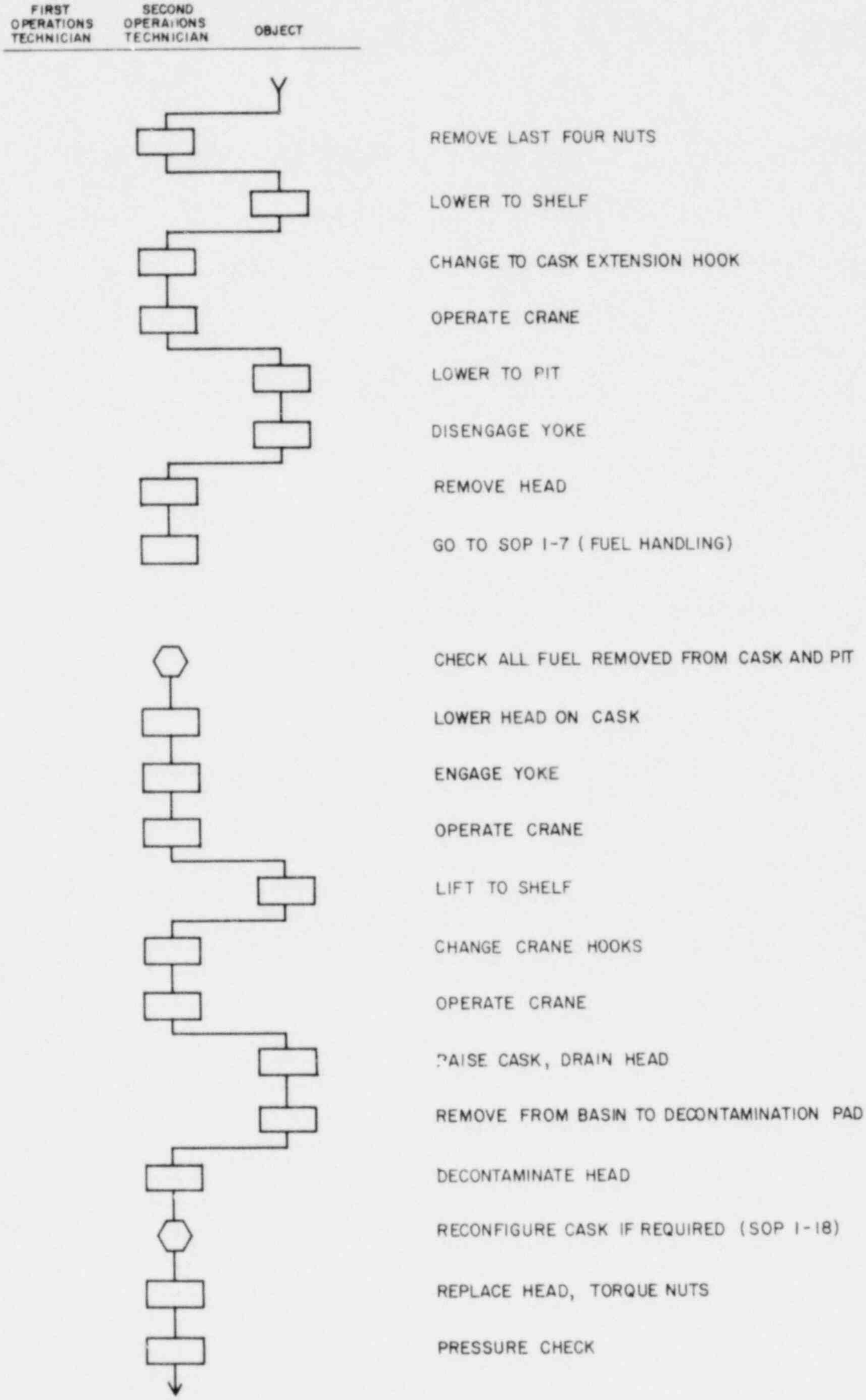
The symbology is used in a columnar format with the symbols listed under the indicated personnel or machine (object). OSDs were developed for the following activities:

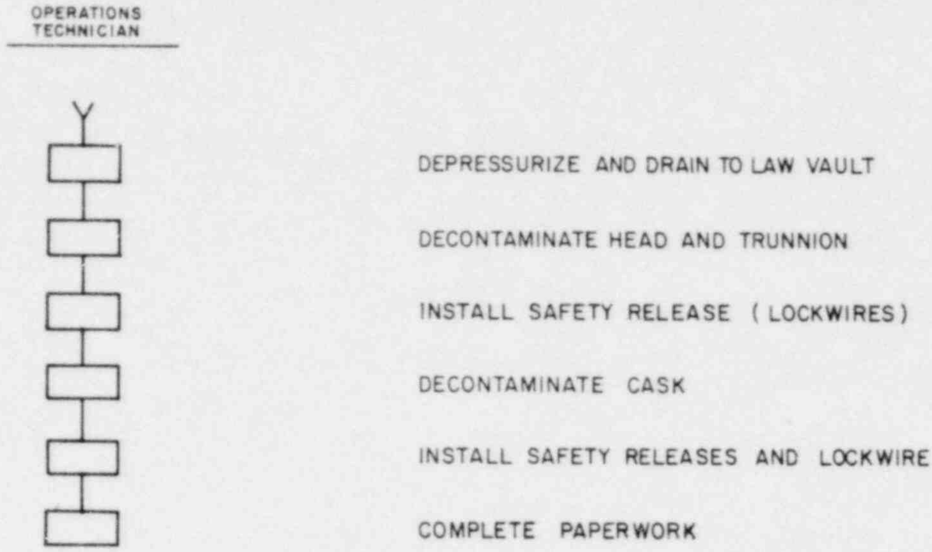
- o Receipt and Handling of a Loaded IF-300 Cask
- o Fuel Removal and Storage
- o Hydrostatic Testing of the IF-300 Cask
- o Preparation of IF-300 for Off-Site Shipment
- o Basin Cooler Operations
- o Basin Water Analysis Compliance Test
- o Basin Filter Operation
- o Demineralizer Unit Operation
- o LAW Evaporator System Operation
- o Electro-Decontamination Operation
- o Basin Leak Detection System Operation
- o Emergency Action for Basin Coolers
- o Handling of Casks Containing Leaking or Failed Fuel

RECEIPT AND HANDLING OF A LOADED IF-300 CASK

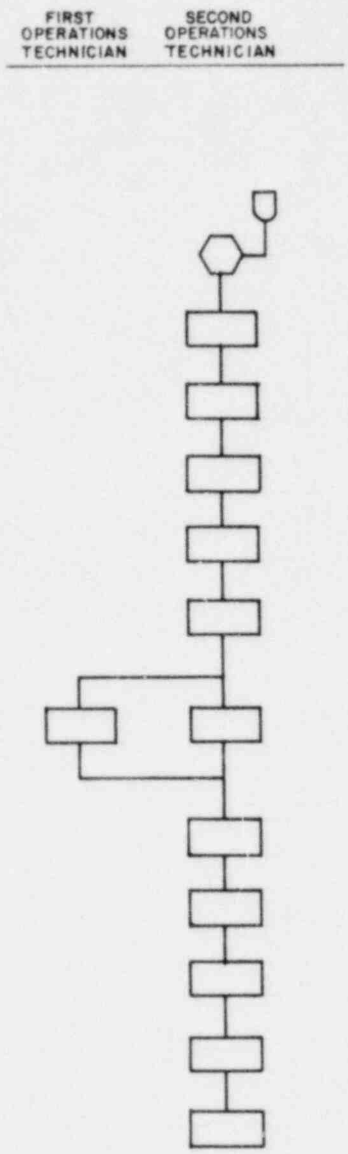



FIRST OPERATIONS TECHNICIAN
SECOND OPERATIONS TECHNICIAN
OBJECT
INSTALL LIFTING TRUNNIONS AND ATTACH YOKE
OPERATE CRANE
LIFT TO UPRIGHT POSITION
MOVE TO DECONTAMINATION PAD
CHECK CASK TEMPERATURE WITH PORTABLE THERMOCOUPLE
UNHOOK YOKE, SET UP SCAFFOLD
VENT CASK TO LAW VAULT
IF CASK DRY, FILL WITH BASIN WATER, FLUSH AND SAMPLE COOLANT
IF CASK WET, SAMPLE COOLANT
FLUSH CASK, CHECK GAMMA RADIATION, FLUSH CASK, SAMPLE COOLANT
DRAIN/VENT, CLOSE DRAIN VALVE, UNHOOK HOSE
REMOVE SHIPPING GRIME
REMOVE ALL BUT FOUR CASK HEAD CLOSURE NUTS
DISCONNECT PORTABLE THERMOCOUPLE
OPERATE CRANE
ENGAGE YOKE
CLOSE VENT VALVE, DISCONNECT HOSE
CHECK PIT (NO FUEL) AND CASK POSITION
REMOVE GRIME
OPERATE CRANE
LIFT TO BASIN


FIRST OPERATIONS TECHNICIAN
SECOND OPERATIONS TECHNICIAN
OBJECT
REMOVE LAST FOUR NUTS
LOWER TO SHELF
CHANGE TO CASK EXTENSION HOOK
OPERATE CRANE
LOWER TO PIT
DISENGAGE YOKE
REMOVE HEAD
GO TO SOP I-7 (FUEL HANDLING)
CHECK ALL FUEL REMOVED FROM CASK AND PIT
LOWER HEAD ON CASK
ENGAGE YOKE
OPERATE CRANE
LIFT TO SHELF
CHANGE CRANE HOOKS
OPERATE CRANE
RAISE CASK, DRAIN HEAD
REMOVE FROM BASIN TO DECONTAMINATION PAD
DECONTAMINATE HEAD
RECONFIGURE CASK IF REQUIRED (SOP I-18)
REPLACE HEAD, TORQUE NUTS
PRESSURE CHECK


OPERATIONS TECHNICIAN
DEPRESSURIZE AND DRAIN TO LAW VAULT
DECONTAMINATE HEAD AND TRUNNION
INSTALL SAFETY RELEASE (LOCKWIRES)
DECONTAMINATE CASK
INSTALL SAFETY RELEASES AND LOCKWIRE
COMPLETE PAPERWORK

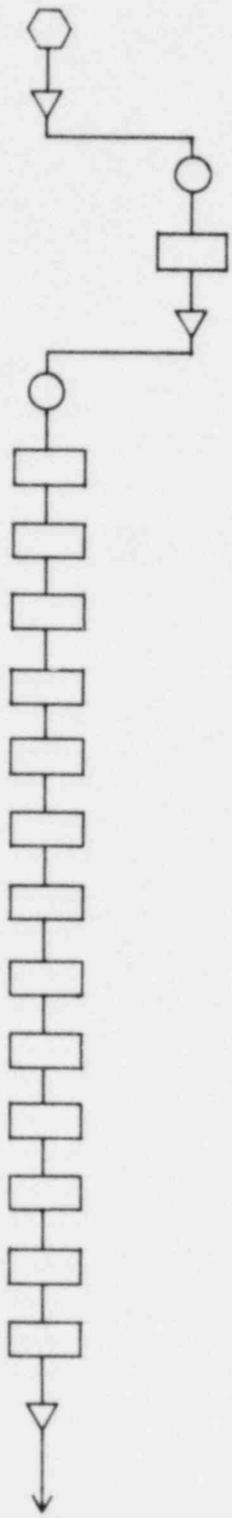
FUEL REMOVAL AND STORAGE



- CASK TRANSFERRED TO PIT (SOP I-3)
- CHECK LOCATIONS FOR STORAGE
- GRAPPLES, LIGHTS, TV, VIEWING BOXES, BINOCULARS, PERISCOPE READY
- TRANSFER BASKET TO PIT
- GRAPPLE FUEL, REMOVE FROM CASK
- PLACE FUEL IN BASKET, RELEASE GRAPPLE (MANUAL RELEASE MAY BE REQUIRED)
- REPEAT UNTIL BASKET IS FULL
- IDENTIFY FUEL BUNDLES (TWO TECHNICIANS MUST VERIFY)
- COMPLETE CHECK SHEET
- LOWER PIT GUARD TO BASKET TRANSFER POSITION
- ATTACH BASKET LIFTING TOOL TO BASIN CRANE HOOK
- ENGAGE BASKET, RAISE THROUGH PITGUARD, MOVE TO STORAGE
- STORE BASKET LIFTING TOOL

HYDROSTATIC TESTING OF THE IF-300 CASK

QUALITY ASSURANCE	OPERATIONS TECHNICIAN	MAINTENANCE



REPLACE RELIEF VALVE WITH GAUGE (SOP I-13)

ATTACH QUICK DISCONNECT

MOVE CASK TO RAILCAR (SOP I-12)

RUN DEMINERALIZED WATER TO CASK

ATTACH DRAIN HOSE, OPEN VALVES

ADD DEMINERALIZED WATER

CLOSE VENT VALVE

PRESSURIZE

CHECK FOR LEAKS

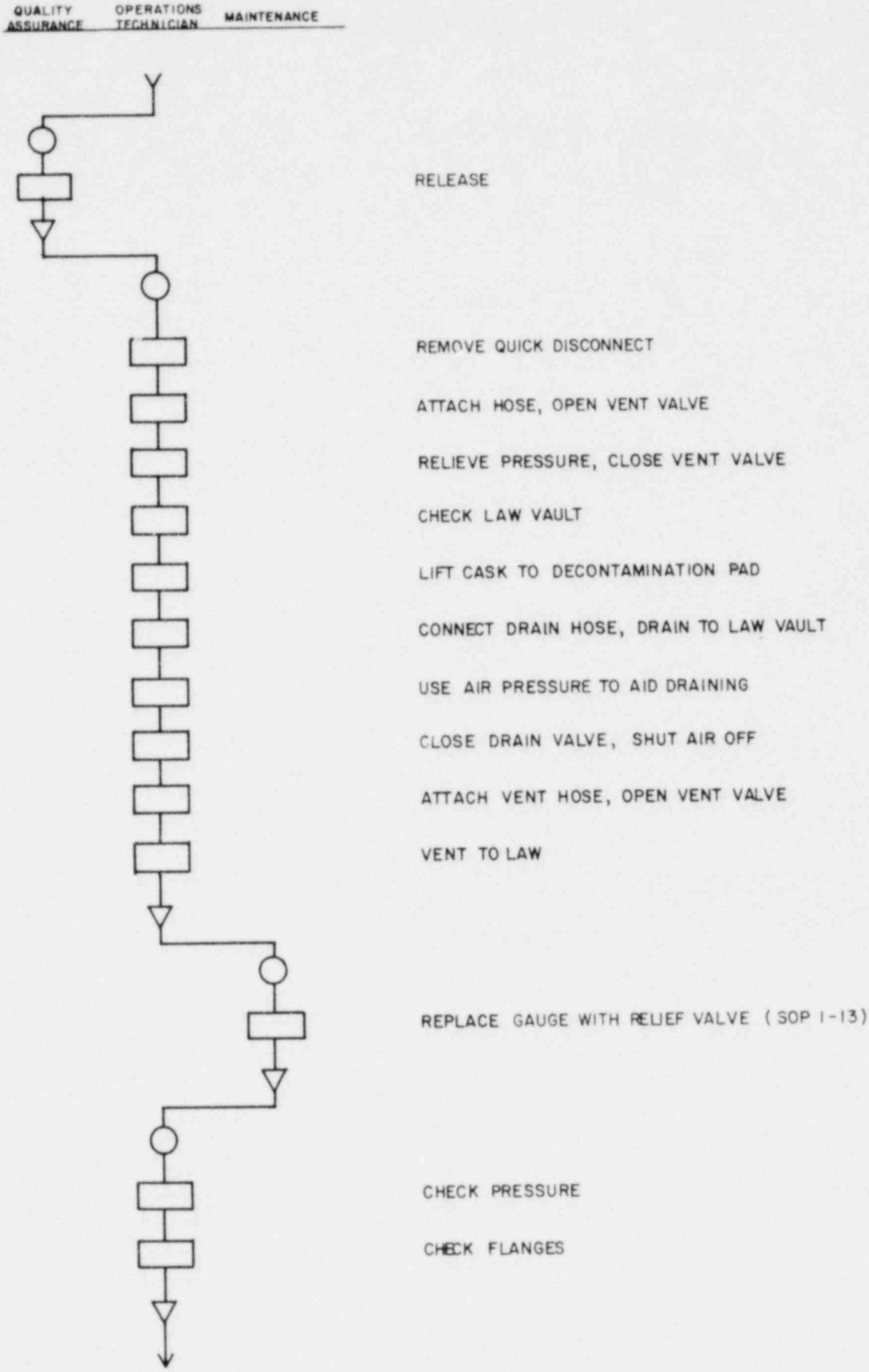
DISCONNECT WATER

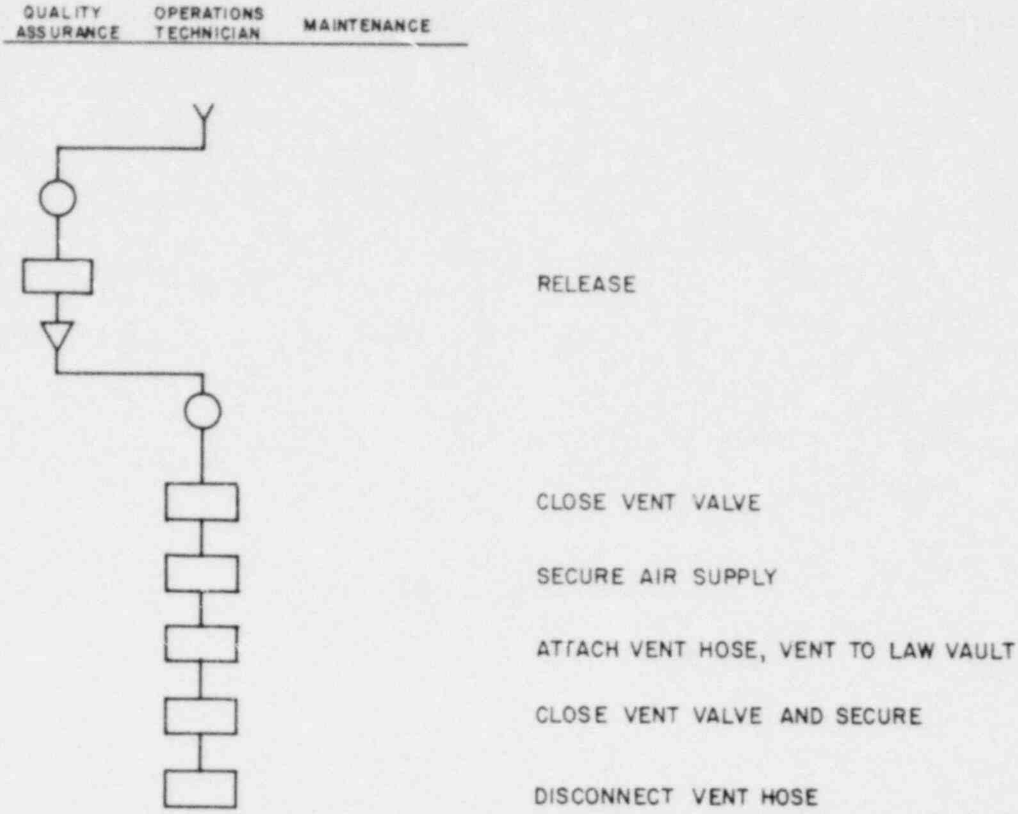
ATTACH HYDROSTATIC PUMP (400 psig)

