DAIRYLAND POWER COOPERATIVE • P.O. BOX 817 • 2615 EAST AV SOUTH • LA CROSSE, WISCONSIN 54601
(608) 788-4000

October 31, 1980

In reply, please
refer to LAC-7196

DOCKET NO. 50-409

Director of Nuclear Reactor Regulation
ATTN: Mr. Darrel G. Eisenhut, Director
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

SUBJECT: DAIRYLAND POWER COOPERATIVE
LA CROSSE BOILING WATER REACTOR (LACBWR)
PROVISIONAL OPERATING LICENSE NO. DPR-45
ENVIRONMENTAL QUALIFICATION OF ELECTRICAL EQUIPMENT

REFERENCES:
(1) NRC Letter, Eisenhut to Linder, dated 9/19/80.
(2) Draft Interim Technical Evaluation Report on Equipment Environmental Qualification, dated 10/13/80.
(3) DPC Letter, Linder to Ziemann, LAC-6982 dated 6/12/80.
(4) NRC Letter, Eisenhut to All Licensees, dated 9/5/80.
(5) Safety Analyses Report, LACBWR, Pages 14 thru 30

Gentlemen:

In response to your order (Reference 1), the attached enclosures provide the balance of information requested by your staff.

Very truly yours,

DAIRYLAND POWER COOPERATIVE

Frank Linder

Frank Linder, General Manager

FL:JDP:abs

CC: J. Keppler, Reg. Dir., NRC-DRO III
NRC Site Resident Inspectors

THIS DOCUMENT CONTAINS
POOR QUALITY PAGES

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Mr. Darrel G. Eisenhut, Director
Division of Licensing
U. S. Nuclear Regulatory Commission

LAC-7196
October 31, 1980

STATE OF WISCONSIN)
)
COUNTY OF LA CROSSE)

Personally came before me this 31st day of October, 1980, the above named Frank Linder, to me known to be the person who executed the foregoing instrument and acknowledged the same.

Ann J. Malin

Notary Public, La Crosse County, Wisconsin.
My Commission Expires 2/26/84.

1. SOLENOID VALVES

1.1 Low Pressure Core Spray Valve (Item 1 of Enclosure 2)

This valve functions to inject core spray directly into the high pressure core spray header without using the high pressure core spray pumps. When the differential pressure between the primary system and the reactor containment building is 30 psig or less and reactor water level of -12 inches, this valve will open and demineralized water from the overhead storage tank will flow by gravity at a rate of approximately 85 gpm to the high pressure core spray bundle.

While LACBWR feels that these Class H coils with explosion proof housings served by mineral insulated cable are completely suitable for this environment, attempts to obtain qualification data will be more time consuming and costly than replacement of the solenoid valve. DPC will therefore replace this item with a currently qualified model by June 30, 1982.

Interim operation with the existing equipment poses no risk as:

(1) The valve was originally selected for the harsh environment.

(2) The valve is in a fail-safe state (closed) - that is it does not have to change position for high pressure core spray to function, additionally there is an in-series check valve (53-26-001).

(3) Should the valve fail to open, a totally redundant core cooling system (alternate core spray and manual depressurization combination system) which is single failure proof is available.

(4) Use of the manual depressurization system would permit low pressure core spray through the valve if it failed in an open position.

1.2 High Pressure Service Water Alternate Supply to the High Pressure Core Spray System (Item 2 of Enclosure 2)

This valve functions to supply an additional water source to the high pressure core spray system. As the high pressure core spray system is intended as the short term emergency core cooling system, and its water supply for this function is maintained in the overhead storage tank, this valve does not have a direct safety related function. Failure of this valve, which would lead to its changing state would not cause a bypass of water from the overhead storage tank because of check valve (53-26-004) which is in series with the control valve.

Not withstanding the fact that use of this valve is not required, it does have a Class H coil with an explosive proof housing and is served by mineral insulated cable and thus is judged suitable for the harsh environment.

LACBWR will, for consistency of certification on solenoid valves in this service, replace this valve with one having current qualification by June 30, 1982.

1.3 Demineralized Water Supply to the Overhead Storage Tank (Item 3 of Enclosure 2)

This valve functions to supply additional water to the overhead storage tank. As the high pressure core spray system is intended as the short-term emergency core cooling system and its water supply for this function is maintained in the overhead storage tank at all times, this valve does not have direct safety related function. Failure of this valve, which would lead to its changing state, would not cause a diversion of water from the overhead storage tank because of check valve No. 69-26-002, which is in series with the control valve would prevent back flow.

Not withstanding the fact that use of this valve is not required, it does have a Class H coil with an explosive proof housing and is served by mineral insulated cable and thus is judged suitable for the harsh environment.

LACBWR will, for consistency of certification on solenoid valves in this service, replace this valve with one having current qualification by June 30, 1982.

1.4 Solenoid Valve for 4-Inch Containment Vessel Offgas Vent Header - Isolation Valve Solenoid Outside Containment (Item 4 of Enclosure 2)

This valve serves as a containment isolation valve on the four-inch containment vessel offgas vent header. The valve is not located inside the containment building, but in a portion of the tunnel. The valve is subjected to a mild environment; therefore, no qualification for a harsh environment is required. The isolation function of the control valve is totally redundant to the inside containment isolation valve. No action by DPC is required on this solenoid valve, and it should be removed from the list.

1.5 Shutdown Condenser Steam Inlet Valves (Items 5 and 6 of Enclosure 2)

These solenoid valves control the parallel inlet valves to the shutdown condenser and manual depressurization system.

While LACBWR feels that these solenoids served by mineral insulated cable are completely suitable for this environment. Attempts to obtain qualification data will be more time consuming and costly than replacement of the solenoid valve. DPC will therefore replace this item with a currently qualified model by June 30, 1982.

Interim operation with the existing equipment poses no risk as:

(1) the valves were originally selected for the harsh environment, and

(2) the two parallel lines are totally redundant one to the other.

1.6 Isolation of Nonessential Demineralized Water System Loads in Containment (Items 7 and 8 of Enclosure 2)

These solenoid valves control the valve which is closed upon a containment isolation signal to remove nonessential demineralized water loads within the containment building. One solenoid valve was previously identified in Reference (2); both valves are addressed in this letter. As the water supply for the overhead storage tank is maintained at all times in an amount adequate for the short-term emergency core cooling system purpose for which the high pressure core spray system is intended, the valve is not directly safety related.

Notwithstanding the fact that use of this valve is not required, Dairyland Power Cooperative feels it is suitable for the harsh environment.

LACBWR will, for consistency of certification on solenoid valves in this service, replace this valve with one having current qualification by June 30, 1982.

1.7 Isolation of Nonessential High Pressure Service Water System Loads in Containment (Items 9 and 10 of Enclosure 2)

These solenoid valves control the valve which is closed upon a containment isolation signal to remove nonessential high pressure service water system loads within the containment building.

As the water supply for the high pressure core spray system to perform its design function as a short-term emergency core cooling system is maintained at all times in the overhead storage tank, this valve is not directly safety related.

Notwithstanding the fact that use of this valve is not required, Dairyland Power Cooperative feels it is suitable for the harsh environment.

LACBWR will, for consistency of certification on solenoid valves in this service, replace this valve with one having current qualification by June 30, 1982.

1.8 Reactor Building Main Steam Isolation Valve Control Solenoids (Item 11 of Enclosure 2)

This dual solenoid control valve controls the containment isolation valve in the main steam line. The control assembly which includes the solenoid valves was scheduled previously by LACBWR for replacement. Solenoid valves with current qualification will be utilized. This replacement will be installed by June 30, 1982.

Operation of this system in the interim with the currently installed equipment poses no significant risk as the MSIV closure is accomplished immediately upon a low reactor water level which would indicate a loss of coolant accident leading to a harsh environment.

There is no requirement to reopen the MSIV in a post LOCA condition. Additionally, a redundant valve exists in the main steam line located outside the containment building which can be closed as a backup. The valve is electric motor operated, controlled remotely from the control room with the provision for local manual closing. It is powered from 480-volt Essential Bus 1A.

1.9 Reactor Cavities Vent Routing Valve (Items 12 and 13 of Enclosure 2)

This equipment (control valve 55-25-001 and soleniod valve 55-25-011) should be removed from the list of equipment requiring environmental qualification. This control valve routes the reactor cavity and fuel storage well vent line to either the containment building ventilation system or the 4-inch containment vessel offgas vent header. Both of these routings have downstream containment isolation valves which are covered in the equipment qualification program. This three-way valve is not safety related nor will it be required to function in a post-LOCA environment.

1.10 Reactor Containment Building Ventilation (Items 14-25 of Enclosure 2)

These control valves (Items 22-25) are closed to isolate the containment building from the outside environment. Closure is effected by removing the air through closure of the solenoid valves (2 per control valve, Items 14-21).

DPC has previously provided (Reference 3) a commitment to replace the solenoid valves with currently qualified equipment. It (Reference 3, NRC Question 5) has also described the functioning of the solenoid valves to ensure environmental adequacy. The containment isolation is accomplished by two valves in series on the inlet and the exhaust; the limit switches provide no control function and are for indication only.

Interim operation with the existing solenoid valves pose no risk as:

(1) The existing solenoid valves were originally selected for this application with Class F and Class H coils.

(2) Functioning of these valves occurs immediately upon a LOCA and no further use is required in a post-accident situation.

(3) Replacement valves have been ordered and will be installed prior to June 30, 1982.

1.11 Solenoid Valves for 4-Inch Containment Vessel Offgas Vent Header-Isolation Valve Solenoids Inside Containment (Items 26-28 of Enclosure 2)

This valve serves as a containment isolation valve in the 4-inch containment vessel offgas vent header. The control valve itself (Item 28) is a mechanical component, discussed in Reference (3), and should be removed from this qualification program. The solenoid valves (Items 26 and 27) are designed to operate in this environment. Attempts to obtain classification data will be more time consuming and costly than replacement. However, DPC will replace these items with currently qualified valves by June 30, 1982.

Interim operation with the existing solenoid valves pose no risk as:

(1) the valves were originally selected for the harsh environment,

(2) will be required to operate only once immediately upon a LOCA; once the control valve is closed, no reopening in a post accident situation is required,

(3) the control valve has redundant solenoid valves, and

(4) the control valve has a redundant isolation valve outside of the containment building which performs the same function.

1.12 Post Accident High Range Radiation Monitors (Items 29 and 30 of Enclosure 2)

Installation of these monitors has commenced. They have been procured to comply with a Three Mile Island Short Term Lessons Learned requirement. Installation of these monitors is required by October 1, 1981 (Reference 4). Complete qualification data will be supplied to the NRC at that time.

1.13 Terminal Blocks in Water Tight Junction Boxes (Item 31 of Enclosure 2)

The terminal strips in five environmentally qualified junction boxes did not have qualification documentation available. DPC will replace these strips at the first outage of sufficient duration following the receipt of the replacement terminal strips. The replacements are Buchanan terminal strips, Models NQB-112 and NQB-106. The qualification test program is attached as Enclosure 3.

1.14 Demineralized Water Transfer Pump Switchgear (Item 32 of Enclosure 2)

This switchgear provides power to the 1B demineralized water transfer pump. This equipment is not safety related as the short-term emergency core cooling system (the high pressure core spray system) already has its water supply for this function in the over-head storage tank. The long-term emergency core cooling system (the alternate core spray system) does not use demineralized water. Operationally, the 1B demineralized water transfer pump has a redundant pump which has switchgear located outside the containment building. Additionally, the 1B pump itself is located outside the containment building. No action by DPC is required on this switchgear, and it should be removed from the list.

1.15 Mineral Insulated Cable Epoxy (Item 33 of Enclosure 2)

The epoxy was used in terminal boxes on the ends of mineral insulated cable. All safety-related MI cable terminations are located inside water tight housings. No safety-related MI cable terminations are exposed to the LOCA atmosphere. The epoxy, therefore, should not be an item on the qualification program.

1.16 DC Motor Starter for the Alternate Core Spray Valve (Item 34 of Enclosure 2)

This motor starter controls one of the redundant alternate core spray valves located within the turbine building. As the event which could create a hostile environment in this area does not require use of the alternate core spray system (Reference 5), this is no requirement for this equipment to be qualified.

1.17 Containment Building Post Accident Pressure and Water Level Indicator Transmitters (Items 35-38 of Enclosure 2)

Two containment water level indicators and two containment pressure indicators are required for post accident information when a LOCA has occurred and containment personnel entry is not possible. This equipment is not required for steam line break outside containment; however, their water tight housings are judged to withstand the resulting short-term hostile environment. Therefore, documentation on this equipment is not required.

1.18 Safety Valve Position Switch Housing Sealant (Item 39 of Enclosure 2)

Our discussion with NAMCO revealed a silicone rubber sealant was used for qualification testing. The sealant used to close the environmental housings on these switches must meet the criteria specified in the qualification test by NAMCO. LACBWR used General Electric RTV-11 silicone rubber sealant.

NAMCO has agreed to furnish LACBWR a written statement on the specific sealant used in their test program and LACBWR will compare its actual material to the manufacturer's. If the material used at LACBWR is not comparable, it will be replaced with an acceptable sealant at the first plant outage of sufficient duration following receipt of the specified material.

1.19 Reactor Containment Building Thermocouples (Item 40 of Enclosure 2)

We have investigated the Type J iron constantan thermocouples used at LACBWR and have a continuous 304 stainless steel sheath for their entire length through the containment penetration (see Enclosure 4). Therefore, thermocouple extension wires are not used within the containment building.

We will have an analysis of the thermocouples used to verify qualification acceptability. The results of this analysis will be presented to the NRC by April 1, 1981.

1.20 Reactor Containment Building Air Monitor System (Item 41 of Enclosure 2)

The monitor system functions to indicate gaseous and particulate levels in the containment ventilation system during operation. It provides a high radiation closure signal to the containment ventilation system. The closure actuation setpoints have been established at not more than 5 times background, thus activation of isolation can occur following any primary system leak as detected by the immediate particulate monitor within approximately 1.5 minutes.

Small leaks would be first indicated on the primary system leak detection system by humidity and radiation conditions which is expected to cause operator action to isolate containment ventilation prior to reaching the closure activation setpoint for isolation by the subject monitor.

The LOCA environment from this leak would not be severe enough in that time span to affect the monitor. If, however, the monitor were affected, its failure mode is to isolate containment. Once isolated, the post accident procedures do not require the reopening of containment ventilation. Due to this design and the redundancy of closure signals from high primary system pressure, high containment building pressure and low reactor water level, no environmental qualification is required for this monitor.

1.21 <u>Mineral Insulated Cable Penetrations</u> (Item 42 of Enclosure 2)

The epoxy sealant used in most terminations of mineral insulated cable has previously been addressed (Item 33 of Enclosure 2). The thermal strain present under LOCA conditions of the containment penetration has been analyzed and found to be of a low enough magnitude to have no effect on penetration integrity (see Enclosure 5).

1.22 <u>Reactor Vessel Water Level Transmitters</u> (Item 43 of Enclosure 2)

The reactor water level indicators, which are part of the reactor protective system narrow range, initiate reactor shutdown (high and low water level), emergency core cooling system start (low water level), and containment isolation (low water level). This equipment performs these functions in a short time following a loss of coolant event. The application information for these transmitters (as required by Page 17 and 21 of Reference 2) is attached as Enclosure 6. The unique installation at LACBWR remotes the level transmitter amplifier out of the harsh environment.

DPC will review the qualifications of this equipment against the specific vendor test data by April 1, 1981. If the type qualifications cannot be substantiated, replacement water level transmitters of current qualification where required for alternate core spray will be installed by June 30, 1982.

1.23 High Pressure Core Spray Pump Motors (Item 44 of Enclosure 2)

These pumps are used or short-term emergency core cooling. They were modified for the harsh environment; however, testing qualification documentation is not available. A redundant system, the alternate core spray system, which has its pumps located outside the LOCA environment, is available.

DPC will analyze the design of the high pressure core spray pump motors to assure their current applicability to the harsh environment. The results of this analysis will be furnished to the NRC by April 1, 1981.

1.24 Specific Design Concerns Addressed in Reference (2)

1.24.1 Inclusion of Additional Equipment

(1) Overhead Storage Tank Level Indicator -LACBWR does not have a remote level indicator on the overhead storage tank. It does have low and high level switches. Qualification of this equipment is not required as the overhead storage tank is filled at all times when operating with a sufficient quantity of water to perform the short-term cooling function it was designed for. The known rate of water removal due to the use of positive displacement high pressure core spray pumps makes a qualified water level indicator unnecessary.

(2) Reactor Control Rod Drive Scarm Solenoids -The design of the LACBWR control rod drive system includes a hydraulic scram system with dual solenoids which are redundant to each other. The removal of electrical power from either solenoid causes the associated control rod to scram to the fully inserted position in approximately 2 seconds. As the functioning of these control rod scram circuits would occur at the onset of a LOCA and these circuits do not have the capability of with-drawing the control rod once inserted, no qualification is required.

(3) Reactor or Main Steam Pressure Transmitter/Reactr Protection System Instrumentation - This system includes reactor water level (discussed as Item 43 in Enclosure 2), reactor power to flow instrumentation, and reactor primary system pressure. The power-to-flow and primary pressure were not designated as post-accident monitoring instruments and reactor water level, containment temperature, water level, and pressure are utilized for this purpose.

(4) Main Steam Flow Transmitters -LACBWR is a single steam line BWR and would not utilize a steam flow transmitter following a LOCA to measure cooling through unaffected loops. As this is not a post accident cooling mode and the steam line would be isolated, there is no requirement for qualified equipment.

(5) Any Safety Related Control Station -The only safety related control station at LACBWR is the reactor control room which is in a mild environment.

1.24.2 Temperature Localized Time/Profiles in the Turbine Hall

The localized time/temperature profiles in the turbine following a main steam line break outside containment are attached as Enclosure 7. Radiation levels in the turbine building resulting from a LOCA are attached as Enclosure 10.

1.24.3 Containment Building Time/Temperature Profile

The post accident containment building time/temperature profile has been recalculated to determine the effects of the heat removal capability of the component cooling water system. The results of the study are attached as Enclosure 8. The system's redundant pumps are powered by switchgear located in the reactor containment building (1A pump) and the turbine hall (1B pump) to preclude a single event from affectng system operation. Both pumps are supplied by an onsite emergency diesel generator in the event offsite power is lost.

