UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

August 2, 1979

MEMORANDUM FOR: George Frampton, Deputy Director
NRC/TMI Special Inquiry Group

FROM: Gordon L. Chipman
Human Factors Task Force

SUBJECT: HUMAN FACTORS WORK PLAN AND RESPONSE TO QUESTIONS

We have completed the items you requested in your memorandum of July 19, 1979. The detailed work plan has been coordinated with all members of the task force, and it appears we have a working understanding of this Division of Labor. While there may be minor shifts in the future, the attached assignment and work scope should be considered as a working document. The enclosed individual work plans have been developed in light of the overall work plan. The enclosed responses to your questions were prepared with input from all members of the Task Force.

We received the responses to the RFP, and expect to complete the evaluation processes and identification of the most qualified contractor today. Nearly everyone who attended the B&W simulator presentation was impressed with how tame the transient was after the first 20 minutes. In light of this the scope of the task to construct a detailed time line and video tape a walk-through of the accident will be reevaluated after we have selected a contractor.

Gordon L. Chipman
Human Factors Task Force
NRC/TMI Special Inquiry Group

Enclosures:
1. Assignment and work scope
2. Individual work plans
3. Responses to questions

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TASK OUTLINE

HUMAN FACTORS EVALUATION OF CONTROL ROOM DESIGN AND OPERATOR PERFORMANCE AT TMI-2

I. Background

Following the accident at Three Mile Island Unit No. 2, the Commission established a Special Inquiry to assure that the NRC will have the fullest possible understanding of the events at Three Mile Island. The purpose of that evaluation is to take whatever further steps may be necessary to prevent any similar accident in the future. A major area of investigation by the Special Inquiry is the response of the operating personnel to the events. Specifically, the Inquiry must determine to what extent the control room design, operator training and selection, operator performance, and other factors, significantly influenced the sequence of events. The work scope described below is essential to the completion of this objective.

II. Special Inquiry Group Tasks

Group Assigned	A. Operators[1/]
1	o Examine background and experience prior to Met Ed employment
1	o Determine educational background
1	o Identify NRC requirements for selection
1	o Identify Met Ed requirements for selection
1	o Evaluate application of selection requirements to operators
1	o Identify NRC training requirements
1	o Identify Met Ed training program/requirements
1	o Determine formal training of TMI-2 operators -- Curriculum -- Lecture training -- Simulator training - how accurate simulation -- Instructor background -- Performance of trainee -- Recurring training -- Training of Supervisors

[1/] Operators include: CR operators, CR supervisors, plant auxiliary operators (Maint. Personnel) and appropriate management personnel.

1 o Determine on job training for operators

-- Duration
-- Formality of program
-- Capability of instructor(s)
-- Performance of trainee
-- Drills on watch

1-4 *o Evaluate training program

-- Other utilities' programs comparison with Met Ed

1-4 o Evaluate performance of operators in meeting NRC requirements (test results, etc.)

o Actions/Inactions <u>before</u> the accident

4-2 -- Identify critical system malfunctions/misalignments
4-2 -- Identify human factors involvement in system malfunctions
4-2 *-- Determine when and how recognition of malfunction was achieved
4-2 *-- Determine when and how correction of the malfunctions was achieved

2-3,4 o Actions/Inactions during accident

-- Determine detailed sequence of events
-- Identify significant operator actions/inactions

B. Precursors related to Human Factors

1-2,3,4,5 o Identify significant precursors that could have impacted TMI-2

1 o Determine the response by NRC, industry, Met. Ed. to each of these significant precursors.

1 o For each precursor, determine what information was gained/should have been gained

1-2,4 o Determine what information feedback was utilized by NRC, Met. Ed.

-- To update training
-- To update procedures
-- To update plant
-- To update control room
-- Other

*These evaluations are to be performed in conjunction with the contractor.

1 o Compare emphasis on precursor events by Met Ed and other utilities

C. Control Room Design

1 o Identify NRC regulations and regulatory guides

1 o Identify published standards and recommended practices of other organizations

1 o Identify the criteria utilized in TMI-2 CR design

1-2,4 o Identify the CR design philosophy

-- NRC philosophy
-- Met Ed philosophy
-- Vendor philosophy
-- Architect/Engineer philosophy

1-2 * o Determine the dominant influence on TMI-2 CR design

2 * o Evaluate the conformance of CR design to human engineering principles

2 * o Compare design process to that utilized in other CR's of the same vintage

2 * o Evaluate the human factors considerations utilized in design of critical systems, controls and procedures

2 * o Compare CR design (from a human factors viewpoint) with designs of other complex man/machine systems

-- NASA
-- DOD
-- Chemical Industry
-- Nuclear Navy

D. Plant Design & Control (outside CR)

1 o Identify NRC requirements for plant design and control related to human factors

-- Reactor and secondary system

1 o Identify Met Ed influence on design

* These evaluations are to be performed in conjunction with the contractor.

4-2,1 Miller, Doyle
- For plant control other than CR, determine
  - -- Human factors application
  - -- Communication
  - -- Signals in CR

E. Procedures

4-1 o Evaluate effectiveness of administrative (shift turnover) procedures.

4-1 o Determine process for development of emergency procedures.
- -- By whom
- -- Review and/or approval
- -- Update in light of precursors

4-2,1 * o Evaluate effectiveness in time of emergency

4-2 * o Evaluate effectiveness in TMI-2 accident

4-2 * o Evaluate operators' use of procedures

4-2,1 o Examine need for simplification of procedures

All F. *Evaluate, in conjunction with contractor, the adequacy of the following, particularly as they related to the accident:

- o NRC requirements
- o Met Ed & their contractors and vendors in applying human factors principles
- o Operator selection and training
- o Control room design
- o Feedback of information from precursors
- o Plant design
- o Emergency procedures

* These evaluations are to be performed in conjunction with the contractor.

III. Outside Contractor Tasks - Group 2, Contract Management

Task A - Control Room Design at TMI-2

The Contractor shall:

1. Identify the criteria which directly influenced the CR design as specified by the NRC and standards organizations.

   a. Review Title 10 of the Code of Federal Regulations, NRC Regulatory Guides and Standard Review Plans as provided by the NRC which dictated the design of the control room and point out those criteria which require the application of human engineering principals to such designs.

   b. Identify relevant standards and recommended practices published by organizations other than NRC which deal with nuclear power plant control room design.

   c. Identify which of the criteria identified in 1.b. were utilized in the design of the TMI-2 control room.

