WESTINGHOUSE CLASS 3

QUALIFICATION TESTING OF
ITT/BARTON TRANSMITTERS
PRODUCTION LOT NO. 2

1688 298

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ABSTRACT

This report documents the qualification test results of a sample of ITT Barton Model [ ]a,c transmitters from Lot No. 2 production run. The testing consisted of irradiation, seismic and severe environment simulation and demonstrates the adequacy of the instruments to perform required functions under these postulated adverse conditions. The environmental qualification was performed in accordance with IEEE-323, 1971 and the seismic simulation testing was in accordance with IEEE-344, 1975.

1.0 INTRODUCTION

The ITT Barton Model [ ][a,c] differential pressure transmitter and Model [ ][a,c] pressure transmitter were developed in conjunction with Westinghouse for use in nuclear power plants. These transmitters are used for normal operation and for operation after a high energy line break which results in a high temperature, humidity and pressure condition and possibly a high radiation environment.

Westinghouse had previously tested, qualified and reported the first production run of these transmitters and the results have been submitted to the NRC (NS-TMA-1950 and NS-TMA-2120). The second lot of transmitters, which is the subject of this report, was also procured under lot control techniques for materials, manufacturing processes and procedures. The transmitters in a lot were required to be manufactured to the same baseline design from the same drawings using identical components and subassemblies by similarly trained people. To verify the qualification of the total lot, which is identified in Table 1-1, sample transmitters were selected from the lot, as identified in Table 1-2, and subjected to a lot verification test consisting of: irradiation, seismic simulation and steam/temperature/pressure/chemical spray testing as outlined in Table 1-3.

The differences between the Barton transmitters in lot No. 2 and the transmitters in lot No. 1, other than the material procurement and manufacturing period, are identified below.

[1688 301][b,c,e]

TABLE 1-1

ITT/BARTON PRODUCTION LOT NO. 2
SERIAL NUMBERS

Pressure Transmitters-Model [ ]a,c

318 to 349
352 to 372
384 to 401
413 to 438
460 to 465

Test Units - 370, 371, 372

Differential Pressure Transmitters-Model [ ]a,c

349 to 505
544 to 567
576 to 633
652 to 750

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Test Units 500, 501, 503, 504

TABLE 1-2

PRODUCTION LOT NO. 2 TEST UNITS

Type	Model No.		Serial No.	Test Facility Designation	Range	
Pressure		a,c	371	BD-1		a,c
Pressure			370	BD-2		
Pressure			372	BD-3		
Differential Pressure			500	BE-1		
Differential Pressure			503	BE-2		
Differential Pressure			504	BE-3		
Differential Pressure			501	BE-4		

NOTE: All test units have a 4 mADC to 20 mADC output signal except BD-1 which has a 10 to 50 mADC. These two output spans are obtained by changing the value of a resistor in the output stage of the transmitters.

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TABLE 1-3

SENSOR QUALIFICATION PROGRAM TEST SEQUENCE

1. Receive transmitters and inspect
2. Perform 21-point calibration check[(a)]
3. Perform time response test on certain units[(b)]
4. Deliver transmitters to radiation test facility
5. Install transmitters in source area
6. Perform 21-point calibration check
7. Irradiate transmitters for 30 minutes
8. Perform 21-point calibration check
9. Irradiate transmitters
10. Perform 21-point calibration check
11. Deliver transmitters to FH site
12. Perform time response test on certain units[(b)]
13. Perform 21-point calibration check
14. Deliver transmitters to seismic test facility
15. Monitor output of transmitters during seismic test
16. Perform 21-point calibration check
17. Monitor output of transmitters during environmental test
18. Perform 21-point calibration check.

NOTES:

a. All 21-point calibration checks were performed in accordance with SAMA Standard PMC20.1-1973.

b. Pressure transmitter BD-1 and differential pressure transmitter BE-4.

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2.0 FUNCTIONAL REQUIREMENT AND TEST CRITERIA

2.1 GENERAL

The pressure and differential pressure transmitters in this production lot are required to meet the short term (minutes) protective functions (e.g. reactor trip, safety injection) requirement and/or the long term (days) post-accident monitoring functions. Allowable short term and long term accuracy requirements for the various functions, wherein these transmitters are utilized, are identified in Table 2-1. These accuracies are expressed in terms of deviation from the normal accuracy for all functions.

The required test sequence for the program was radiation exposure followed by seismic simulation and adverse environment (high energy line break) simulation as described in the following paragraphs.

2.2 RADIATION CONDITIONS

The radiation doses were established based on Total Integrated Dose (TID) source terms with credit taken for shielding based on the location of the transmitters. The resultant doses are conservative with respect to both the postulated loss of coolant accident and the postulated steam line break accident. The instrument radiation test conditions are given in Table 2-2. The normal worse case integrated radiation dose for any transmitter inside the containment is 4×10^4 Rads for a 40 year total.

2.3 SEISMIC SIMULATION

The seismic simulation test was a biaxial multifrequency test per the response spectra shown in Figure 2.1. Three different input signals (tests) are required to duplicate the total response spectra.

