ATTACHMENT 1

22. EVALUATION OF FIRE RATING FOR VENTILATION DUCTS IN TURBINE BUILDING AND BATTERY ROOMS SURRY POWER STATION

Description of Evaluation

This evaluation assesses the adequacy of ventilation ducts in the Turbine Building and Battery Rooms to be able to maintain the fire rating of the fire barrier in which the duct is installed. This evaluation is being performed in accordance with GL 86-10, Interpretation #4, which allows engineering evaluations of fire area boundaries.

Area Description

TURBINE BUILDING

The Turbine Building (FA 31) consists of three primary elevations, 9 ft. 6 in. (basement), 35 ft. 0 in. (mezzanine), and 58 ft. 6 in. (turbine deck). To the north of the Turbine Building is the Service Building containing the Control Room (FA 5) and the Unit 1 and 2 Emergency Switchgear Rooms (ESGR) (FAs 3 & 4) and other areas not relevant to this evaluation. The Station Administration Building is to the west, the Condensate Polishing Building is to the east and the south wall is an exterior wall facing the main transformers. The north wall separating the Turbine Building from the Control Room and Emergency Switchgear Rooms is a reinforced concrete wall. The doors, dampers, and penetration within the wall have a three hour fire rating.

There are four Safety Related ventilation ducts penetrating the north wall of the Turbine Building. This wall acts as a three hour fire barrier to separate the Turbine Building from adjacent Fire Areas. The ducts in question penetrate the north wall of the Turbine Building. Two of the ducts are located on elevation 40 ft. 6 in. near column lines 7C and 9C. These ducts penetrate the wall separating the Turbine building and the Control Room. Two additional ducts are installed at elevation 22 ft. near column lines 6C and 10C. These ducts penetrate the wall between the Turbine Building and the Unit 1 and 2 Emergency Switchgear Rooms. All of the ducts are provided with three hour rated fire dampers; 1-VS-FDMP-9, 19 & 2-VS-FDMP-10, 20. The dampers however are installed approximately 5 ft. from the barrier surface. Three of the dampers (9, 19, & 20) are located on the Turbine Building Side of the wall and damper 10 is located on the Unit 2 Emergency Switchgear Room side of the barrier. The exterior of the duct between the damper and the barrier surface is wrapped with 1 inch thick Thermo-Lag 330 fire barrier material.

BATTERY ROOMS

Battery Room 1A (FA 9) and Battery Room 1B (FA 10) are located within the Unit 1 Emergency Switchgear Room (FA 3), which is located on the 9 ft. 6 in. elevation of the Service Building. Battery Room 2A (FA 11) is located within the Unit 2 Emergency Switchgear Room (FA 4), which is also located on the 9 ft. 6 in. elevation of the Service Building. Each battery room has a floor area of approximately 120 ft^2, with a ceiling approximately 8 ft. high. Each battery room is contained entirely within the ESGR. Each battery room has reinforced concrete walls on two sides and 8 in. concrete block walls on the other two sides (see Evaluation 19). The ceiling is constructed of poured concrete on steel decking.

Each of the three battery rooms have two ventilation ducts (one supply and one return duct) that penetrate the roof, but the supply ducts for Battery Rooms 1A & 1B have been taken out of service and isolated approximately 2 ft. above the barrier. All of the ducts are provided with three hour fire rated dampers (1-VS-FDMP-1, 2, 11, 12, & 2-VS-FDMP-3, 13). The dampers are installed approximately 6 in. above the barrier surface. The exterior of the duct between the damper and the barrier surface is wrapped with 1 inch thick Thermo-Lag 330 fire barrier material.

Fire Protection Features

TURBINE BUILDING

Combustible loading in the Turbine Building is moderate. Major contributors to the combustible loading are lube oil and cable insulation. The Turbine Building has a full area automatic sprinkler system on the 35 ft. 0 in. and the 9 ft. 6 in. elevations. Upon sprinkler system water flow, an alarm is transmitted to the Control Room. The major lube oil components are diked and have individual deluge systems actuated by heat detectors over the hazard. These provide annunciation to the Control Room upon system actuation. The Turbine Building is also provided with portable fire extinguishers and manual hose stations for manual fire fighting by the fire brigade.