1.24.4 Effect of Initial Containment Air Temperature on Containment Pressure After a LOCA

A summary of calculations performed at three different temperature points is attached as Enclosure 9.

ITEM	REFERENCE (2) ITEM	EQUIPMENT DESCRIPTION	EQUIPMENT NO.
1	2	ASCO SOLENOID WPX 8315B3	53-25-005
2	3	ASCO SOLENOID HV-2023014RG	53-25-006
3	4	ACSO SOLENOID HV-2029244RG	69-25-002
4	5	ASCO SOLENOID 8300B9RF	55-25-014
5	5	ASCO SOLENIOD 8300B9RF	62-25-006
6	5	ASCO SOLENOID 8300B9RF	62-25-009
7	5	ASCO SOLENOID 8300B9RF	67-25-002
8	NR	ASCO SOLENOID 8300B9RF	67-25-003
9	6	ASCO SOLENOID 8300B9F	72-25-003
10	6	ASCO SOLENOID 8300B9F	75-25-004
11	18	ASCO SOLENOID X-8344	61-22-005
12	19	ASCO SOLENOID 8300B9RF	55-25-011
13	19	BS&B 4" 3-WAY CONTROL VALVE	55-25-001
14	20	ASCO SOLENOID LM831612	73-25-003
15	20	ASCO SOLENOID LM831612	75-25-004
16	20	BARKSDALE SOLENOID 178350AC2A1	73-25-016
17	20	BARKSDALE SOLENOID 178350AC2A1	73-25-017
18	NR	ASCO SOLENOID LM831612	73-25-007
19	NR	ASCO SOLENOID LM831612	73-25-008
20	NR	BARKSDALE SOLENOID 178350AC2A1	73-25-018
21	NR	BARKSDALE SOLENOID 178350AC2A1	73-25-019
22	20	20" SUPPLY VALVE	73-25-001
23	20	20" SUPPLY VALVE	73-25-002
24	21	20" EXHAUST VALVE	73-25-005
25	21	20" EXHAUST VALVE	73-25-006
26	22	ASCO SOLENOID 8300B9RF	55-25-013
27	22	ASCO SOLENOID 8300B9RF	55-25-022
28	22	4" BS&B VALVE	55-25-003
29	24	HIGH RANGE RADIATION MONITOR GENERAL ATOMIC MODEL RD-23	PLANNED
30	24	HIGH RANGE RADIATION MONITOR GENERAL ATOMIC MODEL RD-23	PLANNED
31	13	BUCHANAN TERMINAL BLOCKS NQB-112 AND NQB-106	
32	8	ALLIS-CHALMERS SWITCHGEAR	RX BLDG. MCC-1A
33	11	MINERAL INSULATED CABLE EPOXY	
34	10	MOTOR STARTER CUTLER HAMMER, MODEL NO. K646676A	FOR 38-30-002
35	14A	FOXBORO PRESSURE TRANSMITTER	37-45-307
36	14B	FOXBORO PRESSURE TRANSMITTER	37-35-302
37	15	FOXBORO LEVEL TRANSMITTER	37-42-302
38	15	FOXBORO LEVEL TRANSMITTER	37-42-310
39	12	SEALANT FOR NAMCO LIMIT SWITCHES	
40	23	CONTAINMENT BUILDING THERMOCOUPLES	

ITEM	REFERENCE (2) ITEM	EQUIPMENT DESCRIPTION	EQUIPMENT NO.
41	25	CONTAINMENT RADIATION MONITOR	
42	17	CONTAINMENT PENETRATION THERMAL STRESS	
43	7	REACTOR VESSEL WATER LEVEL TRANSMITTERS	50-42-302 50-42-303 50-42-306
44	1A	1A HIGH PRESSURE CORE SPRAY PUMP MOTOR	53-06-001
	1B	1B HIGH PRESDSURE CORE SPRAY PUMP MOTOR	53-06-002

NR = NOT REFERENCED.

OUTLINE OF A QUALIFICATION TEST PROGRAM FOR TERMINAL AND FUSE BLOCKS

ject C5143

Prepared for

Control Products Division
Amerace Corporation
Union, New Jersey

Prepared by

Performance Qualification Laboratory
Franklin Research Center
Philadelphia, Pennsylvania

June 27, 1979
Revised 7/27/79

Franklin Research Center
A Division of The Franklin Institute

1. INTRODUCTION

This document presents an outline of a qualification test program for terminal and fuse blocks submitted by the Control Products Division of Amerace Corporation. The rationale for the program outlined herein is provided as a supplement to this document. Further detail on the planned tests and test methods will be available in a procedural document entitled Test Checklist. The checklist, which will contain instructions to experienced FRC test personnel, is primarily intended to assure that all elements of the test program are performed and necessary data are obtained.

2. OBJECTIVE OF THE TEST PROGRAM

The primary objective of the test program is to demonstrate that the specimens are qualified for out-of-containment use according to the requirements of Control Products and their client(s).

A secondary objective is to extend the demonstration to include inside-containment use for a typical simulated-LOCA exposure (also described as a steam/chemical-spray exposure).

3. DESCRIPTION OF TEST SPECIMENS

The test specimens will consist of one-piece multi-terminal blocks, individual modular terminal blocks and fuse blocks which are mounted onto retaining rails. The specimens include terminals of the flat-strap type which accept conductors terminated in spade or ring lugs; and terminals of the tubular type which accept bare, non-terminated conductors. The specimens are identified in the attached Table 1.

FRC Project C5143

POOR ORIGINAL

Table 1. Description and Identification of Test Specimens

SPECIMEN NO.	DESCRIPTION	TYPE CONTACT (Note a)	CATALOG NO.	EXTENSION WIRE SIZE (AWG)	MOLDING COMPOUND
C5143-A -B -C	6-circuit one-piece block (3 assy's)	Strap	616822-3 (NQB106)	12	Durez Grade 152 Phenolic
-D -E -F	12-circuit one-piece block (3 assy's)	Strap	616822-6 (NQB112)	12	↓
-G -H -I	6-circuit one-piece block (3 assy's)	Tube	later	12	↓
-J -K -L	12-circuit one-piece block (3 assy's)	Tube	later	12	↓
-M -N -O	Assemblies consisting of: • Medium duty block • Medium duty block • Heavy duty block • Heavy duty block plus end sections and mounting rail	 Strap Tube Strap Tube	 616835 616840 616836 616839	12	Reichhold Grade 25397 Phenolic
-P -Q	Assemblies consisting of: • Fuse block • Fuse block • Fuse block w/puller • Fuse block w/puller plus end section and mounting rail. (Note b)	 Strap Tube Strap Tube	 616837 later 616838 later	12	↓

17 total specimens: 6 will be exposed to a steam/chemical spray profile.

Notes: a. Strap - Flat screw-strap contact. Requires terminal lug on wire.
Tube - Tubular screw contact. Fastens directly to bare wire conductors.

b. Fuses will be replaced by simulated fuses containing a non-fusible conductor.

4. ASSEMBLY AND ARRANGEMENT OF SPECIMENS

For thermal aging the specimens will be grouped as follows

Enclosure No.	Specimen No.	Thermal Aging Parameters
1	M, N, O, P and Q	8.3 d at 121°C
2	A, B, C, D, E, F, G, H, I, J, K and L	39.6 d at 165°C

For the remainder of the test sequence, the specimens will be separated into three separate groups as follows:

Group No.	Specimen Nos.	Description of Specimen Enclosure	Purpose of Group
1	A, D, G, J, M and P	NEMA 4, with EPDM gasket, 20 in x 20 in x 6 in (Hoffman Co.)	Primary group for complete test program
2	B, E, H, K, N and Q	NEMA 4, same as above	Secondary group for spare specimens and back up usage.
3	C, F, I, L and O (No fuse block in this group)	No enclosure	Spares

During environmental exposures and tests, the enclosures containing the specimens will be vertically oriented; i.e., one 20-in-dimension will be parallel to the vertical axis and the 6-in-dimension will be horizontal. The specimens will be firmly fastened (at appropriate times) to the back, mounting plates in the enclosures so that one 12-terminal one-piece block, one 6-terminal one-piece block and one modular assembly will be mounted with their longest dimension vertically oriented; the remaining specimens will be horizontally oriented.

The specimens will remain in the enclosures until they are removed for the final wire-retention test.

Approximately 8-ft lengths[+] of 1/C #12 AWG Anaconda Durasheath, EPR insulation 7strand copper wire, Tinned will be connected to the specimens and extended through the bottom of the enclosures.

[+]The long (8-ft) lengths will be necessary to extend the wires to outside of the steam/chemical-spray test vessel of Section 5.14.

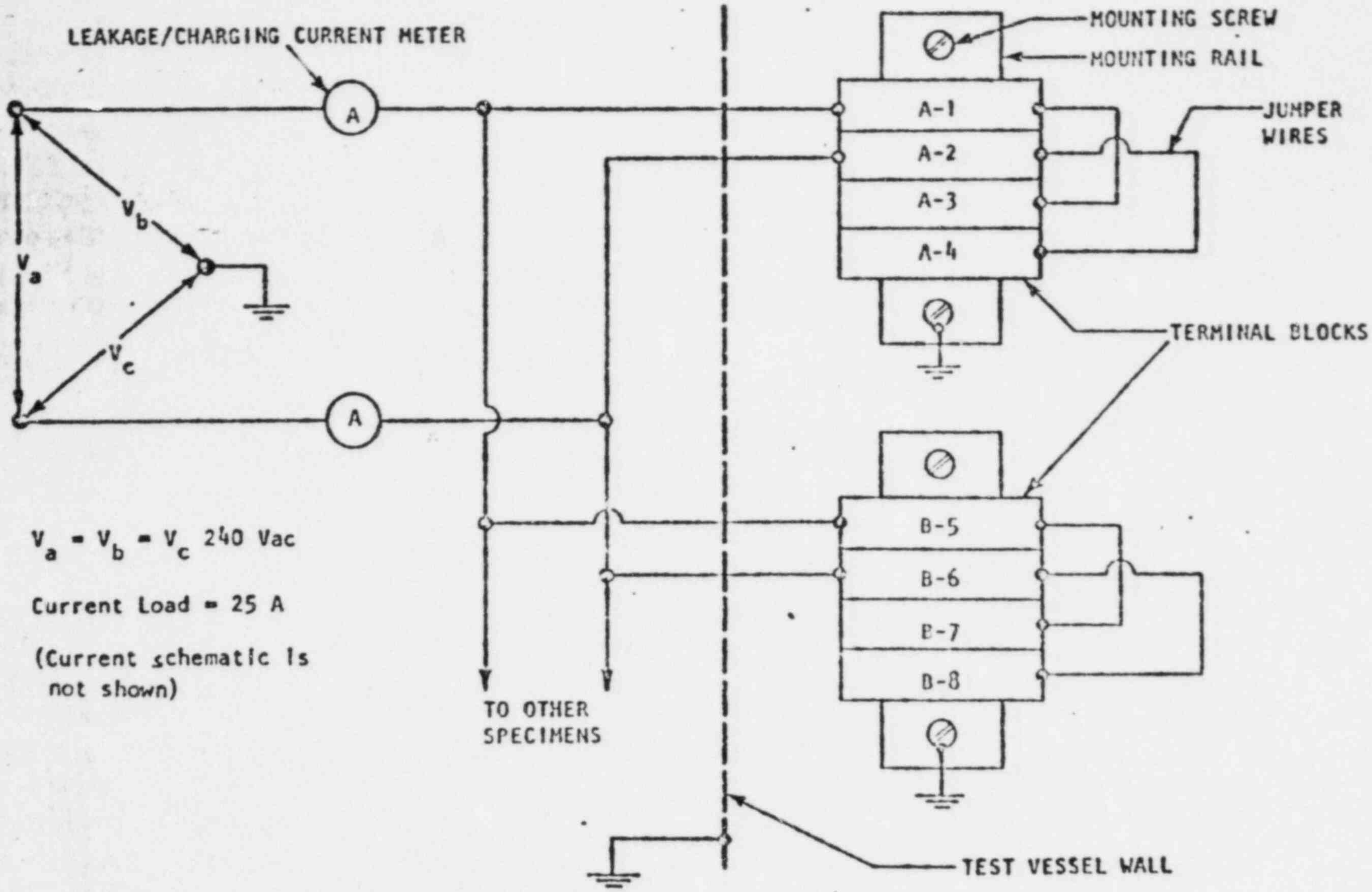

Figure 1. Electrical Schematic for Three-Phase Potential Loading of Test Specimens

Wires to be connected to *strap-type* terminals will be terminated with crimped-on lugs; fastening screws will be tightened to values of torque selected by the client. The bare, stranded-wire ends of the other extension wires will be clamped in the *tubular* terminals with screw torques selected by the client.

The extension wires between alternate terminals will be connected in series as short jumper wires as illustrated in Figure 1.

Enclosures 1 and 2 will have gasketed covers and any venting of the interior will occur through air passages around the extension wires which exit the bottom of the enclosure through a plastic-lined (probably PVC) 1-in steel box-connector designed for non-metallic sheathed cables.* There will also be a 0.25-in-diam drain hole in the bottom of the enclosures.*

Because of the need to conduct separate thermal aging programs for Durez and Reichhold molding compounds (see Table 1 and Section 5.4), the assembly and mounting of the specimens will be conducted in phases as discussed in Section 5.

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*See rationale which supplements this program outline.

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FRC Project C5143

5. TEST SEQUENCE AND FLOW

The *test sequence* which will be followed in this program is listed below; the elements are described in the following pages of this outline.

1. Insulation Resistance measurements (IR).
2. Thermal aging
3. Assemble and torque
4. Torque Test (TT)
5. Contact Resistance Test (CRT).

6. Radiation aging
7. Repeat of CRT and IR measurements
8. Vibration aging (VA)
9. Repeat of CRT and IR measurements
10. Seismic test
11. Repeat of CRT and IR measurements
12. High potential withstand test
13. Steam/chemical-spray test
14. Repeat of CRT and IR measurements
15. High potential withstand test
16. Special TT
17. Wire retention test

The *flow* of the test program considers the *test sequence* above, program objectives (Section 2.0) and mounting arrangements for testing of the specimens (Section 3.0). The program *flow* is described in Figure 2.

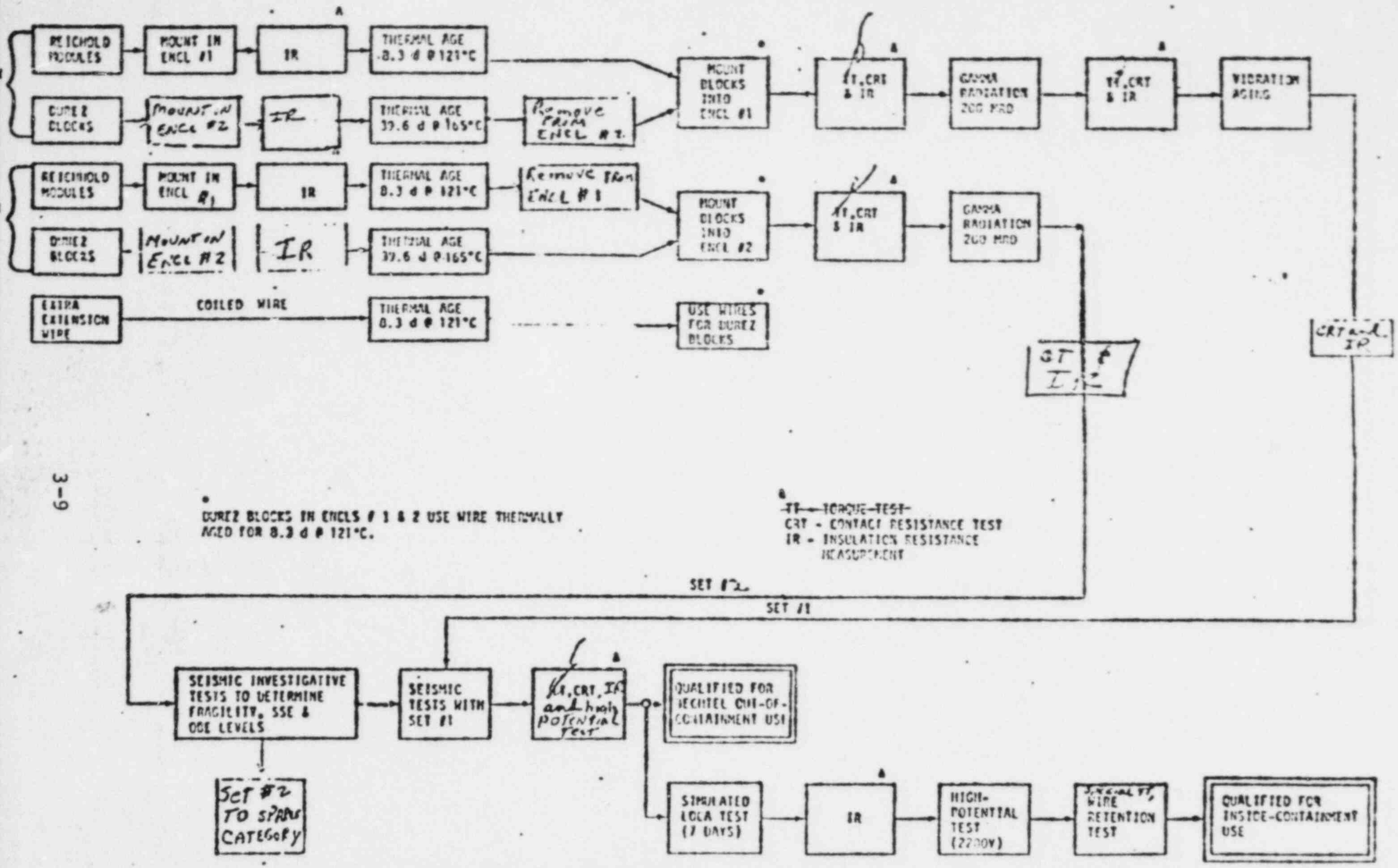


Figure 2. Flow of Test Program for Terminal Blocks

3-9

POOR ORIGINAL

ENCLOSURE 3

6. TESTS AND TEST METHODS

6.1 TORQUE TEST (TT)*

After assembly of the specimens, the screws will be retightened with values of torque specified by Control Products to verify that relaxation of the screws had not occurred during the previous handling of the specimens. Any evidence of relaxation will be noted and recorded. This test will be repeated at various times during the program as noted in Section 3.