2.4 ACCIDENT ENVIRONMENT CONDITIONS

The containment temperature profile is intended to envelope the calculated containment temperature conditions associated with a spectrum of postulated steam line break accidents and postulated loss of coolant accident and should be compared with plant specific information.

The environmental test (steam/pressure/temperature/chemical spray) shown in Figure 2.2 was aimed toward a [ ]a,b,c saturated condition [ ]a,b,c with a peak at about [ ]a,b,c of short duration occurring in order to adequately simulate the required rise time of [ ]a,b,c. The [ ]a,b,c saturated condition was held for [ ]a,b,c minutes and test conditions were stabilized at [ ]a,b,c hours. Chemical spray, consisting of [ ]a,b,c ppm boric acid dissolved in water and adjusted to a pH of [ ]a,b,c by sodium hydroxide, was applied for the first [ ]a,b,c of the test at a flow rate of approximately [ ]a,b,c.

Included in the temperature test profile is an accelerated post accident simulation at [ ]a,b,c. The [ ]a,b,c period at elevated temperature represents a [ ]a,b,c post accident monitoring period at a normal average in-containment temperature of [ ]a,b,c. This profile is calculated by using a conservative activation energy [ ]a,b,c in the Arrhenius equation for estimating thermal aging characteristics.

2.5 FAILURE CRITERIA

Failure criteria for the verification program are established for the individual seismic test and the environmental portion of the test program. Since the high energy lines inside containment are designed for seismic effects, the in-containment instruments are not assumed to be subjected to simultaneous seismic and environmental effects. Consequently errors due to these events are evaluated separately. The seismic error criterion allows for a variation of ±10 percent of output span during the seismic simulation. For performance of reactor trip/ safety injection functions used to mitigate the consequences of a high energy pipe break, a deviation of ±10 percent of output span is permitted.

The ±10 percent requirement for environmental accuracy is the algebraic sum of the effects on transmitter accuracy due to the containment ambient temperature and radiation at the time of the protective function initiation. This requirement is predicated upon the assumption that, at the time of protective function initiation, the total integrated dose to the transmitter is [ ]^{a,b,c} rads and the containment temperature environment for the electronics is [ ].^{a,b,c} For post accident monitoring functions (except wide range pressure and steam pressure), the goal is to limit the deviation in accuracy to about ±25 percent for the algebraic combination of the effects due to temperature and radiation from [ ]^{a,b,c} following the event. At [5 minutes]^{a,b,c} the assumed combination would be [ ]^{a,b,c} rads and at [ ]^{a,b,c} the assumed combination is [ ]^{a,b,c} rads. For wide range pressure and steam pressure transmitters the goal is to limit the deviation in accuracy to ±10 percent following the postulated steam line break accident. Each transmitter is temperature compensated to ensure these requirements are met (e.g., if no error due to radiation is expected at [ ]^{a,b,c} rads the transmitter would be temperature compensated so that its error does not exceed [ ]^{a,b,c} of output span at [ ]^{a,b,c} even if the ambient temperature remained at [ ]^{a,b,c} for a long period of time).

The test program will be considered successful if the above criteria are met by all transmitters in the program. However, infrequent failures of a random nature can be expected during the testing of a sample. One failure or two different failures during the test of three similar units will be considered random and the test a success unless the failure(s) investigation reveals potential common mode problems. It should be noted that these are generic error allowances and individual plant evaluations may show that larger instrument errors are acceptable.

TABLE 2-1

ALLOWABLE ACCURACY TOLERANCES FOR IN-CONTAINMENT TRANSMITTERS REQUIRED TO MITIGATE OR MONITOR THE EFFECTS OF POSTULATED ACCIDENTS (RADIATION AND ENVIRONMENT)

Transmitter Function	*Accuracy (Percent of Span) Short Term	Long Term
1. Pressurizer Pressure	+10	N/A
2. Pressurizer Water Level	N/A	±25
3. Steam Generator Pressure**	+10	±10
4. Steam Generator Water Level (Narrow Range)	+10	±25
5. Steam Generator Water Level (Wide Range)	NA	±25
6. Steam Flow	-10	N/A
7. Pressure-Reactor Coolant System (Wide Range)	N/A	±10
8. Containment Sump Water Level	±10	±25

* Accuracy is the allowable deviation from the normal accuracy.

** Located outside the containment.

TABLE 2-2

RADIATION TEST CONDITION SIMULATION

Calculated* 4 mo dose: 4×10^7 rads total integrated dose; dose rate varies between $\sim 2.5 \times 10^6$ R/hr to $< 10^4$ R/hr

Test Conditions: [

·]b,c,e

* Based on postulated loss of coolant accident assuming TID-14844 and shielding

Acceleration
(g's)

2.5

Frequency (Hz)