CLOSE DRAIN VALVE DISCONNECT PUMP

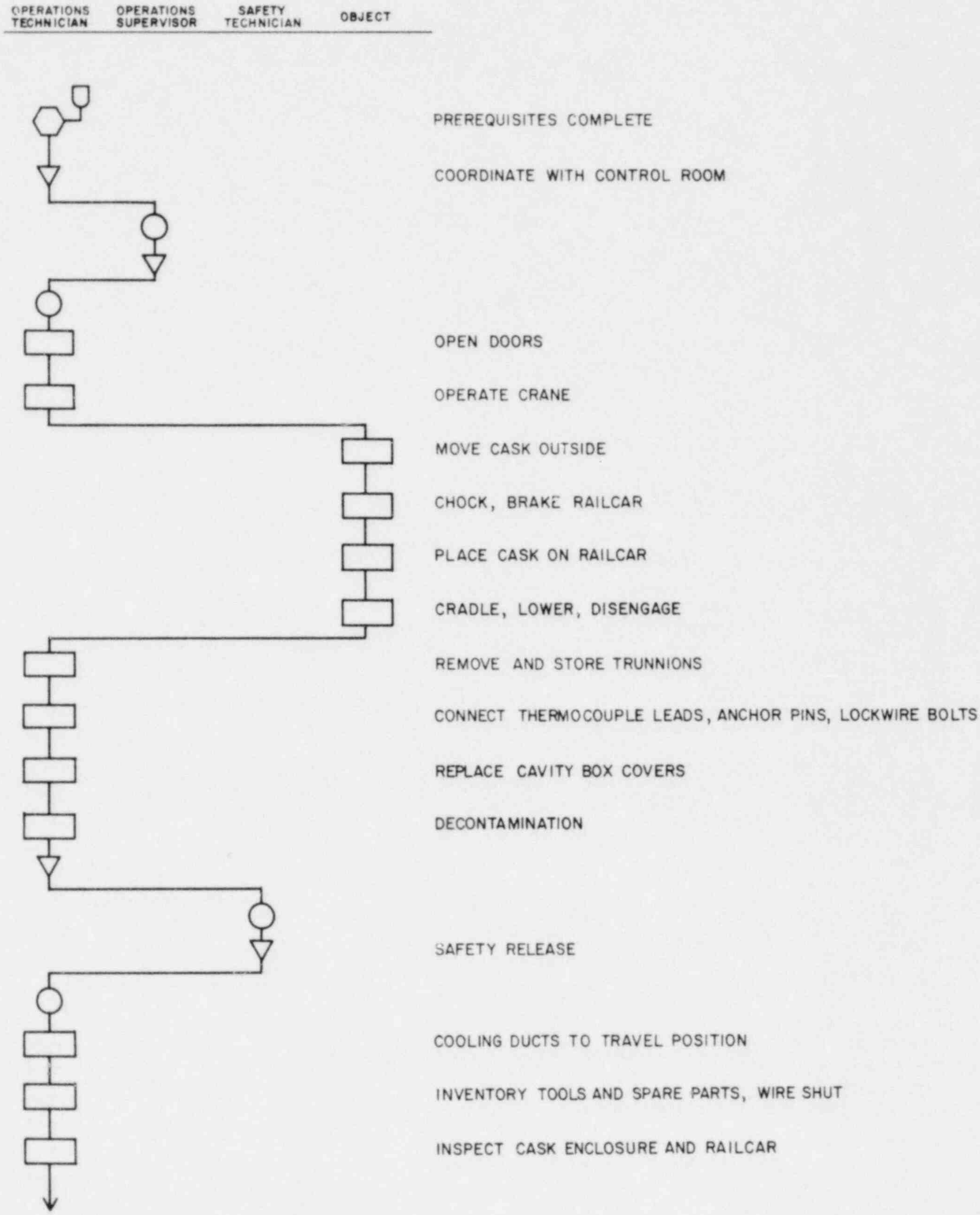
CHECK PRESSURE, TEMPERATURE, LEAKS

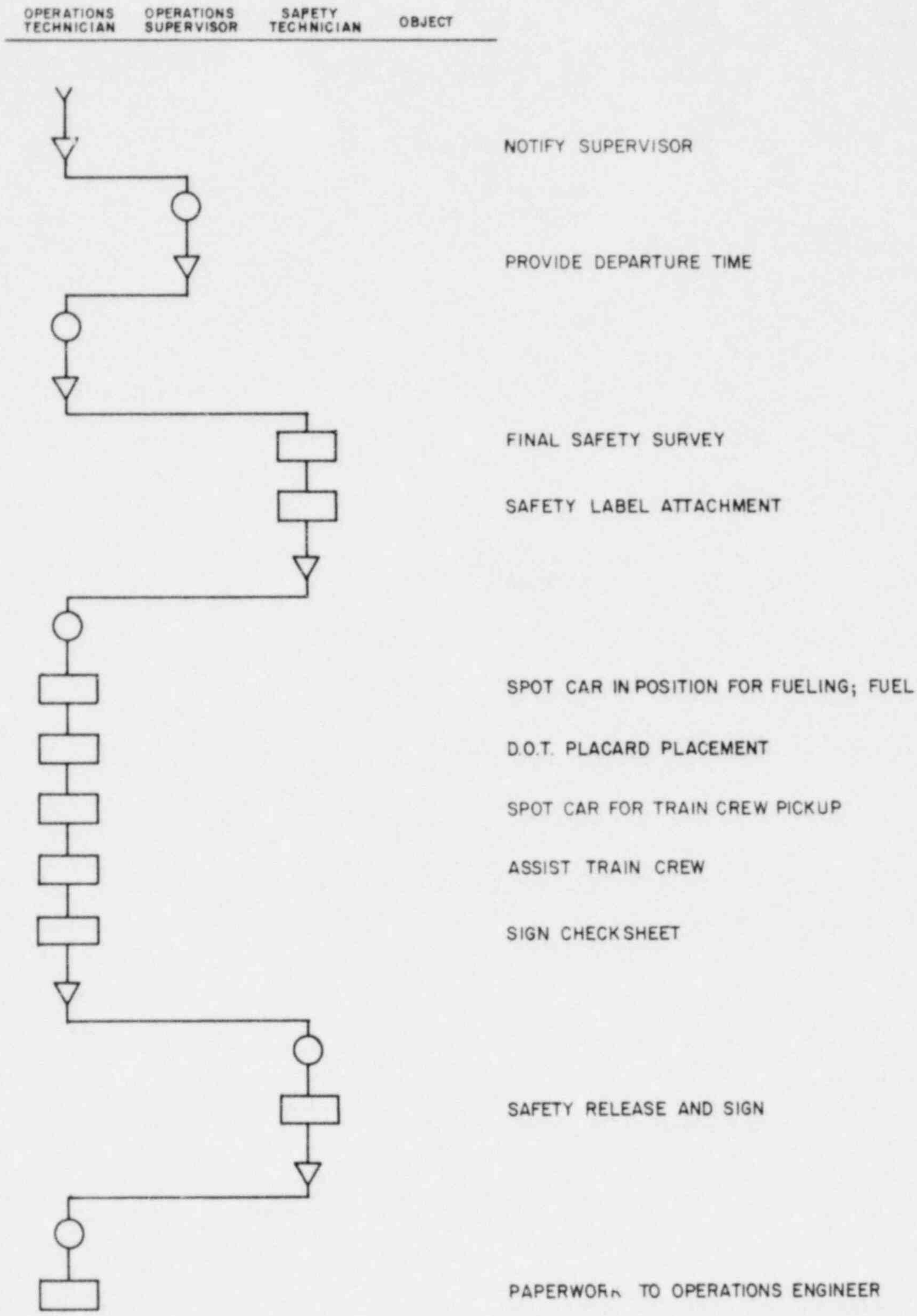
CONNECT THERMOCOUPLE


QUALITY ASSURANCE
OPERATIONS TECHNICIAN
MAINTENANCE
RELEASE
REMOVE QUICK DISCONNECT
ATTACH HOSE, OPEN VENT VALVE
RELIEVE PRESSURE, CLOSE VENT VALVE
CHECK LAW VAULT
LIFT CASK TO DECONTAMINATION PAD
CONNECT DRAIN HOSE, DRAIN TO LAW VAULT
USE AIR PRESSURE TO AID DRAINING
CLOSE DRAIN VALVE, SHUT AIR OFF
ATTACH VENT HOSE, OPEN VENT VALVE
VENT TO LAW
REPLACE GAUGE WITH RELIEF VALVE (SOP I-13)
CHECK PRESSURE
CHECK FLANGES


QUALITY ASSURANCE
OPERATIONS TECHNICIAN
MAINTENANCE
RELEASE
CLOSE VENT VALVE
SECURE AIR SUPPLY
ATTACH VENT HOSE, VENT TO LAW VAULT
CLOSE VENT VALVE AND SECURE
DISCONNECT VENT HOSE

PREPARATION OF IF-300 FOR OFF-SITE SHIPMENT

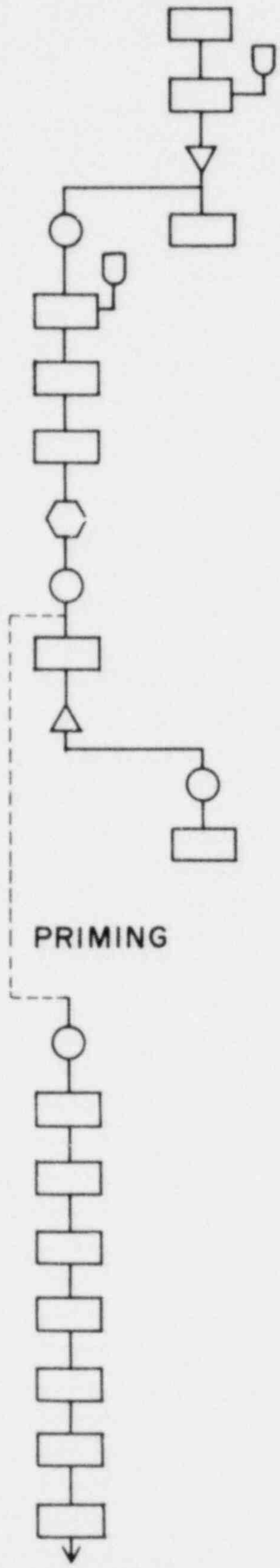



OPERATIONS TECHNICIAN
OPERATIONS SUPERVISOR
SAFETY TECHNICIAN
OBJECT
NOTIFY SUPERVISOR
PROVIDE DEPARTURE TIME
FINAL SAFETY SURVEY
SAFETY LABEL ATTACHMENT
SPOT CAR IN POSITION FOR FUELING; FUEL
D.O.T. PLACARD PLACEMENT
SPOT CAR FOR TRAIN CREW PICKUP
ASSIST TRAIN CREW
SIGN CHECKSHEET
SAFETY RELEASE AND SIGN
PAPERWORK TO OPERATIONS ENGINEER

BASIN COOLER OPERATIONS

OPERATIONS TECHNICIAN | OPERATIONS SUPERVISOR

START-UP PROCEDURES



VERIFY WATER LEVEL AT 60-63%

COMPLETE VALVE CHECK OFF LIST FOR COOLER

TURN ON BASIN CONTROL

MONITOR AND CHECK PRESSURE AGAINST TABLE I

CHECK FOR LEAKS AROUND BASIN AREA

PRIME PUMP

DECIDE IF PRESSURE AND FLOW ARE EQUAL

① PRESSURE AND FLOW <u>ARE</u> EQUAL

DETERMINE PUMP TO BE ON LINE, TURN OTHER OFF

TELL CRO PUMP ON LINE

TURN FANS ON FROM IN CONTROL ROOM

PRIMING

② PRESSURE AND FLOW <u>ARE NOT</u> EQUAL

REMOVE PUMP DISCHARGE PRESSURE INDICATORS

INSTALL CHICAGO COUPLING

TURN ON P-810 TO INCREASE DEMIN WATER PRESSURE

ADD WATER TO PUMP AND INLET LINE

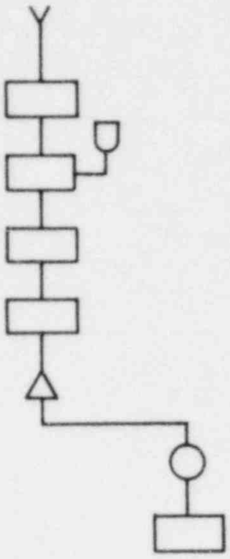
CRACK INLET VALVE

CLOSE INLET AND CRACK DISCHARGE

CLOSE DEMIN WATER VALVE

OPERATIONS TECHNICIAN OPERATIONS SUPERVISOR

PRIMING (cont'd)



TURN PUMP ON

THROTTLE VALVE TO MAINTAIN PRESSURE CHECKING CHART

REMOVE PRIMING HOSE

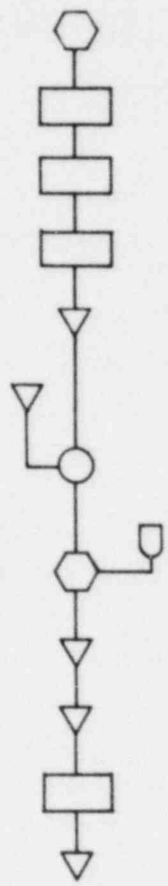
DETERMINE PUMP TO BE ON LINE, TURN OTHER OFF

TELL CRO PUMP ON LINE

TURN FANS ON

BASIN WATER ANALYSIS COMPLIANCE TEST

OPERATIONS TECHNICIAN



WEEKLY SAMPLE AS PART OF SATURDAY ROUNDS, BRING CONTAINERS, PLASTIC BAG, GLOVES

RINSE CONTAINERS WITH FIRST DIPPER FULL

TAKE FOUR 200 ml SAMPLES, 2 FEET DEPTH, 6 FEET IN FRONT OF SKIMMER

DELIVER SAMPLE TO LAB

LOG DATE, TIME, SAMPLE NO., INITIALS

ALSO MAKE LOG BOOK ENTRY

ENTER LAB RESULTS

IF EXCESSIVE, ENTER EVALUATION AND CORRECTIVE ACTION REQUIRED

NOTIFY SENIOR ENGINEER/ RADIATION SAFETY

PLOT DATA ON WALL CHART

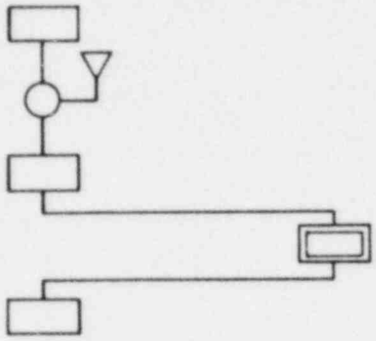
TAKE ACTION REQUIRED

SIGN AND FILE DOCUMENT

BASIN FILTER OPERATIONS

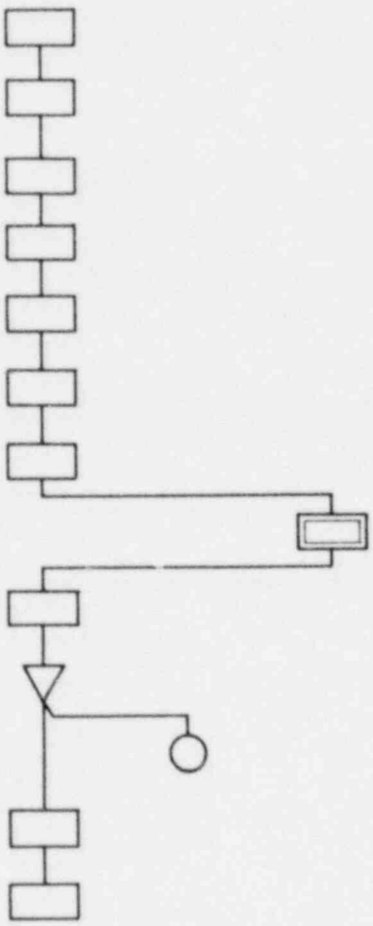
OPERATIONS TECHNICIAN | OPERATIONS SUPERVISOR | OBJECT

REMOVAL FROM SERVICE



- VERIFY VALUE SELECTOR SWITCH IN CORRECT POSITION
- RECORD READINGS IN BASIN FILTER LOG BOOK
- PLACE FILTER / HOLD SWITCH IN HOLD
- SYSTEM OUTLET VALVE CLOSES, RECIRCULATION VALVE OPENS, DECREASED FLOW RATE
- RECORD FILTER PRESSURE AND SYSTEM FLOW RATE IN BASIN FILTER LOG BOOK

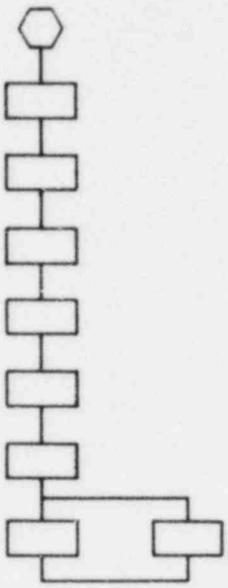
RETURN TO SERVICE



- VERIFY ALL SWITCHES AND VALVES IN CORRECT POSITION
- VERIFY BASIN LEVEL $\geq$ 58%
- VERIFY STRAINER BLOW DOWN VALVE OPEN
- VERIFY DOWN STREAM OF SYSTEM OUTLET OPEN
- SLOWLY OPEN FILTER OUTLET VALVE
- VERIFY SKIMMER INLET AND BASIN RETURN VALVES OPEN
- PLACE HOLD/FILTER SWITCH TO FILTER POSITION
- SYSTEM OUTLET VALVE OPENS, RECIRCULATION VALVE CLOSES
- IF PROBLEMS ARE ENCOUNTERED, PERFORM THREE SYSTEM CHECKS
- IF PROBLEM PERSISTS, INFORM OPERATIONS SUPERVISOR
- WHEN SYSTEM RETURNS TO SERVICE CHECK PRESSURE ACROSS STRAINER, IF THERE IS A FLOW PROBLEM PERFORM STRAINER OPERATION
- TAKE APPROPRIATE READINGS AND RECORD IN BASIN FILTER LOG

FIRST OPERATIONS TECHNICIAN | SECOND OPERATIONS TECHNICIAN

VACUUM CLEANER OPERATIONS



BASIN LEVEL MUST BE >58%

CLOSE VACUUM SWEEPER TO FILTER SYSTEM VALVE

CONNECT VACUUM CLEANER HOSE TO SWEEPER HEAD

CONNECT OTHER END TO DESIRED VACUUM CONNECTION

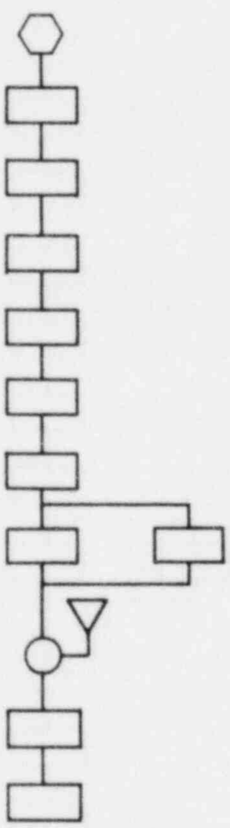
RECORD FLOW RATE OF FILTER VESSEL AND STRAINER DIFFERENTIAL PRESSURE IN BASIN FILTER LOG

VERIFY VACUUM HEAD IS BELOW WATER LEVEL

OPEN VACUUM SWEEPER TO FILTER SYSTEM VALVE

THROTTLE SKIMMER TO FILTER SYSTEM VALVE, SECOND OPERATIONS TECHNICIAN MONITORS FLOW RATE

CASK CAVITY CLEANING



BASIN LEVEL >58%

CLOSE VACUUM SWEEPER TO FILTER SYSTEM VALVE

REMOVE SWEEPER HEAD

ATTACH CLEANING WAND OR TOOL

RECORD FLOW RATE OF FILTER VESSEL AND STRAINER DIFFERENTIAL PRESSURE IN BASIN FILTER LOG

VERIFY VACUUM SWEEPER HEAD IS BELOW WATER LEVEL

OPEN VACUUM SWEEPER TO FILTER SYSTEM VALVE

THROTTLE SKIMMER TO FILTER SYSTEM VALVE, SECOND OPERATIONS TECHNICIAN MONITORS FLOW RATE

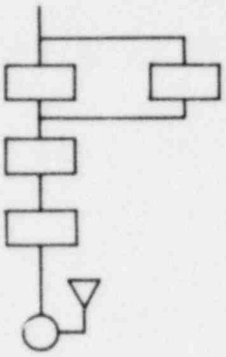
RECORD READINGS IN BASIN FILTER LOG

CLEAN CASK INTERIOR

MONITOR: FLOW RATE OF FILTER VESSEL, RADIATION

FIRST OPERATIONS TECHNICIAN	SECOND OPERATIONS TECHNICIAN

RETURN OF FILTER SYSTEM TO NORMAL OPERATIONS



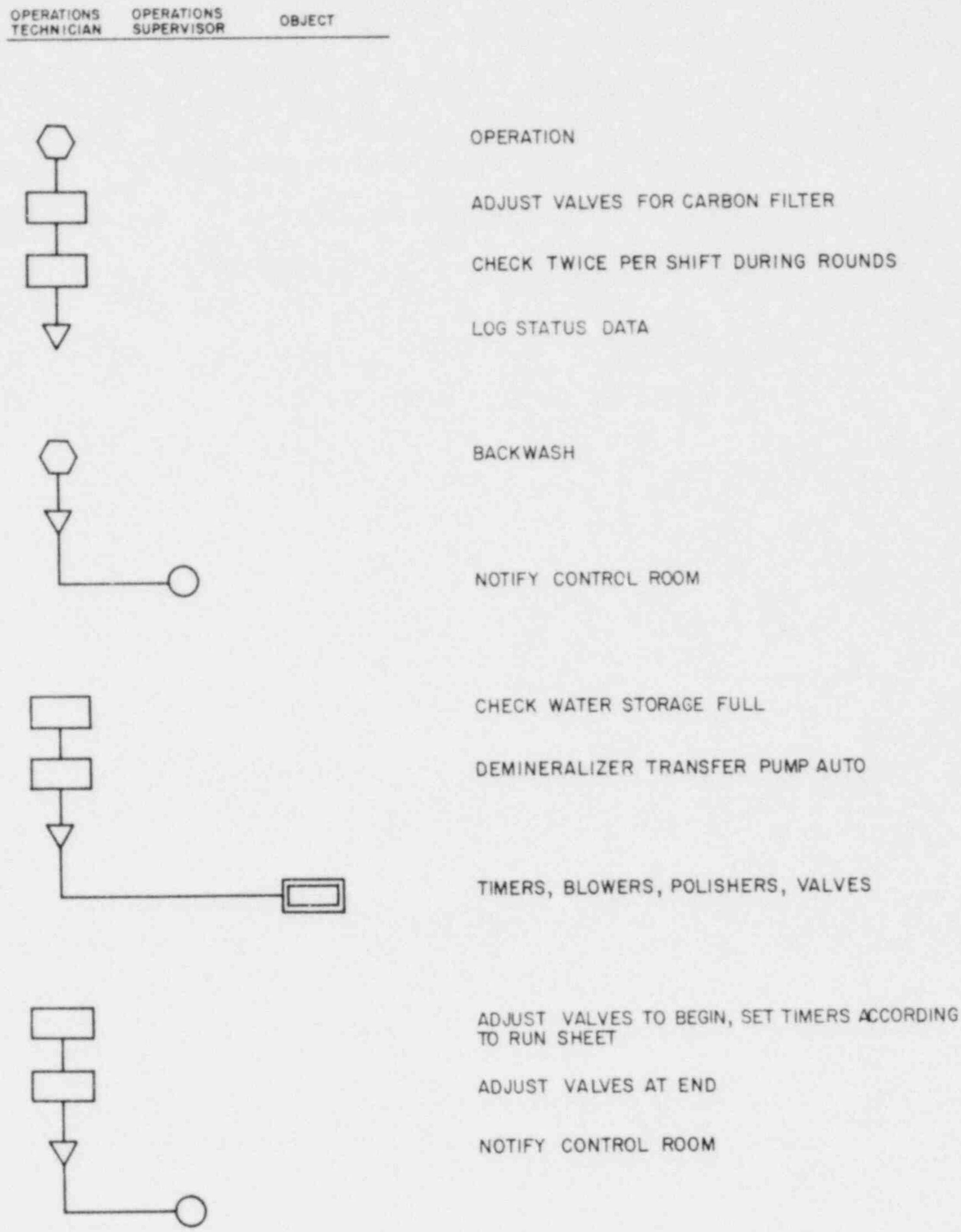
OPEN SKIMMER VALVE TO FILTER SYSTEM, SECOND OPERATIONS TECHNICIAN MONITORS FLOW RATE