BATTERY ROOMS

Both the Emergency Switchgear Rooms and the Battery Rooms have ionization smoke detectors mounted at the ceiling. The smoke detectors annunciate to the Control Room. There is no fixed fire suppression system in the Battery Rooms; however, portable fire extinguishers are located nearby. A manually actuated, total flooding, Halon 1301 fire suppression system is installed in each Unit's Emergency Switchgear Room. The system is primarily for the ESGR, but the system is sized large enough to include discharge into the Battery Rooms as a nozzle is located in each room.

The combustible loading within the Battery Rooms indicates the standard fire duration is 96 minutes for rooms 1A & 1B and 77 minutes for room 2A. The only combustibles are the battery casings and the insulation on the power cables to the batteries. The chance of significant transient combustibles or of an ignition source within the battery room is unlikely due to the administrative controls (i.e.; no storage, no smoking, no welding/cutting) and due to the physical configuration of the area (these are single use rooms). It is not considered likely for a battery short circuit to cause an ignition of the combustibles due to the low voltage of the batteries. There is no other equipment in the room which could cause an ignition.

The combustible loading within the Emergency Switchgear Rooms is high. The combustible loading for the Unit 1 and 2 Emergency Switchgear Rooms consist of large amounts of electrical cable insulation. There is also a potential for a small amount of transient lubricating oil to be transported via the unit 2 Switchgear Room to Mechanical Equipment Room # 3.

Safe Shutdown Equipment

TURBINE BUILDING

The Turbine Building contains several circulating and service water MOVs, AOVs for breaking condenser vacuum, and other valves that are required for safe shutdown.

The Turbine Building also contains manual isolation valves for the Charging Pump Service Water (CPSW) System. These valves are located in valve pits below elevation 9 ft. 6 in. in each unit's Turbine Building. The flow path for the CPSW system is such that either the Unit 1 or Unit 2 CPSW piping can supply water to the CPSW pumps for each unit.

BATTERY ROOMS

The only equipment located in the Battery Rooms are the station batteries. The station batteries are part of the safety-related 125V DC power system; however, they are not required for safe shutdown under Appendix R.

There are numerous pieces of safe shutdown equipment located in the ESGRs (i.e., Auxiliary Shutdown panels, instrumentation, bypass switches, vital buses, 4kv switchgear, load and motor control centers, etc.) Alternate safe shutdown capability is provided in accordance with Appendix R for the case of a fire in either Unit's ESGR.

Evaluation

The pass/fail criteria for fire dampers based on Underwriters Laboratories Standard UL 555 is the passage of flame through the damper. The passage of smoke or heat is not a factor in the evaluation of fire dampers. The duct configuration will have similar characteristics as a fire damper, i.e. no flame passage even though smoke and heat will be allowed to pass to the opposite room.

For the purpose of this evaluation, no flame passage means that no flame leaves the duct on the non-fire side of the barrier. It is noted that the inside of the duct on the non-fire side of the barrier may be impinged by flame, but this is of no consequence since the duct is assumed to no longer be able to fulfill its purpose of providing ventilation. For fire to enter the duct this assumes that the equipment feeding the duct is damaged.

Southwest Research Institute (SwRI) Final Report No. 01-2427-001, dated October 1988, conducted fire endurance tests on unprotected steel duct systems (see Attachment 1). The objective of the test program was to demonstrate whether an unprotected steel duct that does not contain a fire damper at the barrier opening, will remain in place throughout a 120 minute fire exposure and effectively maintain the integrity of the fire barrier at that opening, consistent with the criteria for fire dampers. The test exposes the ducts to a standard fire exposure as defined by ASTM E-119. Three ducts were tested by SwRI. Two ducts were constructed of 22-gauge galvanized steel sheet and the third duct was constructed of 20-gauge stainless steel sheet. Where the ducts extended through the furnace walls, the gaps between the ducts and the block walls were fire stopped with ceramic fiber blanket. There were no significant observations recorded throughout the 120 minute fire exposure. Even though the two 22-gauge steel ducts deformed within the furnace, none of the duct sections collapsed or fell into the furnace and the integrity of each system, where it extended through the fire wall, remained intact. No through opening developed between a fire stop and a duct at any wall penetration.