6.2 CONTACT RESISTANCE TEST (CRT)*

Groups of specimens will be electrically connected in series and a dc test current of 2.5 A will be passed through the series circuit. With the 2.5 A current passing through the circuit, the voltage drop will be measured across each contact point: between a wire conductor and a tubular clamp or between wire-terminating lugs and the conducting strip on the terminal block. The measurements will be made at various times throughout the program; and any significant voltage drop across a contact will be converted to contact resistance by calculation (i.e., R = E/2.5).

6.3 INSULATION RESISTANCE MEASUREMENT *

The insulation resistance (IR) of the specimens will be measured utilizing the extension wires connected as shown in Figure 1. The IR will be measured first between the odd-numbered terminals connected together (e.g., terminals A-1 and A-3) and the even-numbered terminals connected together and to the mounting rail (if present) and the ground potential.

*Note that specimens will not undergo TT and CRT until after thermal aging. See Figure 2.

Then the IR will be measured between the even-numbered terminals (e.g., terminals A-2 and A-4, etc.) and the odd-numbered terminals connected to the mounting rail (if present) and the ground potential. The IR test potential will be 500 Vdc, held for a minimum of 15 seconds.

The IR measurements will be made at various times throughout the program. In the event of anomalous measurements, the IR of specific terminals can be measured except during the steam/chemical spray exposure when physical access to test specimens is not possible unless each terminal is connected by separate extension wires to the outside of the test vessel.

6.4 THERMAL AGING

The assemblies will be placed in a forced-air-circulation oven at the temperatures and for the times listed below:

Specimens	Thermal Aging Conditions
A. Terminal blocks of Reichhold Chemicals Grade 25397 phenolic molding compound. Also, lengths of extension wire which will be used later with Durez specimens.	199 h (8.3 d) @ 121°C (250°F)
B. Terminal blocks of Durez (Hooker Chemicals and Plastics, Inc.) Grade 152 phenolic molding compound.	950 h (39.6 d) @ 165°C (329°F)

After thermal aging, the unmounted specimens of Durez (except Group 3) will be assembled with wires thermally aged at the lower temperature of 121°C and fastened into enclosures 1 and 2 along with the Reichhold specimens.*

*See Figure 2 and the rationale which supplements the program outline.

6.5 REPEAT OF TT, CRT AND IR MEASUREMENTS

After thermal aging, and other environments discussed hereafter, the assemblies will be subjected to diagnostic tests consisting of torque tests (TT), contact resistance tests (CRT), and insulation resistance (IR) measurements.

6.6 GAMMA RADIATION EXPOSURE

The assemblies will be exposed to a 200-Mrd, *air-equivalent* dose of gamma radiation from a cobalt-60 source at a rate not to exceed 1.0 Mrd/h (An average rate of 0.6 to 0.8 Mrd/h is anticipated.)

6.7 REPEAT OF TT, CRT AND IR MEASUREMENTS

The assemblies will be subjected to TT, CRT and IR measurements.

6.8 VIBRATION AGING TESTS

Group 1 specimens in enclosure 1 will be firmly mounted to a stiff test fixture in a manner representative of installation in a generating station (e.g., a unistrut interface between the enclosure and the test fixture). The test fixture, in turn, will be mounted to a vibration test facility table with the face of the table parallel to the floor. (The enclosure will be vertical as described in Section 4 and illustrated in Figure 3.)

The enclosure with specimens will be vibrated (in sequence) along three orthogonal axes, one of which shall be vertical. The enclosure will be vibrated from 3 to 60 Hz in 0.5-octave intervals at the amplitudes shown in Table 2. At each frequency the vibration will be maintained for 15 minutes.

During the vibration aging, the extension wires and terminal blocks will be connected in series with an electrical circuit carrying 0.25 A (ac or dc) and including a strip chart recorder to monitor circuit integrity.

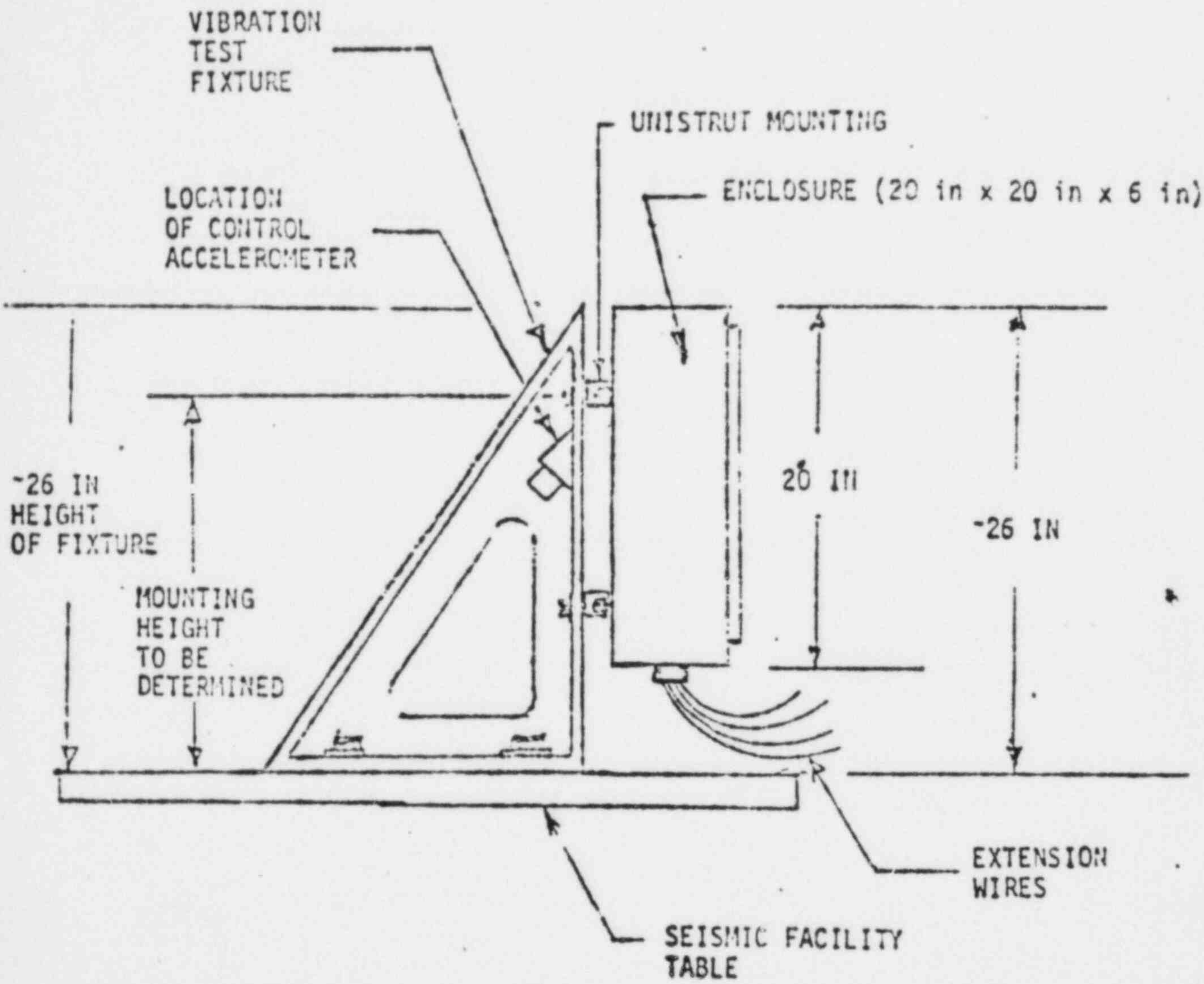


Figure 3. Schematic of Vibration/Seismic Test Fixture

POOR ORIGINAL

Table 2. Vibration Aging Levels

Vibration Frequency (Hz)	Nominal Acceleration (g)	Nominal Table Motion (in. d.a.)*
3.0	0.03	0.060
4.2	0.05	0.060
6.0	0.11	0.060
8.5	0.22	0.060
12.0	0.44	0.030
17.0	0.59	0.040
24.0	1.18	0.040
33.9	1.18	0.020
48.0	0.71	0.006
60.0	0.74	0.004

*d.a. - double amplitude or peak-to-peak motion

NOTES:
1. Dwell for 15 minutes at each frequency.
2. Repeat vibration in each orthogonal axis; total time for each axis = 3 x 15 = 45 minutes; total time at all frequencies = 10 frequencies x 45 minutes/frequency = 450 minutes (7.5 hours).
3. Tolerances of acceleration levels will be approximately ± 20% of the nominal value.

6.9 REPEAT OF CRT AND IR MEASUREMENTS

The assemblies will be subjected to CRT and IR measurements.

6.10 SEISMIC TESTS

6.10.1 Fragility Testing

6.10.1.a Mounting and Orientation

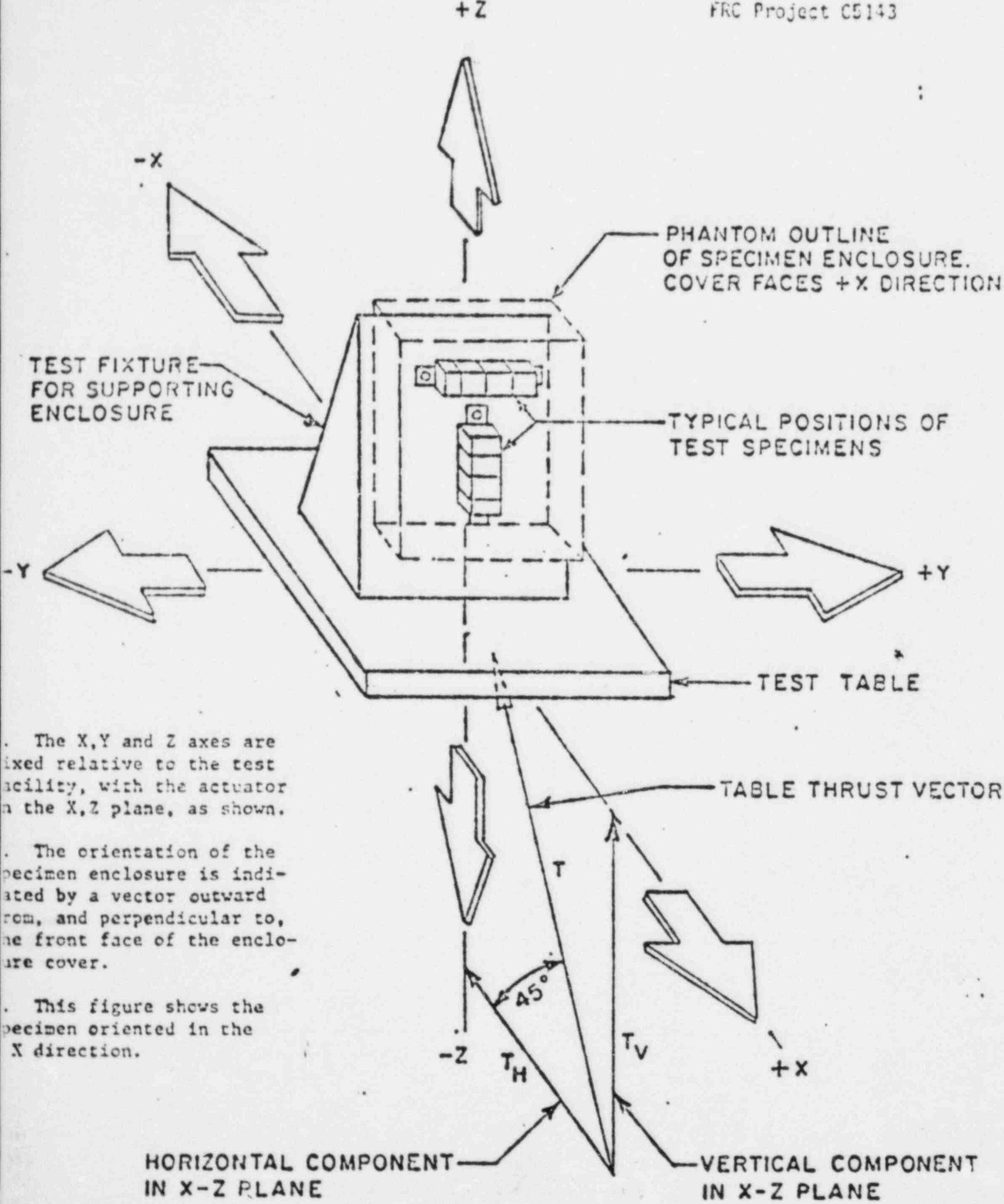
Group 3 specimens will be mounted in an enclosure (See Table 1 and Figure 2) and will be bolted firmly to a stiff test fixture as described in Section 6.8 above except that the direction of actuator thrust to the table will be at an angle of 45° above the horizontal plane. The four cardinal horizontal axes of the enclosure will be identified as +X, +Y, -X and -Y as shown in Figure 4. The first orientation of the enclosure will be with the horizontal component of motion parallel to the shortest dimension of the enclosure.

6.10.1.b General Method and Test Levels

1) With the enclosure in the initial orientation described in Section 6.10.1.a, the specimens will be subjected to multifrequency vibration of 30-second duration over the frequency range of 1 to 40 Hz. The amplitude of vibration for this first test will be adjusted until the input of the facility table attains a level approximately equal to 50 percent of the maximum facility capability as depicted in Figure 5. The response of the table will be analyzed at one-third octave levels and 5, 2.5 and 1 percent damping. (The analysis can be accomplished without repeating the actual vibration.)

After the above vibration exposure, the specimens will be examined (while mounted in the enclosure) for absence of mechanical failures such as obvious loosening of block fasteners, broken barriers, etc.

2) With the enclosure in the same orientation, the procedures of paragraph 1) above will be repeated at levels of 75 percent, and then 100 percent of the maximum facility capability, or until specimen failure occurs.

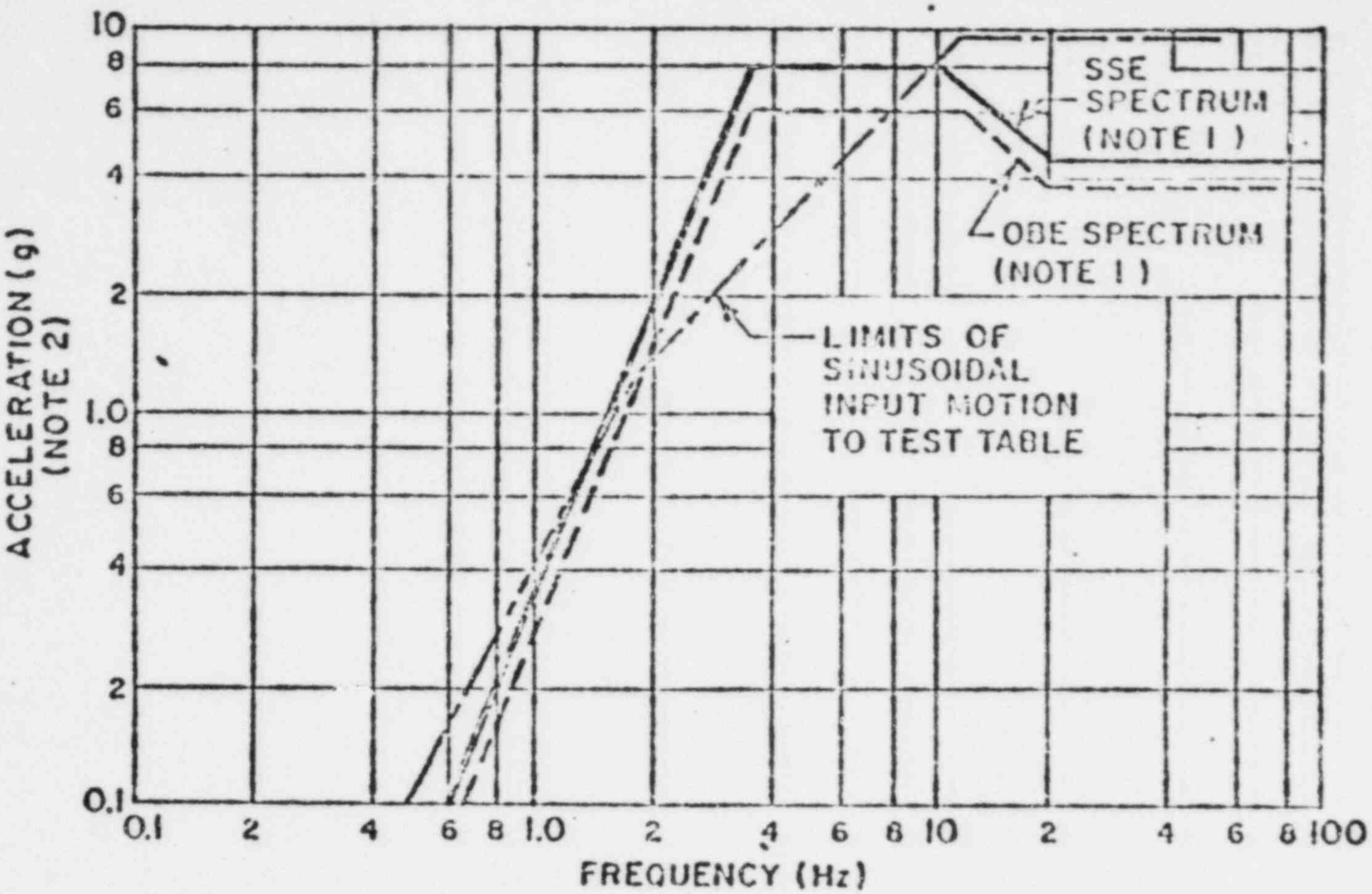


. The X,Y and Z axes are ixed relative to the test acility, with the actuator n the X,Z plane, as shown.

. The orientation of the pecimen enclosure is indi- ated by a vector outward rom, and perpendicular to, he front face of the enclo- ure cover.

. This figure shows the pecimen oriented in the X direction.

