File NC505-12
Project 84NK29824

April 17, 1985

FACT-FINDING REPORT

on

AIR DUCT PENETRATIONS THROUGH ONE HOUR FIRE RESISTIVE WALL ASSEMBLY

UNDERWRITERS LABORATORIES INC.

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an independent, not-for-profit organization testing for public safety

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American Iron and Steel Institute
Washington, D.C.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

This Fact-Finding Report describes the performance of air duct penetrations through a 1 hr rated fire resistive wall assembly when the wall assembly was subjected to a fire test conducted in accordance with the requirements of the Standard for Fire Tests of Building Construction and Materials, UL 263 (ASTM E119).

The air duct assemblies which penetrated the wall assembly consisted of two square 10 in. by 10 in. inside dimension galvanized steel ducts and one square 10 in. by 10 in. inside dimension Class I rigid fiberglass duct. The outside surface of one galvanized steel air duct was covered with foil-scrim-kraft faced fiberglass duct insulation on the fire and non-fire side of the wall assembly. All the air duct assemblies had open duct drops on both sides of the wall assembly. None of the air duct assemblies contained fire dampers. The fire resistive wall assembly consisted of 5/8 in. thick gypsum wallboard screw-attached to steel studs which were spaced 24 in. on center.

This investigation was undertaken at the request of the American Iron & Steel Institute (AISI) to develop test data relative to the fire performance of insulated steel air ducts, uninsulated steel air ducts, and Class I rigid fiberglass air ducts, without dampers, penetrating a 1 hr fire resistive wall.

The following objectives were associated with the conduct of this test:

(1) develop fire performance data on the ability of insulated steel, uninsulated steel, and rigid fiberglass air duct systems to remain secure within the wall opening without developing through openings allowing the passage of flame and hot gases through the wall and duct assemblies,

(2) develop data on the influence of the air ducts on the transmission of heat to the unexposed surfaces of the wall and duct assemblies and

(3) the radiation of heat from the surfaces of the duct assemblies to adjacent surfaces.

For this investigation, the measurement of temperatures on the unexposed surface of the wall utilized thermocouples that were covered with 6 by 6 in. ceramic pads as described in Standard UL 263. The thermocouples used to measure the temperatures on the top surface of the duct assemblies were attached with tape and were not covered with ceramic pads so as not to interfere with the measurement of radiant heat from the surface of the duct assemblies to adjacent untreated wood surfaces.

Information developed in this investigation is to be used for submittal by the sponsor to the Air Conditioning Committee of National Fire Protection Association (NFPA) in connection with the development of the Standard for Installation of Air Conditioning and Ventilation Systems, NFPA 90A, which specifies the use of fire dampers in openings in partitions requiring fire resistive ratings of 2 hr or more and does not now contain provisions for the protection of openings in walls and partitions requiring fire resistance ratings of less than 2 hr.

The fire performance included temperatures measured and recorded at various locations within, top surface of, to the side of and above the air duct assemblies, the structural integrity of air duct assemblies, the passage of flames through the air duct assemblies, and the passage of flames through the wall assembly.

Because of the furnace design and the characteristic of rising hot gases, the value of the pressure differential between the furnace chamber and the surrounding laboratory volume changes as the distance from the test frame sill changes. During the fire test, a plane of zero pressure differential between the laboratory and the furnace existed in the furnace chamber. Above this plane, the pressure within the furnace was greater than the laboratory and below this plane, the pressure within the furnace was less than the laboratory. The location of the zero pressure plane was maintained at approximately 36 in. above the test frame sill.

D E S C R I P T I O N O F T E S T A S S E M B L Y

MATERIALS:

The following is a description of the materials used in the test assembly.

Floor/Ceiling Tracks - The floor/ceiling tracks were fabricated from 0.025 in. thick galvanized steel. The channel shaped tracks were 3-5/8 in. deep with 1 in. long legs.