2. Identify the actual design basis and operating logic which led to the as-built design of the control room. Review the design studies and analyses of Metropolitan Edison Co. and its associates as provided by the NRC leading to as-built design of the control room and determine what human engineering principles were applied.

3. Determine if the CR was designed in accordance with the design basis and criteria identified in 1 and 2 above.

   a. Review control room contractual documents, Final Safety Analysis Report, Construction specifications and as-built drawing as provided by the NRC to determine the human factors aspects of the control room design.

   b. Visit Three Mile Island site for familiarization and to complete accurate description of the control room in its pre-accident configuration.

   c. In conjunction with the NRC Special Inquiry contract project manager ("NRC project manager") compare the human factors aspects of the actual design of the control room (as determined under 3 a and b above) with the criteria and bases that led to the design (as determined under 1 and 2 above).

   d. In conjunction with the NRC project manager, and using the results of 3.c., identify those implicit philosophical or broad based design concepts which had a significant impact on the human factors design of the control room (i.e. single failure concept).

   e. Determine if the quantity and prominance of information presented in the control room are consistent with the design bases and criteria.

4. Compare the design process for TMI-2 CR with that used in other nuclear plant control rooms of the same vintage.

   a. In conjunction with the NRC project manager, identify a limited number of plants (at least 2) of the same generation as TMI-2.

   b. Obtain reconnaissance level information (documents and discussions) on human factors criteria and design bases used.

   c. Visit the control rooms identified above, and assess the degree to which these designs were constructed in accordance with their respective criteria. NRC will assist contractor in obtaining access to such control rooms.

   d. On a broad basis and in conjunction with the NRC project manager, compare the process that resulted in the application of human engineering principles to the design of the control room of TMI-2 with that of the plants identified in 4.a above.

Task B - Control Room Activity

The Contractor shall:

1. Construct a full scale mock-up of the TMI-2 control room panels utilizing photographs for the panels identified in the table below. The mock-up must be transportable in sections. Drawings of the panels will be provided by NRC in conjunction with Task A.3.b. Visit the TMI-2 CR to provide familiarity with the actual CR layout.

2. Prepare a timeline diagram of the control room activities during the first 150 minutes of the accident.

   a. Using event chronologies and operator interviews provided by NRC, define operator activities.

   b. NRC will identify the critical timeline actions/inactions within the control room which significantly influenced the outcome of the accident.

3. Video tape an enactment of the timeline sequence of events for use in the analysis of operator performance.

4. Based on the emergency procedures and other formal guidance available to the operators, develop an idealized timeline.

5. In conjunction with the NRC project manager, identify the control room design factors which influenced critical actions/inactions (2.b. above). Emphasis should be placed on the most significant human engineering issues.

Table of Control Room Panels to be Modeled

Control Room Desk - CONS-1
Computer Console - CONS-2
Aux. Systems Control Console - CONS-3
Plant Control Console - CONS-4
Turbine Control Console - CONS-5
Electric Control Consoles - CONS-6A, 6B, 6C
Fire Detection Panel - PNL-7
Coolant Systems Monitoring Panel - PNL-8
Reactor Coolant Drain Tank Panel - PNL-8A
Push Pull Control Panel - PNL-9
Plant Equipment Temp. Recording Panel - PNL-10
Radiation Monitoring Panel - PNL-12
SFAS Panel - PNL-13
Control Rod Drive Panel - PNL-14
Containment Isolation Panel - PNL-15
Turbine Supervisory Panel - PNL-16
Turbine Auxiliary Monitoring Panel - PNL-17
Station Electric Aux. Monitoring Panel - PNL-18
Vital Power Panel - PNL-19
Nuclear Instrumentation - CAB-20, 21
HVAC Panel - PNL-25
Diesel Generator No. 1 & 2 Panels - PNL-26, 29
Computer Programmers Console - CAB-188A

Task C - Operator Performance

The Contractor shall:

1. Determine the adequacy of the training program to assure the operators' capability to diagnose problems and take appropriate actions during normal and emergency conditions.

    a. NRC will provide documents describing operator training program, TMI-2 emergency operating procedures and will make available NRC operator licensing personnel to describe the regulatory program.

    b. In conjunction with the NRC project manager, determine if the operator training was adequate in particular with respect to the significant actions/inactions taken by the operators on the TMI-2 accident.

2. Identify the basis for each significant action/inaction resulting from operator performance that cannot be attributed to inadequate training. Where additional interviews with operators are required, this will be arranged through the NRC project manager. Types of results that might be obtained include: mismatched operator aptitude, poorly defined lines of authority or task assignments within the CR, etc.

3. Evaluate the adequacy of the transfer of information between shifts, and between operators and maintenance personnel at TMI. Review NRC and Met Ed requirements for information transfer and the implementation of these requirements at TMI-2. Compare the information transfer procedures of TMI-2 with those used in the plants identified in Task A.4.a. above.

Task D - Application of Human Factors Principles to Control Room Design

The Contractor shall:

1. Identify the systems components and procedures in the control room which played a critical role during the first 150 minutes of the accident.

    a. NRC will identify the critical timeline actions/inactions (critical points) within the control room which significantly influenced the outcome of the accident (B.2.b.) and provide applicable emergency procedures (C.1.a).

    b. For each critical point, identify the systems, components and procedures in the control room which did or should have played a role in the decision process.

    c. NRC will provide documentation of the chronology of events and existing operator interviews as necessary. Requirements for additional interviews will be coordinated through the NRC contract manager.

2. For each critical system, component and procedures identified in 1 above, identify the relevant human factors considerations. This will include the factors in the relevant Human Factors engineering standards.

3. Determine the degree of compliance of the critical system and component designs and procedures to the applicable human factors principles (standards).

4. Where areas of non-compliance are identified in 3 above, in conjunction with the NRC project manager, determine the impact on operator performance at critical points.