Figure 4. Seismic and Vibration Axes Related to Specimen Orientation and Thrust Vector



Notes: 1. SSE and OBE spectra are response levels at 5% damping for a multifrequency seismic test.

2. Values of acceleration apply to thrust axis of bi-axial (in-phase) shaker. For example, with the axis oriented at an angle of 45° with the horizontal direction, the values of acceleration amplitude in the horizontal and vertical directions will be approximately 71% of the values in this figure.

Figure 5. Maximum Input Motion and Response Spectrum Capability of FRC Seismic Test Facility

3) The enclosure (with test fixture) will be rotated 90 degrees about its vertical axis so that the horizontal component will be directed along another cardinal direction of the enclosure. The procedures of paragraphs 1) and 2) will be repeated.

4) The procedure of paragraph 3) will be repeated until the enclosure is subject to fragility testing in all four cardinal directions.

5) The maximum test level at which the specimens did not fail will become the basis for a Safe Shut down Earthquake (SSE) test level to be used during subsequent seismic testing with group 1 specimens.

6.10.2 SSE and OBE Testing

6.10.2.b General Method and Test Levels

1) Group specimens in enclosure 1 will be mounted in the same manner as described in Section 6.10.1 above. The specimens will be subjected to multifrequency vibration of 30-second duration over the frequency range of 1 to 40 Hz. The amplitude of vibration for the first test will be adjusted in one-third octave intervals until the response spectrum at the interface between the test fixture and the enclosure, analyzed at 5 percent damping, attains a level approximately equal to two-thirds of the SSE level determined in Section 6.10.1 above. This two-thirds SSE level will be considered the Operating Basis Earthquake (OBE) level.

The response spectrum at the fixture-to-enclosure interface will also be analyzed at 1 and 2.5 percent damping.

During the seismic testing, circuit integrity will be monitored as described in Section 6.8.

The criteria for successful performance will be continued circuit integrity and absence of significant mechanical failures (see Section 6.10.1.b).

2) With the enclosure in the same orientation, the procedures of paragraph 1) above will be repeated except that the assembly will be subjected to a total of five 30-s vibrations at the OBE level plus one 30-s vibration at the established SSE level. All test response spectra at the enclosure mounting point will be analyzed at 1, 2.5 and 5 percent damping.

3) The enclosure (with test fixture) will be rotated 90 degrees about its vertical axis so that it is oriented along another cardinal direction as defined in Figure 4. The procedures of paragraph 1) and 2) will be repeated.

4) The procedure of paragraph 3) will be repeated until the specimen is subjected to five OBE and one SSE vibration in each of the four cardinal directions (i.e., +X, +Y, -X and -Y in Figure 4).

6.10.3 Excitation Control

The level of seismic excitation will be controlled by the response of an accelerometer mounted on the test fixture and aligned in the direction of the table input motion (see Figures 3 and 4).

6.11 REPEAT OF CRT AND IR MEASUREMENTS AND HIGH POTENTIAL WITHSTAND TEST

The assemblies will be subjected to TT, CRT and IR measurements.

6.12 STEAM/CHEMICAL-SPRAY (SIMULATED-LOCA) TEST

Group 1 specimens in their enclosure will be mounted in a test vessel for steam/chemical-spray exposure. The extension wires will be routed out of the vessel through epoxy-potted pressure-sealing penetrations.* The specimens will be connected into a 240 Vac/3ϕ circuit as shown in Figure 1. A 25-A current load will be supplied through the terminals. A spray nozzle will be positioned in the vessel to spray the top of the enclosure.

The specimens, while electrically loaded, will be subjected to a 7-day steam/chemical-spray exposure in accordance with the profile in Figure 6.

The chemical spray will consist of a solution containing 3000 ppm boron as boric acid and 0.064 molar sodium thiosulfate, buffered with sodium hydroxide to a pH of 10.5 at room temperature.

*Detailed description of the enclosures, the mounting of the specimens and the method of cable entry into the enclosure will be available to the client as part of the <u>Test Check List</u>. See Section 1.0.

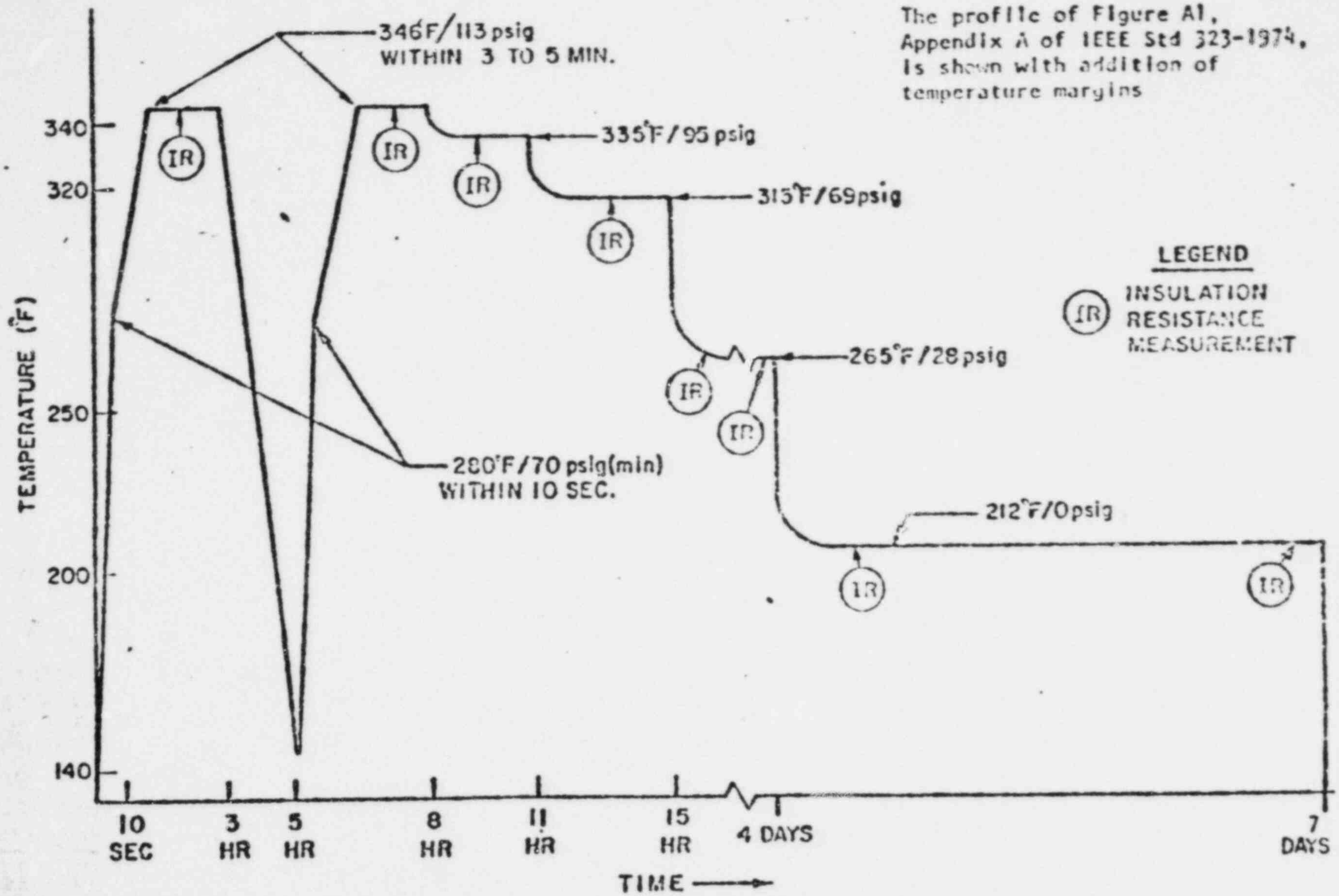


Figure 6. Temperature/Pressure Profile for Simulation of Loss-of-Coolant Accident Environment

The chemical solution will be sprayed at a rate of 0.15 gpm per square foot over a horizontal area at the top of the NEMA enclosure. Some spray will also impinge on the cover of the enclosure. Fresh spray solution will be used for the first three hours (minimum) of each dwell at 346°F. Thereafter, the spray solution will be recirculated from the pool of spray solution and steam condensate that collects at the bottom of the chamber. The pH will be monitored daily and, if necessary, fresh spray solution will be added to restore the required pH value.

The values of potential and current in the energizing circuits will be monitored periodically and recorded. If the values of potential and current drift away from the specified values, they will be adjusted to the required levels. If any specimen fails, the energizing circuit will be disconnected from the specimen. The IR of the specimens will be measured at the times indicated in Figure 6.

6.13 REPEAT OF IR MEASUREMENTS

After removal of the specimens from the test vessel, they will be subjected to IR measurements.

6.14 FINAL HIGH-POTENTIAL-WITHSTAND TEST

A potential of 2.2 kVac will be applied to each specimen with the adjacent terminals and the mounting rail at ground potential. At the end of 1.0 min, the leakage/charging current will be measured.

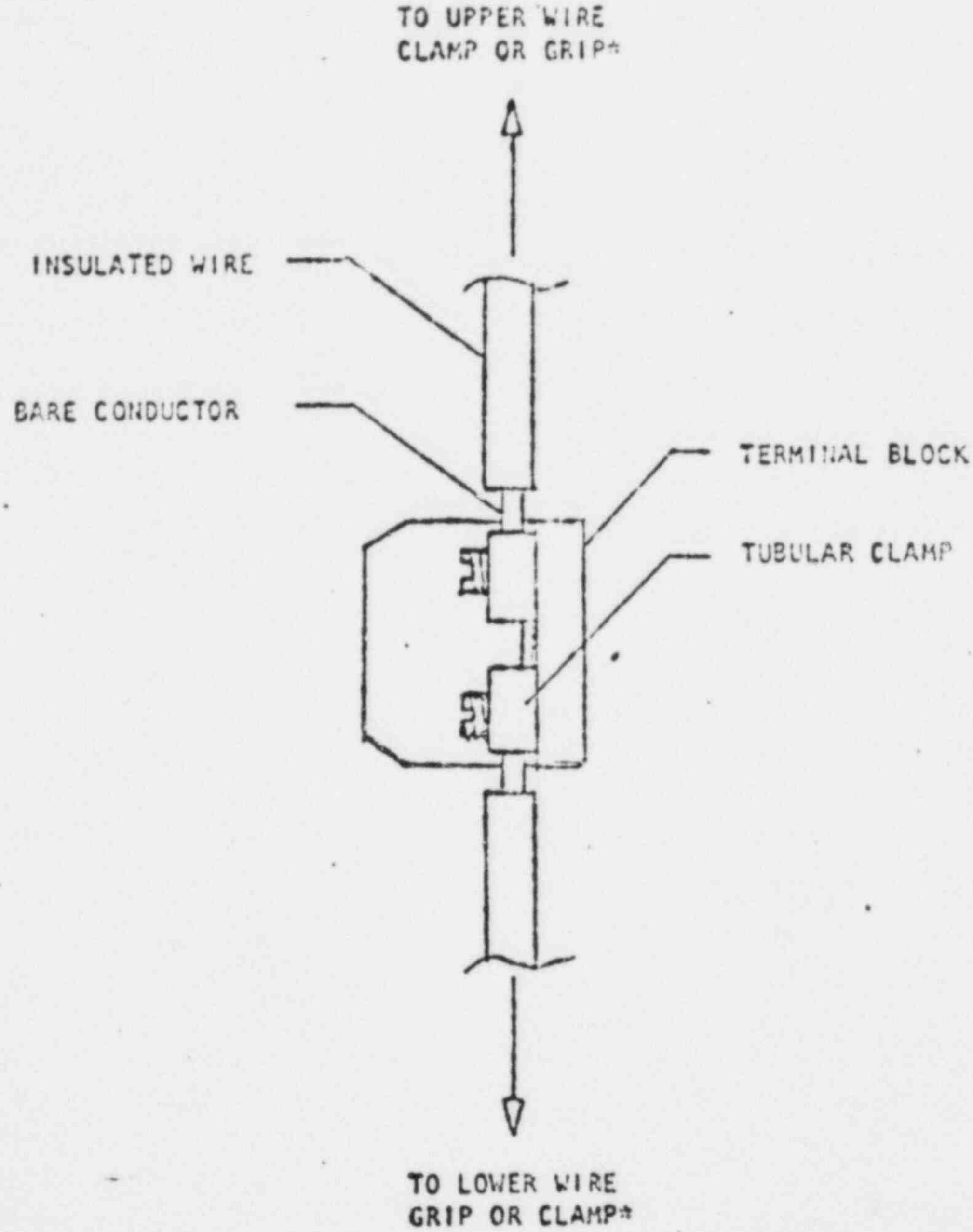
6.15 SPECIAL TORQUE TEST

All mounting and terminal screws will be checked for relaxation through a torque test. A torque screwdriver will be set to a value of 0.9 N·m (8.0 lb·in) below the values used in section 5.1. All the applicable screws will be tested for movement at the reduced torque values. The screws will be rechecked at increments of 0.23 N·m (2 lb·in) until movement is visually detected or the initial value of Section 5.1 is attained, whichever is less. The results will be documented.

> [NOTE: The primary objective of the test program (see Section 2) will have been met at this point if the specimens have performed satisfactorily. The remaining portions of the test program are for meeting the secondary objective.]

6.16 FINAL WIRE RETENTION TEST

This test is applicable only to terminal blocks utilizing tubular wire clamps. The extension wires will be gripped in a manner illustrated in Figure 7 and pulled until a tension force of 70 lb is attained. The 70 lb force will be maintained for 1.0 minute minimum.



*70 LB TENSILE FORCE WILL BE APPLIED BY A TEST MACHINE OR FIXTURE.

Figure 7. Schematic of Wire Retention Test

7.0 FINAL REPORT

At the conclusion of the test program, a final report will be prepared, documenting the tests performed and the results obtained.

Summarized data will be incorporated into the final report and a copy of original data including data sheets, logs and plots of vibration spectra will be provided to Control Products. The original data sheets, logs and strip-chart records will be maintained in FRC files for five years.

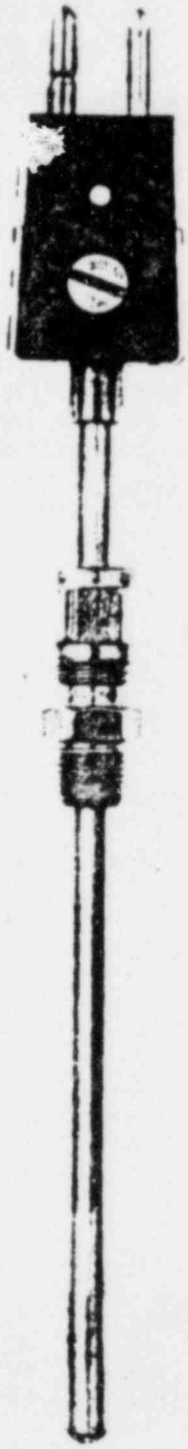
Custom Thermocouples

ENCLOSURE 4

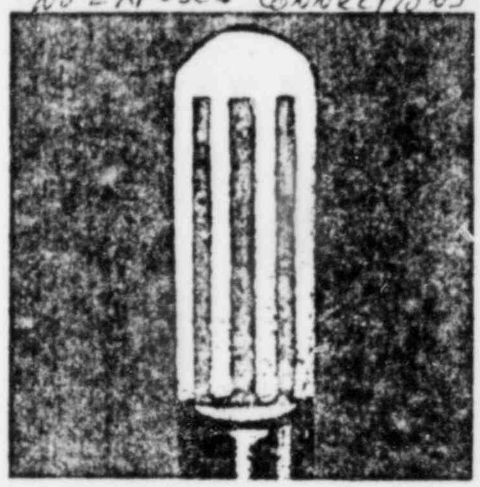
thermocouple application data

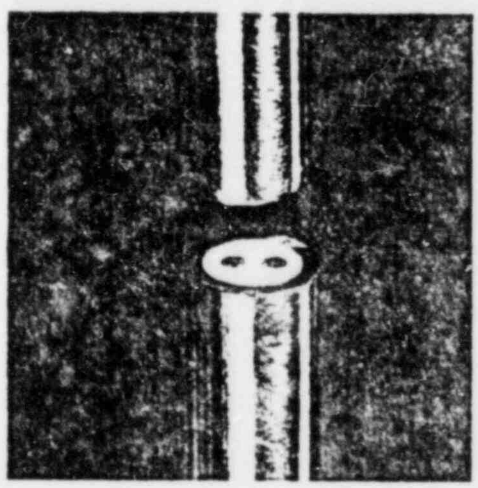
Containment Bldg. Thermocouples.

J-116-G-304-00-20'-1



No EXPOSED Connections within Containment Bldg.