TURBINE BUILDING

The ducts in the Turbine Building are arranged such that they come directly out of a fan unit and pass horizontally through the fire barrier and discharge into the Control Room / ESGR on the opposite side of the barrier. The ducts, minimum 22-gauge sheet metal construction, are for ventilation purposes only and contain no combustible material within the duct.

The fire tests conducted by SwRI indicate the 22 gauge metal duct will provide at least a 2 hour fire rating between the fire damper and the barrier. Although the Thermo-Lag is not being credited with any fire resistance rating, the addition of the Thermo-Lag material around the duct on that side of the barrier is expected to enhance the fire resistance rating of the duct. The fire dampers are located only a short distance (approximately 1′ or 2′) from the barrier.

The fire scenario in question is a fire on one side of the barrier, and the duct needs to keep the fire from going to the opposite side of the barrier. This scenario assumes that there is only a fire on one side of the barrier. Therefore the outside of the duct and the hangers on the non-fire side of the barrier is not being impinged by flame. This will greatly decrease the chance of failure of the duct and hangers.

Activation of the sprinkler system in the Turbine Building would alarm the fire to the constantly manned Control Room. This would alert the fire brigade. Fire hose stations and portable extinguishers are readily available for manual fire fighting by the fire brigade. A manual halon system is provided for suppressing fires in the ESGR. The predominate combustible material in the ESGR is the cable insulation from the fire resistant cable, so the worst case fire in this area is expected to be of limited propagation.

The location where ducts pass through the poured concrete wall is substantial enough to withstand a fire. The slight gap between the duct and the barrier is covered on one side by the Thermo-Lag and is covered on the other side by angle iron or steel. This will prevent any flame from being transmitted through the barrier. Since the duct is mounted to the wall in a sturdy manner and is supported near the damper, there is little chance that the duct will fail at the barrier. The concrete barrier is rated for three hours.

BATTERY ROOMS

The ducts for the Battery Rooms begin at the ceiling of each battery room and extend upward before turning horizontally and connecting to equipment. There is no duct within the battery rooms. The ducts, minimum 22-gauge sheet metal construction, are for ventilation purposes only and contain no combustible material within the duct.

The fire scenario in question is a fire in one of the battery rooms, and the duct needs to keep the fire from going to the opposite side of the barrier. Therefore the worst case scenario is a fire in the battery rooms exposing the safety related equipment in the ESGR. A fire originating in the ESGR would render the safety related equipment and systems in the room inoperable and exposing the battery rooms is not significant since there is no Appendix R safe shutdown equipment in the battery rooms. In addition, the heat and flame from a fire outside of the battery room would be directed upward and away from the duct and damper connection at the roof of the battery room.

The fire tests conducted by SwRI indicate the 22 gauge metal duct will provide at least a 2 hour fire rating on one side of the barrier. Although the Thermo-Lag is not being credited with any fire resistance rating, the addition of the Thermo-Lag material around the duct on the ESGR side of the barrier is expected to enhance the fire resistance rating of the duct. The fire duration within the rooms is less than 120 minutes (96 minutes for rooms 1A & 1B and 77 minutes for room 2A based on the 1994 Appendix R Report). Based on a less than 2 hour fire duration and lack of combustibles within the duct to contribute to the fire, the fire is not expected to spread beyond the battery rooms.

Activation of the smoke detection system in the Battery Rooms would alarm the fire to the constantly manned Control Room. This would alert the fire brigade. Fire hose stations and portable extinguishers are readily available. The fire brigade would also have the option of manually tripping the total flooding Halon 1301 system for the ESGR which would extinguish a fire in the Battery Rooms.

The location where ducts pass through the poured concrete roof is substantial enough to withstand a fire. The slight gap between the duct and the barrier is covered on one side by the Thermo-Lag and is covered on the other side by angle iron or steel . Since the duct is mounted to the roof in a sturdy manner and is supported near the damper, there is little chance that the duct will fail at the barrier. The concrete roof is rated for three hours.