5. Utilizing the information obtained in Task A and B and in 1-4 above, and in conjunction with the NRC project manager, evaluate the integration of the control room design with the reactor system design in the context of human factor program development. This should include the utilization of task analyses of: the role of the CR operator; generating CR staff selection and training requirements; development and testing of operational procedures (including emergency actions); and the effectiveness of Licensee Event Reports (LERs) feedback.

6. Identify the approach taken by other agencies and organizations in the design of comparable complex man/machine systems with respect to the application of human factor principles and one example of advanced CR design concept being offered by a U.S. nuclear plant supplier. The agencies and organizations investigated should include comparable industries (chemical, etc.), the armed services and NASA.

   The procedural and decision-making process employed by each selected organization will be compared to the process utilized in the design of TMI-2. Significant variations should be identified and their impact on the performance of the operation estimated in conjunction with the NRC managers.

IV. <u>Deliverables</u>

1. For all tasks A-D

   a. Letter status reports every 2 weeks.

   b. Preliminary final letter report of all findings by September 28, 1979.

   c. NRC will provide comments by October 3, 1979 and Final Letter report of all findings incorporating NRC comments by October 10, 1979.

2. Contractor may be required to deliver the CR mock-up to the Washington, DC, metropolitan area before the termination of the contract. If the mock-up is not requested by the NRC by contract termination, the contractor may dispose of the mock-up.

3. The contractor shall be available to brief NRC Commissioners and other groups (not to exceed 10 briefings or hearings) regarding their work and findings on an as needed basis.

4. Except as specifically authorized by this contract, or as otherwise approved by the Contracting Officer, records or other information, documents and material furnishing by the Commission to the Contractor in the performance of this contract shall be used only in connection with the work performed under this contract. The Contractor shall, upon completion or termination of this contract, transmit to the Commission all records or other information, documents and material, and any copies thereof, furnished by the Commission to the Contractor or data developed by the Contractor in the performance of this contract.

ENCLOSURE 2

WORK PLANS

7/25/79

Gordon Chipman

WORK PLAN

HUMAN FACTORS TASKS	7/20	7/27	8/3	8/10	8/17	8/24	8/31	9/7
Visit [illegible] Simulator								
Evaluate Proposals - select contractor								
Provide Documents to Contractor								
NRC Documents								
Met. Ed. et al								
4. [illegible] critical points in sequence								
Brief Contractor including immediate needs								
6. Work with contractor to identify other plants and industries for comparisons								
7. Obtain copy of B&W video tape					--- ?			
8 Identify interviewees								
9. Prepare for interviews develop Qs.								
10. Conduct Interviews								
11. Arrange for visits and conduct with other plants (2-3)								
12 Visit TMI 2 CR with contractor					→ ?			
13. Oversee Contractor - stay abreast of [illegible]								

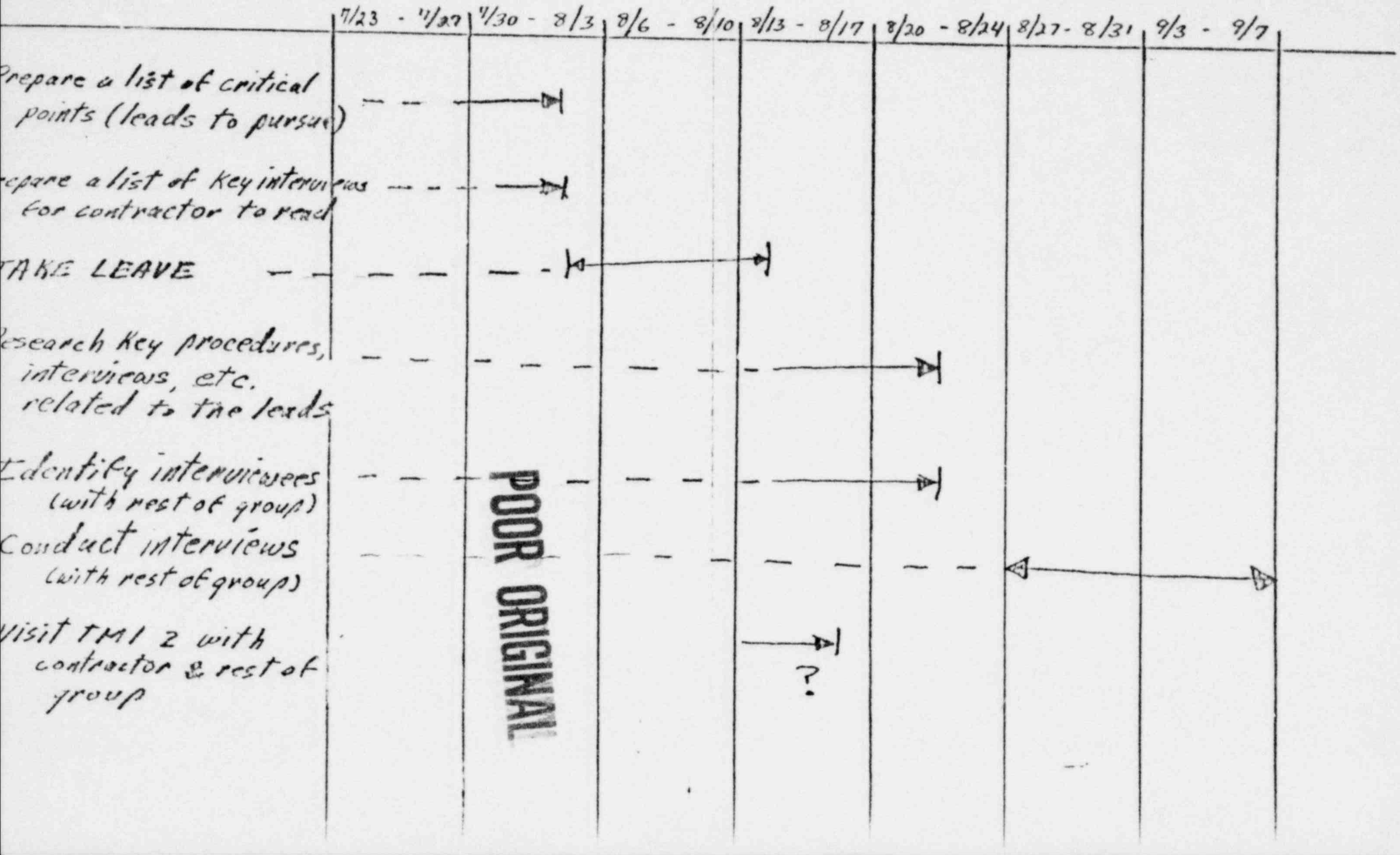
POOR ORIGINAL

WORK PLAN

DENNIS ALLISON

HUMAN FACTORS TASKS

Basic task is to identify critical operator actions
Look for reasons in training, procedures, discipline, safety consciousness (pursue leads)
Interface with others who are doing more extensive background type work.