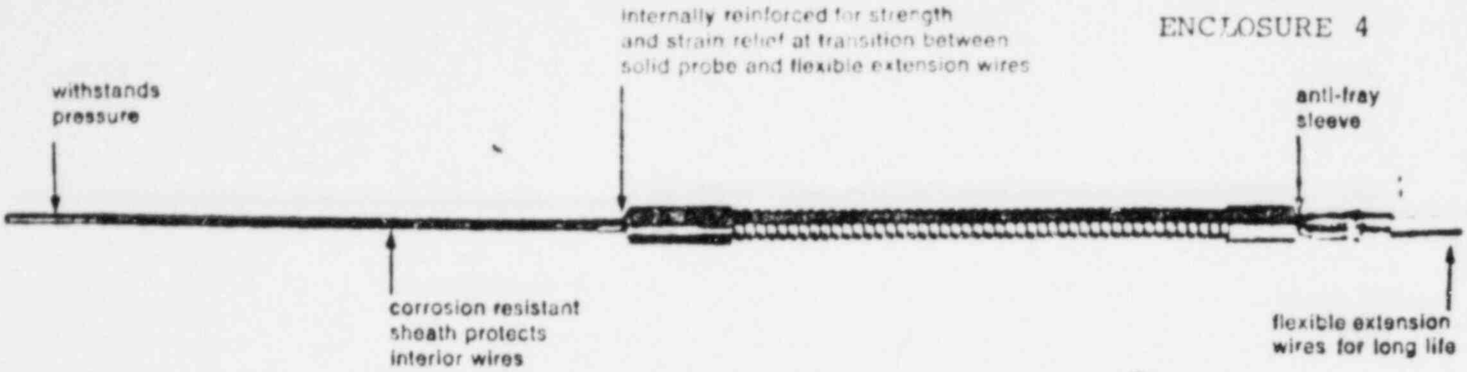


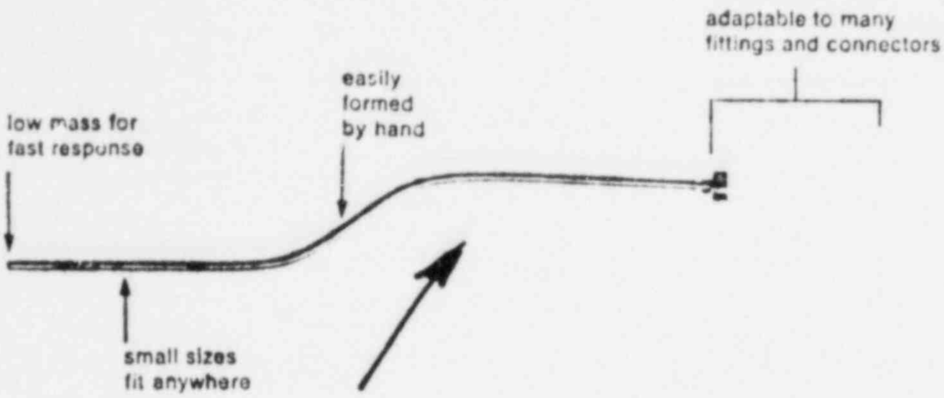
If your thermocouples are not in our Miniature or Industrial Thermocouple catalogs, you can order them here! Thermo's custom CERAMOCOUPLE® is built from our well known CERAMO® thermocouple wire. CERAMO thermocouple components and finished custom thermocouple assemblies are all made in our factories with rigid quality control checks at every production stage. This, plus Thermo's know-how accumulated during more than three decades of thermocouple manufacturing experience means a Custom CERAMOCOUPLE that meets the highest standard of thermocouple quality.

The cutaway photographs show a CERAMO nucleus; the carefully selected, matched, calibrated pair of thermocouple wires. These wires are accurately positioned in compacted ceramic insulation and surrounded by a tight fitting, protective metal sheath. The electrical and physical properties of CERAMO make it the most **versatile, rugged, and dependable** thermocouple configuration available today.

THERMO ELECTRIC
Saddle Brook, New Jersey 07662
Brampton, Ontario L6W 3J2
Leiden, Box 515, The Netherlands

Printed USA, Section 6 ct, Edition 2



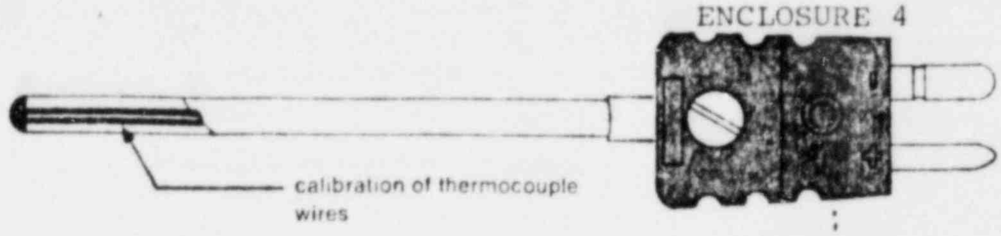


CERAMOCOUPLE "Plus" Benefits

Thermo Electric provides a superior thermocouple by taking every precaution against component failure. Why gamble your product or your process on thermocouples that don't have this built in TE quality?

- **Easily Formed** Although basically rigid, CERAMO can be formed to fit installations where straight thermocouples cannot be used. It can be formed on a radius as small as its own outside diameter, yet retain its form after being bent.
- **Small Size** CERAMO fits openings too small for conventional thermocouples. Outside diameters start at 1/25 of an inch.
- **Durability** In many applications a CERAMOCOUPLE can operate without a protection tube. They have withstood 50,000 psi external pressure under controlled conditions, and are used as standard temperature sensors in such harsh environments as jet and rocket engine exhausts.
- **Fast Response** The smaller mass of CERAMO reduces thermal lag, consequently CERAMOCOUPLE response to temperature change is faster than larger, less rugged thermocouples. To illustrate: a 1/16 inch OD CERAMOCOUPLE responds as rapidly to temperature change as a butt welded 16 gage bare wire thermocouple.
- **Long Life** Life span is increased up to 135 times. In a typical chemical industry application a 1/8 inch OD CERAMOCOUPLE lasted 7 to 9 months, while 14 gage bare wire thermocouples failed in 2 to 14 days. In many nuclear reactor applications, reactor life is dependent on CERAMOCOUPLE quality. A
- CERAMOCOUPLE in aluminum industry annealing, heat treating and aging furnaces provides the response of a ceramic beaded thermocouple and the long life of a thermocouple in a protection tube.
- **Wide Temperature Rating** With the proper choice of materials, CERAMO will operate satisfactorily at 4000°F; as low as minus 450°F.
- **Corrosion Resistance** CERAMO has excellent resistance to moisture, chemicals, petroleum products, nuclear radiation and abrasion, depending on the sheath material selected. The sheath also offers excellent electrostatic interference shielding for sensitive thermocouple circuits.
- **Accuracy** CERAMO conforms to ISA and ASA Limits of Error.
- **Applications** The above characteristics plus the versatility of CERAMO have made it an unbeatable performer in such applications as heat treating furnaces, ovens, chemical baths, extruders and oil refinery furnace tubes. In each case a CERAMOCOUPLE was selected because it offered the right combination of properties necessary to do the job in an economical and efficient manner.

1. Calibration



sample ordering code **J** 1

Ordering Code Digit 1: Select the calibration which provides the highest sensitivity for your temperature range, or that matches your instrumentation. It is usually not necessary to consider the environment in which the thermocouple is to be used at this time, unless you are ordering an exposed measuring junction.

Commonly Used Thermocouples

Ordering Symbol	Temperature Range °F	Sensitivity (average change per °F in μV)	Limits of Error Standard	Limits of Error Special*	Conductor Identification Pos. (+)	Conductor Identification Neg. (—)
J	32 to 530	30	±4°F	±2°F*		
	530 to 1400	32	±3/4%	±3/8%*	magnetic	nonmagnetic
T	−300 to −75	14		±1%*	copper color	
	−150 to −75	17	±2%	±1%*	nonmagnetic	nonmagnetic
	−75 to +200	22	±1½°F	±3/4°F*		
	200 to 700	30	±3/4%	±3/8%*		
K	32 to 530	23	±4°F	±2°F*		
	530 to 2300	22	±3/4%	±3/8%*	nonmagnetic	magnetic
E	32 to 600	39	±3°F	±2 1/4°F*		silver color
	600 to 1600	44	±1/2%	±3/8%*	nonmagnetic	nonmagnetic
S,R	32 to 1000	5	±2.5°F*			softer than
	1000 to 2700	7	±1/4%*			positive conductor

Limits of error per ASA C96.2
Percentages refer to the temperature being measured
*To specify special limits of error, use a double calibration symbol, e.g.: JJ.

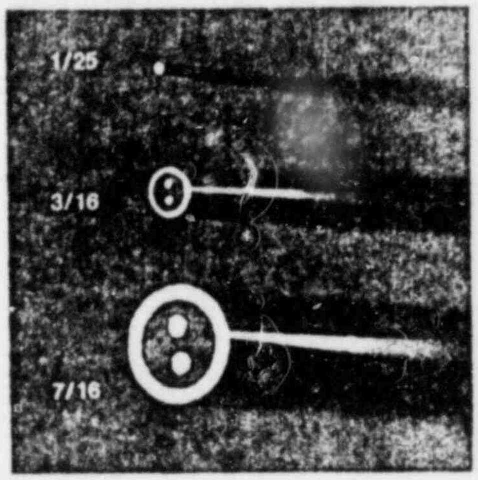
Type J, Iron (+)-Constantan (−), is the most commonly used calibration.
If **unprotected:**
1. The wires will function in a vacuum, inert, oxidizing or reducing atmosphere.
2. The iron wire may be attacked by ammonia, nitrogen and hydrogen atmospheres.
3. In sub-zero temperatures the iron wire may rust or become brittle.

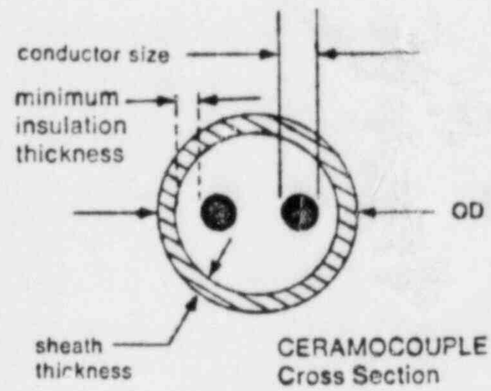
Type T, Copper (+)-Constantan(−), is commonly used for sub-zero to 700°F temperatures. Preferred to type J for sub-zero applications because of copper's higher moisture resistance, as compared to iron. If **unprotected,** it will still function in a vacuum, inert, oxidizing or reducing atmosphere.

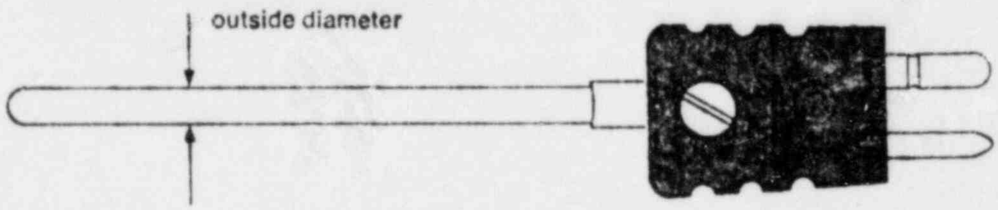
Type K, Chromel* (+)-Alumel* (−), is generally used to measure high temperature to 2300°F. It should not be used for accurate temperature measurements below 900°F after prolonged exposure above 1400°F. If **unprotected** it can be used only in inert or oxidizing atmospheres. It has a short life in alternately oxidizing and reducing atmospheres, and in reducing atmospheres, particularly in the 1500 to 1850°F range.

Type E, Chromel* (+)-Constantan (−) has the highest emf output of any standardized metallic thermocouple. If used **unprotected,** type E wires are not subject to corrosion at sub-zero temperatures. They can be used in inert, oxidizing or reducing atmospheres. Because they cover a wide temperature range with a single calibration curve, type E thermocouples are preferred for computer applications.

2. Outside Diameter







sample ordering code J 14 (1) (2)

Ordering Code Digit 2: Select a thermocouple diameter considering tabular information below. Larger sizes generally yield longest life and greater strength; smaller sizes have faster response.

Ordering Table

Ordering Symbol	Nominal OD (inches)	OD Tolerance +	OD Tolerance —	Conductor Size Nominal (AWG)	Conductor Size Minimum (inches)	Minimum Insulation Thickness (inches)	Minimum Sheath Thickness (inches)	Max. Length (feet)
125	1/25 (.040)	.0015	.001	36	.005	.004	.006	50
116	1/16 (.0625)	.0015	.001	30	.010	.005	.009	100
332	3/32 (.094)	.002	.002	26	.015	.006	.010	100
18	1/8 (.125)	.0015	.001	24	.020	.012	.012	100
316	3/16 (.1875)	.0015	.001	20	.031	.022	.020	50
14	1/4 (.250)	.002	.002	18	.040	.025	.028	50
516	5/16 (.3125)	.003	.002	15	.057	.030	.037	49
38	3/8 (.375)	.003	.002	14	.064	.035	.045	36
716	7/16 (.4375)	.005	.005	12	.077	.040	.050	28

These sizes for two wire construction only. For duplex and other special constructions refer to Saddle Brook.

Suggested Upper Temperature Limits for Protected CERAMOCOUPLE

	Suggested Upper Limit for CERAMOCOUPLE OD of:						
Calibration	1/25"	1/16"	1/8"	3/16"	1/4"	5/16"	7/16"
J	900°F	1000°F	1000°F	1200°F	1200°F	1200°F	1200°F
T	300°F	400°F	400°F	700°F	700°F	700°F	700°F
K	1400°F	1800°F	1800°F	2000°F	2000°F	2000°F	2100°F
E	800°F	1000°F	1000°F	1000°F	1100°F	1200°F	1300°F

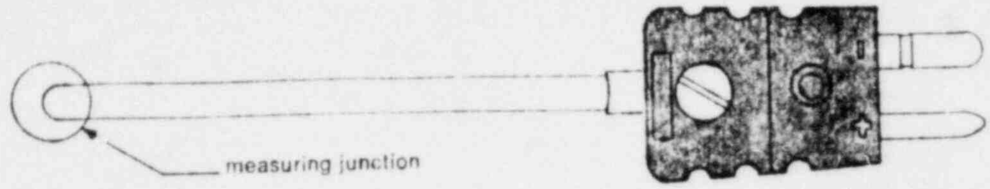
The ratings specified above are the maximum service temperatures at which a thermocouple will yield a satisfactory life. Since the field of thermocouple applications is extremely diverse, there are cases in which thermocouples may be used above suggested limits, and on the contrary, those in which satisfactory life will not be obtained at the suggested upper limit.

Typical Response Time Data for Standard CERAMOCOUPLE

Thermocouple OD (inches)	Type of Measuring Junction	Typical Response (seconds)
1/25	grounded	0.07
1/25	insulated	0.11
1/16	grounded	0.09
1/16	insulated	0.28
1/8	grounded	0.34
1/8	insulated	1.6
3/16	grounded	0.7
3/16	insulated	2.6
1/4	grounded	1.7
1/4	insulated	4.5
1/4	exposed loop	0.09

Values listed are the average of several CERAMOCOUPLE elements checked in each category. They show the time required to indicate 63.2% of a temperature change. The tests were performed during a step change from room temperature to boiling water.

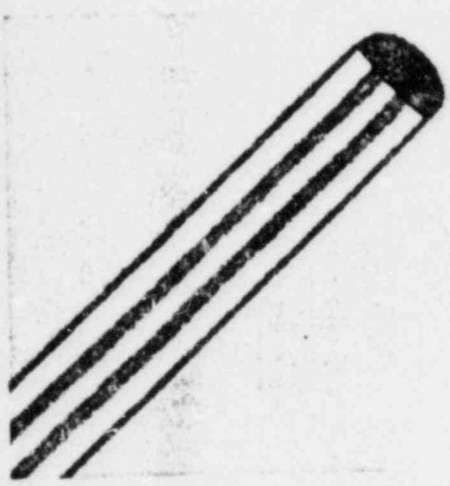
3. Measuring Junction



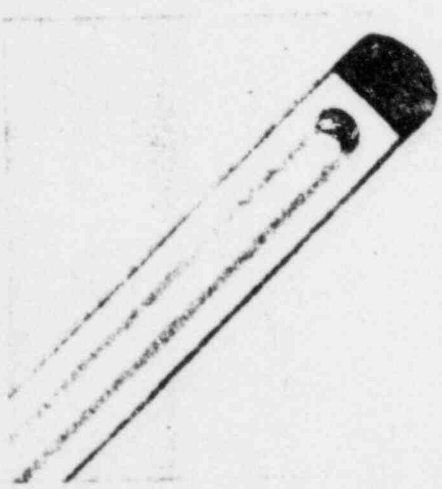
sample ordering code

J	14	G
1	2	3

Ordering Code Digit 3:
Each of the junctions described offers different performance characteristics. The closed grounded junction is considered standard because it is generally the most suitable type, combining fast response with complete environmental protection of the thermoelements.



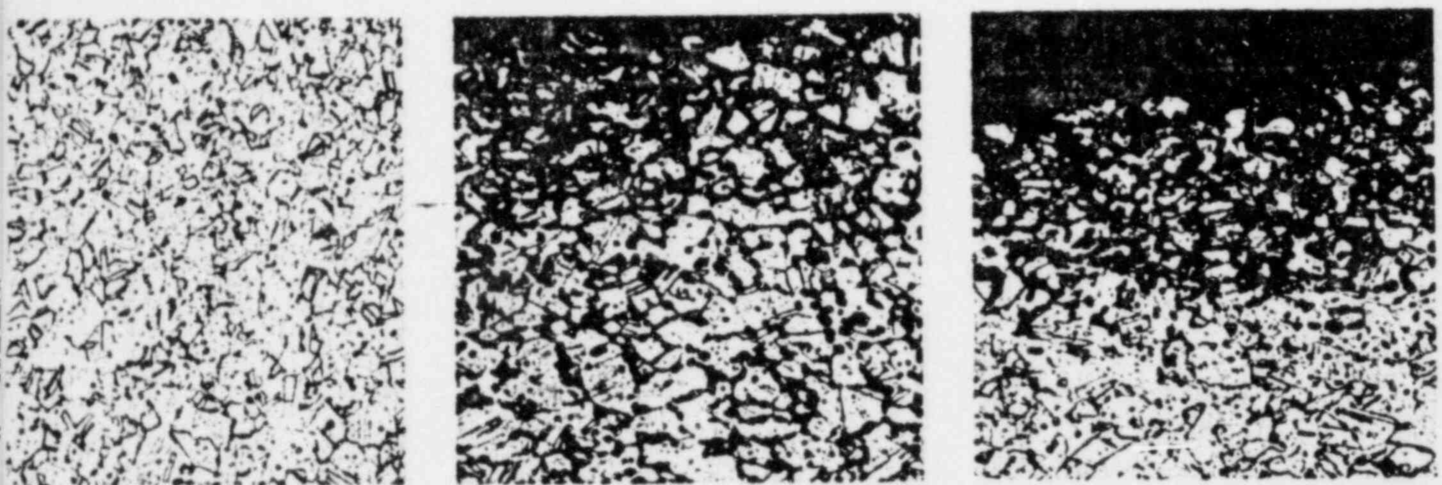
Ordering Symbol G **Grounded Measuring Junction**
In this construction, the measuring junction is completely sealed from contaminants and becomes an integral part of the tip of the thermocouple. Response time approaches that of an exposed loop thermocouple, and in addition, the junction conductors are completely protected from harsh environmental conditions. Small diameter thermocouples with grounded junctions may be selected to match or better the response time of larger exposed loop thermocouples. The operational life and upper temperature limit of the junction will be extended due to the protection offered by the CERAMO sheath. The radiograph shown is a production run CERAMOCOUPLE.