Conclusion

The four ventilation ducts which penetrate the north wall of the Turbine Building and the six ventilation ducts that penetrate the roof of the Battery Rooms are considered adequate to maintain the integrity of the fire barrier in which they are located. This determination is made in accordance with Generic Letter 86-10. The technical bases that justify this conclusion are summarized as follows:

1. Based on fire tests conducted by SwRI, the ducts in the Turbine Building and battery rooms are expected to provide at least a 2 hr. fire resistance rating without the Thermo-Lag. The addition of the Thermo-Lag only enhances the fire resistance rating of the duct.

2. The longest standard fire duration within the battery rooms is less than or equal to 96 minutes.

3. The only equipment located in the Battery Rooms are the station batteries. The station batteries are part of the safety-related 125V DC power system; however, they are not required for safe shutdown under Appendix R.

4. There are no combustibles inside the duct.

5. Sprinklers in the Turbine Building will provide detection and early fire control. Smoke detectors in the Battery Rooms and Emergency Switchgear Rooms will provide detection of a fire and annunciate it to the Control Room. Extinguishers and hose stations are available for manual fire fighting in all areas. In addition, the total flooding Halon system in the ESGR is available for manual operation and is expected to extinguish a fire in the Battery Rooms.

6. Failure of the duct at the barrier penetration is unlikely. This is due to the sturdy construction of the barrier where the duct passes through the barrier.

SOUTHWEST RESEARCH INSTITUTE
POST OFFICE DRAWER 28510 • 6220 CULEBRA ROAD • SAN ANTONIO, TEXAS, USA 78284 • (512) 684-5111 • TELEX 244846
DEPARTMENT OF FIRE TECHNOLOGY

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AD-HOC FIRE ENDURANCE TEST OF UNPROTECTED STEEL DUCT SYSTEMS

FINAL REPORT

SwRI PROJECT NO. 01-2427-001

OCTOBER 1988

Prepared for:

HUGHES ASSOCIATES, INCORPORATED
2730 UNIVERSITY BOULEVARD WEST, SUITE 902
WHEATON, MARYLAND 20902

By: Nigel Stamp
Nigel R. Stamp
Research Scientist
Fire Testing Services

Reviewed by: Carl A. Hafer, P.E.
Carl A. Hafer, P.E.
Manager
Fire Testing Services

Approved by: Alex B. Wenzel
Alex B. Wenzel
Director, Fire Technology
for
Dr. Robert E. Lyle
Vice President, Chemistry
and Chemical Engineering

SAN ANTONIO, TEXAS
DALLAS / FT WORTH, TEXAS • HOUSTON, TEXAS • DETROIT, MICHIGAN • WASHINGTON, DC

I. OBJECTIVE

The objective of this program was to demonstrate whether an unprotected steel duct that does not contain a fire damper at the fire barrier opening, will remain in place throughout a 120-minute fire exposure and effectively maintain the integrity of the fire barrier at that opening, consistent with the criteria for fire dampers. The results obtained from this test program will be used to determine whether fire dampers are needed in existing steel duct systems at 2-hour fire barriers or what modifications to the duct system would be required to protect the fire barrier opening.

II. INTRODUCTION

The test exposes the test specimens to a standard fire exposure (ASTM E119-83, Standard Methods of Fire Tests of Building Construction and Materials) controlled to achieve specified temperatures throughout a specified time period, as shown below:

TIME	TEMPERATURE
0 minutes	Ambient
5 minutes	1000°F (538°C)
10 minutes	1300°F (704°C)
30 minutes	1550°F (843°C)
45 minutes	1638°F (892°C)
60 minutes	1700°F (927°C)
2 hours	1850°F (1010°C)
4 hours	2000°F (1093°C)

This report describes the analysis of three distinct assemblies, and includes descriptions of the test procedure followed, the assemblies tested, and all results obtained. The results presented in this report apply only to the material tested, in the manner tested, and not to any identical or similar materials or material combinations. All test data are on file and are available for review by authorized persons.