HLOrnstein 8/2

7/20 | 7/27 | 8/3 | 8/10 | 8/17 | 8/24 | 8/31

B&W Lynchburg – Singer-Silver Spring
Background write-ups

Compile listings of NRC requirements regarding control room & operators, collating portions of TMI 2 PSAR, FSAR, staff SERs regarding utility staff
- management
- operators
- technical capabilities
- [illegible]
- training requirements
- [illegible] course, control room design
- responsibilities
- operating procedures and philosophy

Review recently acquired, NRC, B&W/Met Ed information (e.g. reports etc)

Prepare interview lists and questions:

NRC
Met Ed
GPU SVCS
GPU

staff, [illegible]
training rqts
control room evolution design & philosophy
philosophy of operating plant
feedback mechanism for operator data & other plant experience
safety reviews
B-mf [illegible] – control room & [illegible] interaction

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B&W [illegible] staff
regarding

training
simulators
requalification
philosophy of operator
actions/procedures

operator/CR interface

B&W night/service group
interactions with utilities
[illegible] (generation of procedures
feedback of operating histories
(LERs/Bulletins
[illegible] role in CR design
philosophy of operator
actions

Start interviews;

continuing discussions will be necessary with NRC
staff in areas of operator requirements
training, inspection/enforcement, instrumentation
& control,

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Jim Snell
Group 4

WORK PLAN

Human Factors Task

when & how recognition and correction of pre-accident malfunc[tions] were achieved

Receive list of "Malfunctions"	→ 8/10
review PORC/GRC/GORB mtg notes, Plant eqmt records	8/10 – 8/17
leave	8/20 – 8/26
interview Participation	8/27 – 9/7
write Drafts	9/7 →
Procedures	
Evaluate Effectiveness/Process of Development	8/1 – 9/7
1. Particular Emerg Proced...	

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ENCLOSURE 3

RESPONSE TO QUESTIONS

1. Describe briefly what kinds of licenses NRC grants and NRC's requirements for shift manning.

The NRC presently grants two kinds of operator licenses:

Reactor Operator (RO)

Senior Reactor Operator (SRO)

The educational and training requirements for the operators are described in Section 2 below.

The primary NRC requirement for staffing the control room with licensed, reactor operators is stated in 10 CFR 50.54(k):

> "An operator or senior operator licensed pursuant to Part 55 of this chapter shall be present at the controls at all times during operation of the facility."

Additional requirements are described in Standard Review Plan 13.1.2-2, the most pertinent of which are:

"(a) A licensed senior operator who is also a member of the station supervisory staff should be onsite at ·; times when at least one unit is loaded with fuel.'

"(b) For each control room from which one or more reactors are in operation, an additional operator should be onsite and available to serve as relief operator for that control room."

In addition to the aforementioned licensed operator requirements the management of each station having one or more units containing fuel should:

1) either "qualify and designate at least one member of each shift operating crew to implement radiation protection procedures... or assign a health physics technician to each shift..."

2) Include in their shift crew assignments a Licensed Senior Reactor Operator, a Senior Reactor Operator limited to fuel handling with no other concurrent operational duties, [special license "fuel handling foreman,"] to directly supervise the core alterations after initial fuel loading;

3) a fire brigade should be assigned for each shift the minimum size of which is 5 persons - unless a specific site evaluation has been completed and some other number justified;

4) assignments of onsite shift operating crews should have the following minimum (which includes licensed operators):

station with one unit:	3 people at all times	+ 2 additional people when unit is operating
multi-unit station:	3 people per unit at all times	+ 1 additional person per operating unit

NRC's minimum shift crew requirements for licensed reactor operators during power operation are shown on Table 1. (Page 4)

Presently, there are no NRC requirements for having a shift supervisor with greater technical skills than that of the Licensed Senior Reactor Operator.

Licensing exams for Reactor Operators and Senior Reactor Operations (initial exams vs. requalification or cross licensing exams) are made up by NRC personnel. These licensing examinations are administered and graded by NRC employees, as well as people from National Laboratories, college professors

who work with research reactors; e.g., Oak Ridge National Laboratory
Hanford
Savannah River
MIT
U of Illinois
Georgia Tech
U of California

Requalification exams and cross licensing exams are made up and administered by the utilities' training staff - with NRC audit review of the examinations and the results.

2. Describe NRC's educational and training requirements for operators, senior operators, engineers.

The following list summarizes NRC's guidelines for educational and training requirements for licensing nuclear reactor operators.

Reactor Operator

selection	High School Diploma or equivalent
criteria	Two years of power plant experience
	Minimum of one year at a nuclear power plant (meaningful operations, construction, or design work)

Training Requirements

Cold training - for potential reactor operators who have no previous experience - This program usually starts two years before fuel loading.

Phase I Basic Courses

12 weeks usually at nuclear training ceters or universities; includes 10 weeks of nuclear physics, health physics, chemistry, and plant technology and 2 weeks of practical operational training on a nuclear training or research reactor where the applicants participate in fuel loading experiments, coefficient measurement experiments, perform reactivity calculations, and manipulate controls during 10 reactor startups.