Ordering Symbol U **Insulated Measuring Junction**
In this construction, the thermocouple conductors are welded together to form the junction, which is insulated from the external sheath with magnesium oxide. The response time for an insulated junction is slightly longer than for a grounded junction thermocouple of the same outside diameter. In insulated junction thermocouples, however, conductors are electrically insulated from the sheath; a feature advantageous in applications where thermocouples are used in conductive solutions, or when used for differential, averaging (parallel) or additive (series) applications, or wherever isolation of the measuring circuitry is required.

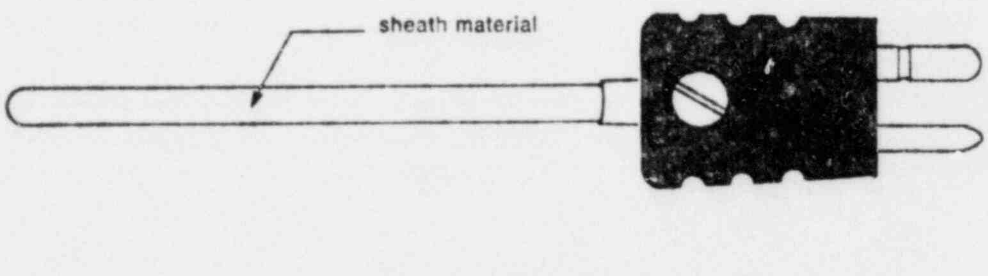
Ordering Symbol E **Exposed Loop Measuring Junction**
The exposed loop junction offers a faster thermal response time than the other junctions described here, while the CERAMO sheath material protects the remainder of the thermocouple length. This type junction is limited to mild environmental conditions or one time usage under more severe conditions. Care must be taken not to allow the exposed insulation to become contaminated with conductive substances, especially moisture. For low temperature applications, the insulation may be sealed with one of many available sealing compounds. In most applications the disadvantages of the exposed loop junction can be overcome and response time preserved by using a smaller diameter grounded junction, or with a "Coax" or reduced diameter tip construction.

Sheath Material



B C

Careful selection of sheath material with consideration for the application environment can often greatly extend thermocouple life expectancy, as shown in the sheath material ordering table. These 400 X photomicrographs compare a good stainless steel sheath free of grain boundry carbides (A), with the same sheath material having detrimental carbide precipitation (B), and heavy outside diameter surface attack (C).



sample ordering code J 14 G - 304

1	2	3	4
J	14	G	304

Ordering Digit 4: Select a sheath material that will yield good corrosion resistance, resistance to temperature and thermal shock, strength, and abrasion resistance in **your** application. For long service life, only contaminant free sheathing of known chemical and physical composition is used. CERAMO is bright annealed to remove contaminants, and meets ASTM specifications where applicable.

Ordering Table Digit 4:

Ordering Symbol	Sheath Material	Maximum Temp. (cont. service, air)	Melting Range	Application Notes
304	stainless steel 304	1650°F	2550-2650°F	The general purpose austenitic stainless steel. Subject to carbide precipitation in the 900 to 1600°F range. Corrosion resistant in the annealed condition. Not affected by sterilizing solutions, foodstuffs, most dyestuffs, organic chemicals and many inorganic chemicals.
310	stainless steel 310	2100°F	2550-2650°F	Very high elevated temperature strength and scale resistance. Superior to 304 in many high temperature applications. Good resistance to carburizing and reducing environments. Subject to carbide precipitation in the 900 to 1600°F range.
316	stainless steel 316	1650°F	2500-2550°F	Higher corrosion resistance than Type 304. High creep strength. Withstands sulphuric acid compounds, resists tendency to pit in phosphoric and acetic acids. Subject to carbide precipitation in the 800-1500° range.
347	stainless steel 347	1600°F	2550-2600°F	Columbium stablized grade intended to prevent harmful precipitation of chromium carbides and the resulting susceptibility to intergranular corrosion . For corrosion conditions and intermittent heating and cooling applications between 800°F and 1500°F.
I 600	Inconnel* 600	2100°F	2500-2600°F	Good in severely corrosive environments at elevated temperatures. High hot-strength and resistance to progressive oxidation and fatigue. Nonmagnetic. Use in sulfur free atmosphere.
HX	Hastelloy† X	2200°F	2350°F	Alloy, principally nickel, chromium iron and molybdenum.
P 10 R	platinum 10% rhodium	2500°F	3370°F approx.	Addition of rhodium increases service temperature, strength and corrosion resistance.
TA	tantalum	not recommended	5425°F	Useful to 4000°F in inert gas environments or in a vacuum.

Other materials that can be made into tubing can be used for sheath material.

*Trademark, International Nickel Co., Inc.

†Trademark, Union Carbide Corp.

Options

Special Tests:
In addition to our standard quality control tests and inspections, we can perform and certify the following:

1. Mass spectrometer helium leak: tests sheath integrity
2. Liquid penetrant test: detects surface flaws in probe sheath
3. Radiographic inspection: determines precise condition of conductors at measuring junction, angle of twist, pack integrity, welding penetration
4. Metallurgical examination: determines grain size of sheath
5. Point calibration: gives exact amount of deviation from NBS standards at specified temperatures. Thermocouples to be tested must be at least one foot long. Standard temperatures of test are: −320, +75, 212, 400, 500, 800, 1000, 1500, 1800. Freeze point calibration is also available for thermocouples at the following temperatures: 449.384,621.32,787.1, 1220.0, 1761.4 and 1981.94. All temperatures are degrees Fahrenheit. When requesting calibration, specify the immersion length you plan to use in your application.

- **Insulation**
The standard CERAMOCOUPLE insulating material is magnesium oxide (MgO). The MgO used in CERAMO is of the highest purity commercially available. Boron content is low for nuclear applications. It maintains high electrical resistivity to temperatures in excess of the temperature limits of the sheath and wires. Forming CERAMO to a radius equal to its outside diameter will not affect the insulating qualities. If another insulation is required, consult our Saddle Brook office.

Commonly Used Mineral Insulations

Material	Formula	Melting Point °F	Max. Limit in Oxidizing Atmosphere °F
Magnesia	MgO	5000	4350
Alumina	Al_2O_3	3700	3550

Thermocouple Installation Practices

1. The thermocouple tip should be located in a position where the mass velocity is high to assure good heat transfer. However, if the velocity is in excess of 300 ft/sec measuring errors could result from frictional heating (contact Thermo Electric for information on stagnation thermocouples).
2. When used in a protecting tube or thermowell, the thermocouple should touch bottom for optimum response and accuracy. Spring loaded CERAMOCOUPLE elements are described in our Industrial Thermocouple catalog.
3. A pair of thermocouple connectors or a connection head is recommended between thermocouple and extension wire to provide accurate readings, positive connections, easier checking and replacement. TE's color coded quick coupling connectors offer a quick method of identifying thermocouple calibration, without tagging.
4. It is generally advisable to extend the thermocouple beyond the outer surface of the processing equipment to prevent heat damage to the transition and eliminate calibration error.

   The latter is especially important with type R and S thermocouples using copper alloy extension wires, which approximate the platinum rhodium temperature emf curve very closely up to 200°F. Beyond 200° the error grows increasingly large so as to be unacceptable in most applications. Other thermocouple **extension** wires, in general, are not calibrated beyond 400°F and accordingly, ambient temperatures exceeding this point could create measuring inaccuracies.

Please check your nearest Thermo Electric office for availability of thermocouple configurations, materials and dimensions not listed.

Thermocouple Accessories are described in the following catalogs, available upon request:
Thermocouple Connectors
Connector Panels
Thermocouple and Extension Wires
Selector Switches for thermocouples
Thermocouple Terminal Boxes and terminal blocks

LOCA ENVIRONMENTAL EFFECTS ON CONTAINMENT MINERAL INSULATED CABLE PENETRATIONS

During normal operation, the entire penetration is at thermal equilibrium with no differential thermal movements between the component parts. Immediately following a recirculation line break or a steam line break, however, the component parts of the penetration will react with varying thermal growth rates to the sudden increase in environmental ambient temperature. This differential response will be due to size and geometrical differences among the various parts of the penetration assembly, and to material property differences.

Reference (2) characterizes the penetration assembly exclusive of the cable, its sheath, ferrule and threaded fittings as "massive". This is inaccurate. The SS plate assembly through which the cables pass is not "massive" from a thermal stress/strain point of view. The plate assembly is characterized by a very low Biot modulus ($hL/k < 0.1$), implying that the temperatures throughout the plate will be substantially uniform at any instant of time. Thus, there will be no significant differential thermal strains in one part of the plate relative to other parts of the plate which might cause distortions near the interface with the threaded cable penetration fittings. The problem is therefore reduced to consideration of the differential thermal response of the copper/brass cable penetration fittings relative to the stainless steel plate assembly to which they attach.

Copper and brass are characterized by a much larger thermal diffusivity than stainless steel ($^{k}/c_p$ - 4.42 square feet/hour for pure copper, approximately 1.14 square feet/hour for brass vs. approximately 0.15 square feet/hour for type 304 SS). The magnitude of the thermal diffusivity is related to the speed of temperature response of a body when subjected to a change in environmental temperature: the greater the diffusivity, the more rapid is the temperature response. This means that as the penetration assembly heats up following the sudden application of the high ambient temperature (277^{o}F maximum), the temperature of the steel plate will lag behind that of the brass/copper penetration subassembly. This situation, coupled with the slightly larger coefficient of linear expansion of brass, ensures that the thermal strains which occur in heatup will be of the type to augment the sealing forces existing between the steel plate and brass fitting (i.e. the I.D. of the threaded hole in the stainless steel plate increases, but not as quickly as the increase in O.D. of the threaded portion of the fitting).

For a rapid cooldown, the above-mentioned factors would tend to work against the leak-tightness of the cable penetrations. But Enclosure 8 shows that rapid cooling of the containment atmosphere does not occur following a LOCA. Ambient temperature reduction occurs quite gradually, so that all parts of the penetration assembly will be in thermal equilibrium with the containment atmosphere. No differential thermal strain will result from this situation.

Conclusion: For that time period in which the containment ambient temperature changes rapidly, the induced thermal stresses in the penetration assembly act in a direction to provide greater sealing force and greater leak-tightness. Post-LOCA containment cooldown rates are not great enough to produce the reverse effect after peak containment temperature has been reached.

REACTOR VESSEL SAFETY SYSTEM WATER LEVEL TRANSMITTERS

MODEL

Water Level #1 T/613DM - MS2-0
Water Level #2 T/613DM - MS2-0
Water Level #3 E13DM Style B (No other Letters)

CASE

Water Level #1, Style E
Water Level #2, Style E
Water Level #3, Style B

CURRENT

Water Level #1, 2, 3 10-50 MA DC

AMP

Water Level #1, 2 Remote Amplifier N119LN
Water Level #3 Remote Amplifier N0141NL

BODY

Water Level #1, 2, 3 Body Material Stainless Steel
Cover-Cast Aluminum, Water Tight

CAPSULE

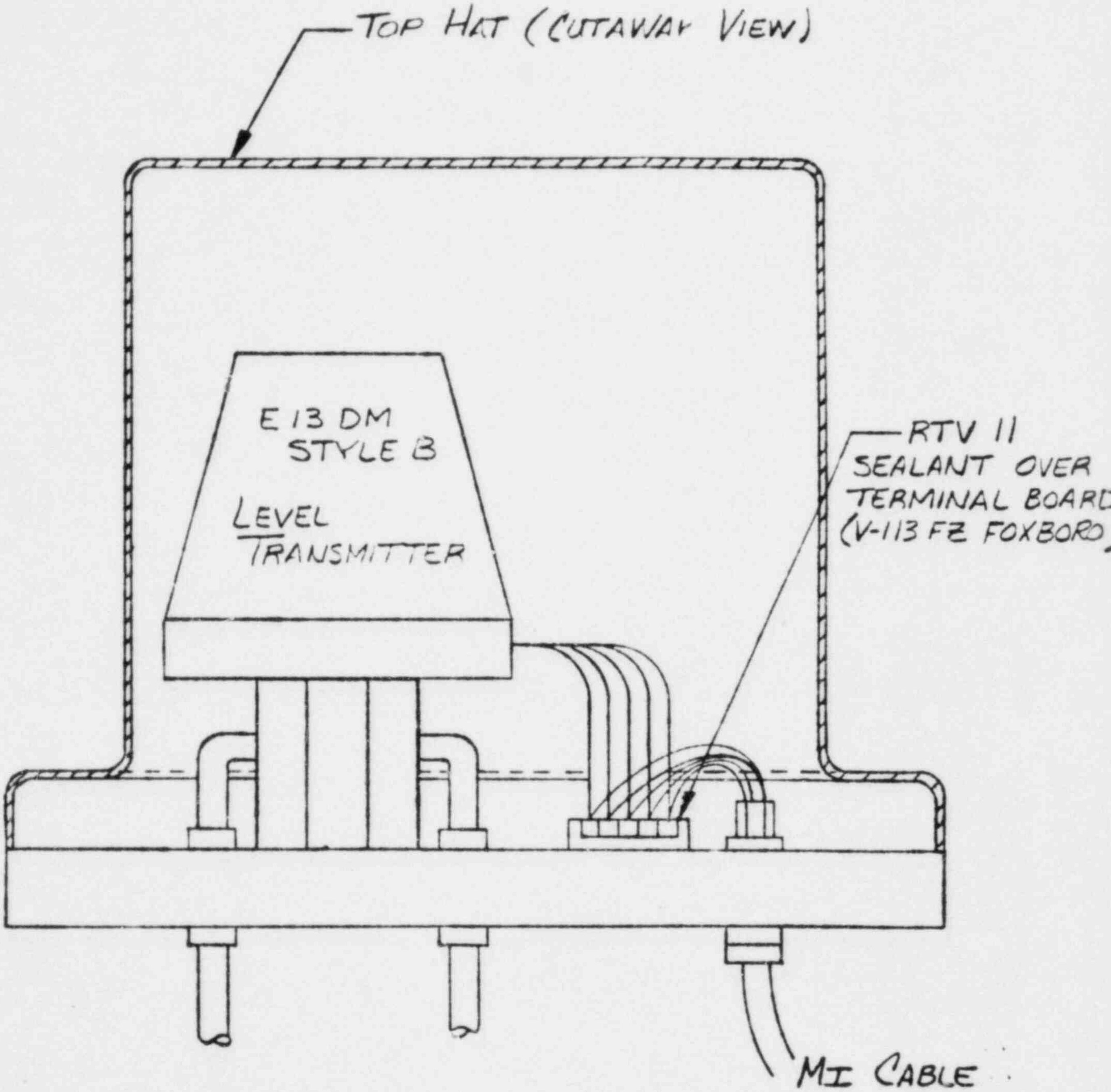
Water Level #1, 2, 3 Capsule 316SS A62139 U102XF (Teflon)

ELECTRICAL CONNECTION

See attached diagram.

SPECIAL MODEL

None.


TOP HAT (CUTAWAY VIEW)
E 13 DM
STYLE B
LEVEL
TRANSMITTER
RTV 11
SEALANT OVER
TERMINAL BOARD
(V-113 FZ FOXBORO)
MI CABLE

LA CROSSE BOILING WATER REACTOR
ENVIRONMENTAL AMBIENT TEMPERATURES FOR THE TURBINE BUILDING FOR MAIN STEAM LINE BREAKS AND MAIN FEEDWATER LINE BREAKS

REFERENCES: (1) ACNP-66564, Description of Post-Accident Safeguards Provisions for the La Crosse Boiling Water Reactor, Allis-Chalmers Atomic Energy Division, September 1966.

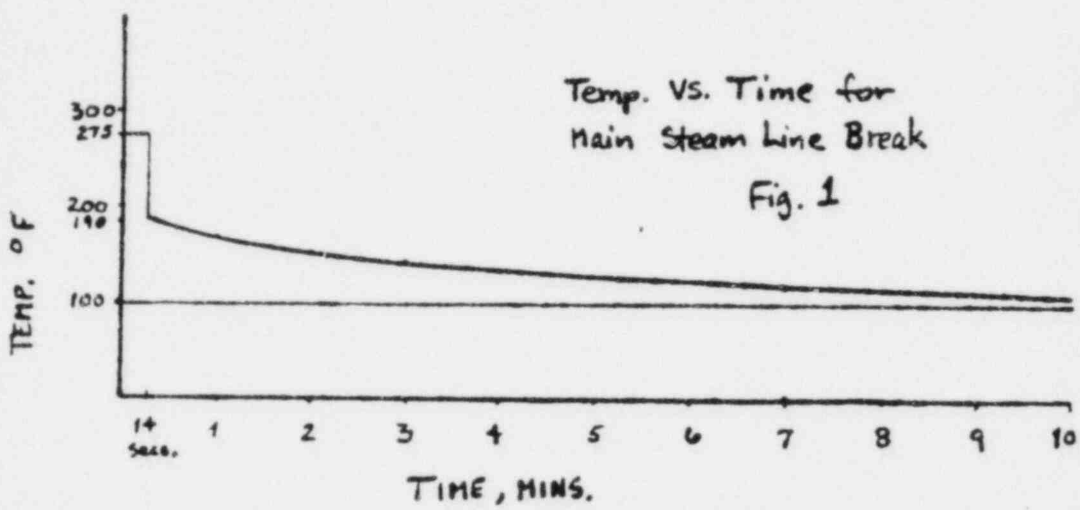
(2) ACNP-66530, Answers to Questions Received from the Division of Reactor Licensing, Answer IV-12, Allis-Chalmers AED, April 1966.