ALLOW SYSTEM FLOW TO STABILIZE

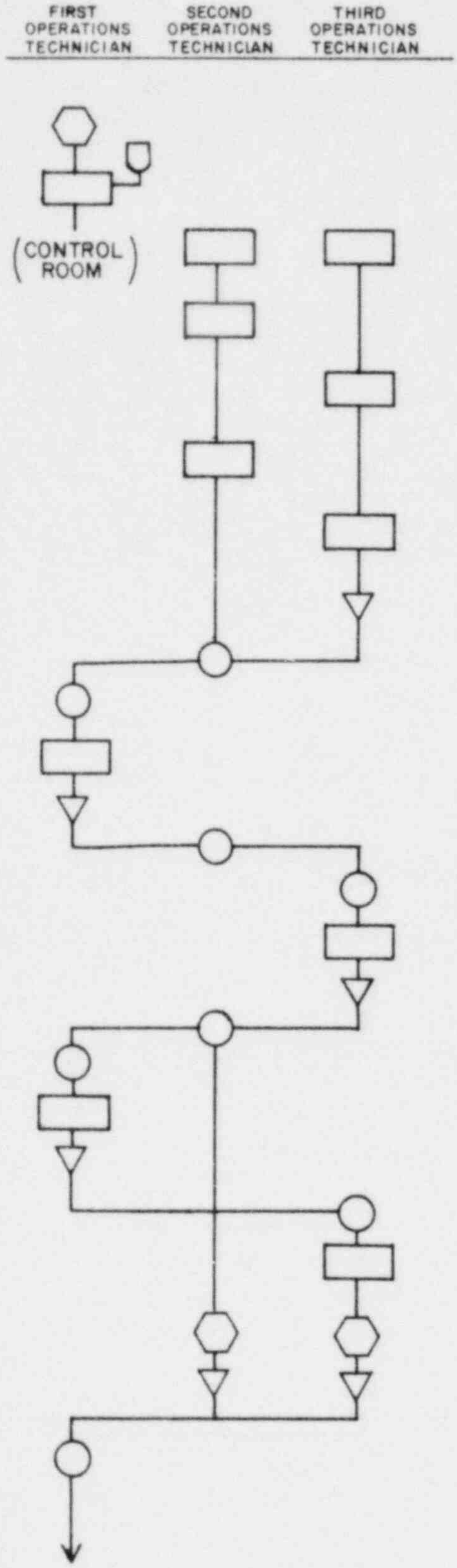
CLOSE VACUUM SWEEPER TO FILTER SYSTEM VALVE

RECORD READINGS IN BASIN FILTER LOG

DEMINERALIZER UNIT OPERATION



LAW EVAPORATOR SYSTEM OPERATION



DETERMINE SYSTEMS OPERABLE AND PERSONNEL AVAILABLE WITH COMMUNICATION

DON RADIATION PROTECTION GARMENTS

GO TO CANYON

GO TO LAW MAINTENANCE PIT

REMOVE OFF-GAS COVER, ENGAGE CANYON CRANE

OPEN VALVE

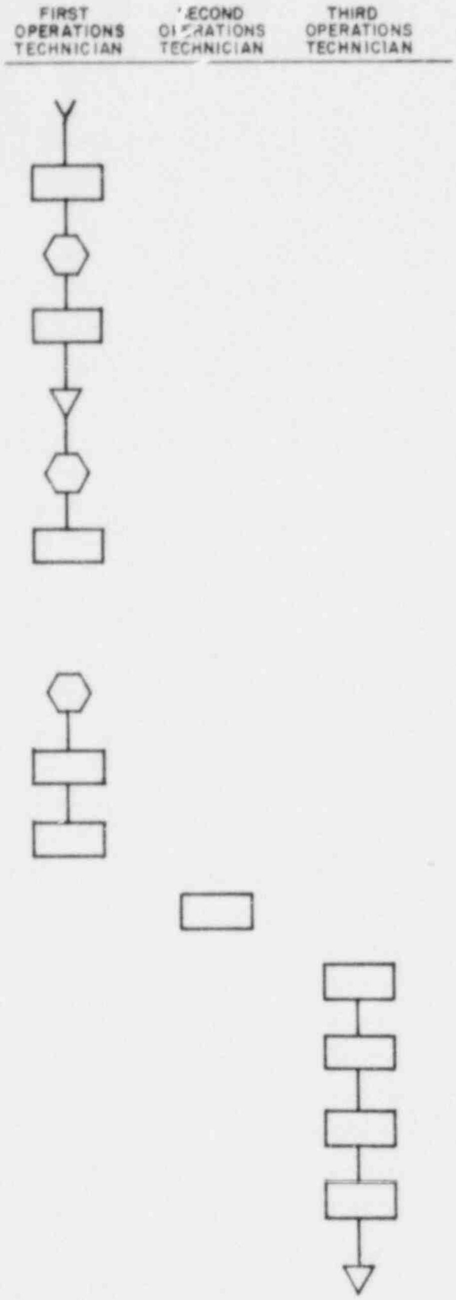
TURN ON P-570, SET VALVES

CHECK PUMP OPERATION

CHECK LEVEL

CHECK FLOW, LEAKS

LEAVE CANYON



CONTROL LEVEL DENSITY AND VAPOR PRESSURES

REDUCE STEAM, SAMPLE DENSITY AND JET OFF-GAS CELL SUMP ONCE PER SHIFT

LOG DATA EVERY TWO HOURS

SHUTDOWN

ADJUST VALVES AND PUMPS TO FLUSH

EXTENDED SHUTDOWN

ADJUST VALVES AND PUMPS TO FLUSH

SHUTDOWN P570

ENTER CANYON

ENTER OFF GAS CELL, CLOSE VALVE

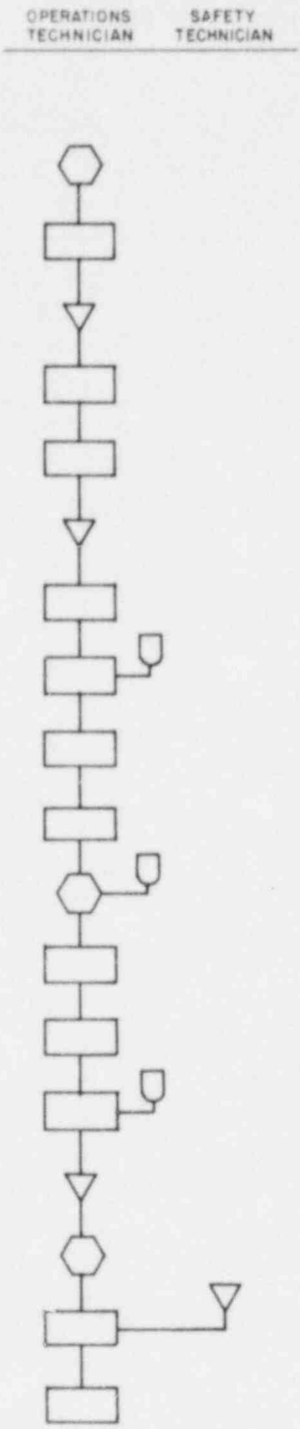
ADD DEMINERALIZED WATER

CHECK FLOW RATE

OPEN VALVES

COMPLETE CHECKLIST

ELECTRODECONTAMINATION OPERATION



DETERMINE THAT TOOL OR ITEM REQUIRES DECONTAMINATION

PRE-CLEAN AT DECONTAMINATION PAD; PAINTSTRIP; DEGREASE

LOG CONTAMINATION LEVEL

NOTE SURFACE AREA, CALCULATE CURRENT

CHECK POWER SUPPLY

PLACE WARNING SIGNS

CLOSE LOCAL RECTIFIER DISCONNECT

INSURE ADEQUATE CATHODES AND ACID LEVEL

DON SAFETY EQUIPMENT

LOWER PIECE INTO ACID, PUSH LOCAL "ON"

ADJUST VOLTAGE AND CURRENT TO PROPER LEVELS

POWER TO ZERO

REMOVE AND RINSE OVER ACID

DIP TO RINSE, DRY, CHECK CONTAMINATION

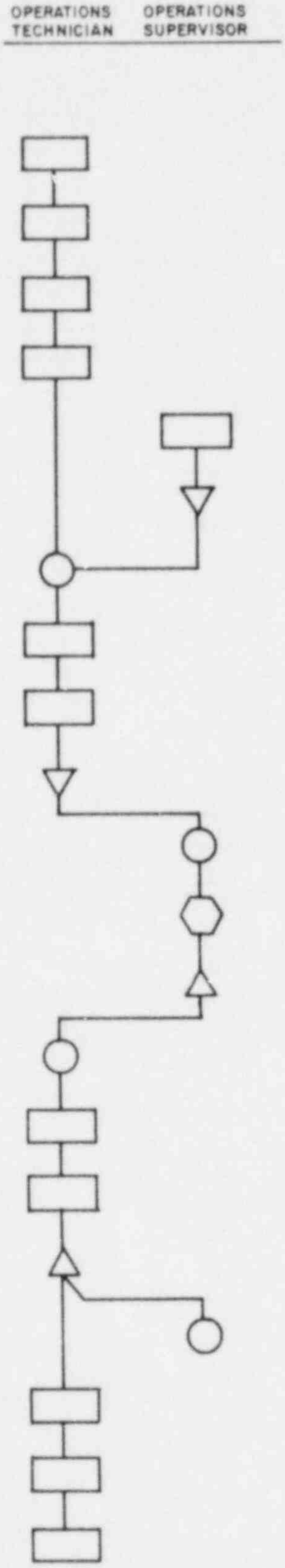
LOG CONTAMINATION

REPEAT AS REQUIRED

PLANT SAFETY MUST RELEASE ITEM

STORE DATA SHEET

BASIN LEAK DETECTION SYSTEM OPERATION



LEVEL CONTROLLER SWITCH TO 'HAND' POSITION

STEAM SUPPLY VALVE TO JET

OPEN JET VALVE

TURN ON POWER SWITCH

APPOINT SAMPLES

TELLS OPERATIONS TECHNICIAN TO START SAMPLING PROCEDURE

OBTAINS SURGICAL GLOVES

ATTACH TUBING TO BASIN SYSTEM

ASK SUPERVISOR FOR PERMISSION TO COLLECT SAMPLE

SUPERVISOR DECIDES ON PERMISSION,
AND TELLS OPERATIONS TECHNICIAN

JET OUT SYSTEM

OPEN JET SUCK VALVE AFTER SUFFICIENT FLOW

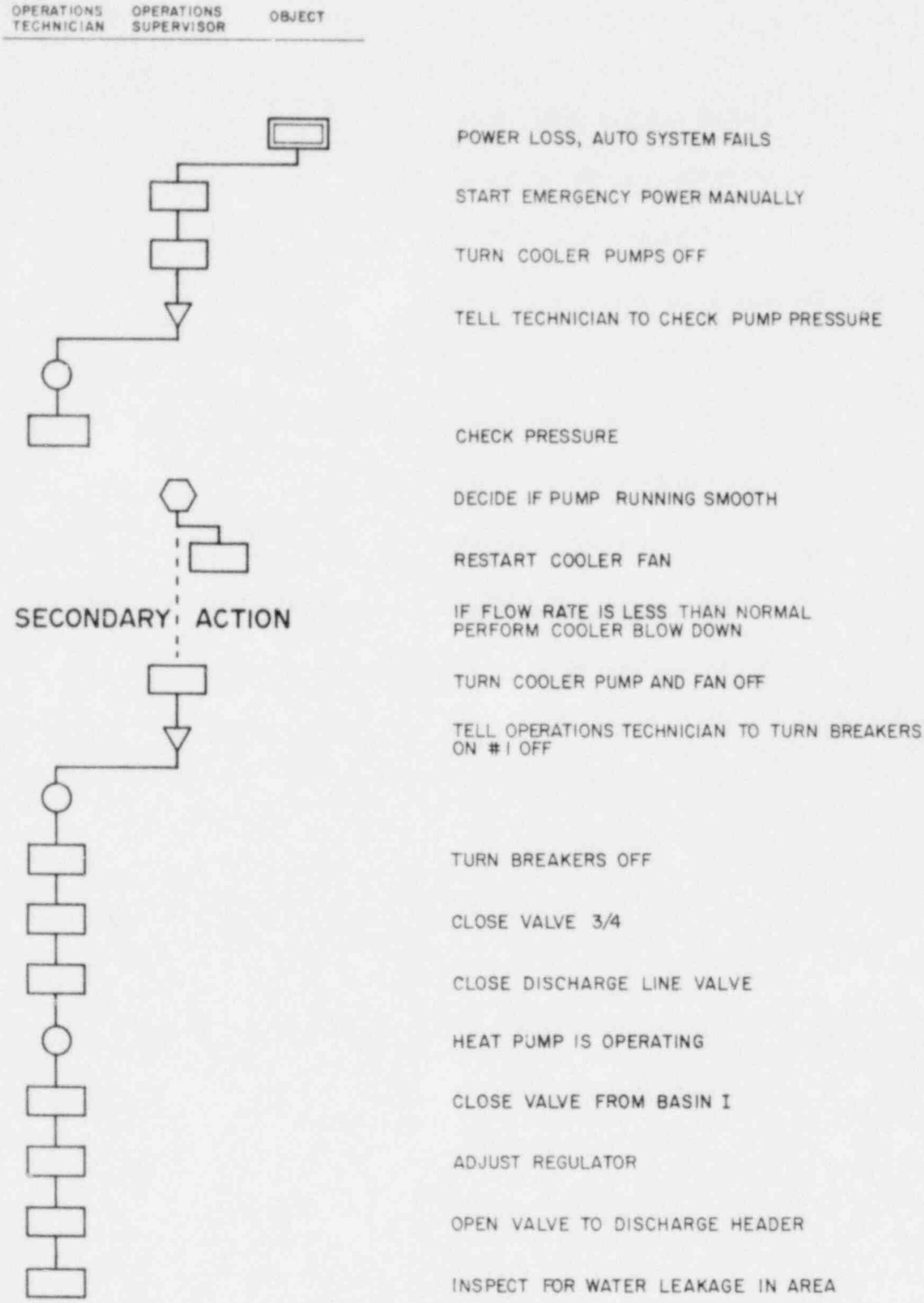
INFORM CRO SAMPLE TAKEN

PUT SAMPLE IN CONTAINER AND TRANSFER

CLEAN SAMPLE BOX

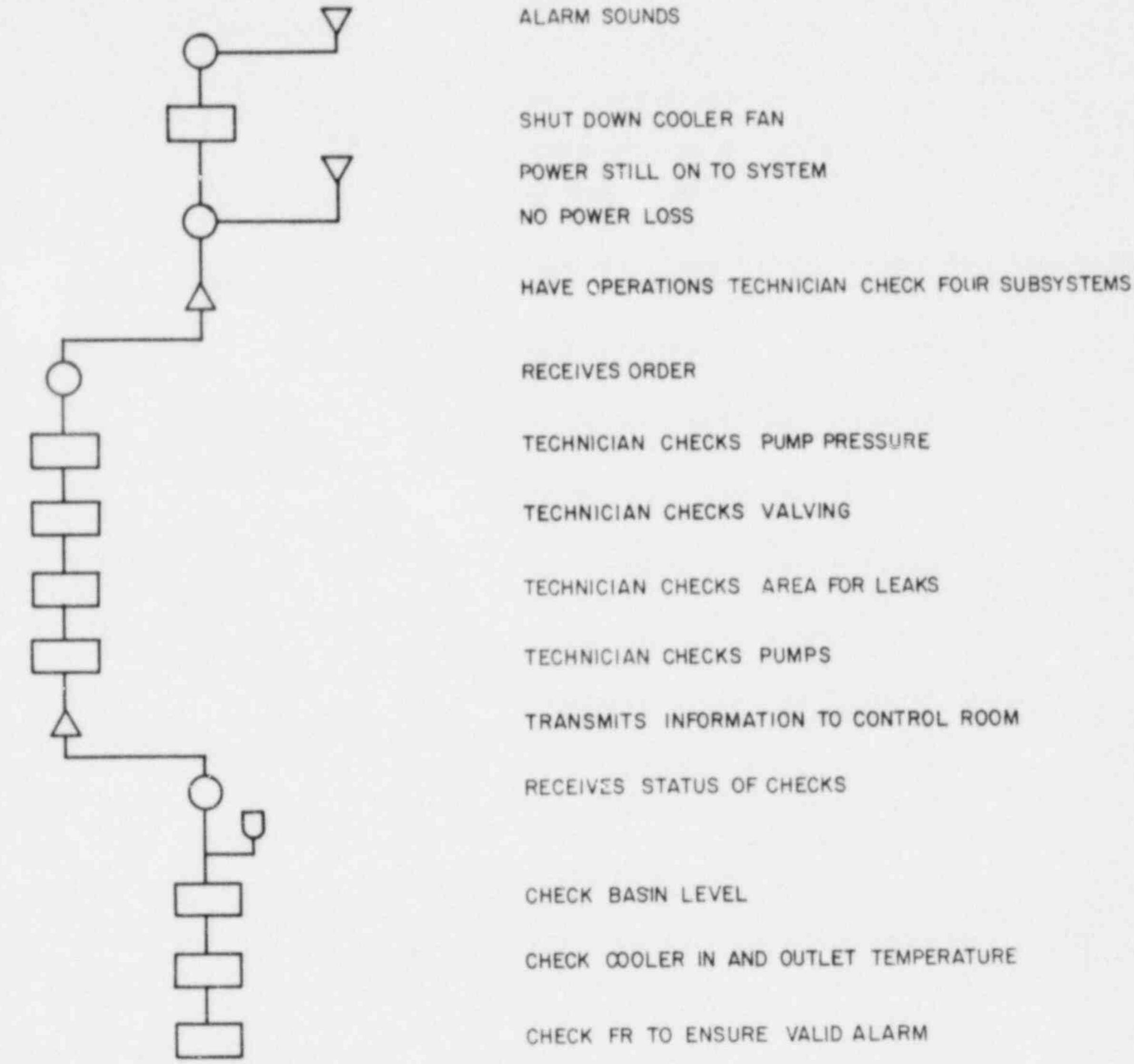
LOG SAMPLE CHECKS, FORWARD TO OPERATIONS ENGINEER