Steel Studs - The steel studs were fabricated from 0.025 in. thick galvanized steel. The channel shaped studs were 3-5/8 in. deep with 1-1/4 in. long legs and 5/16 in. long stiffeners.

Gypsum Wallboard - The gypsum wallboard was 5/8 in. thick and bore UL's Classification Marking for Fire Resistance Classification.

Steel Sleeves - The steel sleeves were 12 in. long, 10 by 10 in. (O.D.) and fabricated from 0.059 in. thick galvanized steel.

Framing Angles - The framing angles used in mounting the steel sleeves in the wall assemblies had 1-1/2 in. long legs and were fabricated from 0.079 in. thick galvanized steel.

Galvanized Steel Air Duct Insulation - The glass fiber insulation was supplied in rolls, 48 in. wide by 48 in. long. The nominal density of the fiberglass insulation was approximately 1 lb/ft^3. The outside face of the fiberglass insulation was covered with 7 mil thick aluminum foil-scrim-kraft facing.

Galvanized Steel Air Duct Assemblies - The two galvanized steel air duct assemblies were fabricated from 0.022 in. thick material and each duct assembly had a 10 by 10 in. inside dimension.

Rigid Fiberglass Air Duct Assembly - The rigid fiberglass air duct material was fabricated from 4 ft wide by 8 ft long by 1 in. thick boards. The density of the boards was approximately 4 lb/ft^3. The air duct material bore the UL Classification Mark for use in fabrication of a Class I air duct per the requirements of the Standard for Factory-Made Air Ducts and Connectors, UL 181.

Fasteners - All fasteners used in the assembly were steel. The floor tracks were secured to the sill of the test frame with No. 8-32 by 3/4 in. long bolts spaced approximately 16 in. OC.

The steel studs and the floor/ceiling tracks were secured together with Type S-12 by 1/2 in. long pan head screws.

The gypsum wallboard was secured to the steel studs with Type S by 1 in. long bugle head screws. The fasteners were spaced 8 in. OC along the wallboard joints in the field.

WALL ASSEMBLY:

The wall assembly was nominally 15 ft wide by 10 ft high and consisted of 3-5/8 in. deep, 0.025 in. thick, steel studs spaced 24 in. OC. Additional studs were added to accommodate the penetration framing. The studs were covered on the exposed and unexposed sides with a single layer of 5/8 in. thick gypsum wallboard which was screw-attached to each stud.

AIR DUCT ASSEMBLIES:

Three air duct assemblies were included in the test assembly. The air duct assemblies included two galvanized steel air ducts and one rigid fiberglass air duct. The galvanized air ducts were fabricated from 0.022 in. thick steel. The inside dimension of the ducts was 10 by 10 in. A steel sleeve was utilized for each air duct assembly where it penetrated through the wall. One galvanized steel air duct assembly was covered with glass fiber duct insulation on the fire and non-fire side of the wall assembly. The other galvanized steel duct assembly was uninsulated. The horizontal center line of the galvanized steel air duct penetrations, with and without insulation, was 96 in. above the test frame sill. The remaining air duct assembly was fabricated from 1 in. thick rigid fiberglass air duct material with an aluminum foil-scrim-kraft facing. The inside dimensions of the rigid fiberglass air duct assembly was 10 by 10 in. The horizontal center line of the rigid fiberglass air duct penetration was 78 in. above the test frame sill. None of the air duct assemblies contained fire dampers.

Galvanized Steel Air Duct Assemblies - The two galvanized steel duct assemblies were fabricated from 0.022 in. thick material. The duct assemblies were fabricated from several sections to form L-shaped units. Each duct assembly contained a 6 in. square drop outlet which was centered 10 ft, 3 in. from the unexposed surface of the wall assembly and a 6 in. square drop outlet which was centered 12 in. from the end of the duct trunk on the exposed side of the assembly. The ends of each duct assembly were closed and the duct drop outlets were open.