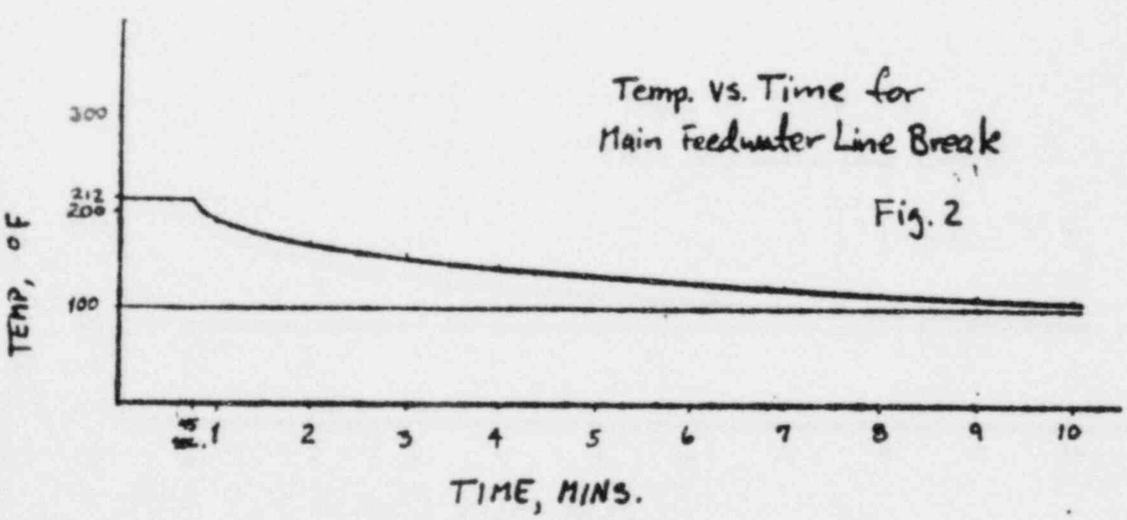
Information is provided, summarizing the results of calculations which determine the transient ambient temperatures at four locations in the turbine building for two types of high-energy pipe breaks: a main steam line break and a main feedwater line break.

Finally, the amount of water which might accumulate in the pipe tunnel in the event of a main feedwater break was determined. This quantity was calculated to be 204,848 lbm, corresponding to 3,283 cubic feet.

REF.

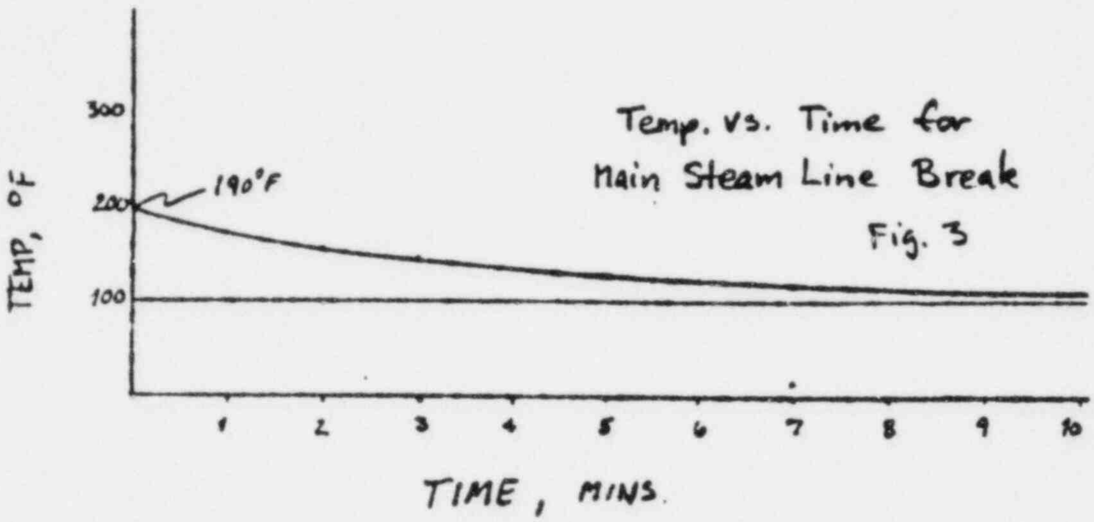
Locations 1 & 2 : Pipe Tunnel, Elev. 629'
ACS & MSIV Areas.





REF.

Locations 3 & 4: Boiler Feed Pumps Elev. 640'
#3 Feedwater Heater



Temperature vs. time for Feedwater Line Break is identical to that illustrated for Locations 1 & 2 [Enclosure (2), Figure 3]

LA CROSSE BOILING WATER REACTOR
ENVIRONMENTAL AMBIENT TEMPERATURES FOR THE REACTOR CONTAINMENT BUILDING FOR A LOCA IN CONTAINMENT

REFERENCES:

(1) ACNP-66564, Description of Post-Accident Safeguards Provisions for the La Crosse Boiling Water Reactor, Allis-Chalmers Atomic Energy Division, Sept. 1966.

(2) ACNP-66530, Answers to Questions Received from the Division of Reactor Licensing, Answer IV-12, Allis-Chalmers AED, April 1966.

Included are the results of calculations performed to assess the capability of the CCW piping to be utilized as a heat sink for post-main steam line break conditions within containment. These calculations assume that, initially, the scenario of Reference (1), Section 5.2 obtains, and that the temperature response of containment for time $t < 10$ hours corresponds to that shown in Figure 5.1 of Reference (1). Starting at time $t = 10$ hours, the scenario is modified to take credit for containment heat removal through the CCW piping. No credit is taken for operation of the containment spray system at any time following the break.

The heat transfer characteristics of the CCW piping were assumed to be as follows: (a) total heat transfer surface area (CCW piping and components) = 1000 square feet; (b) combined natural-convection/condensation heat transfer coefficient h = 50 Btu/hr. square feet $^{\circ}F$; (c) surface temperature of CCW components = $90^{\circ}F$.

The following data were extracted from Reference (2):

(a) Containment Free Volume = 264,160 ft^3.

(b) Total Mass of Primary Water Open to Containment Atmosphere = 66,173 pounds.

(c) Total Energy Released to Containment at Time Equal Zero = 39.5×10^6 Btu.

(d) Energy Absorbed by Containment Air = 3345 Btu/$^{\circ}F$.

(e) Decay Heat Energy Added = 336,000 $t^{0.8}$ Btu (t=time in minutes).

Utilizing the above data, the following energy balance equation was solved for T, by trial and error methods, for successive times t > 10 hours:

$$264,160 = \frac{v_g}{u_{fg}} \times [39.54\times10^6 - 8.1312\times10^7 - 3345\ (T-80) - 66173\ u_f + 8.889\times10^6\ t^{0.8} - 5\times10^4\ (t-t_o)\ (T-90)]$$

WHERE:

t = Time after steam line break in hours

t_o = 10 hours

T = Containment ambient temperature in degrees F

v_g = Specific volume of saturated steam at temp T, cubic feet/lbm

u_{fg} = Internal energy of evaporation, Btu/lbm

u_f = Internal energy of saturated liquid, Btu/lbm

Initial conditions: at $t=t_o$, $T=175^oF$

Results of the process are tabulated in Table 1, plotted in Figure 1.

REF.

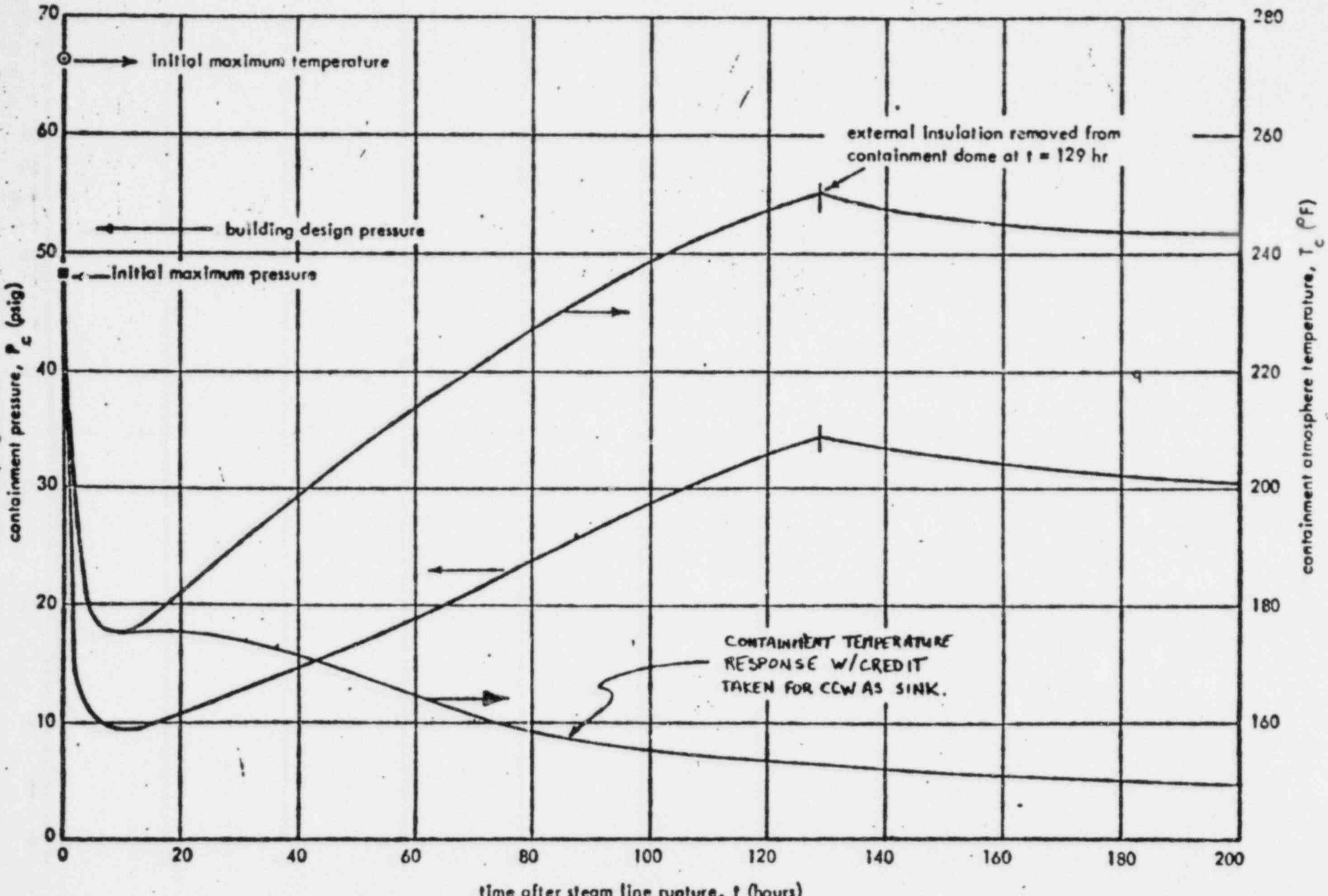
TABLE 1

LACBWR CONTAINMENT TEMPERATURE

VS. TIME

USING CCW SYSTEM AS HEAT SINK

TIME AFTER BREAK, HRS	CONTAINMENT TEMP., °F
10	175
12	177
14	176
16	176
20	174
24	172
30	170
36	168
48	165
72	161
100	157
200	149



8-4

PRESSURE AND TEMPERATURE IN REACTOR BUILDING
AFTER THE MAXIMUM STEAM LINE FAILURE

TAKEN FROM REF(1) FIG. 5.1

ENCLOSURE 8

EFFECT OF INITIAL CONTAINMENT AIR TEMPERATURES ON CONTAINMENT PRESSURE AFTER A LOCA

REFERENCE: Amendment 13 (ACNP-66501, January 1966) - Answers to DRL Questions to LACBWR Safeguards Report for Operating Authorization.

The peak containment pressure immediately following a LOCA (Postulated MCA) was determined in the Reference from the following energy balance for release of steam and water from the primary system to the Containment Building and the resulting partial pressures of steam and air.

$$264,160 = \frac{v_g}{u_{fg}} [39.54 \times 10^6 - 3345(T-T_o) - 66,173 (u_f)]$$

Where the variable properties apply to the final saturation conditions for steam at equilibrium in the containment volume, and

v_g = Specific volume of saturated vapor, ft^3/lb

u_{fg} = Internal energy difference by evaporation, Btu/lb

u_f = Internal energy of saturated liquid, Btu/lb

T = Final saturation temperature, ^oF

T_o = Initial average containment air temperature, ^oF

The constants in the above energy balance are:

Total primary system mass = 66,173 lb

Total contained energy = 39.54×10^6 Btu

Containment free volume = 264,160 ft^3

Heat absorption by contained air = 3345 Btu/^oF

The reference calculation assumed $T_o = 80^oF$.

The calculations have been repeated for a range of initial containment air temperatures, T_o, from 60^oF to 90^oF with the following results:

Initial Cont. Temp. (°F)	Peak Cont. Temp. (°F)	Steam Partial Press. at Peak (psia)	Air Partial Press. at Peak (psia)	Containment Pressure at Peak	
				psia	psig
60	271.5[illegible]	42.92	20.68	63.60	48.90
80	271.72	43.05	19.92	62.97	48.27
90	271.79	43.10	19.56	62.66	47.96

Conclusion: The initial average containment air temperature has a very minor effect on the peak containment pressure during a LOCA and in fact a higher initial temperature produces slightly lower peak transient pressures.

ACNP 66501

CALCULATIONS

The analysis performed was based on the following conservative assumptions:

(a) Ten percent of the total fuel cladding in the active core reacts with water.

(b) Hydrogen generated by the reaction contributes to the containment pressure either through added volume or through energy release due to recombination.

(c) The reaction contributes to the containment pressure rise while the containment is at peak pressure immediately after the maximum credible accident (MCA).

The heat evolved in the stainless-steel steam reaction is assumed to be 255 Btu/lb based on a reaction temperature of 2781 F (Reference: GEAP-3335, "Metal-Water Reactions," Leo F. Epstein, January 30, 1960). Hydrogen evolved from the reaction is 0.441 liter (@ STP) per gram of stainless steel (Reference: Table 5.5 of ORNL-NSIC-5).

1. Calculation of Building Pressure Following MCA (Neglecting Metal-Water Reaction)

Total primary system mass = 66,173 lb

Total Contained Energy = 39.54×10^6 Btu

Containment Free Volume = 264,160 ft^3

Heat Absorption by Contained Air = 3345 Btu/°F

An energy balance for release of steam and water from the primary system to the containment building leads to the following approximate equation:

$$264,160 = \frac{(v_g)}{(u_{fg})} \left[39.54 \times 10^6 - 3345\ (T - 80) - 66,173\ (u_f) \right]$$

where the variable properties apply to the final saturation conditions for steam at equilibrium in the containment volume, and

v_g = specific volume of saturated vapor, ft^3/lb

u_{fg} = internal energy difference by evaporation, Btu/lb

u_f = internal energy of saturated liquid, Btu/lb

T = final saturation temperature, °F

ACNP 66501

By trial and error, the above equation is solved to obtain the partial pressure of steam at the final conditions. The solution indicates a steam partial pressure of 43 psia at T = 272 F.

$$PP_{air} = 14.7 \left[\frac{460 + 272}{540}\right] = 19.9 \text{ psia}$$

$$\text{FINAL PRESSURE} = PP_{steam} + PP_{air} = 62.9 \text{ psia or } 48.2 \text{ psig.}$$

2. Calculation of Assumed Metal-Water Reaction, and Effect on Final Containment Pressure

(a) The total cladding weight over the active core length is 4080 lb. The energy release from the assumed 10 percent of the cladding reacting with water is:

255 Btu/lb x 408 lb = 104,000 Btu

The hydrogen generation is:

$$0.441 \frac{\text{liter}}{\text{g of s.s.}} \times (408)\ (454) \text{ g of s.s.}$$

= 81,800 liters

= 2890 ft^3 at STP

(b) Correction of the energy balance to account for the additional 104,000 Btu yields the following:

$$264,160 = \frac{(v_g)}{(v_{fg})} \left[(39.54 + 0.104) \times 10^6 - 3345\ (T_f - 80) - 66,173\ (v_f)\right]$$

The solution indicates a steam partial pressure of 43.35 psia.

$$PP_{air} = 19.9 \text{ psia}$$

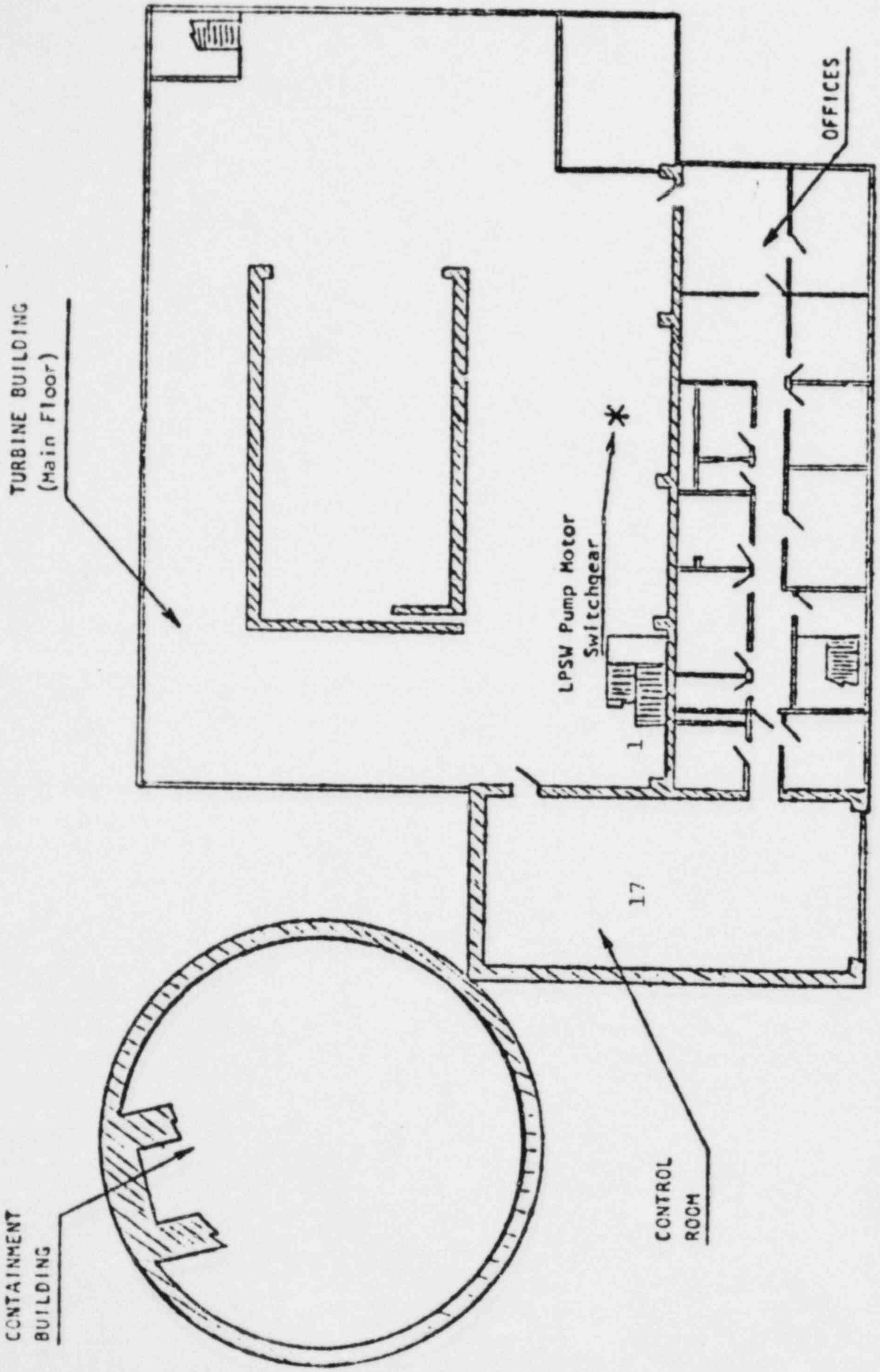
$$PP_{hydrogen} = 14.7 \times \frac{2890}{264,160} \times \frac{732}{492} = 0.24 \text{ psia}$$

$$\text{FINAL PRESSURE} = PP_{steam} + PP_{air} + PP_{hydrogen} = 63.5 \text{ psia or } 48.8 \text{ psig.}$$