FIGURE 2-1
Broad Band Required Response Spectra

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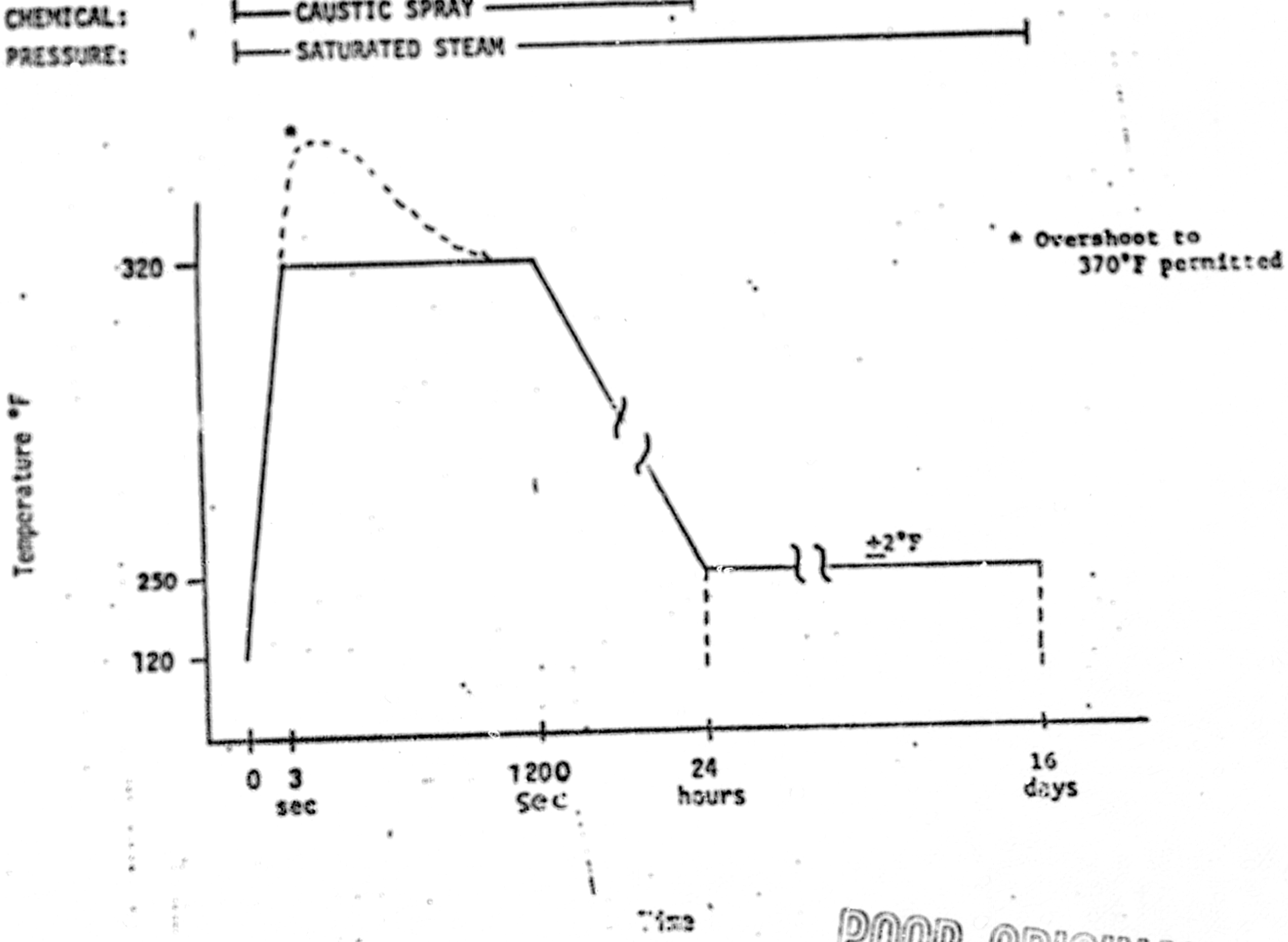

FIGURE 2.2

TEST CHAMBER ENVIRONMENT

3.0 RADIATION TEST

3.1 RADIATION TEST FACILITY

The initial phase of testing involved exposure of the process measurement instruments to gamma radiation at rates equivalent to those which would occur in containment during normal life and applicable accident conditions. The irradiation tests were conducted by Westinghouse personnel at the Isomedix, Inc., facility located in Parsippany, New Jersey. The source of gamma radiation at this facility is cobalt-60, whose field strength is approximately 1,500,000 curies. The source consists of metallic cobalt strips arranged on a sliding frame assembly, which is raised and lowered by a hydraulic system from below the cell floor under 18 feet of water. The source strength and radiation field determinations were made by Isomedix, Inc., personnel by placing red Persplex dosimetry in matrix mapping patterns which encompassed the instrument installation area. The determination of the source strength in the designated mapping area was conducted for 30 minutes by the Isomedix personnel; cognizant Westinghouse personnel observed the readout of the dosimetry after the 30-minute exposure period. All irradiation tests were conducted in air at ambient and atmospheric conditions.

3.2 RADIATION TEST PROCEDURE

The transmitters were delivered to the Isomedix test facility by Westinghouse personnel for irradiation. Upon delivery the test units were inspected and prepared for test in accordance with Sensor Qualification Program Test Procedures.