EMERGENCY ACTION FOR BASIN COOLERS

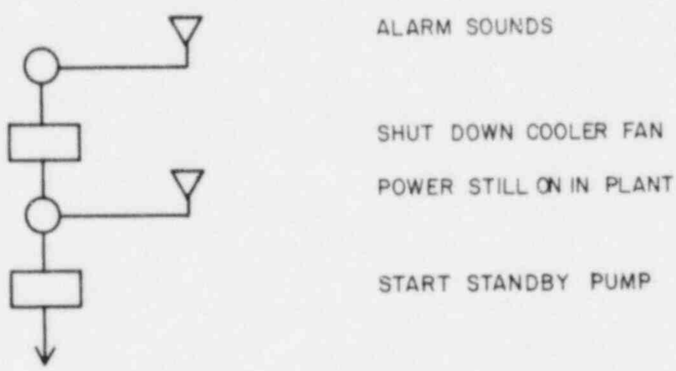


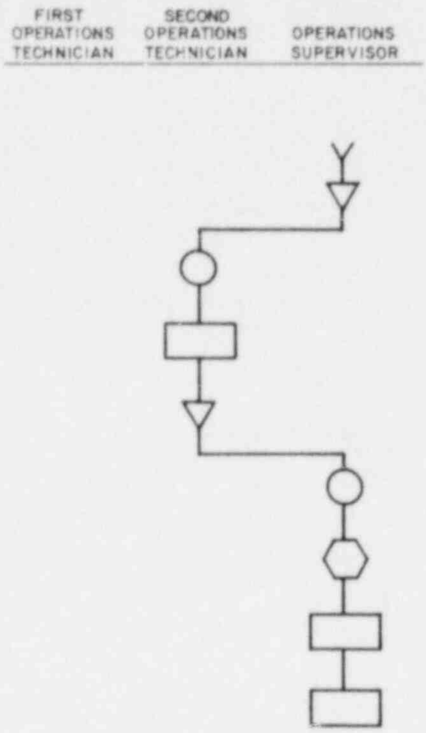
OPERATIONS TECHNICIAN | OPERATIONS SUPERVISOR | OBJECT

LOW FLOW ALARM



P-102-3 OR 4 SHUTDOWN ALARM





HAVE OPERATIONS TECHNICIAN CHECK PUMP VALVING

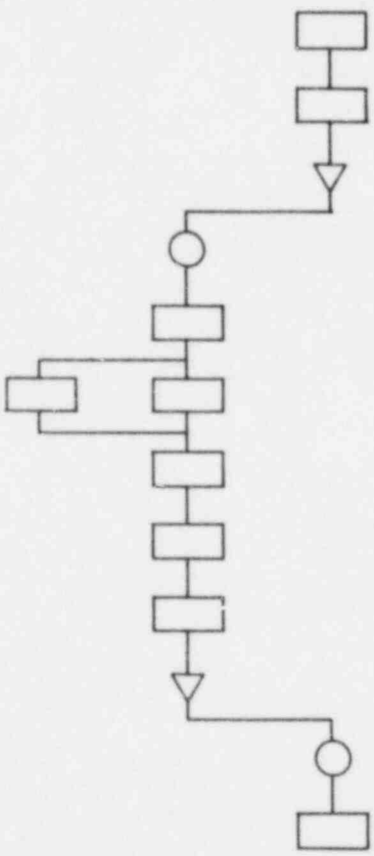
CHECK VALVING, TRANSMIT STATUS

DECIDE IF PUMP IS RUNNING CORRECTLY

RESTART FANS IF PUMPS ARE RUNNING CORRECTLY

IF PUMPS CANNOT BE STARTED, OR IF FLOW IS LESS THAN NORMAL GO TO SECONDARY ACTION

TERTIARY ACTION



TURN BASIN PUMPS AND FANS OFF

TAG CONTROLS

TELL OPERATIONS TECHNICIANS TO HEAT AREA

COVER COOLERS WITH TARPS

COVER FAN OPENINGS WITH PLASTIC SHROUD

LIGHT SPACE HEATERS AT SHROUD AREAS

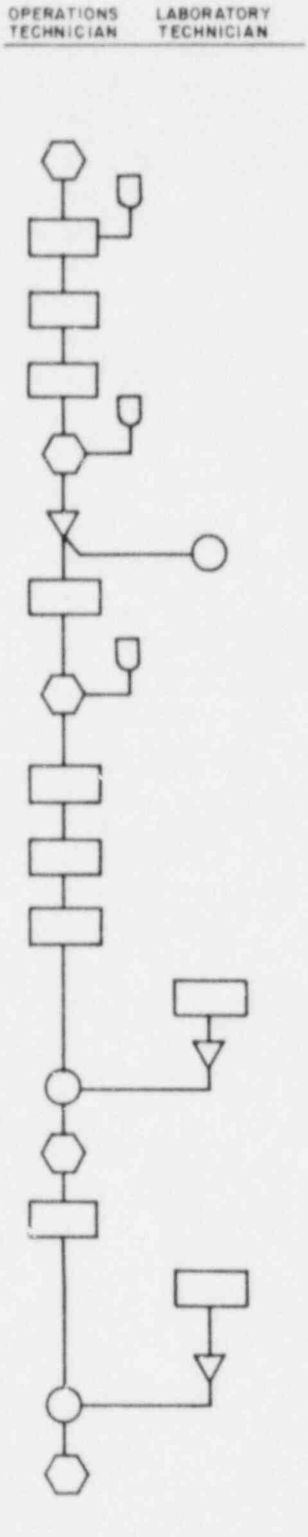
MONITOR AREA EVERY HOUR

MONITOR COOLER LINE TEMPERATURE FOR HEATING

TRANSMIT INFORMATION TO SUPERVISOR

ASSESS INFORMATION

HANDLING OF CASKS CONTAINING LEAKING OR FAILED FUEL



SUSPECT LEAK I-35

EVACUATE PERSONNEL FROM HAZARDOUS AREAS

FLUSH CASK

OBTAIN COOLANT SAMPLE AND VISUAL CHECK

IF PARTICULATE MATTER, GET LABORATORY TECHNICIAN TO FILTER

GM TUBE TEST DEVICE CHECK

IF RESULT >50,000 CPM, THEN CHECK GAMMA ISOTOPE

FILL CASK FULL OF WATER

VENT CASK AND MONITOR TEMPERATURE

TAKE SAMPLE

CHECK FOR CESIUM

RECEIVE CESIUM ANALYSES

IF <2.5 RETURN TO CASK TURNAROUND PROCEDURES, IF NOT CONTINUE

TAKE SAMPLE

CHECK FOR CESIUM

RECEIVE ANALYSES

IF STILL >2.5 FLUSH CASK AND REPEAT CHECKS ONCE
IF <2.5 RETURN TO CASK TURNAROUND PROCEDURES
IF STILL >2.5 NOTIFY HIGHER MANAGEMENT

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APPENDIX C

GENERAL ELECTRIC MORRIS OPERATION DOCUMENTS REVIEWED

Retraining Instructions Manual

Plant Operations Training Manual Plant Operations Training Plan, including scripts and audio-visual aids.

Emergency Brigade Training Manual

MOIs Reviewed:

Expecially	Subject
MOI-155	Training
MOI-305	Criticality Evacuation
MOI-606	Training Program for Plant Operations
MOI-911	Safety Training

Although safety and security training was provided to SRL personnel, security training documentation was not available for review due to an inability to establish an acceptable need to know.

The following SOPs were reviewed in detail:

1-3	Cask Handling
1-7	Fuel Handling
1-11	Cask Testing
1-12	Cask Turnaround
1-20	Basin Filter Operation
1-22	Basin Cooling
1-24	Emergency Cooling
1-27	Basin Leak Detection
1-35	Leaking Casks
1-49	Crane Operation
5-2	LAW Evaporator
7-3	Rounds
8-2	Demineralizer Operation
10-1	Electrodecontamination
16-10	Basin Water Analysis Compliance Test
No SOP	Control Room Operation

Additional Documents Review:

NRC 10 CFR 72 Licensing Requirements for the Storage of Spent Fuel in an Independent Fuel Spent Storage Installation, Attachment F of Application for Licensing under 10 CFR 72. Operator Training and Certification Program - Morris Operation.

NEDG 21889 Spent Fuel Receipt and Storage at the Morris Operation, Astrom, KA and Eger, KJ June 1978 Sandia Contract 05-9189.

NEDO 21894 Radiological Emergency Plan, September 1980.

NUREG/CR-0956 Commentary on Spent Fuel Storage at Morris Operation, Eger, K.J. and Zima, G.E. July 1979 Battelle NW Lab

NUREG 0709 Safety Evaluation Report July 1981.

Wargo, J. R. "Spent Fuel Options." Nuclear Industry, May 1981, 28, 6-10.

Results of biennial exams

APPENDIX D

BIOGRAPHICAL AND MORRIS OPERATION INFORMATION FOR OPERATIONS TECHNICIANS
(from the Task Inventory Background Information Section)

This appendix contains summary statistics from the Task Inventory Background Information Section for the Operations Technicians. Statistics include the number of respondents, maximum and minimum response, the mean, and standard deviation. The first seven responses concern biographical and job perception issues. Time spent performing various activities comprise the remainder of the responses. The last column provides an interpretation, based on the mean response, and is adapted from the response scales in the Background Information section of the Task Inventory.

	N	Maximum	Minimum	Mean	Standard Deviation	Interpretation
Time in Present Job (years)	13	11	1	7.3	3.3	--
Time in Nuclear Related Jobs (years)	12	19	2	9.9	5.5	--
Highest Grade Completed	13	16	12	13.6	1.7	--
Age	13	60	31	41.0	8.0	--
What do you think of your job	13	6	5	5.2	0.4	Fairly interesting
How does your job use your talents	13	5	3	4.3	0.8	Quite well
How well does your training fit your job	13	7	3	5.0	1.0	Very well
How much time do you spend performing activities below:						
Rounds	12	6	3	5.0	1.1	Slightly above average
Cask Preparation for shipment (IF-300)	12	7	2	4.0	1.6	About average
Demineralizer Operstions	12	6	2	4.0	1.2	About average
Cask Unloading (IF-300)	12	7	1	4.1	2.0	About average
Fuel Handling/Storage	12	7	2	4.8	1.4	Slightly above average
Basin Cooling Operations	12	6	1	3.3	1.7	Slightly below average
Hydrostatic Cask Testing	12	6	1	2.9	1.9	Slightly below average

	N	Maximum	Minimum	Mean	Standard Deviation	Interpretation
Crane Operations	12	7	3	4.9	1.2	Slightly above average
Basin Filter Operations	12	7	1	3.5	1.8	About average
LAW Vault Evaporation	12	7	1	3.8	1.7	About average
Control Room Operations	13	7	1	4.3	1.6	About average
Basin Leak Detection	12	7	1	3.1	3.1	Slightly below average
Electrodecontamination	12	7	1	3.3	1.9	Slightly below average
Dealing with Leaking Casks (IF-300)	9	7	1	2.6	2.0	Slightly below average
Basin Water Analysis Compliance Test	12	6	1	3.5	1.7	About average
Emergency Cooling	9	6	1	3.2	2.0	Slightly below average
Training, Studying, Practicing	13	6	1	4.1	1.2	About average
Routine Housekeeping	13	7	2	4.6	1.5	Slightly above average
Helping with Experiments	12	6	1	3.6	1.4	About average
Accountability	11	6	1	3.3	1.4	Slightly below average
Writing SOPs or Training Material	13	7	1	3.6	1.8	About average
Handling Solid Wastes (Barrels)	12	7	2	4.4	1.5	About average

	N	Maximum	Minimum	Mean	Standard Deviation	Interpretation
Taking Breaks or Waiting for Tasks	12	7	1	3.5	1.5	About average
Working with Basin Pumps	12	6	1	3.1	1.7	Slightly below average
Operating Utilities (Air, Water)	12	7	2	3.9	1.5	About average
Filling Out Forms, Checklists	13	7	1	4.3	1.9	About average

APPENDIX E

TASK INVENTORY DATA SUMMARY

This appendix includes summary statistics for all 217 tasks which are grouped under the corresponding activity. The statistics are listed by the six Task Inventory variables for each of the tasks. Statistics include the number of certified individuals responding to each task (N), the minimum and maximum response, and the mean and standard deviation of the responses. For error-new-person, the statistic indicated is the total number of predicted errors for the task and not the mean.

Note that the error and predicted error measures were obtained with scales different from the other variables. The error response scale was constructed in an inverse direction to the other scales while the predicted errors was the number of times that respondents selected each as being more error likely for novice personnel. All of the response scales and the Task Inventory are presented in Appendix A.