TABLE 1

MINIMUM SHIFT CREW REQUIREMENTS FOR LICENSED

REACTOR OPERATORS DURING POWER OPERATION

Control Room Arrangement			Type	SRO	RO	Total Number of Licensed Operators
Single Unit			A	1	2	3
Dual Unit	Single Control Room		B	1	2	6
	Common Control Room		C	2	3	5
Triple Unit	Single Control Room		D	1	2	9
	Dual + Single	Single Control Rm.	E	1	2	3
		Dual Control Rm.		2	3	5
	Common Control Room		F	3	4	7

EXCEPTIONS TO CURRENT STAFF POSITION:
TECHNICAL SPECIFICATIONS - MINIMUM ALLOWABLE LICENSED REACTOR OPERATORS DURING POWER OPERATION

Nuclear Plant	Type	SRO	RO	Comments
Browns Ferry 1, 2, & 3	E	3	4	Short 1 RO
La Crosse	A	1	1	Short 1 RO
Oconee 1, 2, & 3	E	3	4	Short 1 RO
Point Beach 1 & 2	C	1	3	Short 1 SRO

Phase II <u>Design Lecture Series</u>

6 weeks - familiarizes trainee with the design features of his plant.

Phase III <u>Observation Training and Simulator Training</u>

Observes day to day operation of a nuclear power plant including surveillance testing and radiation protection programs. The trainee receives two to three months of training on a power plant simulator in which he observes and participates in all phases of plant operations, startup, load and power changes, normal, abnormal, and emergency conditions.

The observation training is from 1 to 3 months, the simulator training is from 2 to 3 months. The minimum time for the combination is 4 months.

Phase IV Onsite testing (6 month minimum) applicants for a cold examination must complete a site training program at the reactor site for which the reactor operator will receive his license. In addition to classroom work the applicant engages in the day to day plant activities including procedure writing, construction checkout, and preoperational testing.

<u>Hot Training Program</u> - Training for applicants who will be taking their NRC license exam following reactor criticality. (Usually candidates are selected from plant auxiliary operators who normally have 1½ - 2 years of operating experience at that facility (training conducted onsite).

The technical training for the hot training program is the same as that which is required for applicants in the cold training program. However, the hot training applicants participate in on-the-job training which involves manipulation of controls during 5 reactivity changes and at least 2 training startups of the reactor. The two training startups of the reactor can be replaced by training at an appropriate nuclear power plant simulator.

Some trainees participate in reactor and plant operations during the commissioning phase of the facility up to the point where the reactor operates at a power level of 20% - this provides the applicants with hands on experience. The hot training program generally proceeds in a manner similar to the one described for the cold licensing program, and covers a period of 6 to 8 months (minimum of 500 hours lectures and 3 months of observation and "hands on" manipulation of power plant controls).

License Examinations - for Reactor Operator - same for Hot and Cold training programs.

Written examinations: six to eight hours essay type questions covering:

a) principles of reactor operation

b) features of facility design

c) general operating characteristics

d) instrumentation and control

e) safety and emergency systems

f) standard and emergency operating procedures

g) radiation control and safety

Oral examinations: four to six hours to verify applicant's capability of:

a) reading and interpreting the control instrumentation of the facility

b) manipulating the control equipment in a safe and competent manner

c) operating the facility during normal and emergency conditions

d) knowing the radiological safety practices and the purpose and function of radiation monitoring equipment.

The oral examination is conducted at the plant - mostly in the control room - where the applicant points out and explains the function and way of using plant instrumentation and controls. The applicant is tested on hypothetical accident scenarios - including mock manipulation of controls.

The applicant must also tour the plant and demonstrate his knowledge of the plant, emergency systems, administrative procedures, radiation monitoring equipment, etc.

Senior Reactor Operator - Selection Criteria

High School Diploma or equivalent

Four years of responsible power plant experience (minimum of one year at a nuclear plant, and a maximum of two years of the remaining three years of power plant experience may be fulfilled by academic or related technical training on a "one-for-one basis")

Examination requirements

Written examination comprised of questions in the same seven categories as the Reactor Operator examination, plus five other areas; i.e.,

h) reactor theory

i) radioactive material handling, disposal, and hazards

j) specific operating characteristics

k) fuel handling and core parameters

l) administrative procedures, conditions, and limitations.

Criteria for selection and training of nuclear power plant personnel are generally within the general guidelines of ANSI N18.1 - 1971 - (See Table 2) per Reg. Guide 1.8 "In some cases, plant design features or unusual operating conditions may indicate that additional or specialized expertise beyond qualifications presented in ANSI N18.1 - 1971 is needed. This determination will be made on a case-by-case basis."

It is the utility's responsibility to obtain competent personnel to man the power plant. In their safety analyses the utility is required to submit their plant's organizational plans including job requirements and descr ,tions and personnel qualifications. The utilities are also required to submit details of their training plans for all employees. Details of the subject matter for each course, on site, as well as at other training institutions, simulators, etc., are provided to NRC for review and approval per Standard Review Plan 13.2. The utility's safety analysis reports: "should demonstrate that the training provided, or to be provided, for each position on the plant staff will be adequate to provide assurance that all plant staff personnel qualification requirements will be met as of the time needed;

prior to operator license exams, prior to fuel loading, or prior to appointment or reappointment to the position."

The decision for a particular individual to pursue a particular license is his decision influenced by salary and status -- however it would appear that the utility has veto power over corporate expenditures on the individual's training.

TABLE 2

MINIMUM EDUCATION AND EXPERIENCE FOR AMERICAN NATIONAL STANDARD FOR SELECTION AND TRAINING OF NUCLEAR POWER PLANT PERSONNEL

(This Chart is not a part of the American National Standard For Selection and Training of Nuclear Power Plant Personnel, ANSI N18.1-1971; but for information only.)

	REQUIRED						SUGGESTED			REMARKS
	Experience (years)			Academic Training (years)	License		Education (years)			
	Total Power Plant	Nuclear Power Plant	Other Applicable		RO	SRO	Academic	Related Technical Training	Amount of Education (2) Creditable for Experience	
Manager										
Plant Manager (or Assistant)	10	3				X (1)	4		4	
Operations Manager	8	3				X	2 or	2	2	
Maintenance Manager	7	1					2 or	2	2	
Technical Manager		1	7				4		4	
Supervisor										
Supervisor requiring AEC license	4	1			X or	X	2 or	2	2	High school diploma or equivalent required
Supervisor not requiring AEC license			4							High school diploma or equivalent required
Professional-Technical Personnel										
Reactor Engineer and Physicist			2	4						
Instrumentation and Control Engineer			5				2 or	2	4	6 months experience in nuclear instrumentation and control
Radiochemist			5				2 or	2	4	1 year experience in radiochemistry
Radiation Protection Specialist *			5				2 or	2	4	
Operator - Technician - Repairman										
Operator to be AEC licensed	2	1			X					High school diploma or equivalent required
Technician			2					1		
Repairman			3							
Technical Support Personnel										
Engineer in Charge			5	4						Shall be competent in their field
Other personnel										

These values are minimum and it is recommended that they be exceeded.