III. TEST PROCEDURE

SwRI's large horizontal exposure furnace is capable of exposing a maximum test specimen of 12 ft long and 16 ft wide. The 80-in. deep furnace is equipped with 14 premixed air/natural gas burners located across the walls, 18 in. up from the bottom and controlled by a variable air/gas ratio regulator. Capable of a maximum heat output of 14 million Btu/hour, these burners are arranged well below the exposed face of the specimen to ensure an even temperature at the face of the specimen. Windows are located on all sides of the furnace to allow observation of the surface exposed to flame.

The conduct of the fire test is controlled according to the standard time/ temperature curve, as indicated by the average temperature obtained from the readings of ten thermocouples symmetrically located across the face of the specimen, 12 in. away. The thermocouples are enclosed in protection tubes of such material and dimensions that the time constant of the thermocouple assembly lies between 5.0 and 7.2 minutes, as required by the standard. The furnace temperature during a test is controlled such that the area under the time/temperature curve is within 10 percent of the corresponding area under the standard time/temperature curve for 1 hour or less tests, 7.5 percent for those less than 2 hours, and 5 percent for those tests of 2 hours or more duration.

Temperatures of both the unexposed and exposed surfaces are measured with No. 20 B&S gauge, type K (Chromel-Alumel) welded thermocouples.

The furnace pressure was controlled at the Client's request to be approximately +0.03 in. of water pressure, measured 0.78 in. (20 mm) below the insulated cover slabs.

IV. TEST ASSEMBLY

A. Duct No. 1

A rectangular steel duct, constructed of 36 x 30-in. x 22-ft long 22-gauge galvanized steel sheet, was comprised of three 5-ft sections and two 3.5-ft sections. The duct construction conformed to the Sheet Metal and Air Conditioning Contractors National Association, Incorporated (SMACNA), HVAC Duct Construction Standards, Metal and Flexible, First Edition, 1985. The longitudinal seams were of the button punch snap-lock type, identified as L-2 in the SMACNA standards. The transverse (girth) joints were of the Standing S type, identified as T-11 in the SMACNA standards to give a minimum rigidity of Class D. The duct section was supported by a trapeze comprising 0.375-in. diameter steel hanger rods and 2.5 x 0.25-in. steel angle, located at the midpoint of the span (6 ft from the furnace walls). Both of the hanger rods were positioned 2 in. away from the sides of the duct. The trapeze was adjusted so the top surface of the duct was located approximately 30 in. below the underside of the insulated cover slabs.

B. Duct No. 2

A circular duct, constructed of 36-in. diameter x 22-ft long 20-gauge stainless steel sheet, was comprised of four 4-ft sections and two 3-ft sections. All joints between the duct sections were continuously welded together. The duct construction conformed to SMACNA, HVAC Duct Construction Standards, Metal and Flexible, First Edition, 1985. It was supported at the mid-point (6 ft from the furnace walls) by a 3-in. wide x 20-gauge stainless steel band wrapped around the duct which was attached to an adjustable clevis type hanger suspended from a 0.5-in. diameter steel hanger rod. The hanger assembly was adjusted so that the top surface of the duct was located approximately 24 in. below the underside of the insulated cover slabs.

C. Duct No. 3

A rectangular steel duct, constructed of 36 x 30-in. x 22-ft long 22-gauge galvanized steel sheet, was comprised of three 5-ft sections and two 3.5-ft sections. The duct construction conformed to SMACNA, HVAC Duct Construction Standards, Metal and Flexible, First Edition, 1985. The longitudinal seams were of the button punch snap-lock type, identified as L-2 in the SMACNA standards. The transverse (girth) joints were of the Standing S type, identified as T-11 in the SMACNA standards to give a minimum rigidity of Class D. The duct was reinforced with 1.5 x 1.5-in. x 10-gauge (0.138-in.) steel angle tack welded to the duct (see SMACNA, HVAC Construction Standards, Metal and Flexible, First Edition, 1985). The angle reinforcement was located a minimum of 2 in. away from both the inside and outside of the furnace wall. The duct was supported by a pair of trapezes located 4 ft on center, comprising 0.375-in. diameter steel rods and 2.5 x 0.25-in. thick steel angle. The hanger rods were adjusted so that the top surface of the duct was located approximately 30 in. below the underside of the cover slabs. They were insulated with 0.5-in. diameter x 1-in. thick x 14-lb/ft^3 Manville Thermo-12 calcium silicate pipe insulation. The insulation was cut to fit on-site and the longitudinal joints were tightly butted together and wired in place with 16-gauge stainless steel wire, 12 in. on center.