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
CASK UNLOADING							
Position Rail Switches and Gates	N	24	24	24	24	24	24
	Minimum	1	1	1	2	2	
	Maximum	4	4	5	4	5	
	Mean	2.6	2.1	2.9	3.1	4.7	8.0
	Standard Deviation	1.1	1.0	1.1	0.6	0.6	
Operate Rail Car Brakes, Chocks, and Couplings	N	24	24	24	24	24	24
	Minimum	1	1	1	2	2	
	Maximum	6	5	4	5	5	
	Mean	2.9	2.4	2.9	3.6	4.5	12.0
	Standard Deviation	1.2	1.2	1.0	1.0	0.7	
Operate ISCO to Move Rail Car	N	23	23	24	24	24	24
	Minimum	1	1	2	2	2	
	Maximum	5	5	5	5	5	
	Mean	3.2	2.7	3.7	3.2	4.3	13.0
	Standard Deviation	1.1	1.2	1.1	0.7	0.8	
Survey Radiation of Car, Cask, and Head	N	23	22	24	24	24	24
	Minimum	1	1	2	2	1	
	Maximum	5	6	5	4	5	
	Mean	2.3	2.4	3.6	3.1	4.0	10.0
	Standard Deviation	1.2	1.5	0.9	0.8	1.2	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Dismantle IF-300 to Access Cask	N	24	24	24	24	24	24
	Minimum	1	1	2	2	1	
	Maximum	4	7	6	5	5	
	Mean	3.4	3.3	3.8	4.0	4.4	7.0
	Standard Deviation	0.9	1.4	1.1	0.8	1.0	
Operate Crane and Trunnion	N	24	24	24	24	24	24
	Minimum	2	1	2	2	1	
	Maximum	6	5	5	5	5	
	Mean	3.7	3.2	3.6	3.9	4.6	8.0
	Standard Deviation	1.0	1.1	5.0	0.8	0.9	
Lift and Move Cask to Basin	N	24	24	24	24	23	24
	Minimum	2	1	2	2	3	
	Maximum	5	6	5	5	5	
	Mean	3.5	3.2	3.9	3.6	4.8	12.0
	Standard Deviation	0.9	1.2	0.8	0.7	0.4	
Remove Cask from Basin with Crane	N	24	24	24	24	23	24
	Minimum	2	1	2	2	3	
	Maximum	5	6	6	5	5	
	Mean	3.5	3.4	4.0	3.6	4.8	10.0
	Standard Deviation	0.9	1.2	0.8	0.8	0.4	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Sample Coolant	N	24	24	24	24	24	24
	Minimum	1	1	1	2	2	
	Maximum	4	4	4	5	5	
	Mean	3.1	2.5	2.8	3.3	4.5	6.0
	Standard Deviation	1.0	1.2	0.9	0.7	0.7	
Check Pressures and Temperature of Cask	N	24	24	24	24	23	24
	Minimum	1	1	2	2	2	
	Maximum	5	4	5	4	5	
	Mean	3.4	2.7	2.9	3.1	4.3	8.0
	Standard Deviation	1.0	1.2	0.8	0.6	0.78	
Flush Cask, Venting to LAW Vault	N	24	24	24	24	23	24
	Minimum	1	1	2	1	3	
	Maximum	5	6	5	4	5	
	Mean	3.3	3.2	3.2	3.2	4.7	6.0
	Standard Deviation	1.0	1.2	0.8	0.3	0.5	
Remove Road Grime	N	24	24	24	24	23	24
	Minimum	2	1	1	2	3	
	Maximum	6	5	5	5	5	
	Mean	3.7	3.3	3.0	3.0	4.7	1.0
	Standard Deviation	1.1	1.2	1.0	0.8	0.7	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Unbolt and Remove Cask Head	N	24	24	24	24	24	24
	Minimum	2	1	3	2	2	
	Maximum	6	7	6	6	5	
	Mean	3.6	3.9	4.7	3.8	4.4	10.0
	Standard Deviation	1.1	1.5	0.7	0.9	0.9	
Install Cask Head	N	24	24	24	24	24	24
	Minimum	1	1	3	2	2	
	Maximum	6	7	7	6	5	
	Mean	3.5	3.6	4.8	3.5	4.2	11.0
	Standard Deviation	1.1	1.3	0.8	0.8	1.0	
Decontaminate Head, Cask, and Trunnion	N	24	24	24	24	23	24
	Minimum	2	1	2	2	2	
	Maximum	7	7	7	5	5	
	Mean	4.2	4.7	4.6	3.5	4.0	4.0
	Standard Deviation	1.3	1.6	1.1	0.8	1.1	
Perform Pressurization Check	N	24	24	24	24	23	24
	Minimum	1	1	1	2	2	
	Maximum	6	4	5	5	5	
	Mean	3.3	2.8	3.3	3.4	4.4	8.0
	Standard Deviation	1.2	1.2	0.8	0.7	0.8	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Install Lock Wires	N	23	23	23	23	23	23
	Minimum	1	1	1	1	3	
	Maximum	5	4	4	4	5	
	Mean	3.3	2.5	2.3	2.7	4.3	1.0
	Standard Deviation	1.1	1.1	0.7	0.8	0.6	
Complete IF-300 Checklist (initials and date)	N	23	23	23	23	23	23
	Minimum	1	2	1	1	1	
	Maximum	7	6	5	4	5	
	Mean	4.0	3.7	2.8	1.6	3.7	9.0
	Standard Deviation	1.5	1.1	1.0	0.8	1.3	
Accomplish Other Tasks (if any)	N	14	14	14	14	14	14
	Minimum	2	1	1	1	2	
	Maximum	6	4	4	4	5	
	Mean	3.8	3.5	3.2	3.0	4.4	2.0
	Standard Deviation	1.0	1.0	0.9	1.2	0.9	
CRANE OPERATIONS							
Check Operations	N	23	23	23	23	23	23
	Minimum	1	1	1	1	1	
	Maximum	6	6	4	4	5	
	Mean	3.9	3.2	2.8	2.3	4.3	4.0
	Standard Deviation	1.2	1.5	0.8	0.9	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Hook Load	N	24	24	24	24	24	24
	Minimum	1	1	2	2	3	
	Maximum	7	6	5	5	5	
	Mean	3.5	3.3	3.4	3.4	4.1	10.0
	Standard Deviation	1.1	1.1	0.9	0.8	0.7	
Lift Load Vertically	N	24	24	24	24	24	24
	Minimum	1	1	2	2	3	
	Maximum	6	6	5	5	5	
	Mean	3.6	3.3	3.0	3.5	4.6	5.0
	Standard Deviation	1.0	1.2	0.8	0.7	0.6	
Move the Load from Location to Location	N	24	24	24	24	24	24
	Minimum	2	1	1	2	3	
	Maximum	6	6	4	5	5	
	Mean	3.7	3.6	3.0	3.6	4.5	3.0
	Standard Deviation	0.9	1.1	1.0	0.8	0.6	
Place the Load in Wanted Area	N	24	24	24	24	24	24
	Minimum	1	1	1	2	2	
	Maximum	6	5	4	5	5	
	Mean	3.6	3.2	3.2	3.6	4.3	3.0
	Standard Deviation	0.9	1.0	0.9	0.7	0.7	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Unhook Load from Crane	N	24	24	24	24	24	24
	Minimum	1	1	2	1	1	
	Maximum	7	6	5	4	5	
	Mean	3.6	3.1	3.2	3.3	4.3	3.0
	Standard Deviation	1.0	1.2	0.8	0.8	1.0	
Perform Small Movements	N	24	24	24	24	24	24
	Minimum	1	1	1	2	1	
	Maximum	6	5	5	4	5	
	Mean	3.5	3.0	3.4	3.1	4.3	5.0
	Standard Deviation	1.1	1.2	0.9	0.7	0.9	
Inspect the Conditions of Cables and Welds	N	24	24	24	24	23	24
	Minimum	1	1	1	1	3	
	Maximum	7	7	5	4	5	
	Mean	3.4	3.2	3.0	2.5	4.4	7.0
	Standard Deviation	1.5	1.4	1.0	0.8	0.7	
Change Hooks and Slings	N	24	24	24	24	24	24
	Minimum	1	1	1	2	3	
	Maximum	7	6	5	5	5	
	Mean	3.3	3.2	3.5	3.4	4.2	6.0
	Standard Deviation	1.3	1.2	0.9	0.8	0.7	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Complete Forms	N	24	24	22	23	23	24
	Minimum	1	1	1	1	2	
	Maximum	6	6	4	4	5	
	Mean	3.4	3.0	3.7	1.5	4.0	6.0
	Standard Deviation	1.5	1.5	0.9	0.7	1.1	
Accomplish Other Tasks (if any)	N	14	14	14	14	14	14
	Minimum	1	1	1	1	2	
	Maximum	5	4	4	4	5	
	Mean	3.1	3.0	3.3	3.0	4.5	0.0
	Standard Deviation	1.2	1.3	0.9	1.0	0.9	
FUEL REMOVAL AND STORAGE							
Operate Crane for Basket Moving	N	24	24	24	24	23	24
	Minimum	2	2	2	2	1	
	Maximum	6	5	5	5	5	
	Mean	4.0	3.5	3.6	3.3	4.1	9.0
	Standard Deviation	1.3	0.9	0.8	0.9	1.1	
Engage Fuel Grapple	N	24	24	24	24	24	24
	Minimum	1	1	2	2	1	
	Maximum	6	5	5	5	5	
	Mean	3.6	3.2	4.0	3.4	4.4	9.0
	Standard Deviation	1.0	1.1	1.0	0.7	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Remove Fuel from Basket	N	24	24	24	24	24	24
	Minimum	1	1	2	2	2	
	Maximum	6	6	5	6	5	
	Mean	3.3	3.0	3.9	3.7	4.7	13.0
	Standard Deviation	1.2	1.3	0.7	1.0	0.6	
Place Fuel in Basket	N	24	24	24	24	24	24
	Minimum	1	1	2	2	2	
	Maximum	6	6	5	6	5	
	Mean	3.5	3.4	4.0	3.7	4.7	12.0
	Standard Deviation	1.1	1.3	0.8	1.0	0.6	
Disengage Fuel Grapple (normal operation)	N	24	24	24	24	24	24
	Minimum	1	1	1	2	3	
	Maximum	4	5	4	4	5	
	Mean	3.3	2.8	3.2	3.3	4.7	5.0
	Standard Deviation	1.0	1.2	0.9	0.7	0.5	
Disengage Fuel Grapple Manually	N	23	23	24	24	24	24
	Minimum	1	1	2	2	4	
	Maximum	4	7	7	6	5	
	Mean	2.0	2.7	5.1	4.3	4.9	10.0
	Standard Deviation	1.4	2.0	1.3	0.9	0.2	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Identify Fuel Bundles	N	24	24	24	24	24	24
	Minimum	1	1	2	1	2	
	Maximum	7	5	6	4	5	
	Mean	3.9	3.4	4.0	2.4	4.2	4.0
	Standard Deviation	1.2	1.1	1.1	0.9	0.9	
Lower and Raise Pit Guard	N	24	24	24	24	23	24
	Minimum	1	1	1	1	3	
	Maximum	6	5	5	5	5	
	Mean	3.2	2.7	2.8	2.8	4.8	3.0
	Standard Deviation	1.3	1.3	1.3	1.1	0.4	
Place Basket in Storage Grid Location	N	24	24	24	24	24	24
	Minimum	1	2	2	2	4	
	Maximum	6	5	5	5	5	
	Mean	3.5	3.4	3.8	3.2	4.5	10.0
	Standard Deviation	1.0	0.9	0.8	0.8	0.5	
Complete Paperwork, Checklists, and Logs	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	7	5	4	5	
	Mean	4.1	3.7	3.0	1.5	3.5	13.0
	Standard Deviation	1.0	1.3	1.0	0.7	1.2	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Accomplish Other Tasks (if any)	N	14	14	14	14	14	14
	Minimum	2	1	1	1	2	
	Maximum	4	4	4	5	5	
	Mean	3.3	3.4	3.2	3.1	4.2	0.0
	Standard Deviation	0.8	1.0	0.9	1.2	1.1	
HYDROSTATIC TESTING							
Add Demineralized Water to Cask	N	24	24	24	24	23	24
	Minimum	1	1	1	2	3	
	Maximum	5	6	4	4	5	
	Mean	2.8	3.4	2.8	2.9	4.7	2.0
	Standard Deviation	1.3	1.5	0.9	0.6	0.5	
Pressurize Cask	N	24	24	24	24	24	24
	Minimum	1	1	1	2	2	3
	Maximum	6	7	5	5	5	
	Mean	3.1	3.6	3.1	3.4	4.6	4.0
	Standard Deviation	1.4	1.5	2.0	0.7	0.5	
Inspect for Leaks, Pressures, Temperatures	N	24	24	24	24	24	24
	Minimum	1	1	1	2	3	
	Maximum	7	6	4	4	5	
	Mean	3.3	3.3	3.1	3.1	4.7	2.0
	Standard Deviation	1.1	1.4	0.9	0.7	0.5	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Attach Hydrostatics Pump; Pressurize, Disconnect	N	24	24	24	24	24	24
	Minimum	1	1	1	2	3	
	Maximum	7	7	5	5	5	
	Mean	2.8	3.2	3.7	3.6	4.5	8.0
	Standard Deviation	1.5	2.7	0.9	0.7	0.6	
Obtain QA Releases	N	23	23	23	23	22	23
	Minimum	1	1	1	1	4	
	Maximum	5	6	4	4	5	
	Mean	2.7	2.5	3.0	1.8	4.9	0.0
	Standard Deviation	1.3	1.4	0.9	0.9	0.2	
Check LAW Vault	N	23	23	23	23	22	23
	Minimum	1	1	1	1	3	
	Maximum	5	5	5	6	5	
	Mean	2.7	2.3	2.9	2.6	4.5	2.0
	Standard Deviation	1.3	1.2	1.2	1.5	0.7	
Vent Valve Operation	N	24	24	24	24	24	24
	Minimum	1	1	1	2	3	
	Maximum	4	4	4	4	5	
	Mean	2.7	2.3	2.7	2.9	4.6	2.0
	Standard Deviation	1.2	1.1	0.9	0.7	0.6	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Move Cask with Crane (to and from rail car)	N	24	24	24	24	23	24
	Minimum	1	1	1	2	3	
	Maximum	5	5	5	6	5	
	Mean	2.8	2.8	3.4	3.5	4.7	7.0
	Standard Deviation	1.4	1.2	0.9	0.8	0.5	
Drain Cask to LAW Vault Using Air Pressure		24	24	24	24	23	24
	Minimum	1	1	1	2	4	
	Maximum	4	5	5	5	5	
	Mean	2.2	2.8	3.2	3.4	4.7	4.0
	Standard Deviation	1.2	1.3	1.0	0.8	0.4	
Vent Cask to LAW Vault	N	24	24	24	24	23	24
	Minimum	1	1	1	2	4	
	Maximum	7	5	4	4	5	
	Mean	3.1	2.6	2.8	3.0	4.7	2.0
	Standard Deviation	1.5	1.3	1.0	0.7	0.4	
Coordinate with Maintenance for Relief Valve/Gage Changes	N	23	23	23	23	23	23
	Minimum	1	1	1	1	3	
	Maximum	6	6	5	4	5	
	Mean	2.5	2.9	2.9	2.2	4.6	3.0
	Standard Deviation	1.4	1.6	1.1	1.0	0.5	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Connect Hose, Make Quick Disconnects	N	24	24	24	24	23	24
	Minimum	1	1	1	2	3	
	Maximum	6	4	4	4	5	
	Mean	3.3	2.6	3.1	3.2	4.4	3.0
	Standard Deviation	1.3	1.2	0.9	0.7	0.7	
Complete Checklist, Paperwork	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	6	6	5	4	5	
	Mean	3.4	3.5	3.0	1.5	4.0	7.0
	Standard Deviation	1.5	1.4	1.1	0.7	1.0	
Accomplish Other Tasks (if any)	N	14	13	13	13	13	14
	Minimum	1	1	1	1	3	
	Maximum	4	4	4	4	5	
	Mean	2.7	3.0	3.3	2.8	4.5	0.0
	Standard Deviation	1.3	1.2	0.9	1.2	0.6	
OFF-SITE SHIPMENT PREPARATION							
Operate Crane to Place Cask on Rail Car	N	24	24	24	24	23	24
	Minimum	1	1	2	2	3	
	Maximum	5	4	6	6	5	
	Mean	3.5	3.3	3.7	3.7	4.7	13.0
	Standard Deviation	0.9	1.0	1.0	0.9	0.5	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Connect Cask to Rail Car	N	24	24	24	24	24	24
	Minimum	1	1	2	3	3	
	Maximum	5	5	5	5	5	
	Mean	3.3	3.4	3.8	3.9	4.7	9.0
	Standard Deviation	1.1	1.3	0.9	0.7	0.5	
Decontaminate Cask	N	24	24	24	24	23	24
	Minimum	2	1	2	2	3	
	Maximum	7	7	7	5	5	
	Mean	4.2	5.2	4.8	3.9	4.2	6.0
	Standard Deviation	1.1	1.7	1.1	0.8	0.7	
Replace Box covers, Ducts	N	23	23	23	23	23	23
	Minimum	1	1	1	2	3	
	Maximum	4	5	5	5	5	
	Mean	3.3	3.4	3.7	4.0	4.4	5.0
	Standard Deviation	0.9	1.0	1.0	0.9	0.7	
Prepare Tool Box and Spare Parts Box	N	24	24	24	24	23	24
	Minimum	1	1	1	1	2	
	Maximum	4	4	5	4	5	
	Mean	2.4	2.0	3.0	2.4	4.4	4.0
	Standard Deviation	0.9	1.0	0.9	0.8	0.7	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Inspect Cask and Rail Card	N	23	23	23	23	23	23
	Minimum	1	1	1	1	2	
	Maximum	7	6	5	4	5	
	Mean	3.5	3.1	2.9	2.4	4.7	4.0
	Standard Deviation	1.3	1.4	0.9	0.9	0.7	
Coordinate with Control Room and Safety	N	24	24	24	24	24	24
	Minimum	1	1	1	1	2	
	Maximum	7	6	4	3	5	
	Mean	3.6	2.9	2.5	1.7	4.5	3.0
	Standard Deviation	1.35	1.4	0.8	0.6	0.7	
Move Rail Car with ISCO	N	23	23	24	24	24	24
	Minimum	1	1	2	2	3	
	Maximum	5	5	5	5	5	
	Mean	3.2	2.8	3.5	3.5	4.7	11.0
	Standard Deviation	0.9	1.2	0.8	0.7	0.6	
Refuel Engine	N	22	22	23	23	23	23
	Minimum	1	1	1	1	4	
	Maximum	4	4	5	4	5	
	Mean	2.4	2.4	2.9	3.2	4.7	0.0
	Standard Deviation	0.9	1.0	1.0	0.9	0.4	
Assist Train Crew	N	24	24	23	24	23	24
	Minimum	1	1	1	1	4	
	Maximum	4	4	4	4	5	
	Mean	1.8	1.7	2.3	2.6	4.9	0.0
	Standard Deviation	1.1	0.9	0.8	1.0	0.1	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Complete Check Sheets, Paperwork	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	6	6	5	3	5	
	Mean	3.7	3.7	3.0	1.5	3.9	9.0
	Standard Deviation	1.2	1.4	1.0	0.5	1.0	
Accomplish Other Tasks (if any)	N	13	13	13	13	13	13
	Minimum	1	1	1	1	3	
	Maximum	4	4	4	4	5	
	Mean	3.3	3.6	3.3	3.0	4.6	1.0
	Standard Deviation	1.1	0.8	0.9	0.9	9.7	
BASIC COOLER OPERATION							
Verify Water Level	N	24	24	24	24	24	24
	Minimum	1	1	1	1	2	
	Maximum	6	5	4	3	5	
	Mean	3.5	2.7	1.8	1.6	4.6	4.0
	Standard Deviation	1.3	1.4	0.9	0.7	0.7	
Complete Valve Check Off Lists	N	24	24	24	24	24	24
	Minimum	1	1	1	1	2	
	Maximum	6	5	5	4	5	
	Mean	3.1	3.2	3.0	2.0	4.2	10.0
	Standard Deviation	1.3	1.2	0.9	0.7	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Monitor Pressure Against Table I	N	20	20	20	20	20	20
	Minimum	1	1	1	1	4	
	Maximum	6	4	4	3	5	
	Mean	3.5	2.5	2.4	1.8	4.7	2.0
	Standard Deviation	1.6	1.1	0.9	0.6	0.4	
Check for Leaks	N	24	24	24	24	24	24
	Minimum	1	1	1	1	2	
	Maximum	7	5	5	4	5	
	Mean	4.0	3.4	3.2	2.8	4.5	4.0
	Standard Deviation	1.6	1.3	0.9	1.0	0.7	
Remove Pump Discharge Pressure Indicator	N	20	20	20	20	20	20
	Minimum	1	1	1	2	3	
	Maximum	3	3	6	5	5	
	Mean	1.3	1.6	3.4	3.6	4.7	5.0
	Standard Deviation	0.6	0.8	1.1	0.7	0.6	
Install Chicago Coupling	N	21	21	21	21	21	21
	Minimum	1	1	1	2	4	
	Maximum	3	4	5	4	5	
	Mean	1.7	1.8	3.1	3.1	4.8	3.0
	Standard Deviation	0.7	0.9	1.0	0.7	0.3	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Turn Pump On to Increase Demineralization Pressure	N	18	18	18	18	18	18
	Minimum	1	1	1	1	4	
	Maximum	4	4	4	4	5	
	Mean	1.6	1.8	2.6	2.5	4.8	7.0
	Standard Deviation	0.9	1.1	1.1	0.7	0.3	
Prime Pump	N	23	23	23	23	23	23
	Minimum	1	1	2	2	2	
	Maximum	5	5	7	4	5	
	Mean	2.3	3.2	4.7	2.8	4.3	11.0
	Standard Deviation	1.2	1.5	1.[illegible]	0.6	0.8	
Throttle Valve, Checking Pressure	N	23	23	23	23	22	23
	Minimum	1	1	1	1	4	
	Maximum	4	5	5	4	5	
	Mean	2.3	2.5	3.0	2.7	4.7	
	Standard Deviation	1.1	1.2	1.0	0.7	0.4	
Notify Personnel - Pump On Line	N	23	23	23	23	22	23
	Minimum	1	1	1	1	3	
	Maximum	6	4	4	3	5	
	Mean	2.7	2.1	1.7	1.5	4.6	2.0
	Standard Deviation	1.3	1.3	0.9	0.5	0.6	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Turn Fans On	N	24	24	24	24	23	24
	Minimum	1	1	1	1	4	
	Maximum	6	4	4	4	5	
	Mean	3.3	2.3	1.7	2.0	4.8	1.0
	Standard Deviation	1.3	1.3	0.8	0.9	0.3	
Complete Paperwork, Logs	N	23	23	23	24	23	24
	Minimum	1	1	1	1	2	
	Maximum	7	7	4	3	5	
	Mean	3.8	3.3	2.7	1.5	4.4	7.0
	Standard Deviation	1.7	1.6	1.0	0.5	0.8	
Accomplish Other Tasks (if any)	N	14	14	13	14	14	14
	Minimum	1	1	1	1	3	
	Maximum	6	4	4	4	5	
	Mean	3.5	3.2	2.9	2.7	4.7	0.0
	Standard Deviation	1.2	1.2	1.0	0.9	0.6	
BASIN WATER ANALYSIS (COMPLIANCE TEST)							
Take Water Samples from Basin	N	24	24	24	24	24	24
	Minimum	2	1	1	2	1	
	Maximum	7	7	4	4	5	
	Mean	3.9	3.2	2.5	3.2	4.0	8.0
	Standard Deviation	1.20	1.4	1.0	0.7	1.1	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Log and Initial Data on Samples and Results	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	5	4	4	5	
	Mean	4.2	2.9	2.3	1.5	3.7	9.0
	Standard Deviation	1.1	1.2	0.9	0.7	1.3	
Evaluate Results of Sample Analysis	N	23	22	22	22	22	23
	Minimum	1	1	1	1	1	
	Maximum	6	4	5	2	5	
	Mean	3.3	2.5	3.0	1.4	4.3	8.0
	Standard Deviation	1.4	1.2	1.3	0.5	1.0	
Determine Actions Required	N	21	20	20	20	20	21
	Minimum	1	1	2	1	3	
	Maximum	6	4	7	2	5	
	Mean	2.3	2.0	3.9	1.6	4.5	7.0
	Standard Deviation	1.5	1.0	1.2	0.5	0.6	
Notify Appropriate People	N	22	21	21	21	21	22
	Minimum	1	1	1	1	3	
	Maximum	7	5	4	2	5	
	Mean	3.1	2.5	2.1	1.3	4.6	1.0
	Standard Deviation	1.6	1.3	1.2	0.5	0.5	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Plot Data on Analysis Results	N	20	21	21	21	21	21
	Minimum	1	1	1	1	3	
	Maximum	7	5	6	4	5	
	Mean	2.2	1.8	3.5	1.5	4.3	8.0
	Standard Deviation	1.8	1.1	1.2	0.7	0.8	
BASIN FILTER OPERATIONS							
Place Filter/Hold Switch in Hold	N	24	24	24	24	24	24
	Minimum	1	1	1	1	3	
	Maximum	5	4	4	4	5	
	Mean	2.5	2.0	1.6	1.8	4.5	6.0
	Standard Deviation	1.2	1.2	0.9	0.7	0.7	
Verify All Valves and Switches are in Correct Position	N	24	24	24	24	24	24
	Minimum	1	1	2	1	2	
	Maximum	7	7	6	4	5	
	Mean	3.5	3.1	3.7	2.1	4.2	15.0
	Standard Deviation	1.8	1.5	1.1	0.7	0.8	
Verify Basin Level Greater Than or Equal to 58%	N	24	24	24	24	24	24
	Minimum	1	1	1	1	3	
	Maximum	7	5	4	3	5	
	Mean	3.8	2.3	1.7	1.5	4.7	2.0
	Standard Deviation	1.8	1.4	0.8	0.5	0.5	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Open Filter Outlet Valve	N	23	23	23	23	23	23
	Minimum	1	1	1	1	4	
	Maximum	5	5	4	4	5	
	Mean	2.4	2.0	2.1	2.3	4.7	6.0
	Standard Deviation	1.2	1.2	0.8	0.8	0.4	
Close Vacuum Sweeper to Filter System Valve	N	23	23	23	23	23	23
	Minimum	1	1	1	1	4	
	Maximum	4	4	4	4	5	
	Mean	2.1	2.1	2.7	2.9	4.6	8.0
	Standard Deviation	0.6	1.1	0.9	0.8	0.5	
Remove Sweeper Head and Attach Cleaning Tool	N	24	24	24	24	23	24
	Minimum	1	1	2	3	4	
	Maximum	3	5	6	6	5	
	Mean	1.6	2.7	4.2	4.3	4.7	6.0
	Standard Deviation	0.7	1.5	0.9	0.7	0.4	
Verify Vacuum Head Below Water	N	24	24	24	24	23	24
	Minimum	1	1	1	1	4	
	Maximum	5	5	4	4	5	
	Mean	2.4	2.0	1.7	1.8	4.8	1.0
	Standard Deviation	1.1	1.3	0.9	0.9	0.3	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Open Vacuum Sweeper to Filter System Valve	N	24	24	24	24	24	24
	Minimum	1	1	1	1	4	
	Maximum	4	4	4	4	5	
	Mean	2.3	2.2	2.7	2.7	4.7	9.0
	Standard Deviation	0.8	1.2	1.0	0.8	0.4	
Clean Cask Interior	N	22	22	22	23	22	23
	Minimum	1	1	3	4	4	
	Maximum	3	7	7	7	5	
	Mean	1.2	3.0	5.5	5.0	4.9	9.0
	Standard Deviation	0.5	2.3	1.1	0.8	0.2	
Clean Basin Floor	N	24	24	24	24	24	24
	Minimum	1	1	1	3	4	
	Maximum	6	7	7	6	5	
	Mean	2.6	4.0	5.1	4.3	4.7	5.0
	Standard Deviation	1.2	1.9	1.2	0.7	0.4	
Monitor Water Flow Rates	N	24	24	24	24	24	24
	Minimum	1	1	1	1	3	
	Maximum	7	5	4	4	5	
	Mean	4.0	2.8	2.4	2.0	4.6	5.0
	Standard Deviation	1.7	1.2	0.8	0.9	0.5	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Record Readings in Basin Filter Log	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	5	4	2	5	
	Mean	3.5	3.0	2.4	1.3	3.7	10.0
	Standard Deviation	1.3	1.2	0.9	0.4	1.1	
DEMINERALIZER OPERATIONS							
Adjust Valves	N	23	23	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	5	6	5	4	5	
	Mean	3.0	2.9	3.1	2.4	3.5	11.0
	Standard Deviation	1.1	1.3	1.1	0.9	1.0	
Set Timers	N	23	23	23	23	23	23
	Minimum	1	1	1	1	2	
	Maximum	4	4	5	3	5	
	Mean	1.9	2.1	3.1	2.1	4.1	11.0
	Standard Deviation	0.9	1.1	1.1	0.7	0.8	
Coordinate with Control Room	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	5	4	4	3	5	
	Mean	3.3	2.6	2.4	1.5	4.3	1.0
	Standard Deviation	1.1	1.3	0.9	0.6	1.1	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Check During Rounds	N	24	24	24	24	24	24
	Minimum	2	2	1	1	1	
	Maximum	7	7	4	3	5	
	Mean	4.5	3.8	2.6	1.8	4.0	6.0
	Standard Deviation	1.3	1.0	0.9	0.6	1.3	
Select Operating Unit (A or B)	N	24	24	24	24	24	24
	Minimum	1	1	1	1	2	
	Maximum	5	4	4	3	5	
	Mean	3.7	2.7	1.9	1.6	4.3	5.0
	Standard Deviation	0.9	1.2	1.0	0.6	1.0	
Complete Paperwork, Checklist	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	5	5	2	5	
	Mean	4.3	3.2	2.5	1.3	3.5	9.0
	Standard Deviation	1.1	1.3	1.1	0.4	1.3	
Accomplish Other Tasks (if any)	N	18	18	18	18	18	18
	Minimum	2	3	1	1	1	
	Maximum	7	5	4	4	5	
	Mean	3.8	4.0	3.1	3.1	3.8	5.0
	Standard Deviation	1.1	0.6	1.0	0.9	1.0	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
LAW EVAPORATOR SYSTEM OPERATION							
Check System Operation: Blowers, Vents, Instruments	N	24	24	24	24	24	24
	Minimum	1	1	2	1	2	
	Maximum	7	6	5	5	5	
	Mean	3.5	3.1	3.2	2.6	4.1	13.0
	Standard Deviation	1.6	1.3	1.0	1.1	0.9	
Don Radiation Protection Garments	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	5	6	4	4	5	
	Mean	2.8	2.9	2.8	2.3	4.1	6.0
	Standard Deviation	1.2	1.3	0.9	1.0	1.2	
Operate Canyon Crane	N	24	24	24	24	23	24
	Minimum	1	1	1	2	2	
	Maximum	4	5	5	4	5	
	Mean	2.6	2.7	3.2	3.2	4.4	9.0
	Standard Deviation	0.9	1.2	0.9	0.7	0.9	
Adjust Valves and Pumps	N	24	24	24	24	24	24