(1) SRO license is not required for plant manager, but he or the assistant shall have the background required to sit for examination.

(2) Academic or related technical training in this column may *not* be credited toward nuclear power plant experience. See section 1.0 paragraphs 2 and 3 for nuclear power plant experience equivalence.

* Additional NRC requirement (Radiation Protection Manager -- Bachelor's Degree MS equivalent to one year of professional experience; Ph.D = two years professional experience), at least three years of professional experience should be in applied radiation protection work in a nuclear facility dealing with radiological problems similar to those in a nuclear power station, preferably in a nuclear power station.

3. What training did the operators on duty at TMI get? Describe training course including classroom work, hands-on work, types of scenarios followed, use of multiple failure training. Where does typical operator come from? Describe apprentice, on-the-job, refresher, and simulator training. Who does the training? Does NRC monitor or review the training and how?

The control room licensed operator (RO and SRO) on duty at the time of the accident were all experienced operators with a background of several years operating Navy nuclear power plants. They had all spent approximately 18 months as "auxiliary operators" within the Met Ed system during their training and qualifications to become Reactor Operators at TMI.

The training program of Met Ed was typical of many utilities and followed the requirements and guidelines of the NRC (NUREG-0094). Subsequent to the accident the TMI-2 operators have been critical of the training they received in general.[1] In particular, one of the ROs noted the following:

1. Training is based on the assumption that the design encompasses enough emergencies and anticipated casualties, thus the outcome of any event could be assumed before hand.

2. Although some instrument errors are used during training, basic philosophy is everything is going to work. Never failed 2-3 safety systems on a simulator. Also simulator can't model a solid pressurizer.

3. Training is in response to the types of questions NRC is going to ask during exams. Train to pass a test rather than operate a plant.

4. NRC looks for responses to predetermined emergencies.

5. Because of above, training philosophy is inadequate.

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[1]Oversight Hearings -- Weaver Committee - Serial No. [illegible] Part 1, May 11, 1979, beginning page 151.

The specific Met Ed Training Program has been described in detail.[2] This program will be reviewed in detail to evaluate its adequacy.

The Met Ed Training Staff has provided comments on the adequacy of the training program as it directly relates to the accident at TMI. The plant procedures (2103-1.3) and the operator training specify that the plant shall not be allowed to go solid at any time except for hydrostatic testing. The training emphasizes this prohibition, stressing the possibility of exceeding the high-pressure safety limit of 2750 psig because the pump discharge head is 2900 psig. For high pressurizer level, the procedures (2103-1.3) require securing makeup and increasing letdown. For low pressurizer pressure, the procedures require the opposite: isolate letdown, increase makeup, and, in addition, turn on the heaters.

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[2] Ernst L. Blake Jr. of Shaw, Pittman, Pitts and Trowbridge letter to Mr. George Frampton, NRC/TMI Special Inquiry Group, July 20, 1979, documents G/712-9.a-1 and G/712-9.a-2.

The training staff was asked what the operators would be expected to do, based on their training and experience, if a high pressurizer level indication called for one set of actions and a low RCS pressure called for another. Members of the training staff stated that the operators would definitely have reacted to the high level to avoid going solid. This is based on the TMI training and the B&W operating procedures. The necessity of maintaining pressure is stressed in connection with the avoidance of departure from nucleate boiling, but this is of no concern at the lower power levels existing after the reactor trip.

The training staff was asked if the opeators were taught the significance of saturation pressure. They stated that they were taught this in the basic thermodynamics that is taught. They were asked if the saturated condition would cause the operators to suspect steam voids in the primary system. They stated under the conditions that existed at the beginning of the event, the training staff would not expect the operators to check for the saturation condition immediately. The operators would not expect voiding with the pressurizer full. The injection of cold auxiliary feedwater and HPCI would cause the operators to expect a pressure reduction.

The training staff was asked if the possibility of a level rise in the pressurizer caused by steam flashing in another part of the primary system had ever been recognized and brought to the operators' attention. The answer was "never." The only training in this area is the discussion of the possibility of flashing in the hot legs if the pressurizer level is not maintained.

The training staff was asked if the operators were trained to verify the closure of the electromatic relief valve during events that can be expected to result in its operation. They stated that they were trained to check if it was open, but considering the other events that were occurring during the accident, they would not be expected to check this right away. The means available to check this were the console demand signal, which indicated closed, and the discharge line temperatures. The training staff stated that high discharge line temperatures were not very meaningful because the EMOV had been leaking prior to the incident, which resulted in temperatures that were not much lower than those existing with the valve open. These temperatures and their status are printed out by the alarm printer but these alarms might not get printed out for 20 to 30 minutes under the conditions of the accident because of the large number of alarms.

The training staff was asked if the operator training included actions to be taken if there was a pressure rise in the reactor coolant drain tank (RCDT). They stated that the training on the "Response to High RCDT Alarm" procedure (No. 2204-301B, C5) covered this. However, the alarm and indicators for this system are behind the panels. Also, determining the soruce of the leakage requires a process of elimination because the RCDT is connected to other leakage such as the RC pump seals and, valve packing leakoffs.

It was noted that the safety features actuation system was bypassed by the operators very soon after actuation, even though the coolant injection might not be be throttled back until later. The training staff was asked if the operators were trained to do this. They stated that they were trained to reset as soon as possible. This is done to prevent injection of sodium hydroxide into the reactor. In addition, the operators were trained to be prepared to maintain a 220-inch level in the pressurizer by throttling the HPCI valves. Also, they had to be prepared to throttle the flow to the makeup pumps to prevent exceeding the 550-gpm flow limitation, as the flow would increase if the RCS pressure decreased.