The two ducts with mechanical joints (Duct Nos. 1 and 3) were assembled at SwRI and all three were laid across the 12-ft dimension of SwRI's large horizontal furnace. They were spaced 1.5 ft from the inside furnace walls and 2 ft apart (Figure 1). The height of the furnace walls were then increased by an additional 69 in., using masonry blocks, to ensure that the ducts were exposed on all four sides. A minimum 1-in. clearance was maintained around the perimeter of all three ducts (except for the base of each which was in contact with the masonry). The ducts extended a minimum of 5 ft beyond the furnace on either side. The furnace was then covered with concrete cover slabs insulated with ceramic fiber. The hanger rods for all three ducts extended through the cover slabs and were secured on the unexposed surface. The gaps between the ducts and the masonry block wall were then fire stopped with ceramic fiber blanket.

V. *INSTRUMENTATION*

The temperatures of the outside (exposed and unexposed) surfaces of the steel ducts were measured with No. 20 B&S gauge, type K (Chromel-Alumel) welded thermocouples. Temperature readings were taken on the duct walls, at the duct joints, the hanger rods and the steel angle-section supports. The locations of all thermocouples are shown in Appendix A, Construction Drawings. The radiant heat flux from the unexposed face of Duct No. 3 was measured using a heat flux transducer (radiometer) with a view restrictor attachment producing a 30° angle of view. The radiometer was positioned so that its field of view was entirely filled with the steel duct section and nothing else.

VI. *RESULTS*

On September 9, 1988, at 4:25 P.M., the thermocouple connections were verified and the furnace ignited with the following people in attendance: Mr. Richard G. Gewain and Mr. Joseph Scheffy representing the Client; Mr Bruce G. Campbell representing Rockwell International; and Mr. Andrew Pryor representing the Department of Energy.

The furnace was controlled according to the requirements of ASTM E119-83, Standard Method of Fire Tests of Building Construction and Materials, Section 4, Furnace Temperatures. The furnace pressure was controlled as per the Client's request to be approximately +0.03 in. of water pressure, measured 0.78 in. below the concrete cover slabs.

There were no significant observations recorded throughout the 120-minute fire exposure. None of the duct sections collapsed or fell into the furnace and the integrity of each system, where it extended through the fire wall, remained intact. No through-opening developed between a fire stop and a duct at any wall penetration.

VII. POST-TEST OBSERVATIONS

After the furnace had been allowed to cool down for several days, a thorough investigation was conducted to confirm the condition of the exposed portion of each duct system (see Appendix B, Photographic Documentation).

A. Duct No. 1

The duct had warped such that the top of the duct had buckled downward by a maximum of 11 in. in the center. The sides of the duct had warped and buckled inward by a maximum of 5.5 in. at the center of the 12-ft span. Where the duct extended through the masonry wall, there was a maximum warpage of 2 in. at the top and sides. The hanger assembly was intact and still in place.

B. Duct No. 2

There was minimal, if any, visible distortion of this duct or the hanger.

C. Duct No. 3

The duct had warped such that the top of the duct had buckled downward by a maximum of 8.75 in. in the center. The sides of the duct had warped and buckled inward by a maximum of 3.5 in. at the center of the 12-ft span. Where the duct extended through the masonry wall, there was a maximum warpage of 0.5 in. at the top and sides. Two of the spot welds between the angle reinforcement and the duct had been broken inside the furnace. The hanger assembly was intact and still in place.