Source calibration curves and a radiation map provided by Isomedix were used to position the test units for the selected dose rate of [ ]^{b,c,e} M rad/Hour for a Total Integrated Dose (TID) of [ ]^{b,c,e} Megarads. Once the process instruments had been installed, a 21 point reference accuracy measurement was conducted. Reference accuracy measurements were also obtained after 30 minutes of irradiation and a the completion of the test when the required total integrated dose of least [ ]b,c,e megarads had been obtained. The test units were oriented as required to obtain a symmetrical overall radiation dose. During the irradiation procedure the test units were normally energiz and a simulated pressure signal (dry nitrogen) was used to obtain a signal of approximately 50 percent of calibrated span. The different pressure test units were pressurized to 2100 psig static pressure.

The dose rate was verified by measuring the total integrated dose dur the first 30 minutes of irradiation. The distance from the source to the test units was logged.

When the required exposure time was complete, the test units physical integrity could not be tampered with or altered. Strict material control was enforced to ensure that no transmitter covers could be dis turbed or mechanical or electrical adjustments performed. The only operation permitted at this point was the 21-point reference accuracy measurements on each test unit.

Upon completion of the radiation tests, the test units were returned b Westinghouse personnel to the Forest Hills site for pre-seismic test reference accuracy measurements.

Time response tests on two of the test units were performed before and after irradiation.

3.3 DATA ACQUISITION

At all times during the irradiation testing (including source up or do condition) the test units were powered by WISD 7300 series 40 volt NLP cards. The total instrument loop resistance was 600 ohms, including t 250 ohm test point resistance associated with the NLP card. The outpu signal for each test unit was recorded by an analog strip chart record and a digital data logger.

Reference accuracy measurements were obtained prior to, durin
(30 minutes) and after irradiation and are documented in Tabl
Calibration of all test units was performed in accordance wit
Standard 20.1-1973 by utilizing a 558 step FORTRAN IV compute
designed specifically for calibration data. This code, progr
calculates the slope and intercept of the linear regression l
fitting the data. It also computes the error between the act
calculated ordinates (indicating the maximum such error), the
tion and the span. The routine also determines, as percentag
calibrated span; the repeatability, hysteresis, and change in
The transmitter test summary and results of the irradiation a
presented in the Test Results section of the report.

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4.0 SEISMIC TEST

4.1 SEISMIC TEST FACILITY

The seismic test was conducted at the Westinghouse Advanced Energy Systems Division located in Large, Pennsylvania. This facility has capabilities for performing and monitoring random frequency biaxial seismic simulations. The test machine consisted of a 6 by 6 ft test table coupled to a hydraulic piston capable of creating a peak force of 22,000 lbs with a 20 inch peak to peak stroke and a maximum velocity of 100 inches/second. The angle of the piston and the orientation of the test package were such that equal accelerations were produced in the horizontal, front to back, and side to side directions.

The seismic inputs were recorded on a 14 channel FM tape and played back on a Honeywell model 101 recorder. The individual sine beat signals were attenuated, summed and twice integrated prior to feeding into the hydraulic controller. Table acceleration was measured by Kulite model GAD-813-50 accelerometers and recorded by Brush Mark 200 recorders and on 14 channel FM tape. The control accelerometer was also recorded and analyzed by a Spectral Dynamics Model 13231 shock spectrum analyzer. The test response spectrum was then plotted by an Electro Instruments 500 x-y plotter.

Signals from the test and reference transmitters were conditioned by B&F model 10-800 amplifiers and recorded on Brush Mark 200 recorders.

4.2 SEISMIC TEST PROCEDURE

The test configuration, as indicated in Figure 4.1, results in three equal directional forces by having the table input motion at an angle of 35 degrees from the horizontal and the equipment positioned so that it principal axis is at a 45 degree angle with respect to the horizontal component of the input. This configuration results in equal and simultaneous inputs to all three principal equipment axis. The control accelerometer is mounted on the test table to measure the horizontal

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($\sqrt{2}$ times equipment front to back and side to side input) and vertical accelerations. The actual test response spectra has a peak amplitude of ten times gravity, which is $\sqrt{2}$ times the required response spectra as shown in Figure 4.2.

The testing was preceded by a sine sweep of the entire test setup at a level of 0.2 G at frequencies of 1 to 50 Hz then 50 to 1 Hz at a sweep rate of one(1) octave per minute. This was followed by 5 operating basis earthquakes (OBE) level tests in position 1. Safe shutdown earthquake (SSE) level tests were than conducted in four postions (0°, 90°, 180°, 270°) with three tests in each position to envelop the required broad band response spectra.

4.3 DATA ACQUISTION SYSTEM

The output of all the test units were run to the power supply and data acquisition equipment. Power was supplied from WISD 7300 series NLP cards. The conditioned signals were fed to both strip chart recorders and FM tape recorders.

Accelerometers were mounted on the test table, test fixture and test units. All accelerometer outputs were recorded on strip chart recorders and FM tape recorders. The control accelerometer output was also fed into a shock spectrum analyser. The result of the analysis, which resulted in a acceleration versus frequency correlation was used to determine the success of each test run.