	Minimum	1	1	3	3	2	
	Maximum	4	5	6	7	5	
	Mean	2.8	3.2	3.9	4.4	4.1	12.0
	Standard Deviation	1.1	1.4	0.8	0.9	0.8	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Monitor Operation Visually, Check for Leaks	N	24	24	24	24	24	24
	Minimum	1	1	1	1	3	
	Maximum	5	5	5	5	5	
	Mean	3.0	3.2	3.5	3.7	4.5	6.0
	Standard Deviation	1.3	1.1	0.9	0.8	0.5	
Monitor Operation from Control Room, Log Data Every 2 Hours	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	7	5	3	5	
	Mean	4.5	4.0	2.7	1.4	3.7	8.0
	Standard Deviation	1.5	1.3	1.0	0.5	1.3	
Sample Density	N	24	24	23	24	24	24
	Minimum	1	1	2	1	2	
	Maximum	4	5	6	6	5	
	Mean	2.3	2.5	4.2	3.7	4.1	8.0
	Standard Deviation	1.0	1.4	1.1	1.7	1.1	
Reduce Steam, Jet Off-Gas Cell Sump	N	24	24	24	24	24	24
	Minimum	1	1	1	1	2	
	Maximum	6	4	4	4	5	
	Mean	3.2	2.4	2.5	2.0	4.5	4.0
	Standard Deviation	1.3	1.1	0.8	0.8	0.8	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Shutdown, Valves and Pumps Adjusted to Flush	N	24	24	24	24	24	24
	Minimum	1	1	1	1	3	
	Maximum	5	5	6	5	5	
	Mean	3.2	2.7	3.0	2.6	4.5	10.0
	Standard Deviation	1.1	1.2	1.2	1.2	0.5	
Prepare Extended Shutdown, Add Demineralized Water with Chemical Dolly	N	24	24	24	24	24	24
	Minimum	1	1	1	2	3	
	Maximum	4	6	5	5	5	
	Mean	2.7	3.2	3.7	3.5	4.4	12.0
	Standard Deviation	1.0	1.3	1.0	0.9	0.7	
Configure Valve and Pump in Accordance with Checklist	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	4	5	5	5	5	
	Mean	2.9	3.1	3.5	3.2	4.5	13.0
	Standard Deviation	1.1	1.3	1.1	1.0	0.6	
Accomplish Other Tasks (if any)	N	14	14	14	14	14	14
	Minimum	1	1	1	1	3	
	Maximum	4	5	5	6	5	
	Mean	3.2	3.2	[illegible].4	3.4	4.5	1.0
	Standard Deviation	1.0	1.2	1.0	1.1	0.6	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
ELECTRODECONTAMINATION OPERATION							
Check Contamination Levels of Tools/Equipment	N	23	23	23	23	23	23
	Minimum	1	1	1	2	1	
	Maximum	7	5	5	4	5	
	Mean	3.4	3.3	3.3	2.8	3.5	8.0
	Standard Deviation	1.4	1.0	0.9	0.6	1.2	
Calculate Surface Area, Current, Cathodes	N	23	23	23	23	23	23
	Minimum	1	1	2	1	1	
	Maximum	4	7	7	4	5	
	Mean	2.3	2.5	4.1	1.8	3.5	9.0
	Standard Deviation	1.0	1.3	1.1	0.9	1.3	
Operate Electrodecontamination Controls	N	23	23	23	23	23	23
	Minimum	1	1	1	1	1	
	Maximum	7	6	5	4	5	
	Mean	3.3	3.3	2.9	3.0	4.2	9.0
	Standard Deviation	1.4	1.2	1.0	1.2	1.0	
Place Item in Acid	N	23	23	23	23	23	23
	Minimum	1	1	1	4	1	
	Maximum	7	5	5	5	5	
	Mean	3.5	3.2	3.3	4.3	4.2	8.0
	Standard Deviation	1.4	1.2	1.0	0.4	1.0	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Remove and Rinse Them	N	23	23	23	23	23	23
	Minimum	1	1	1	3	1	
	Maximum	7	5	5	5	5	
	Mean	3.5	3.4	3.3	4.3	4.2	6.0
	Standard Deviation	1.4	1.1	1.1	0.5	1.1	
Complete Logs	N	23	23	23	23	23	23
	Minimum	1	1	1	1	1	
	Maximum	7	5	4	3	5	
	Mean	3.4	3.0	2.7	1.6	3.3	4.0
	Standard Deviation	1.4	1.3	1.0	0.6	1.3	
Obtain Release from Plant Safety	N	23	23	23	23	22	23
	Minimum	1	1	1	1	4	
	Maximum	7	6	6	3	5	
	Mean	3.3	3.2	3.2	1.6	4.7	3.0
	Standard Deviation	1.2	1.2	1.2	0.5	0.4	
Accomplish Other Tasks (if any)	N	14	14	14	14	14	14
	Minimum	1	1	1	1	2	
	Maximum	4	5	5	5	5	
	Mean	3.0	3.0	3.4	2.8	4.2	2.0
	Standard Deviation	1.3	1.2	1.1	1.4	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
BASIC LEAK DETECTION							
Turn Level Controller Switch to Hand Position	N	24	24	24	24	24	24
	Minimum	1	1	1	1	4	
	Maximum	7	4	4	4	5	
	Mean	2.6	1.9	1.7	1.7	4.9	1.0
	Standard Deviation	1.5	1.2	0.9	0.7	0.2	
Place Steam Supply Valve to Jet	N	24	24	24	24	23	24
	Minimum	1	1	1	1	2	
	Maximum	7	4	5	4	5	
	Mean	2.6	2.0	2.2	2.6	4.7	5.0
	Standard Deviation	1.5	1.2	1.2	1.0	0.7	
Turn on Power Switch	N	24	24	24	24	24	24
	Minimum	1	1	1	1	4	
	Maximum	7	4	4	4	5	
	Mean	2.5	1.9	1.7	1.8	4.9	1.0
	Standard Deviation	1.4	1.2	0.9	0.8	0.2	
Attach Tubing to Basin System	N	21	21	21	21	20	21
	Minimum	1	1	1	1	4	
	Maximum	7	6	6	4	5	
	Mean	2.2	2.0	2.9	2.9	4.8	3.0
	Standard Deviation	1.5	1.3	1.2	0.8	0.4	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Open Jet Suck Valve to Collect Sample	N	23	23	23	23	22	22
	Minimum	1	1	1	1	1	
	Maximum	7	5	4	4	5	
	Mean	2.9	2.3	2.3	2.9	4.8	7.0
	Standard Deviation	1.4	1.3	0.9	1.0	0.3	
Collect Sample	N	24	24	24	24	23	24
	Minimum	1	1	1	1	4	
	Maximum	7	6	5	4	5	
	Mean	2.7	2.9	2.6	3.1	4.7	5.0
	Standard Deviation	1.5	1.5	1.1	0.9	0.4	
Put Sample in Container	N	24	24	24	24	23	24
	Minimum	1	1	1	1	1	
	Maximum	7	4	4	5	5	
	Mean	2.7	2.4	2.1	2.6	4.6	0.0
	Standard Deviation	1.5	1.3	0.9	1.0	0.9	
Clean Sample Box	N	24	24	24	24	24	24
	Minimum	1	1	1	1	2	
	Maximum	4	5	4	4	5	
	Mean	2.3	2.4	2.5	2.7	4.4	3.0
	Standard Deviation	1.1	1.3	1.0	0.9	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Log Sample Check and Complete Paperwork	N	24	24	24	24	23	24
	Minimum	1	1	1	1	2	
	Maximum	7	6	4	2	5	
	Mean	3.0	3.0	2.6	1.4	4.4	4.0
	Standard Deviation	1.6	1.5	1.0	0.5	0.7	
Accomplish Other Tasks (if any)	N	14	14	14	14	14	14
	Minimum	1	1	1	1	4	
	Maximum	6	4	4	4	6	
	Mean	3.4	2.9	2.8	2.5	4.9	0.0
	Standard Deviation	1.4	1.2	1.0	1.2	0.4	
EMERGENCY ACTION FOR BASIN COOLERS							
Start Emergency Power Manually	N	21	21	21	21	21	21
	Minimum	1	1	2	1	4	
	Maximum	4	5	5	4	5	
	Mean	1.5	2.0	3.4	2.9	4.9	9.0
	Standard Deviation	1.1	1.4	0.9	0.9	0.3	
Turn Cooler Pumps Off	N	22	22	22	22	22	22
	Minimum	1	1	1	1	3	
	Maximum	4	4	4	4	5	
	Mean	2.3	2.1	2.0	2.1	4.8	1.0
	Standard Deviation	1.0	1.2	0.8	0.7	0.4	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Turn Breakers Off	N	23	23	23	23	23	23
	Minimum	1	1	1	1	3	
	Maximum	4	4	5	4	5	
	Mean	1.9	2.1	2.1	2.4	4.7	3.0
	Standard Deviation	1.0	1.2	1.1	0.8	0.5	
Close Valve 3/4 Turn	N	24	24	24	24	24	24
	Minimum	1	1	1	1	3	
	Maximum	7	4	4	4	5	
	Mean	2.2	2.0	2.3	2.5	4.5	6.0
	Standard Deviation	1.5	1.2	1.0	0.9	0.5	
Adjust the Regulator	N	24	24	24	24	24	24
	Minimum	1	1	1	1	4	
	Maximum	4	4	4	4	5	
	Mean	1.6	1.9	2.7	2.5	4.6	7.0
	Standard Deviation	0.9	1.2	0.9	0.8	0.4	
Open Valve to Discharge Header	N	24	24	24	24	24	24
	Minimum	1	1	1	1	4	
	Maximum	7	4	4	4	5	
	Mean	2.4	2.4	2.8	2.8	4.7	2.0
	Standard Deviation	1.4	1.2	0.9	0.9	0.4	
Inspect for Water Leakage	N	24	24	24	24	24	24
	Minimum	1	1	1	1	4	
	Maximum	7	6	5	5	5	
	Mean	3.4	3.2	3.0	2.8	4.7	7.0
	Standard Deviation	1.9	1.6	1.0	1.0	0.4	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Check Pump Pressure and Valving	N	24	24	24	24	24	24
	Minimum	1	1	1	1	3	
	Maximum	7	5	4	4	5	
	Mean	3.4	2.9	2.7	2.7	4.6	6.0
	Standard Deviation	1.8	1.3	0.9	1.0	0.6	
Check Basin Level	N	24	24	24	24	23	24
	Minimum	1	1	1	1	4	
	Maximum	7	5	4	3	5	
	Mean	3.3	2.4	1.8	1.7	4.8	1.0
	Standard Deviation	1.8	1.4	0.8	0.7	0.3	
Check Cooler Temperature	N	24	24	24	24	23	24
	Minimum	1	1	1	1	3	
	Maximum	7	5	4	3	5	
	Mean	3.4	2.6	2.1	1.7	4.6	1.0
	Standard Deviation	1.9	1.3	0.9	0.6	0.7	
Respond to Alarm	N	24	24	24	24	23	24
	Minimum	1	1	2	1	1	
	Maximum	7	5	4	4	5	
	Mean	2.7	2.6	3.0	2.7	4.6	7.0
	Standard Deviation	1.6	1.3	0.7	1.0	0.9	
Shut Down Cooler Fan	N	24	24	24	24	23	24
	Minimum	1	1	1	1	4	
	Maximum	5	4	4	3	5	
	Mean	2.7	2.3	2.0	1.7	4.8	3.0
	Standard Deviation	1.3	1.2	0.8	0.6	0.3	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Check Valving	N	24	24	24	24	24	24
	Minimum	1	1	1	1	3	
	Maximum	7	6	5	5	5	
	Mean	2.7	2.7	3.0	2.9	4.5	10.0
	Standard Deviation	1.6	1.3	1.0	1.1	0.6	
Check Pump Readings	N	24	24	24	24	24	
	Minimum	1	1	1	1	3	
	Maximum	7	4	4	4	5	
	Mean	3.4	2.7	2.3	2.2	4.7	2.0
	Standard Deviation	1.8	1.2	0.8	0.9	0.5	
Restart Fans	N	24	24	24	24	23	24
	Minimum	1	1	1	1	4	
	Maximum	5	4	4	4	5	
	Mean	2.5	2.2	2.0	2.0	4.8	1.0
	Standard Deviation	1.2	1.1	0.9	0.9	0.3	
Turn Basin Pumps and Fans Off	N	24	24	24	24	23	24
	Minimum	1	1	1	1	1	
	Maximum	4	4	4	3	5	
	Mean	2.3	2.2	1.8	1.7	4.7	4.0
	Standard Deviation	1.0	1.1	0.9	0.7	0.8	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Dif.iculty	Hazard	Error	Error New Person
Cover Coolers with Tarps and Fan Openings with Plastic	N	22	21	22	22	22	22
	Minimum	1	1	4	3	4	
	Maximum	2	7	7	7	5	
	Mean	1.1	3.3	5.9	5.1	4.9	4.0
	Standard Deviation	0.3	2.2	0.9	1.0	0.2	
Light Space Heaters to Heat Area	N	16	15	16	16	15	16
	Minimum	1	1	4	3	4	
	Maximum	2	6	7	7	5	
	Mean	1.0	2.8	5.6	4.7	4.8	3.0
	Standard Deviation	0.25	2.4	1.0	1.0	0.3	
Monitor Area for Heating	N	17	16	18	18	18	18
	Minimum	1	1	1	1	4	
	Maximum	7	5	7	7	5	
	Mean	1.7	2.2	3.6	3.3	4.8	2.0
	Standard Deviation	1.5	1.4	1.5	1.6	0.3	
Log Control Appropriately	N	24	23	23	23	23	24
	Minimum	1	1	1	1	1	
	Maximum	7	5	4	3	5	
	Mean	3.0	2.7	2.8	1.6	4.3	6.0
	Standard Deviation	1.7	1.4	0.9	0.6	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Complete Checklists and Forms	N	24	24	24	24	23	24
	Minimum	1	1	1	1	1	
	Maximum	7	5	4	2	5	
	Mean	3.0	3.0	2.8	1.4	4.3	6.0
	Standard Deviation	1.7	1.6	1.0	0.5	0.9	
Accomplish Other Tasks (if any)	N	13	13	13	13	12	13
	Minimum	1	1	1	1	4	
	Maximum	4	4	4	4	5	
	Mean	2.7	2.9	3.0	3.1	4.9	0.0
	Standard Deviation	1.3	1.3	1.0	0.9	0.2	
CASK HANDLING WITH FAILED OR LEAKING FUEL							
Evacuate Personnel from Hazardous Areas	N	19	18	19	19	19	19
	Minimum	1	1	1	2	3	
	Maximum	2	4	4	4	5	
	Mean	1.2	1.7	2.6	2.9	4.7	5.0
	Standard Deviation	0.4	1.2	1.0	0.7	0.5	
Flush Cask	N	19	18	19	19	19	19
	Minimum	1	1	2	2	1	
	Maximum	6	5	5	6	5	
	Mean	2.2	2.9	3.3	3.7	4.6	8.0
	Standard Deviation	1.5	1.4	0.8	0.8	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Obtain Coolant Sample	N	19	18	19	19	18	19
	Minimum	1	1	1	2	4	
	Maximum	5	5	5	6	5	
	Mean	2.2	2.2	2.8	3.7	4.8	5.0
	Standard Deviation	1.4	1.4	1.0	0.9	0.3	
Fill Cask with Water	N	19	18	19	19	18	19
	Minimum	1	1	2	2	3	
	Maximum	5	5	4	6	5	
	Mean	2.2	3.0	3.1	3.5	4.7	4.0
	Standard Deviation	1.5	1.6	0.7	1.0	0.5	
Vent Cask to LAW Vault	N	19	18	19	19	18	19
	Minimum	1	1	2	2	4	
	Maximum	5	5	4	6	5	
	Mean	2.2	2.5	2.8	3.4	4.7	2.0
	Standard Deviation	1.4	1.5	0.8	1.0	0.4	
Monitor Temperature of Cask	N	19	18	19	19	18	19
	Minimum	1	1	1	1	4	
	Maximum	5	6	4	4	5	
	Mean	2.2	2.3	2.5	2.9	4.8	3.0
	Standard Deviation	1.4	1.6	0.8	0.7	0.3	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Take Sample from Cesium Analysis	N	19	18	19	19	18	19
	Minimum	1	1	1	2	4	
	Maximum	4	4	5	6	5	
	Mean	2.1	2.2	2.8	3.7	4.9	0.0
	Standard Deviation	1.3	1.3	1.0	0.9	0.2	
Contact Personnel if Cesium Measure is High	N	19	18	19	19	18	19
	Minimum	1	1	1	1	4	
	Maximum	5	5	4	4	5	
	Mean	1.2	1.8	2.3	1.9	4.8	2.0
	Standard Deviation	0.9	1.3	0.8	0.9	0.3	
Complete Checklists and Forms	N	19	18	19	19	18	19
	Minimum	1	1	1	1	3	
	Maximum	5	5	4	4	5	
	Mean	2.5	2.7	2.8	1.7	4.6	4.0
	Standard Deviation	1.6	1.6	1.0	0.7	0.7	
Accomplish Other Tasks (if any)	N	11	10	11	11	11	11
	Minimum	1	1	1	1	4	
	Maximum	4	4	4	4	5	
	Mean	2.0	2.3	3.0	2.9	4.9	0.0
	Standard Deviation	1.5	1.4	1.1	1.2	0.3	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
CONTROL ROOM DUTIES							
Start and/or Stop Equipment	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	6	5	5	4	5	
	Mean	3.6	2.7	2.7	2.1	3.7	9.0
	Standard Deviation	1.2	1.2	1.1	1.1	1.2	
Perform Scheduled Security Checks	N	23	23	23	24	23	24
	Minimum	1	1	1	1	1	
	Maximum	6	5	4	3	5	
	Mean	3.6	3.0	2.5	1.6	4.3	3.0
	Standard Deviation	1.1	1.2	0.7	0.6	0.9	
Receive and Transmit Calls	N	24	24	24	24	23	24
	Minimum	3	1	1	1	1	
	Maximum	7	6	4	3	5	
	Mean	4.2	3.5	2.5	1.5	4.2	3.0
	Standard Deviation	0.9	1.2	0.8	0.6	1.3	
Initiate Scheduled Tests	N	24	24	24	24	24	24
	Minimum	1	1	2	1	1	
	Maximum	5	5	4	4	5	
	Mean	3.4	2.9	3.1	1.6	3.9	10.0
	Standard Deviation	1.1	1.3	0.8	0.8	1.1	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Perform Rounds Check	N	24	23	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	7	4	3	5	
	Mean	4.1	4.0	2.8	1.6	3.7	8.0
	Standard Deviation	1.4	4.1	0.9	0.7	1.4	
Respond to Alarms	N	24	24	24	24	23	24
	Minimum	2	2	2	1	1	
	Maximum	7	5	5	4	5	
	Mean	3.8	3.3	3.1	2.0	3.9	14.0
	Standard Deviation	1.1	0.9	0.9	0.8	1.3	
Complete Logs and Other Forms	N	24	24	24	24	24	24
	Minimum	2	2	1	1	1	
	Maximum	7	7	4	2	5	
	Mean	4.3	4.0	3.0	1.4	3.5	10.0
	Standard Deviation	1.0	1.2	0.9	0.5	1.3	
Accomplish Other Tasks (if any)	N	15	15	15	15	15	15
	Minimum	3	2	1	1	1	
	Maximum	7	6	4	4	5	
	Mean	4.0	3.8	3.0	1.9	4.0	1.0
	Standard Deviation	0.9	1.1	0.9	1.0	1.5	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
PLANT ROUNDS							
Inspect the Utility Building and Indicators	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	7	4	4	5	
	Mean	4.2	3.8	2.9	3.0	3.8	8.0
	Standard Deviation	0.8	1.1	0.9	0.8	1.3	
Check the Utility Boiler Systems	N	24	24	24	24	24	24
	Minimum	3	1	2	1	1	
	Maximum	7	6	5	4	5	
	Mean	4.2	3.7	3.0	3.2	3.6	13.0
	Standard Deviation	0.9	1.2	0.8	0.8	1.2	
Check the Demineralizer System	N	24	24	24	24	24	24
	Minimum	3	1	2	1	1	
	Maximum	7	5	5	4	5	
	Mean	4.3	3.5	3.0	3.0	3.5	14.0
	Standard Deviation	0.9	1.0	1.0	0.8	1.2	
Check the Phosphate Tank Indicators	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.8	2.6	2.0	2.7	4.3	3.0
	Standard Deviation	1.0	1.3	0.8	0.8	1.0	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Check the Hydrozone Tank Indicators	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.8	2.6	2.0	2.7	4.3	2.0
	Standard Deviation	1.0	1.3	0.8	0.8	1.0	
Check the Deaerator (V-801) Indicators	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	4	4	5	5	
	Mean	3.8	2.7	2.5	3.1	4.2	2.0
	Standard Deviation	1.1	1.2	1.0	1.0	1.1	
Check the Accumulator (V-806) Indicators	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	4	4	5	5	
	Mean	3.8	2.7	2.5	3.1	4.1	3.0
	Standard Deviation	1.1	1.2	1.0	1.0	1.1	
Check the Degasifier Indicators	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.8	2.7	2.3	2.6	4.1	2.0
	Standard Deviation	1.0	1.3	1.0	0.9	1.0	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Inspect the Chemical Storage Area and Indicators	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	5	4	4	5	
	Mean	3.9	2.7	2.4	2.8	4.3	1.0
	Standard Deviation	1.04	1.2	0.9	0.9	1.0	
Inspect the Water Tower and Indicators	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	5	4	4	5	
	Mean	4.2	3.1	2.5	2.9	4.0	6.0
	Standard Deviation	0.8	1.2	0.9	0.9	1.2	
Inspect the Well House and Indicators	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	5	4	4	5	
	Mean	4.0	2.9	2.3	2.7	4.3	2.0
	Standard Deviation	0.8	1.2	0.9	0.8	1.0	
Inspect the Cold Warehouse	N	24	24	24	24	23	24
	Minimum	1	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.3	2.5	2.1	2.4	4.2	0.0
	Standard Deviation	1.2	1.2	0.9	0.8	1.2	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Inspect Building F and the Indicators	N	24	24	24	24	23	24
	Minimum	2	1	1	1	1	
	Maximum	8	4	4	4	5	
	Mean	3.5	2.6	2.1	2.5	4.2	0.0
	Standard Deviation	1.1	1.2	0.9	0.9	1.2	
Inspect the Emergency Equipment Building	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	5	4	4	5	
	Mean	4.3	3.2	2.6	2.9	4.2	6.0
	Standard Deviation	0.7	1.1	0.9	1.0	1.1	
Inspect the Generator Room and Indicators	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	7	4	4	5	
	Mean	4.3	3.3	2.7	2.9	4.2	6.0
	Standard Deviation	0.8	1.4	0.9	1.0	1.1	
Inspect the Exhaust Blower Room	N	24	24	24	24	23	24
	Minimum	3	1	1	1	1	
	Maximum	7	5	4	4	5	
	Mean	4.2	2.8	2.5	2.8	4.4	4.0
	Standard Deviation	0.7	1.2	0.9	0.9	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Inspect the Compressor Room and Indicators	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	5	5	5	5	
	Mean	4.3	3.4	2.8	3.0	3.7	12.0
	Standard Deviation	0.8	1.1	1.0	1.0	1.3	
Check the Utility Cooling Tower and Indicators	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	5	5	5	5	
	Mean	4.0	3.0	2.9	3.3	4.2	6.0
	Standard Deviation	0.8	1.2	1.0	1.0	1.1	
Inspect the Warm Warehouse	N	24	24	24	24	23	24
	Minimum	2	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.7	2.6	2.2	2.5	4.5	0.0
	Standard Deviation	1.0	1.2	0.8	0.8	0.9	
Inspect the Mockup Tower and Indicators	N	24	24	24	24	23	24
	Minimum	1	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.7	2.6	2.2	2.5	4.5	0.0
	Standard Deviation	1.1	1.2	0.9	0.8	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Inspect the Cask Service Facility	N	24	24	24	24	23	24
	Minimum	2	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.7	2.6	2.2	2.5	4.4	0.0
	Standard Deviation	1.0	1.2	0.7	0.8	0.9	
Inspect the Basin Cooler area	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	6	4	5	5	
	Mean	4.0	3.2	2.7	3.1	4.3	3.0
	Standard Deviation	1.0	1.2	1.1	1.0	1.0	
Inspect the Cask Receiving Area and Indicators	N	24	24	24	24	23	24
	Minimum	3	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	4.0	2.8	2.4	2.6	4.3	2.0
	Standard Deviation	0.9	1.1	0.8	0.9	1.0	
Inspect the Basin Areas	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	5	4	4	5	
	Mean	4.3	3.5	2.6	2.9	4.2	5.0
	Standard Deviation	0.8	1.2	1.0	1.0	1.1	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Inspect the Basin Filter and Indicators	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	5	5	5	5	
	Mean	4.3	3.3	2.8	3.0	4.1	11.0
	Standard Deviation	0.8	1.2	1.0	1.0	1.0	
Check the Basin Coolers and Indicators	N	24	24	24	24	24	24
	Minimum	3	1	1	1	1	
	Maximum	7	5	5	5	5	
	Mean	4.2	3.2	3.0	3.0	4.0	11.0
	Standard Deviation	0.8	1.2	0.9	1.0	1.0	
Check the Heatr Pump System and Indicators	N	23	23	23	23	23	23
	Minimum	3	1	1	1	1	
	Maximum	7	7	5	4	5	
	Mean	4.6	3.8	3.4	2.8	4.0	9.0
	Standard Deviation	1.0	1.5	0.9	0.9	1.2	
Check the Expansion Gate and Indicators	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.7	2.5	2.2	2.5	4.5	1.0
	Standard Deviation	1.0	1.2	0.9	0.8	0.9	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Check the Process Building and Indicators	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	6	4	4	5	
	Mean	4.0	3.4	2.6	2.6	4.4	2.0
	Standard Deviation	0.8	1.2	1.0	0.9	0.8	
Inspect the F(2) Disposal Area and Indicators	N	24	24	24	24	23	24
	Minimum	1	1	1	1	1	
	Maximum	7	4	5	4	5	
	Mean	3.0	2.2	2.5	2.7	4.6	1.0
	Standard Deviation	1.2	1.1	1.0	0.9	0.8	
Monitor the Process Steam Room Indicators when in Service	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	5	5	5	5	
	Mean	3.8	3.1	3.0	3.2	4.3	6.0
	Standard Deviation	1.0	1.2	1.1	1.0	0.9	
Inspect the South Plug Gallery	N	24	24	24	24	23	24
	Minimum	2	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.6	2.5	2.1	2.4	4.6	0.0
	Standard Deviation	1.1	1.1	0.8	0.9	0.8	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Inspect the Analytic Lab	N	23	23	23	23	23	23
	Minimum	1	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.3	2.4	2.2	2.7	4.4	0.0
	Standard Deviation	1.3	1.1	1.0	0.9	1.0	
Inspect the North Plug Gallery	N	24	24	24	24	23	24
	Minimum	2	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.5	2.5	2.0	2.3	4.5	1.0
	Standard Deviation	1.1	1.2	0.9	0.9	0.9	
Monitor the Process Cooling Waters Indicators when in Service	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.7	2.7	2.5	2.7	4.3	5.0
	Standard Deviation	1.1	1.1	0.9	0.9	1.0	
Inspect the North Instrument Gallery and Indicator	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.6	2.5	2.0	2.3	4.6	1.0
	Standard Deviation	1.1	1.2	0.8	0.9	0.8	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Inspect the South Instrument Gallery	N	24	24	24	24	23	24
	Minimum	1	1	1	1	1	
	Maximum	7	4	4	4	5	
	Mean	3.6	2.6	2.0	2.3	4.5	1.0
	Standard Deviation	1.1	1.2	0.8	0.9	0.9	
Inspect the Ventilation Supply Room and Indicators	N	24	24	24	24	24	24
	Minimum	2	1	1	1	1	
	Maximum	7	5	5	4	5	
	Mean	4.0	3.2	2.8	2.9	3.9	8.0
	Standard Deviation	1.0	1.1	1.1	0.9	1.2	
Inspect the Emergency Electrical Room and Indicators	N	24	24	24	24	23	24
	Minimum	1	1	1	1	1	
	Maximum	7	5	5	4	5	
	Mean	4.0	3.1	2.7	2.6	4.3	5.0
	Standard Deviation	1.0	1.3	1.2	1.0	1.0	
Perform Vehicle Checks	N	24	24	24	24	24	24
	Minimum	1	1	1	1	1	
	Maximum	7	7	4	5	5	
	Mean	3.1	3.5	3.2	3.2	3.2	4.0
	Standard Deviation	1.4	1.5	0.9	1.0	1.5	