The training staff was asked under what conditions the operators were trained to shut down the RCS pumps. They stated that the procedures (2203-1.4, Revision 3) and training required pump shutdown for high vibration, low amperage, or low reactor coolant flow, all conditions that existed during the event. In the training staff's view, the conditions that existed during the March 28 event did require shutdown of the pump. They stated that the operator is trained that failure to trip the pump under these conditions could lead to pump seal failure or loss of the impeller.

A general description of typical training programs and NRC requirements follows.

Typical Operators

Applicants for reactor operator and senior operator licenses hired by the utility come from (1) conventional plants throughout the utility, (2) government operated nuclear reactors, and (3) new hires off-the-street. Both the operator and senior operator must be high school graduates or equivalent. Many utilities employ preselection screening using tests designed to determine an individual's suitability for nuclear training. Over one half of the operators have little, if any, nuclear experience at the time they are selected for training. While complete statistics have not been evaluated, a sample size of 303 was found to have the following characteristics. The median age was 36 years for the SRO and 33 years for the ROs in the sample. With all over 25 yers of age, about 80 percent of the currently licensed SROs and about 50 percent of the reactor operators have formal education beyond high school.

Initial Training of Personnel

The NRC requires two types of training programs. The "cold" program provides the necessary training for personnel who will sit for NRC license examinations prior to initial fuel loading. The "hot" program is for applicants who will sit for license examinations following criticality of the reactor.

The NRC required training for cold applicants usually starts 2 years before fuel loading. Applicants who have previous nuclear experience are phased in proper times in accordance with their experience. Applicants with no experience are phased in at proper times in accordance with their experience. Applicants with no experience complete the following program: Phase 1 - Basic courses which normally last 2 weeks are conducted at the nuclear training centers or universities. Phase 2 - Design lecture series takes 6 weeks and familiarizes the trainees with the features of his plant. Phase 3 - Observation training is conducted at both the simulator and on an operating nuclear power plant. The training requires 4 months and consists of observation of day-to-day operation at an operating plant and "hands on" training on a simulator. Phase 4 - is onsite training and takes approximately 1 year.

The hot licensing program follows the same material outlined under the cold licensing program. The training is conducted onsite and requires 6 months to complete. the training program requires a minimum of 500 hours of lectures and 3 months of observation and "hands-on" manipulation of power plant controls, on a day-to-day basis. Training includes 1 week of simulator operation which involves observing reactor transients and coping with accident conditions. On the commercial plant, only the control operators and supervisor are licensed. The balance of plant personnel complete a training program, but are not licensed.

Qualification and Requalification Program

Many utilities employ a preselection screening process using tests designed to determine an individual's suitability for nuclear training. Because many of those selected for training have been out of school for a number of years, some companies have found it advantageous to first conduct a review of basis mathematics and physics for the candidate. Generally these reviews last 4 weeks.

Training programs, together with the training schedule prior to fuel loading, are submitted to the NRC for approval. Usually the training program for applicants with no previous nuclear experience starts 2 years before fuel loading. Applicants who have previous nuclear experience are phased in at the proper times in accordance with their experience.

Applicants with no previous experience are required to complete the entire training program outlined below. The programs outlines below are minimal programs. Applicants must be highly motivated and dedicated to successfully complete these programs. Many applicants will require additional tutoring and time to become competent operators.

At the completion of the training program, operators and senior operators are certified by utility management and are then examined by NRC licensing examiners. If they successfully pass the written and oral examinations, they are issued a license to operate the plant. The written examination for the operator consists of seven categories and generally takes 8 hours to complete. The senior operator written examination consists of the same seven categories plus an additional five. Approximately 6 hours are required to complete the examination. The written examinations are followed by an operating test conducted by an NRC examiner. A typical operating test takes from 4 to 6 hours and consists of a one-on-one oral examination, which tests the applicant's knowledge of the plant operations and procedures.

The NRC approved requalification program requires that each licensed individual demonstrate his competency over a 2-year period to renew his license. The program requirements include preplanned lectures and on-the-job taining, including control reactivity manipulations, understanding of systems, procedures, design changes, changes to facility license and the emergency procedures. The NRC licenses both the operator and supervision to operate all systems in the nuclear power plant.

Practice of Casualty Drills and Plant Evaluations

The utility requalification program provides training and evaluation of the performance of abnormal and emergency procedures. This is accomplished by a training supervisor, reviewing step-by-step, the procedure with the licensed operator or supervisor at the operating control board. Casualty training and evaluation on a reactor simulator is an integral part of many of the plant requalifications programs. On the simulator, the student observes the symptoms and performs the immediate actions required to cope with the accident condition.

The NRC requires the licensed personnel to discuss step-by-step the emergency procedures on the control boards. Many of the utility training programs include training on simulators when the licensee analyzes and copes with the accident condition.

Continued Review of Personnel Performance and Removal From the Program of Those Who Do Not Meet Standards

The utility requalification program provides an ongoing review of personnel performance through preplanned lectures, control manipulations, review of abnormal and emergency procedures and annual written and oral examinations. A grade of less than 80 percent on any category of the written examination requires attendance of the lecture on that category material. A grade of less than 70 percent overall on the annual written examination requires mandatory participation in an accelerated requalification program. The individual is removed from his licensed duties until he has successfully completed the accelerated program and scored not less than 70 percent on a reexamination.

Further, if a licensee has not been actively performing the functions of an operator or senior operator for a period of 4 months, he must demonstrate to the NRC his understanding of facility operation before he is permitted to resume his licensed duties.

1. Schedule. The requalification program shall be conducted for a continuous period not to exceed 2 years, and upon conclusion shall be promptly followed, pursuant to a continuous schedule, by successive requalification programs.

2. Lectures. The requalification program shall include preplanned lectures on a regular and continuing basis throughout the license period in those areas where annual operator and senior operator written examinations indicate that emphasis in scope and depth of coverage is needed in the following subjects:

   a. Theory and principles of operation.
   b. General and specific plant operating characteristics.
   c. Plant instrumentation and control systems.
   d. Plant protection systems.
   e. Engineered safety systems.
   f. Normal, abnormal, and emergency operating procedures.
   g. Radiation control and safety.
   h. Technical specifications.
   i. Applicable portions of Title 10, Chapter I Code of Federal Regulations.