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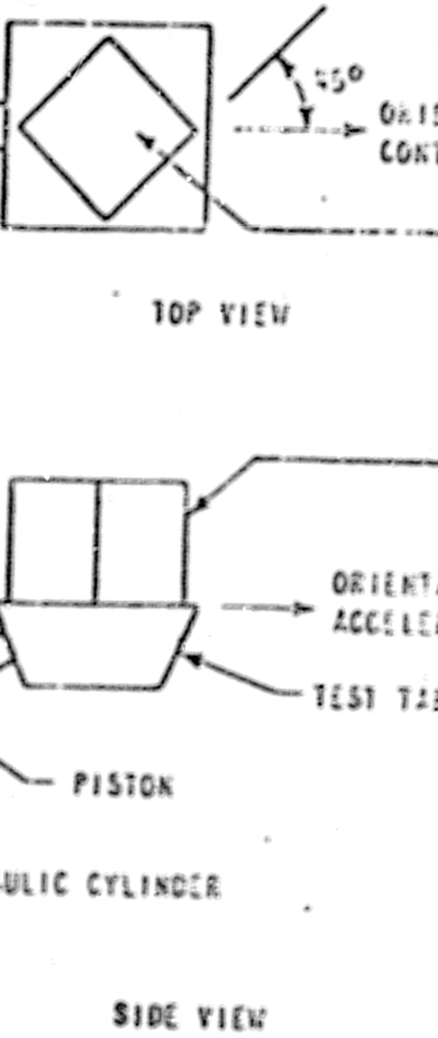

) Schematic of Biaxial Test Setu

5.0 ENVIRONMENTAL TEST

5.1 ENVIRONMENTAL TEST FACILITY

The test facility at Forest Hills, Pittsburgh, Pa., (Figure 5.1) was used for environmental testing of the test units. This comprehensive facility consists of the Trip Test Steam Supply System, Trip Test Chemical Spray System, Test Chemical Spray System, Test Article Environmental Chambers, Severe Environmental Steam Supply System, and High-Pressure Nitrogen Supply System. Data acquisition facilities comprise multipen recorders, digital voltmeters, and a digital data logging system; the digital data logger is the primary system and the analog recorders and digital voltmeters make up the redundant system. Included in the test facility is a diesel-powered emergency power backup system, which comes on line automatically in the event of loss of main site power. Design and construction of the chambers and loop piping complies with the latest ASME Boiler and Pressure Vessel Codes.

The LOCA facility at Forest Hills was constructed to simulate as accurately as possible the in-containment conditions during postulated accidents (for instance, steam-line breaks). The Trip Test Chemical Spray System, an integral part of the test facility, was constructed to simulate the addition of chemical spray during the postulated pipe break. This system consists of an open 1000-gallon stainless steel mixing tank, primary and redundant metering pumps and the required piping, valves, and fittings. The chemical spray consists of [ ]^{a,b,c} ppm boric acid dissolved in water and adjusted to a pH of [ ]^{a,b,c} by sodium hydroxide. The solution is premixed and stored in the 1000-gallon mixing tank. A constant displacement metering pump supplies the room-temperature solution to the main inlet steam line at a flow rate of approximately [ ]^{a,b,c} An option is available for spray injection directly into spray nozzles located in the environmental chamber; however, a distinct advantage is achieved by the injection into the main steam feed, which produces an extremely fast rise time in the chamber during initial transient conditions. Chemical analyses are made periodically to ensure proper chemical makeup.