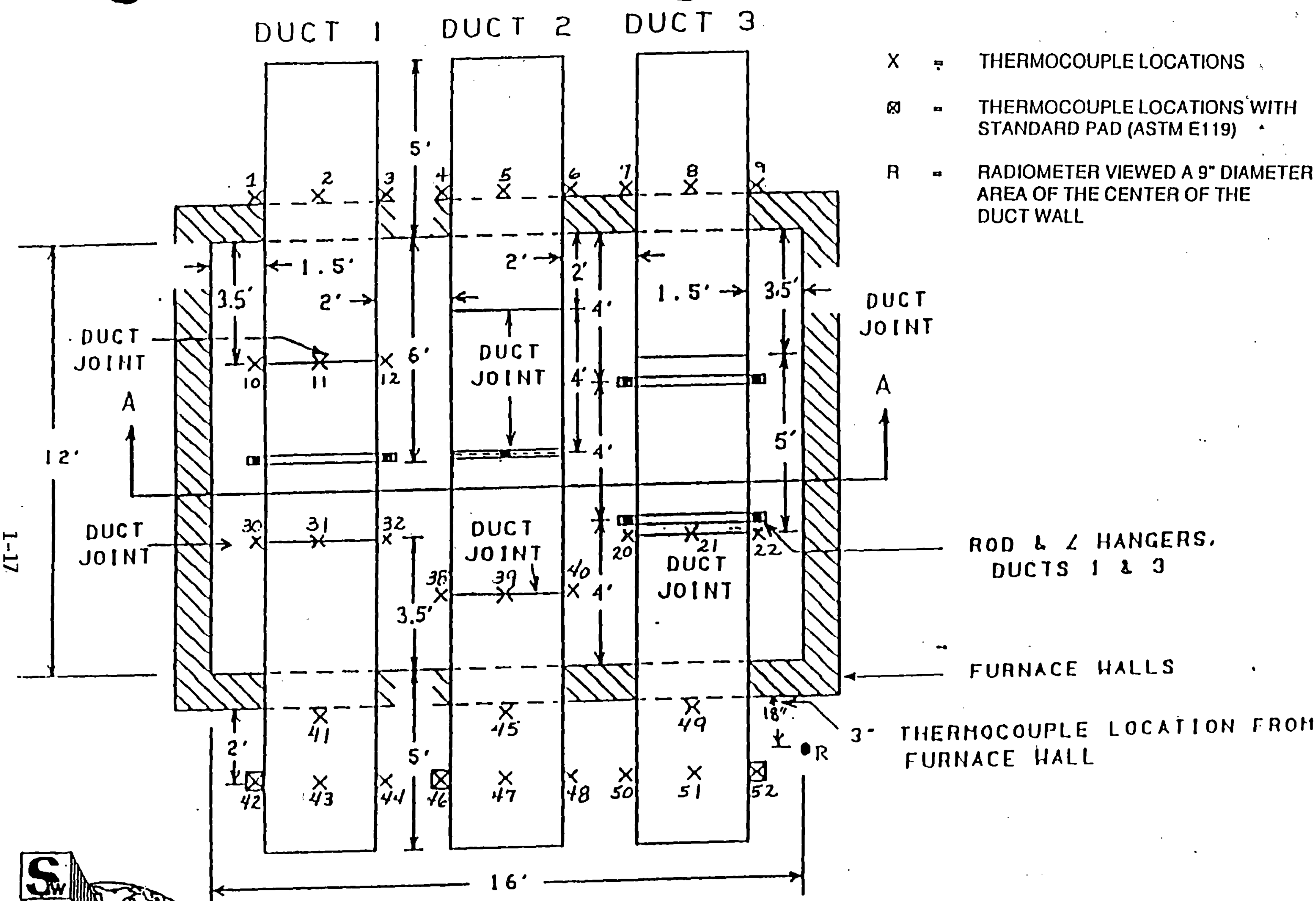
A complete listing, with graphical presentation of data from the radiometer and all thermocouples monitored, is presented in Appendix C.