RADIATION LEVEL IN TURBINE BUILDING FOR LOCA/HELB IN CONTAINMENT

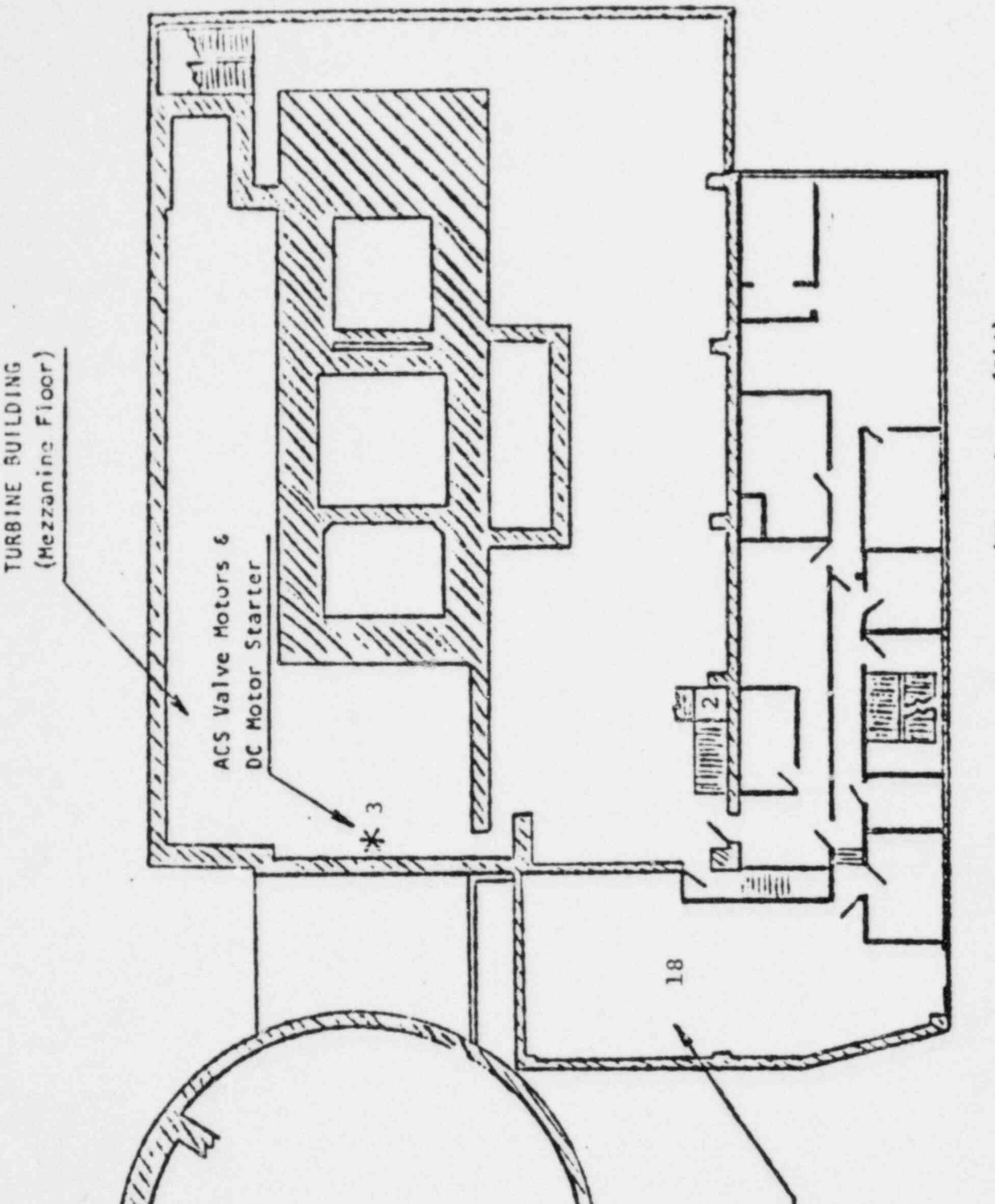
See Figures 1 through 5 for corresponding location of points in following table.

Location	Dose Rate (mRem/hr) at T = 30 Minutes
1	3.6×10^3
2	5.0×10^1
3	1.0×10^4
4	2.5×10^3
5	3.3×10^4
6	3.0×10^3
7	1.1×10^4
8	3.4×10^3
9	4.8×10^4
10	2.8×10^4
11	1.1×10^4
12	1.6 x 106
13	2.43×10^7
14	1.61×10^6
15	1.61×10^6
16	1.66×20^6
17	Figure 5
18	Figure 5



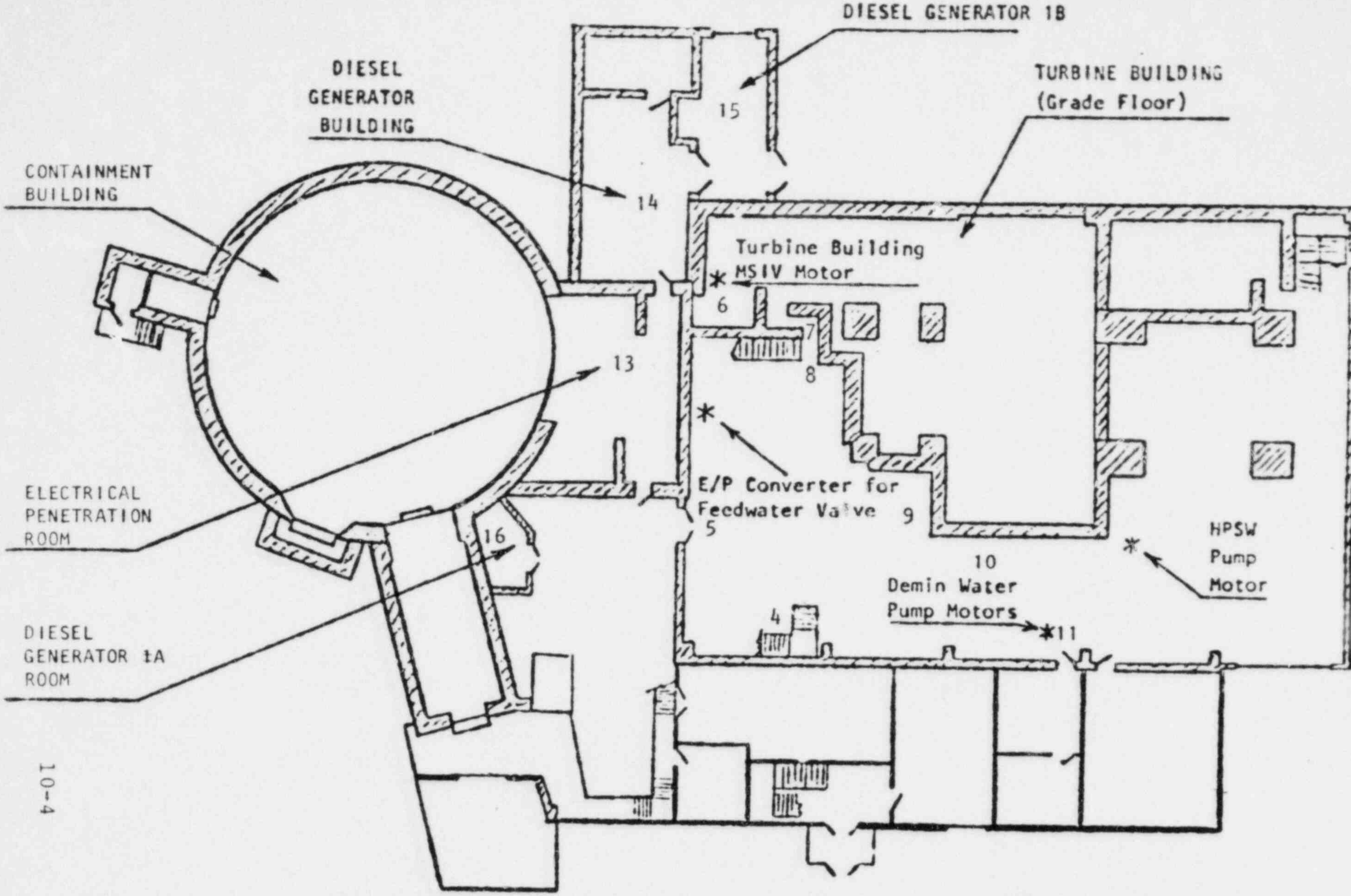
(Elevation ~ 668')

FIGURE 1



(Elevation ~ 654')

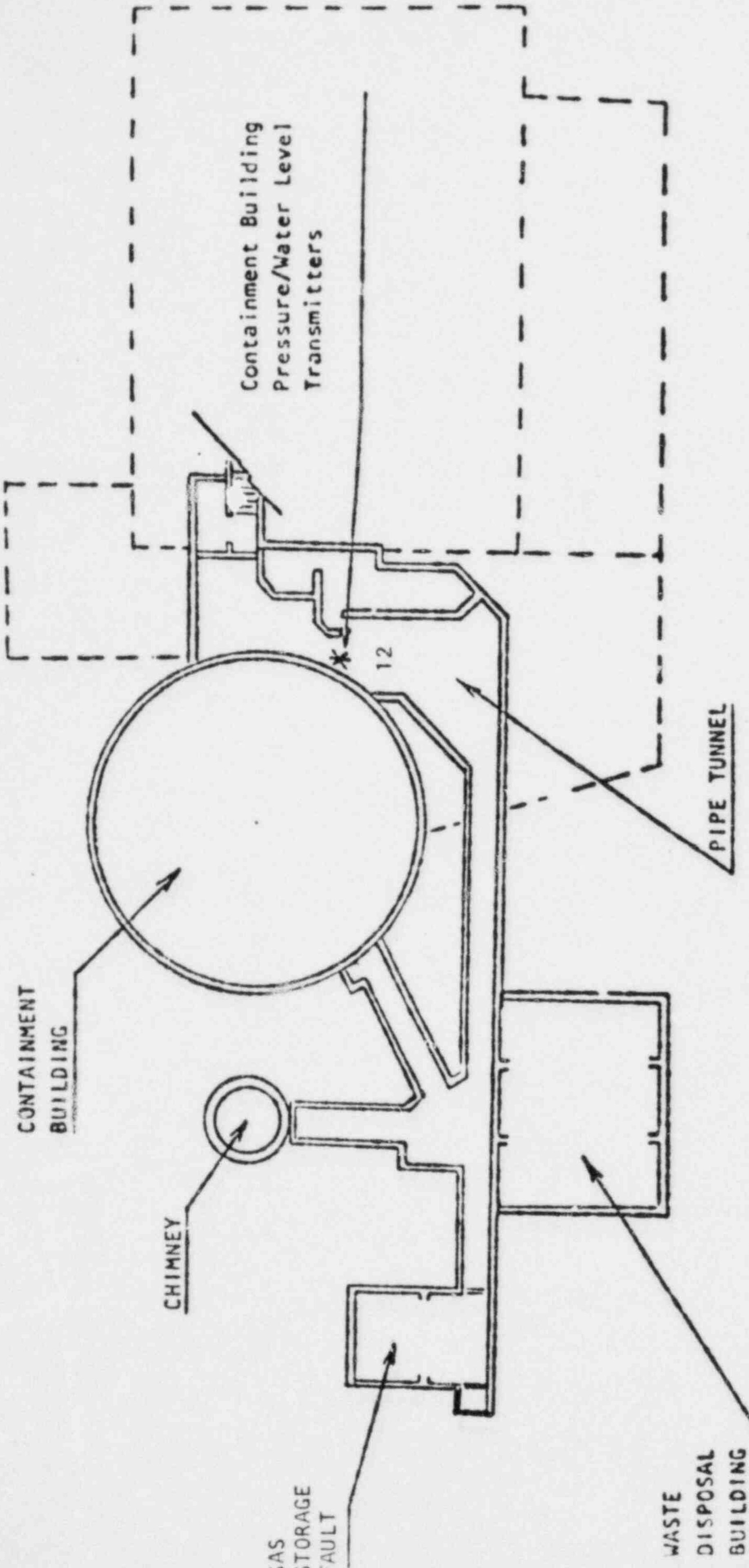
FIGURE 2



(Elevation ~ 640')

FIGURE 3

ENCLOSURE 10



(Elevation ~ 629')

FIGURE 4

CONTAINMENT

mRem/hr T=30 Min	
2	1.7×10^3
9	1.4×10^3
10	9.5×10^2
11	4.4×10^2
12	7.1×10^2
13	1.6×10^2
14	2.9×10^2
15	6.8×10^1
16	1.2×10^2

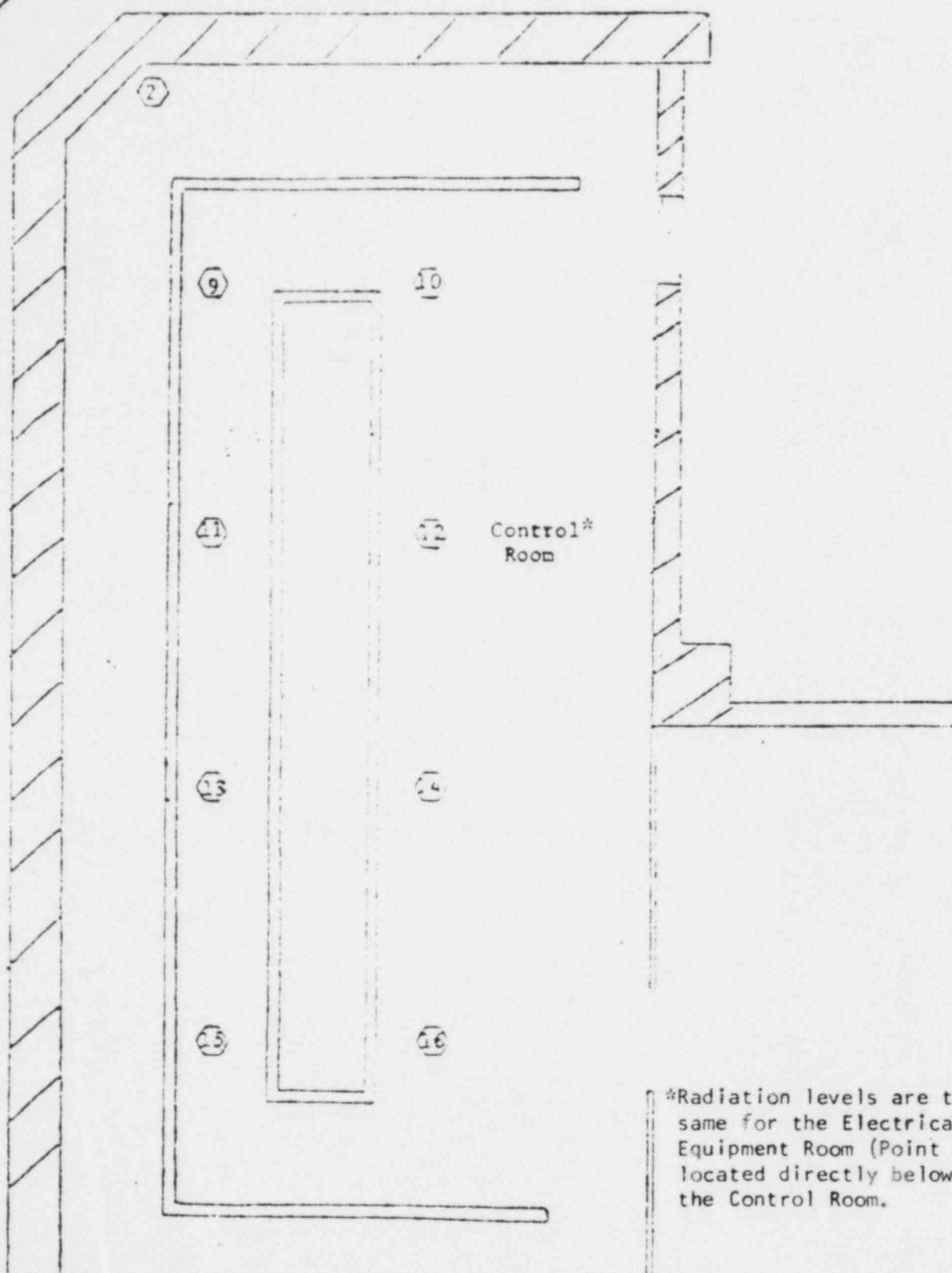


Figure 5

Control Room Receiver Locations

*Radiation levels are the same for the Electrical Equipment Room (Point 18) located directly below the Control Room.