1688 317

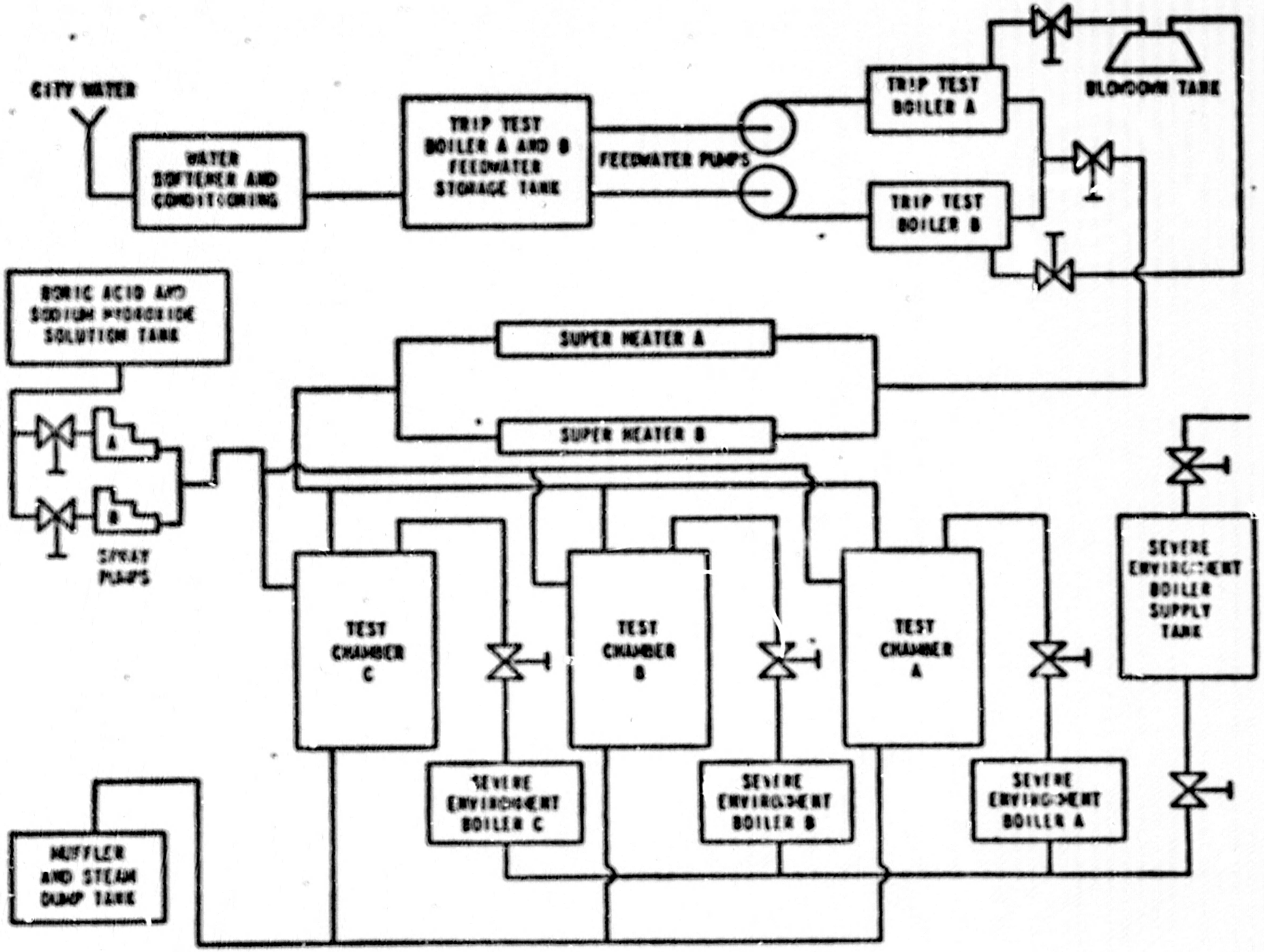

Figure 5-1. Environmental Test Facility Layout

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Steam supply for the simulation of a postulated break accident is provide by an arrangement of oil-fired boilers and electrically powered superheaters. Steam leaving the boilers at 212°F and 14.7 psia enters the superheaters; with this heat addition the steam temperature is raised to 540°F saturated. Steam enters the test chamber through two nozzles located on top of the environmental chamber. Air is permitted to discharge from the chamber through a manually operated discharge valve, which is preset to maintain a back-pressure of [ ]a,b,c in the test chamber. The discharge of the valve exhausts through a steam muffler and water suppression tank located outside the test area.

5.2 ENVIRONMENTAL TEST PROCEDURE

The transmitters were installed in the three test chambers and a 21 point reference accuracy measurement was performed on each test unit. The test units were powered from WISC 7300 series, 40 volt NLP cards during the environment test. The test units were pressurized at approximately 50 percent of calibrated span and differential pressure units were pressurized to 2100 psig static pressure using dry nitrogen as the pressure medium.

The output of the test units were monitored and recorded.

5.3 DATA ACQUISITION SYSTEM

During the environment tests, a combination of analog strip chart recorders, a digital data logger (microprocessor), and a digital data logger (minicomputer) constituted the monitoring system for all instruments. The four-channel analog recorders were used as the primary readout for each instrument during the trip portion of the environmental test. A programmable-microprocessor-based data logging system functioned as a redundant recording system during the trip test and as a primary system during the severe environment test. During the severe environment test, a standby system, composed of a general-purpose wide-range minicomputer, was kept on line at all times. Instrument

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signals were directed via a switching network in which the signal path was directed to the primary data acquistion system and manually switched to the redundant system upon partial or total primary instrument failure.

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6.0 TEST RESULTS

6.1 RADIATION TESTING

The transmitters were exposed via a gamma source at a dose rate of [ ]b,c,e megarads per hour depending on location. The total integrated dose for the seven (7) transmitters varied from a minimum of [ ]b,c,e megarads (BE-2) to a maximum of [ ]b,c,e megarads (BD-2), depending on transmitter location. The transmitter calibration checks associated with the radiation test are summarized, in Table 6.1 as test operations 200, 217, and 250 for pre-irradiation, after 30 minutes and post-irradiation respectively.

The maximum output error for the pressure and differential pressure transmitters during the radiation testing is indicated in Table 6.2. All the errors indicated occurred after 30 minutes of irradiation.

Time response testing which was conducted before and after irradiation on one of each pressure (BD-1) and differential pressure (BE-4) test units indicated [,]b,c,e in time response due to the radiation.

6.2 SEISMIC TESTING

All transmitters remained functional throughout the test and no structural failures or loosening of bolts was observed. The transmitters were subjected to five OBE level seismic simulations and twelve SSE level events (three in each of four positions). The test response spectra (TRS) and the required response spectra (RRS), for each test are shown in Figures 6.1 through 6.17.