   Other training techniques including films, videotapes and other effective training aids may also be used.

   Individual study on the part of each operator shall be encouraged. However, a requalification program based solely upon the use of films, videotapes and/or individual study is not an acceptable substitute for a lecture series.

3. On-the-job training. The requalification program shall include on-the-job training so that:

   a. Each licensed operator of a production or utilization facility manipulates the plant controls and each licensed senior operator either manipulates the controls or directs the activities of individuals during plant control manipulations during the term of their licenses. For reactor operators and senior operators, these manipulations shall consist of at least 10 reactivity control manipulations in any combi-ation of reactor startups, reactor shutdowns or other control manipulations which demonstrate skill and/or familiarity with reactivity control systems.

   b. Each licensed operator and senior operator has demonstrated satisfactory understanding of the operation of all apparatus and mechanisms and knows the operating procedures in each area for which he is licensed.

   c. Each licensed operator and senior operator is cognizant of facility design changes, procedure changes, and facility license changes.

   d. Each licensed operator and senior operator reviews the contents of all abnormal and emergency procedures on a regularly scheduled basis.

e. A simulator may be used in meeting the requirements of paragraphs 3a and 3b if the simulator reproduces the general operating characteristics of the facility involved, and the arrangement of the instrumentation and controls of the simulator is similar to that of the facility involved.

4. Evaluation. The requalification program shall include:

a. Annual written examinations which determine areas in which retraining is needed to upgrade licensed oeprator and senior operator knowledge.

b. Written examinations which determine licensed operators' and senior operators' knowledge of subjects covered in the requalification program and provide a basis for evaluating their knowledge of abnormal and emergency procedures.

c. Systematic observation and evaluation of the performance and competency of licensed operators and senior operators by supervisors and/or training staff members including evaluation of actions taken or to be taken during actual or simulated abnormal and emergency conditions.

d. Simulation of emergency or abnormal conditions that may be accomplished by using the control panel of the facility involved or by using a simulator. Where the control panel of the facility is used for simulation, the actions taken or to be taken for the emergency or abnormal condition shall be discussed; actual manipulation of the plant controls is not required. If a simulator is used in meeting the requirements of paragraph 4c, the simulator shall accurately reproduce the operating characteristics of the facility involved and the arrangement of the instrumentation and controls of the simulator shall closely parallel that of the facility involved.

e. Provisions for each licensed operator and senior operator to participate in an accelerated requalification program where performance evaluations conducted pursuant to paragraphs 4a through 4d clearly indicate the need.

4. Control Room and Instrumentation

The principal design criteria for TMI-2 were developed in consideration of the AEC's General Design Criteria that were PROPOSED in 1967. (Approved in ____________________). The following is a listing of criteria applicable to the control room and the plant instrumentation - as described in the PSAR (through Amendment 12, 10/71).

CRITERION 11 - CONTROL ROOM (Category B)

The facility shall be provided with a control room from which actions to maintain safe operational status of the plant can be controlled. Adequate radiation protection shall be provided even under accident conditions, to equipment in the control room or other areas as necessary to shut down and maintain safe control of the facility without radiation exposures of personnel in excess of 10 CFR 20 limits. It shall be possible to shut the reactor down and maintain it in a safe condition if access to the control room is lost due to fire or other cause.

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CRITERION 12 - INSTRUMENTATION AND CONTROL SYSTEMS (Category B)

Instrumentation and controls shall be provided as required to monitor and maintain variables within prescribed operating ranges.

CRITERION 13 - FISSION PROCESS MONITORS AND CONTROLS (Category B)

Means shall be provided for monitoring and maintaining control over the fission process throughout core life and for all conditions that can reasonably be anticipated to cause variations in reactivity of the core, such as indication of position of control rods and concentration of soluble reactivity control poisons.

CRITERION 16 - MONITORING REACTOR COOLANT PRESSURE BOUNDARY (Category B)

Means shall be provided for monitoring the reactor coolant pressure boundary to detect leakage.

CRITERION 17 - MONITORING RADIOACTIVITY RELEASE (Category B)

Means shall be provided for monitoring the containment atmosphere, the facility effluent discharge paths, and the facility environs for radioactivity that could be released from normal operations, from anticipated transients, and from accident conditions.

CRITERION 18 - MONITORING FUEL AND WASTE STORAGE (Category B)

Monitoring and alarm instrumentation shall be provided for fuel and waste storage and handling areas for conditions that might contribute to loss of continuity ir decay heat removal and to radiation exposures.

CRITERION 22 - SEPARATION OF PROTECTION AND CONTROL INSTRUMENTATION SYSTEMS (Category B)

Protection systems shall be separated from control instrumentation systems to the extent that failure or removal from service of any control instrumentation system component or channel, or of those common to control instrumentation and protection circuitry, leaves intact a system satisfying all requirements for the protection channels.

Beyond the proposed General Design Criteria, the PSAR does not reference any specific requirements for control room design, data display equipment, or instrumentation.

The closest that the PSAR comes to outlining instrumentation requirements is in paragraph 7.1.1.2 Principles of Design (Instrumentation and Control-Protection Systems) - where it states that "The PROTECTION SYSTEMS are designed to meet the requirements of the proposed "Criteria for Nuclear Power Plant Protection Systems," (IEEE 279 dated August 30, 1968)." An annotated copy of IEEE 279-1968 indicating relevant portions is attached Nevertheless, in Section 7.4 of the PSAR, Met Ed outlines their control room design philosophy - see attached. Apparently, the control room described in Section 7.4 of the PSAR meets the AEC's proposed (1967) General Design Criteria.

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In 1969, the NRC was in the process of proposing guidelines with respect to minimum requirements for control room design considerations. The enclosed memorandum. S. Levine dated 6/11/69, exemplifies the status of AEC control room design requirements prevalent at the time TMI was licensed. Group 1 will be tracking down the evolutionary process associated with control room design, instrumentation, and monitoring equipment requirements.