VIII. CONCLUSIONS

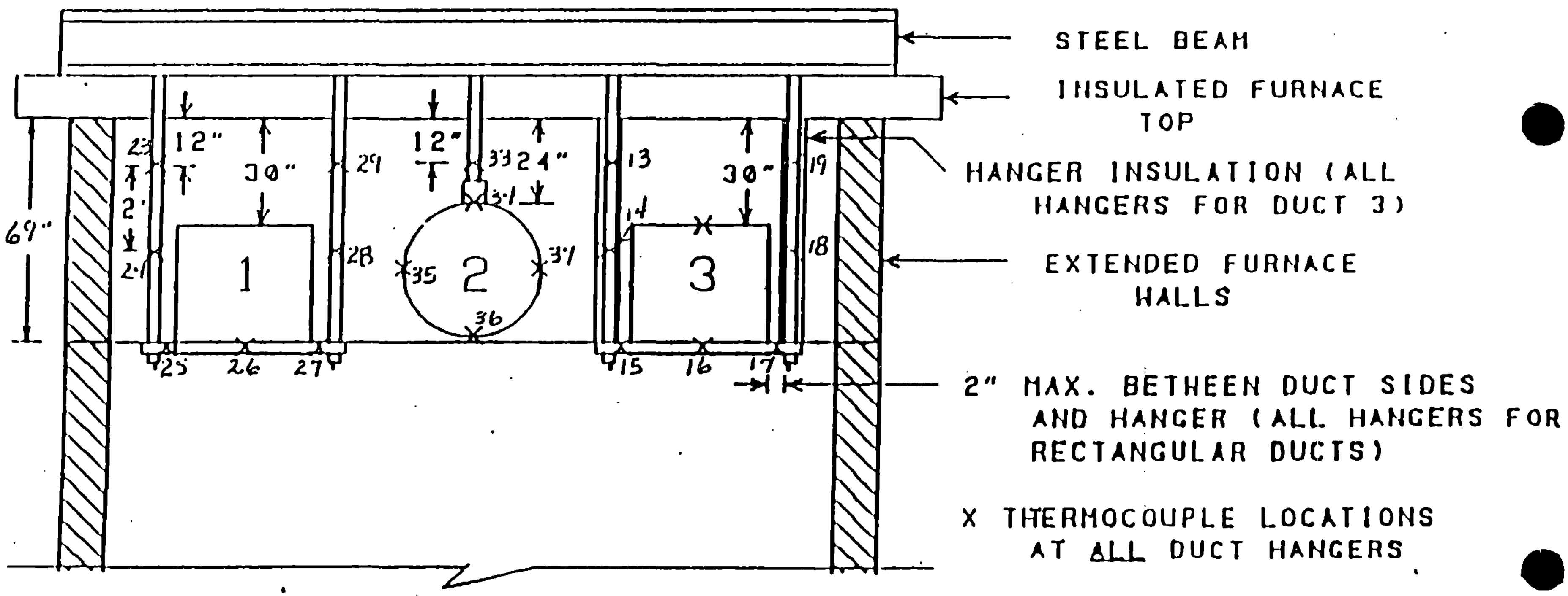
All conclusions relating to this project will have to be drawn by the Client. All necessary temperature data and observations are contained in the appropriate appendices.

APPENDIX A

CONSTRUCTION DRAWINGS


DUCT 1
DUCT 2
DUCT 3
X = THERMOCOUPLE LOCATIONS
⊠ = THERMOCOUPLE LOCATIONS WITH STANDARD PAD (ASTM E119)
R = RADIOMETER VIEWED A 9" DIAMETER AREA OF THE CENTER OF THE DUCT WALL
DUCT JOINT
ROD & ∠ HANGERS, DUCTS 1 & 3
FURNACE WALLS
3" THERMOCOUPLE LOCATION FROM FURNACE WALL
A
12'
16'
5'
6'
3.5'
1.5'
2'
4'
18"

PLAN VIEW


STEEL BEAM
INSULATED FURNACE TOP
HANGER INSULATION (ALL HANGERS FOR DUCT 3)
EXTENDED FURNACE WALLS
2" MAX. BETWEEN DUCT SIDES AND HANGER (ALL HANGERS FOR RECTANGULAR DUCTS)
X THERMOCOUPLE LOCATIONS AT ALL DUCT HANGERS
69"
12"
30"
12"
24"
30"
2'
1
2
3
13
14
15
16
17
18
19
21
23
25
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SECTION A-A