The transmitter output deviations for each test run are shown in Table 6-3. The [ ]b,c,e in the differential pressure transmitters (BE-1, 2, 3, and 4) were also [ ]b,c,e in the reference transmitters, associated with these test units; which are remote from the seismic test table. In some cases these [ ]b,c,e in the reference unit than in the test unit, indicating that most of the [ ]b,c,e. Nevertheless, the indicated errors are less than the 10 percent allowance for deviations during a seismic event.

Each transmitter was subjected to seventeen seismic test runs (5 OBE's and 12 SSE's). The transmitters steady state output returned to within its reference steady state value on all pressure transmitters. [ ]b,c,e of the four differential pressure transmitters [ ]b,c,e the reference accuracy in [ ]b,c,e during the 68 calibration checks performed on the four differential pressure units.

The transmitter calibration checks associated with the seismic test are shown in Table 6.1 as test operations 310 (pre-seismic) and 550 (post-seismic).

6.3 ENVIRONMENTAL SIMULATION TEST

The transmitters were then subjected to the steam/chemical spray test with maximum pressure corresponding to saturated conditions at [ ]a,b,c. The chemical composition was [ ]a,b,c ppm boric acid solution buffered to a pH of [ ]a,b,c with sodium hydroxide. The transmitter calibration checks associated with the severe environmental test are shown in Table 6.1 as test operations 550 (before test) and 760 (after test). The temperature profiles for each test along with the transmitter output deviations during the test are shown in Figures 6.18 through 6.29. These graphs show time periods of 5 minutes, 60 minutes, and 24 hours into the test. The results of the stable condition from 24 hours to 16 days are not graphed but maximum errors are shown in Table 6.4. The test facility designation for the transmitter is noted at the bottom of each graph and where more than one transmitter deviation is plotted on the same graph, the first unit is plot A, second is plot B, etc. The maximum deviations during selected time periods are shown in Table 6.4.

TABLE 6-1
TRANSMITTER PRE- AND POST-TEST CALIBRATION CHECK SUMMARY

Designation	Model	Serial Number	Range	Test Operation(a)	Results -% of Span			
					Reference Accuracy	Deadband	Hysteresis	Repeatability
BD-1								

a. Test operation code

15 - Initial Calibration (FH)
140 - Post Time Response (FH) (BD-1 and BE-4)
200 - Pre-Irradiation (N.J.)
217 - During Irradiation (30 min) (N.J.)
250 - Post-Irradiation (N.J.)
310 - Pre-Seismic (FH)
440 - Post Time Response (FH) (BD-1 and BE-4)
5[illegible] - Post Seismic (FH)

TABLE 6-1 (cont)

TRANSMITTER PRE- AND POST-TEST CALIBRATION CHECK SUMMARY

Designation	Model	Serial Number	Range	Test Operation(a)	Results -% of Span			
					Reference Accuracy	Deadband	Hysteresis	Repeatability
8D-2								

b,c

1688 24

TABLE 6-1 (cont)

TRANSMITTER PRE- AND POST-TEST CALIBRATION CHECK SUMMARY

Designation	Model	Serial Number	Range	Test Operation[(a)]	Results -% of Span: Reference Accuracy	Deadband	Hysteresis	Repeatability
BD-3								

6.5

1688 125

TABLE 6-1 (cont)

TRANSMITTER PRE- AND POST-TEST CALIBRATION CHECK SUMMARY

Designation	Model	Serial Number	Range	Test Operation[a]	Reference Accuracy	Deadband	Hysteresis	Repeatability
					Results - % of Span			
BE-1								[b,c]

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TABLE 6-1 (cont)

TRANSMITTER PRE- AND POST-TEST CALIBRATION CHECK SUMMARY

Designation	Model	Serial Number	Range	Test Operation[a]	Results - % of Span: Reference Accuracy	Results - % of Span: Deadband	Results - % of Span: Hysteresis	Results - % of Span: Repeatability
BE-2								

]b,c,e

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TABLE 6-1 (cont)

TRANSMITTER PRE- AND POST-TEST CALIBRATION CHECK SUMMARY

					Results -% of Span			
Designation	Model	Serial Number	Range	Test Operation[a]	Reference Accuracy	Deadband	Hysteresis	Repeatability
BE-3								

[b,c]

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TABLE 6-1 (cont)

TRANSMITTER PRE- AND POST-TEST CALIBRATION CHECK SUMMARY

Designation	Model	Serial Number	Range	Test Operation[a]	Results -% of Span: Reference Accuracy	Deadband	Hysteresis	Repeatability
BE-4								

b,c,e

1688 .29

TABLE 6.2

OUTPUT ERROR DURING RADIATION EXPOSURE

Test Unit	Model	Range	Maximum Error (Percent of Span)
BD-1			
BD-2			
BD-3			
BE-1			
BE-2			
BE-3			
BE-4			

b,c,e

1688 :30

TABLE 6.3

MAXIMUM DEVIATIONS DURING SEISMIC TEST

(All numbers are in percent of calibrated span)