ACTIVITY/ Task	Statistics	Frequency	Time Spent	Difficulty	Hazard	Error	Error New Person
Complete Shift Rounds Data Sheet	N	24	24	24	24	23	24
	Minimum	3	1	1	1	1	
	Maximum	7	7	5	4	5	
	Mean	4.4	4.2	3.0	2.1	3.3	7.0
	Standard Deviation	1.0	1.4	1.0	0.9	1.4	
Accomplish Other Tasks (if any)	N	12	12	12	12	12	12
	Minimum	3	1	1	1	1	
	Maximum	4	5	4	4	5	
	Mean	3.9	3.9	3.2	3.1	3.5	1.0
	Standard Deviation	0.2	1.0	1.0	1.0	1.7	

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APPENDIX F

ERROR NARRATIVE RESPONSES

The information contained in this appendix was generated by the certified personnel answering the three error questions on the most hazardous task per activity. Included in this listing are the activities, the tasks the personnel chose, and the number (N) of personnel selecting that task as most hazardous. The three error questions which generated the responses were:

1. What is the most serious error(s) that could be performed in doing this task?

2. What feature of the task or the environment in which it is performed contributed to the likelihood of the occurrence?

3. Are there any factors in this task that make it possible to recover from the error without penalty? (or, Can the error be made but corrected immediately so that its consequences are avoided?) Explain your answer.

An "X" is placed in the appropriate question column for each task to indicate the corresponding responses. The personnel responses were summarized from their response sheets and are presented in the last column.

Activities/Tasks	N	Question A	B	C	Respondents Comments
CASK UNLOADING					
Sample Coolant	3	X			High radiation level from coolant.
					Poor analysis and not monitoring the radiation level.
			X		Sample could be hot.
					Very unlikely, would have to have badly failed fuel and improper communication.
				X	Yes, use dose rate meter and two people to do the job.
Perform Pressurization Check	1	X			Release to environment.
			X		Bad connection or pressure buildup.
				X	Speed in handling.
Dismantle IF-300 to Access Cask	4	X			Falling off railcar.
					Personal injury.
			X		Limited work space.
					Narrow walkway on railcar.
				X	Use platforms.
					Wear hard hat.
					Being aware of the problem and communication with other technicians. The duct support braces would help you regain your footing.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
Lift and Move Cask to Basin	2	X			Tipping of cask and loss of cask control could damage basin liner.
			X		Improper engagement and lack of attention by operator.
				X	No recovery. Two people in area to help reduce potential.
Install Cask Head	2	X			Damage to cask head and gasket. Damage to cask alignment pins.
			X		Operation is performed under water with cask head attached to lifting yoke. Poor visibility.
				X	Improved lighting. Have at least two technicians when performing this operation. Good visibility is extremely important. Once the pins are bent, the head must be removed above water and the pins replaced.
Operate Railcar Brakes, Chocks, and Couplings	2	X			Possibility of causing a vehicle collision at the Morris Operation crossing. While coupling a car. A pinching and crushing hazard exists.
			X		Failure to open a valve in the railcar air-brake line. Note following procedures. There is no way to open couplings or connect outlines without placing yourself between the car and Isco.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
				X	Follow procedures.
Unbolt and Remove Cask Head	4	X			Very easily be dropped.
					Pressure inside the cask could release and cause airborne.
					Uneven untorqueing of head.
					Removing head of cask.
			X		Check pressure.
					Not paying attention.
					Part of operator.
					Position of the bolts.
				X	Yes, bolt may fall to the decon pan without damaging it.
					Even headup using feeler gauge.
					Following procedures and checking.
Remove Cask from Basin with Crane	4	X			Not engaging cask yoke on cask trunnion.
					Tipping or dropping cask.
			X		Poor visibility.
					Underwater work.
				X	No recovery without penalty.
					No, improper crane operation resulting in dropping or tipping of cask is irreversible.
					Yes, strict adherence to SOP.

Activities/Tasks	N	Question A	B	C	Respondents Comments
Flush Cask Venting to Low Vault	1	X			While somebody is inside the vault.
			X		Lack of checking.
				X	Only if someone discovers the error.
CRANE OPERATIONS					
Hook Load	6	X			Improper rigging, under rated slings, or cables. Off balance.
					Selection of wrong cable.
					Striking objects with the load.
					Safety latch on the hook might not hold.
			X		Operator error or not knowing center of gravity of object.
					Failed to follow procedures.
					Traveling over many different elevations.
					Unknown factor or lift and stress.
					Generally, everyone checks the vating and condition of the lifting fixture.
					You should have another technician spotting for you.
				X	More experienced operator, supervisor checks rig before lifting.
					Depends on type of object struck.
					Yes, think and take your time.

Activities/Tasks	N	Question A	B	C	Respondents Comments
Lift Load Vertically	2	X			Not engaging yoke to trunnions properly.
					Tipping of load.
			X		Not positioning crane directly.
				X	Assistance in checking.
					Careful control of crane.
Change Hooks and Slings	4	X			Improper or under capacity hook or sling.
					Personal injury.
			X		Proper equipment may not always be in the area.
					Equipment damage.
					The weight and size of sling.
			X		If a sling broke before the load lifted, it might not cause damage.
					Yes, replace all defective cables.
					Yes, if needed, ask for help.
Move Load	1	X			Inadequate rigging.
			X		Inadequate training in moving heavy loads.
				X	Two people check.
Place the Load in Wanted Area	3	X			Damage to equipment such as the scaffold, possible tipping.
					Latching grid by being out of alignment with the grid.

Activities/Tasks	N	Question A	B	C	Respondents Comments
			X		Limited vision.
				X	Recovery can be made if load has not become disengaged. Damage maybe unavoidable. Second person observing from a different viewpoint is helpful.
Unlock Load	1	X			Not being perpendicular in pit.
			X		Visibility through water 50 feet deep.
				X	Moving south quickly to try to obtain perpendicular. If north wall of pit is contacted, it could damage liner.
Perform Small Movements	1	X			Damage equipment.
			X		Everything is done is such close tolerances.
				X	Yes, at least two people on the job.
Move the Load from Location to Location	2	X			Uncontrolled. Fast and swinging movements can cause damage or injury.
			X		Off standard mechanical or electrical conditions can make them unpredictable. Moving too fast.
				X	The crane makes it possible to recover quickly. Watch for erratic movements and unusual sounds. Slow down.

Activities/Tasks	N	Question A	B	C	Respondents Comments
Unlock Load From Crane	1	X			Tipping of cask in unloading fit while unloading lifting yoke.
			X		Task is performed under water.
				X	No.
Installing Cask Head	1	X			Head could bend the guide pins which in turn could prevent head installation.
			X		Poor visibility.
				X	No, once the pins are bent, the head must be removed above water and the pins replaced.
Inspect the Conditions of Cables and Welds	1	X			Inspect cables and welds.
			X		Inability to adequately check because of size and distance.
				X	Perhaps, the possibility of this occurring is very remote.
FUEL REMOVAL AND STORAGE					
Disengage Fuel Grapple	3	X			Most serious error could be falling in the basin. Possibility as grapple is being raised, contact could be made with basket bail. Failure to disengage.
			X		The wall location is a problem. Distance, distortion of vision caused by water depth, especially by water waves.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
			X		Poor visibility.
				X	Extreme caution and wear a life jacket per safety procedure.
					An incident similar to this occurred with basket being lifted from grid.
					Underwater viewing equipment monitoring. Second set of eyes. Halt lift before encountering problem.
Lower and Raise Pit Guard	3	X			Falling into basin.
			X		Weight of pole and use of balance.
					To push it by technician on wall.
					Slipping.
				X	Two people working at all times.
					Life jackets are required.
Remove Fuel From Basket	2	X			Being out alignment.
					Fuel can catch on basket and slide tube guides.
			X		Working in 40 feet of pit water.
				X	Yes, visual observation by two.
					Sound of crane may alert experienced operator.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
Place Fuel in Basket	3	X			Damage to fuel.
					Possibility of fuel drop.
					Fuel not aligned with basket opening causing the fuel bundle to strike the side.
			X		Tolerance between fuel and basket are small.
					Crane failure.
					Depth perception, lowering fuel bundle too fast.
				X	Second operator observing operator.
					Yes, move slow, listen to your buddy's warnings.
Disengage Fuel Grapple Manually	10	X			Applying too much pressure causing objects to break.
					Damage fuel bundle or grapple.
					Slipping and falling.
					Injury to operator and equipment.
					Not familiar with equipment.
			X		Not following instructions.
					Underwater work.
					Lack of good visibility.
					Haste in removal of grapple.
					Getting off balance.
					Task is seldom if ever done.

Activities/Tasks	N	Question A	B	C	Respondents Comments
				X	Two or more technicians on job.
					Yes, repair the grapple.
					Slow and careful movements of crane operation.
					Wear a life jacket.
					Error can usually be corrected immediately.
Identify Fuel Bundles	1	X			Mistake in identifying fuel bundle.
			X		Getting numbers mixed up with each other.
				X	Records from reactor are available.
Manual Fuel Disengagement	1	X			Fuel could be damaged.
			X		Job is not routine.
				X	Other people review approach.
Place Fuel in Basket	1	X	X		Equipment not the environment because only one element is moved at ome time.
				X	Yes, there are back-up systems to protect against major problems.
HYDROSTATIC TESTING Pressurize Cask	2	X			Cask overpressurization.
					Spreading contaminated water.
			X		Not paying attention.
					Improper fitting of disconnects.