Test Run	BD-1	BD-2	BD-3	BE-1	BE-2	BE-3	BE-4
Position 1							
Run 2							
Run 3							
Run 4							
Run 5							
Run 6							
Run 7							
Run 8							
Run 9							
Position 2							
Run 2							
Run 3							
Run 4							
Position 3							
Run 1							
Run 2							
Run 3							
Position 4							
Run 1							
Run 2							
Run 3							

b,c,e

TABLE 6.4

MAXIMUM DEVIATIONS DURING SEVERE ENVIRONMENT

Test Designation	Model and Range	Maximum Deviations in Percent of Calibrated Span During First 5 Minutes	During First 24 Hours	From 24 Hours To 16 Days
[				] b,c,e

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WESTINGHOUSE CLASS 3

b,c,e

1688 :33

INPUT B (OBE)

WESTINGHOUSE CLASS 3

b,c,e

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WESTINGHOUSE CLASS 3

b,c,e

1688 335

INPUT 3 (OBE)

WESTINGHOUSE CLASS 3

b,c,e

1688 336

INPUT 3 (USE)

WESTINGHOUSE CLASS 3

b,c,e

1688 337

INPUT B (SSE)

b,c,e

WESTINGHOUSE CLASS 3

1688 336

INPUT C (SSE)

WESTINGHOUSE CLASS 3

b,c,e

1688 339

b,c,e

1688 340

b,c.

1688 341

INPUT C (SSE)

WESTINGHOUSE CLASS 3

b,c,e

1688 342

INPUT A (SSS)

WESTINGHOUSE CLASS 3

b,c,e

1688 343

WESTINGHOUSE CLASS 3

b,c,e

1688 344

WESTINGHOUSE CLASS 3

b,c,e

1688 345

INPUT C (SSE)

WESTINGHOUSE CLASS 3

b,c,e

[ ]

1688 346

INPUT C (SSE)

WESTINGHOUSE CLASS 3

b,c,e

1688 347

INPUT B (SSE)

WESTINGHOUSE CLASS 3

b,c,e

1688 348

INPUT A (SSE)

WESTINGHOUSE CLASS 3

b,c,e

1688 349

b,c,e

WESTINGHOUSE CLASS 3

1688 350

b,c,e

WESTINGHOUSE CLASS 3

1688 ,51

b,c,e

WESTINGHOUSE CLASS 3

1688 [illegible]52

a,c,e

1688 53

b,c,e

WESTINGHOUSE CLASS 3

1688 354

WESTINGHOUSE CLASS 3

b,c,e

1688 055

WESTINGHOUSE CLASS 3

b,c,e

b,c,e

WESTINGHOUSE CLASS 3

1688 357

b,c,e

1688 358

b,c,e

WESTINGHOUSE CLASS 3

1688 359

b,c,e

WESTINGHOUSE CLASS 3

1688 360

b,c,e

1688 361

7.0 SUMMARY AND CONCLUSIONS

As noted in the data in Section 6, a few anomalies occurred during the test program.

1) During the first half of the radiation test two transmitters (BE-3 and BE-4) were inadvertantly valved out for about 9 hours. Therefore no useful data was recorded during this period. However, the calibration check at the midpoint of the test (when the units are turned) indicated that the transmitters were functioning normally and the second half of the radiation test was conducted with the transmitters valved in.

2) At the completion of the radiation test the calibration check of BE-3 and BE-4 revealed [ ]b,c,e as noted in Table 6.1. The next calibration check at Forest Hills [ ]b,c,e. A recheck of the calibration data at the radiation facility showed that [ ]b,c,e. This was determined by comparing the intended input with the actual input as recorded by the reference transducer.

3) The output from test unit BD-3 [ ]b,c,e into the environmental test. After completion of the test, it was discovered that an external lead wire (part of the 8 foot pigtail supplied with the transmitter) had apparently [ ]b,c,e to the insulation. The wire was exposed to the environment and had [ ]b,c,e. The transmitter met the accuracy requirements after the [.]b,c,e

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4) After completion of the environmental test and after the chamber had been cooled down, BE-3 exhibited about a [ ]b,c,e during the calibration check that was performed while the unit was still in the chamber. The transmitter was removed and another check in the lab revealed the [.]b,c,e The Barton representative tapped the unit with a wrench and the [ ]b,c,e. This anomaly is still under investigation at Barton.

5) BE-2 had a abnormally [ ] of the severe environment test. As the other test units did not exhibit [,]b,c,e it was suspected that a [ ]b,c,e problem exists with BE-2. Barton is investigating this problem.

With the [,]b,c,e all Lot No. 2 test units were within the error allowance for all test conditions. Combining the maximum deviations during the first five minutes in the severe environment test and the radiation error at one megarad yields errors less than 10 percent for those units required for trip functions. Combining deviations for severe environment and radiation at any part in time also yields [ ]b,c,e errors for post accident monitoring functions. The test units were also well within the 10 percent seismic error allowance.

Pending confirmation of the [ ]b,c,e, the Barton Lot No. 2 transmitters are acceptable.

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