Activities/Tasks	N	Question A	B	C	Respondents Comments
				X	Install press. Check all fittings.
Cask with Crane	1	X			Damage equipment.
			X		A large and heavy load.
				X	No.
Attach Hydrostatic Pump; Pressurize; Disconnect	8	X			Personal injury. Splashing pressurized solution on person. Possibility of leaking valve or hose could cause contamination spread. Falling hazards exist due to climbing on railcar and cask. Failure to watch and set up properly.
			X		Not much flat surface on top of cask. Wearing hose. Test is being performed in noncontaminated area. Faulty pressure gage. Slick SS round surface. Work position is not very convenient.
				X	No. Inspect equipment before using. If contamination should occur, decontaminate area and obtain unconditional release from plant safety.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
					Use proper care.
					Relief valves.
					Watch your footing and use ladders where possible.
					Do not fall.
Moving Cask	6	X			Tools or equipments being left on cask and subsequently dropped and thus cause possible injury or damage.
					Damage to railcar.
					Speed of attempted operation.
			X		Needed procedure modification.
					Operator error.
					Little room for poor judgment.
					Crane could fail.
					Tolerance between cask and lifting.
				X	Careful search for items left by personnel performing job to insure that nothing remains that could cause a problem.
					Off-site shipment preparation.
					Two technicians in area.
					Be cautious.
					Yes, watch alignment.
Coordinate with Maintenance for Relief Valve/Gauge	1	X			Not properly installed.
			X		Communication problem.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
Check LAW Vault	2	X			Falling or dropping equipment in vault. Slipping and injuring self.
			X		Improper use of safety equipment. Being aware of th potential hazards.
				X	Set cask down on pad floor and monitoring while lifting gear prior to initiation. Wear safety harness, rubber boots, etc.
Drain Cask to LAW Vault Using Air Pressure	2	X			Anytime you use air pressure with contaminated material, you are taking a risk. Draining the cask probably rates as the highest hazard due to possibility of leakage.
			X		Connections. Leakage problem is minimized because it is on the decon pad.
				X	Shut-off valve within reach.
Vent Cask to LAW Vault	1	X	X	X	N/A.
OFF-SITE SHIPMENT PREPARATION Connect Cask to Railcar	5	X			Pinching injuries could occur. Dropping cask.
			X		Tolerance between cask and lifting. Tight working conditions Equipment is very heavy and hard to handle.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
					Connecting and disconnecting hoses, turning valve.
					Improper crane operation.
				X	Watch alignment.
					Yes, back off and try again.
					Two technicians working together using their training and signals.
					Have assistance.
Replaces Box Cover Ducts	8	X			Personal injury.
					Operation of ducts requires two personnel.
					Overfilling of fuel tank.
			X		Communication problems.
					Operator error.
					Ducts are hard to manipulate.
					Faulty shut off.
					Slide SS surface.
					Not much room on flat surface to move about.
				X	No, could slip and fall or pinch your fingers.
					Final inspection by supervisor.
					Observe safety rules.
					Wear a hard hat.
					No, smoking is allowed during refueling (fire danger).

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
					Be sure of footing.
					No, personal injury would occur.
Assist Train Crew	1	X			Injury.
			X		Lousy weather.
				X	Be careful.
Operate Crane	6	X			Improper switching.
					Tipping or dropping cask; damage the railcar.
					Damage to railcar.
					After setting the cask in car cradle, there is a critical moment as you lower the crane and move it north to start proper angle downward.
					Moving cask too fast.
			X		Inadequate training.
					Operator error, crane lifting device failure.
					Built-in hazard.
					Poor visibility.
					May not watch the relationship of the trunnions and crane cables.
				X	Yes, working with an experienced technician.
					Off-site shipment preparation.
					Set cask back down on pad floor. Monitor while lifting gear prior to initiation.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
					Slow, careful operation. Assure that duct work is properly retracted and have a second technician on the opposite side of the rail-car.
					No.
					Stop all movement.
Decontaminate Cask	4	X			Personnel contamination.
					Untidy work area.
					Could fall off platform.
			X		Person must work adjacent to cask to wipe it clean.
					People not picking up after themselves.
					Be careful.
					Know where the other technician is at all times.
				X	Perform regular self-check.
					Keep work area clean.
					Yes.
					Change protective clothing.
BASIN COOLER OPERATIONS					
Remove Pump Discharge Pressure Indicator	11	X			Release of contaminated water.
					Personal injury.
					Minor water leak.
					These jobs are routine.
					Line under pressure.
					Leave indicator out.

Activities/Tasks	N	Question			Respondents Comments
		A	B	C	
			X		Failure to isolate or drain line.
					Operator error.
					Line may have pressure or be contaminated.
					Hot area.
					System operates under pressure.
					These jobs are routine.
					Not valuing out RI.
					Operator might be called to another job.
				X	Shutting down pump and closing the valve will lessen severity. Draining is essential.
					Yes, proper knowledge of system and detecting errors.
					Observe safety rules.
					Problems could be corrected by retightening gauge.
					Take precautions.
					Proper SWP clothing.
					The back-up system in the control room would see the problem before any major problems could arise.
					Have safety monitor while doing the work.
Check for Leak	5	X			Climbing hazards and dose rate hazards exist.
					Leak in outside system.
					Not seeing the leak in time.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
			X		Required job checks.
					A very small leak could go undetected.
					Moving into the area.
					Poor workmanship.
					Human.
				X	Be careful climbing. Plan your work for limiting your dose rate.
					Observe flanges, plugs, and valves.
					Changing clothes and showering if contaminated.
					Prompt discovery.
Turn Fans On	2	X			Fan throwing its blades.
			X		Communication and misunderstanding.
					Verification. Periodic QA inspection.
				X	Two technicians required.
					No recovery without penalty.
Prime Pump	3	X			Pump could be damaged.
			X		Valving error.
					Shut off pump.
				X	Shut off pump if no pressure develops.
					Yes.
					Proper coordination with control room while priming the pump.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
Install Chicago Coupling	2	X			Contaminated water spilled.
					Personal injury.
			X		Off-standard operation.
					None.
					No.
					Proper preparation.
BASIN WATER ANALYSES					
Take Water Sample from Basin	24	X			Could fall in basin.
					Contamination of personnel.
					Radioactivity is very low.
					Spilling the sample.
			X		Wear life jacket.
					Lack of grooves.
					Sample is taken.
					Leaning over wall.
					Not being careful.
					Water being sampled is contaminated.
					Poor sampling method.
					Bottle spillage can occur.
					Operator error.
					Proper adherance to procedures.
					Handling.
					Samples are taken by dip method from walkway.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
				X	Yes, wash hands.
					Be cautious and wear gloves.
					Wear life preserver.
					The penalty could range from contamination to drowning.
					Clean up spills.
					Basin filter operations.
					Safety department is always checking for contamination.
					Treat the task as a potential hazard.
					Wash arms off.
					Yes, decontaminate walkway and personal.
					Two technicians are a requirement.
BASIN FILTER OPERATIONS					
Remove Sweeper Head and Attach Cleaning Tool	9	X			Exposure to high radiation area.
					Falling into basin and dropping the filter offline.
					Spending too much time.
			X		Performed over water.
					Cleaner head is highly contaminated.
					Periodic replacement of hoses.
					Wet walkways.
					Must be removed from water.
					Working on a narrow ledge.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
				X	No major problems.
					Use dose rate meter.
					Wear life jacket and work quickly.
					Assuring sweeper valve is closed.
					Plan the operations.
Clean Cask Interior	2	X			Receiving airborne contamination.
					High radiation exposure.
					Watch dose meter.
					Falling into pool.
			X		High radiation level in cask.
					No safety monitor.
					No visible hazard.
					Protective clothing required.
					Poor visibility.
					Task is performed over platform.
				X	Take high volume air sample and wear a mask.
					Work done under SWP.
					Have safety monitor while doing the work.
					Protective clothing.
					Yes, follow procedures.
					Place protective tent over cask.
					Safety technician is present.

Activities/Tasks	N	Question A	B	C	Respondents Comments
Clean Basin Floor	3	X			Could fall or be exposed.
			X		Two technicians required. Not paying attention to work area.
				X	Yes, limit your staying time and monitor dose rate.
					No, know where the hot spots are.
DEMINERALIZER OPERATIONS					
Set Timers	2	X			Timer out of synchronization.
					Required time for operation.
			X		Make sure settings are correct.
					Not knowing system.
				X	Experience.
					Process of regenerating the unit can be shut off and the timer connected.
Regenerate Unit	2	X			Spilling caustic.
					Getting 50 percent sodium hydroxide solution on the body.
			X		Proper protective equipment.
					Hooking up hoses.
				X	No recovery without penalty.
					Use safety shower.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
Check Acid/Caustic	4	X			Acid and caustic burn hazard exist.
			X		The nature of the chemicals make it hazardous.
					Acid and caustic is pumped to the demineralizer units for regeneration.
				X	Wear protective clothing. A safety shower nearby.
					Yes, training and clean up.
Adjust Valves	14	X			Leak from valves.
					Mistakenly leave a valve open or closed.
					Operator could be splashed with acid or caustic solution should a valve on line leak during regeneration.
					No water flow.
					Cutting water off to boiler.
					Misalignment of valves.
					Acid/caustic burns.
					May slip and fall.
					Incorrect line up of valves.
			X		If technician does not follow SOP.
					Some close quarters in valve adjustment.
					Improper tagging of valves.
					Operator error.
					Small leaks in valves and tubing.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
					Technician not familiar with system.
					Not properly trained.
					Normal industrial hazard and congestion.
					Elevation of valves and equipment.
					Two units side by side are almost identical.
				X	Maintenance checks.
					Use of protective clothing.
					SWP requirement and job site inspection.
					Yes, knowing the system.
					Rinse down with water.
					Yes, system has low level alarm.
					Get ladder and try again.
Take Sample	1	X			Diluted acid.
			X		Caustics are involved.
				X	Wear eye protection.
Sample Chemical	1	X			Receive chemical burn.
			X		Sloppy or careless work.
				X	Wear face protection. Open the sample valves slowly. Do not overfill sampler.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
LAW EVAPORATOR SYSTEM OPERATIONS					
Monitor Operations Visually, Check for Leaks	5	X			Falling into LAW vault.
					Area is contaminated.
			X		Failure to use safety harness.
					Climbing in canyon and riding crane bucket.
					Having to physically enter vault.
					Instruments, vent, and jets are located in the area.
					Broken line connection.
				X	No recovery without penalty.
					Safety chain on bucket, two men are required.
					Planning the work.
					Wear protective clothing.
Adjust Valves and Pumps	9	X			Personal injury.
					Technician may fall.
					Safety gear is used.
					Has a high dose rate.
			X		Negative working conditions.
					Slip hazards.
					The way the system is designed.
					Equipment failure.
					Location of evaporator.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
					Safety line and valve adjustment.
					Radiation surveys.
					Location of equipment creates problems.
				X	Injury or pump delay completion.
					Proper, safe equipments.
					Protective clothing on RWP or SWP.
					Yes, preplanning.
					Two technicians are a requirement.
					Safety technician monitors.
Sampling Density	7	X			Falling and the solution is contaminated.
					Personal injury.
			X		Poor lighting, unsafe working conditions, and low head room.
					Sample taken from vault.
					Slippery surfaces.
					Bulky gloves and cold hands.
					Check safety strap.
					Contamination is present.
				X	Wear safety belt, wear acid suit.
					Proper training.
					Protect self and clothing.
					There is no immediate safety plan.
					Follow procedures.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
Check System Operation, Blower, Vents, Instruments	1	X			Radiation, climbing, and LAW vault pit hazard.
			X		Inaccessibility of equipment.
				X	Pretask planning.
Measure V-S70 Level	1	X			Falling.
			X		Area is damp, not well lit, slippery.
				X	Yes, two people always make entry.
ELECTRO-DECONTAMINATION OPERATIONS					
Place Items in Acid	13	X			Acid splash and electrical arcing. Splashing with hot acid.
			X		Nonfamiliarity with equipment. Protective clothing. Operator error. Open top tank. Working too fast.
				X	Training, go slow and take your time. Follow safety procedures. Supervisor check. Yes, have notes close by. Protective clothing.
Operate Electro-Decontamination Controls	3	X			Possibly electrical shock. Personal injury.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
			X		Lack of protective equipment.
					You do not always see what is happening.
					Use of liquids and electricity.
				X	Two operators are required. Follow written procedures and obtain proper training.
					Part might be repairable but a penalty is incurred.
					Shut off power.
Operate Portable Polisher Tools	1	X			Getting acid in your eye.
			X		Acid is being pumped outside.
				X	SWP job.
Rinse Acid From Item	5	X			Serious error is splashing acid.
			X		Design.
					Heavy gloves make movement awkard.
					Carelessness.
				X	Wear protective gear.
					Take your time and plan your job.
					Wash right away.
					No high pressure sprays.
Electro-Decontamination using Hand Operated Tools	1	X			Acid splash and spill.

Activities/Tasks	N	Question A	B	C	Respondents Comments
			X		Pump under pressure.
					Check hoses, wear protective gear, and clean up.
BASIN LEAK DETECTION					
Collect Sample	14	X			Possible contamination.
					Glass sample could break.
					Spilling solution.
					Cork may come off bottle.
			X		May enter too fast.
					Transporting solution to sample bottle.
					Equipment failure.
					Failure to monitor operation.
					Use of tubing.
					May have limited time.
					Operator error.
					Design.
				X	By shutting off jets.
					Take your time.
					Good working habits.
					Yes, follow procedures.
					Shutting sample valves.
					Protective equipment.
					Replace bottle and tubing, obtain release from safety.

Activities/Tasks	N	Question A	B	C	Respondents Comments
					Make alignment.
					Wash with water.
					Yes, wear goggles and rubber gloves.
Place Steam Supply Valve to Jet	4	X			Burn hazard exists, possible contamination spread.
					Technician may burn self.
			X		Tubing can become loose.
					Steam may leak.
					Steam lines and valves get hot.
				X	Avoid steam lines and cleaning spills.
					Wear gloves.
					Check all tubing connections.
Put Sample in Container	1	X			Spilling sample.
			X		Bumping into equipment.
				X	Protective clothing.
Attach Tubing to Basin System	1	X			Finding contamination in this system.
			X		Leak in the basin liner.
				X	Fixed the leak.
Open Jet Suck Valve	1	X			Air lift cause pressure.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
			X		Normal industrial.
				X	Yes, good understanding and operating techniques.
Clean Sample Box	1	X	X	X	Very rarely done.
EMERGENCY ACTION FOR BASIN COOLERS					
Inspect for Water Leakage	4	X			High radiation level.
					Leaks around valves and flange.
					Fan hazards.
					Spilling sample.
			X		Lack of knowledge.
					Improper seals.
					Radiation area.
				X	Use dose rate meter.
					Check system.
					Lock out breaker.
					Two personnel are required, SWP required.
Cover Coolers with Tarps	13	X			Fall off coolers.
					Receive high radiation exposure.
					Very tight area.
			X		Cold winter weather.
					Work on top of coolers.

Activities/Tasks	N	Question A	B	C	Respondents Comments
					Tarps are very bulky and heavy.
					Poor footing.
				X	Watch dose meter and dress properly.
					Preplanning.
					Supervisor and safety technician monitors stay time.
					Safety rope railings installed prior to job.
					Keep a close eye.
					Work safely but quickly.
Turn Breaker Off	1	X	X	X	Turn breakers off.
Open Valve to Discharge Header	1	X			Incorrect valving.
			X		Limited amount of area.
				X	Yes, valving is checked every day of the year.
Check Valving	2	X			Pumping of basin.
					Improper rating can cause equipment damage.
			X		Improper tag out.
				X	No recovery.
					Yes, detecting error in a short time and making corrections.
Light Space Heater to Heat Area	3	X			Radiation exposure and/or falling.
					Possible burn hazard.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
			X		Climbing under tube. Design small working area.
				X	Two or three person job, monitor exposure. Speedy and careful. Lock out fans.
CASK HANDLING WITH FAILED OR LEAKING FUEL					
Take Sample for Cesium Analyses	2	X			Potential spread of contamination. Hot sampling system.
			X		Better sampling system.
				X	Yes, wear face shield and goggles.
Obtain Codant Sample	7	X			Radiation exposure. High contamination. Possible burn. Spilling of coolant sample.
			X		Possible radioative particles. Tripping over equipment.
				X	Careful monitoring. Yes, decon pad prevents contamination spread. Wear gloves and filter. Area can be cleaned.

Activities/Tasks	N	Question A	B	C	Respondents Comments
Cask Handling with Failed or Leaking Fuel Flush Cask	4	X			Contain radioactive materi?l. Error in monitoring dose rate. Overflow cask.
			X		Gases may escape. High dose rate from flush lines. Clean up water.
				X	Safe operations. Respond quickly to area alarm. Strict adherence to SOP.
Coolant Sample	2	X			High dose rate.
			X		Cramped working quarters. Splash from sample bottle.
				X	Monitoring detector attached to pipe. Wear face shield.
Fill Cask with Water	1	X			Cask could over flow.
			X		Watch level.
				X	Yes.
Evacuate Personnel, Flush Cask and Vent Cask to LAW Vault	1	X			Personnel in airborne atmosphere.
			X		Flushing a cask.
				X	Communications.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
CONTROL ROOM DUTIES					
Respond to Alarm	9	X			Respond to wrong area.
					Failure to notify someone to react to alarm.
					Wrong response.
			X		Not familiar with equipment.
					Boredom from long hours in control room.
					Some trip during normal operation.
					Lack of proper interpretation.
					Incomplete knowledge.
				X	Not familiar with equipment.
					Respond accordingly.
					Yes, early detection of error.
					Need hands-on experience.
					Checking findings.
					Training and plant knowledge.
Start or Stop Equipments	11	X			Start up of equipment.
					Hazard is very low.
					Proper communication.
					Damage to equipment.
					Turning fans on in cold weather.
					Pushing the wrong switch.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
			X		Poor communication.
					Misvalving equipments.
					Not following procedures.
					Improper tagging.
					Read SOP.
				X	Duration of error.
					Alarm on control room.
					Thermal overload on pumps.
					Two technicians startup equipment, ICR in area.
					Check each step.
					Be aware of equipment.
					Two lock-on breakers.
					Retraining.
PLANT ROUNDS					
Check the Demineralizer System	1	X	X	X	Greatest error would be to introduce corrosion.
Check the Phosphate and Hydrozone Tank Indicators	1	X			Adding chemical above eye level.
			X		Chemical can be added without slipping.
				X	Get a short ladder and use it.
Inspect the Basin Cooler Area	2	X			Failure to leak.
					Radiation protection.

Activities/Tasks	N	Question A	B	C	Respondents Comments
			X		Outside work.
					Cooler area is high radiation area.
				X	Room alarm might help.
					Two technicians are required inside area.
Inspect the Water Tower and Indicators	1	X			Failure to monitor.
			X		Technican unavailable.
				X	Low water level alarm in control room.
Check the Deaerator	2	X			Falling when climbing.
					Instrument error.
			X		Poor design.
					Well trained.
				X	No.
					Need hands-on experience.
Inspect Building	1	X			Improper valve alignments.
			X		Complexity of system.
				X	System misreading.
Check the Deaerator and Accumulator	3	X			Falling off.
					Heat hazard.

Activities/Tasks	N	Question A	Question B	Question C	Respondents Comments
			X		Not having a cage guard.
					Poor ladder safety.
				X	Recover from error without penalty.
					Follow procedures.
					Be cautious.
Inspect the Compressor Room and Indicators	1	X			Shutting down compressors.
			X		Very unlikely.
				X	No fault.
Check the Utility Boiler System	6	X			Utility system shutdown.
					Improper knowledge.
					Knowing the system.
					Equipment damage.
					Gas leak in system.
			X		Rounds negligence.
					Lack of experience.
					Operator error.
					Natural gas lines present.
				X	Utility systems have alarms on them.
					Malfunction can be corrected.
					Yes, a quick start up is vital.
					Observe rounds.

Activities/Tasks	N	Question A	B	C	Respondents Comments
Check Heat Pump System and Indicators	1	X			Preheaters.
			X		Hot piping.
				X	Use flashlight to check.
Inspect the Basin Filter and Indicators	1	X			Overexposure.
			X		Filter radiation dose rate will run very high.
				X	Conduct radiation survey first, then plan accordingly.
Monitor the Process Steam Room Indicator	1	X			Trip and bump hazard.
			X		If technician is careless.
				X	Safety technician would monitor activity.

GLOSSARY AND ABBREVIATIONS

Activity. Classification of the large segment of closely related tasks performed during a person's job.

AEC. Atomic Energy Commission.

BWR. Boiling Water Reactor, a type of light water reactor.

CRO. Control Room Operator, generally the operations supervisor.

Demin. Demineralizer.

Error. Human action which falls outside of the limits of acceptable task criteria.

IF-300. A rail car carried cask, manufactured by General Electric.

ISFSI. Independent Spent Fuel Storage Installation.

LAW. Low Activity Waste (vault).

Job. The activities and tasks performed by the person who fills a position.

NRC. Nuclear Regulatory Commission.

NFS. Nuclear Fuel Services, a manufacturer of casks.

OSD. Operational Sequence Diagram.

PWR. Pressurize Water Reactor, a type of light water reactor.

SD. Standard deviation.

SWP. Special Work Permit.

Task. One part of an activity. Each task comprises a special action (verb and object) which results in a meaningful time-rateable output.

Task Analysis. A method which determines the human components in systems.

TI. Task Inventory.

Walk-through. A technique where personnel perform simulated actions on equipment in lieu of actual operations.

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