One of the two galvanized steel duct assemblies was wrapped with glass fiber insulation.

Class I Rigid Fiberglass Duct Air Assembly - The Class I rigid fiberglass air duct assembly was fabricated from 4 ft wide by 8 ft long by 1 in. thick boards. The density of the boards was approximately 4 lb/ft^3. One surface of the boards was covered with an 0.008 in. thick aluminum foil-scrim-kraft facing. The 4 ft long edges of the board were cut with kerf edges to provide shiplap construction when joining adjacent pieces. The air duct material bore the UL Classification Mark as Class I material per the requirements of the Standard for Factory-Made Air Ducts and Connectors, UL 181.

The boards were cut to form a 10 in. by 10 in. (I.D.) L-shaped unit. Longitudinal joints and adjacent 4 ft long sections of duct were joined together with staples and pressure sensitive tape in accordance with instructions provided with the rigid fiberglass air duct board material. The duct assembly contained a 6 in. by 6 in. by 6 in. deep drop outlet which was centered 10 ft, 3 in. from the unexposed surface of the wall assembly and a 6 in. square drop outlet which was centered 21 in. from the end of the duct trunk on the exposed side of the wall assembly. The ends of the duct assembly were closed and the duct drop outlets were opened.

Duct Support System - On the exposed side of the test assembly, each air duct was supported by means of a trapeze support system. The supports for the air duct systems were spaced 24 in. OC. Each support consisted of two 1/4 in. diameter threaded steel rods spaced a nominal 12 in. OC. The galvanized steel ducts, with and without insulation, were supported by 14 in. long, 1 by 1 by 1/8 in. thick steel angles. The rigid fiberglass duct was supported by 14 in. long, 2 by 2 by 1/8 in. thick steel angles.

On the unexposed side of the test assembly, the air ducts were supported by temporary steel framing.

CONSTRUCTION OF TEST ASSEMBLY:

The test assembly was constructed in a manner similar to that shown on ILLS. 1, 1A and 1B.

The floor/ceiling tracks were secured to the test frame. The steel studs were secured to the floor/ceiling tracks at a spacing of 24 in. OC. The vertical edges of a frame to support the air duct penetration was formed from the studs placed toe-to-toe. The horizontal edges of the frame were formed from 36 in. lengths of floor/ceiling tracks folded into U-shapes as shown on ILLS. 1 and 1A.

A single layer of gypsum wallboard was fastened to the steel framing membrane forming the frames for the air duct penetrations as shown in ILL. 1.

A steel sleeve was inserted through each steel frame. Rockwool batt material was installed between the steel sleeve and the wallboard lining of the frame to seal any openings between the sleeve and the wallboard. The framing angles were fastened to the sleeve and to the steel studs to secure the sleeves in place as shown on ILLS. 1 and 1A.

On the exposed surface of the assemblies, the trapeze air duct supports were hung from the lintel of the test frame. The duct supports were spaced 24 in. OC. The air duct assemblies were installed with the ends sealed and open 6 in. square outlets. One end of each duct assembly contained a 90° elbow which was connected to the steel sleeve as shown on ILL. 1A. The horizontal center line of the galvanized steel air duct assemblies was located 96 in. above the test frame sill. The horizontal center line of the rigid fiberglass duct assembly was located 78 in. above the test frame sill. Glass fiber insulation was wrapped around the galvanized steel air duct located on the north side of the assembly. The insulation extended approximately 4 in. beyond the closed end and was folded over and stapled to itself. A 6 in. overlap was provided along the horizontal and longitudinal joints and were taped with a pressure sensitive tape.

On the unexposed surface, one end of the air duct assembly was connected to the steel sleeve and the remaining end was sealed. A 6 in. square air outlet was provided in each duct assembly. The center of each air outlet was located 10 ft, 3 in. from the unexposed surface of the wall assembly as shown on ILL. 1B. The same procedure of wrapping the north galvanized steel air duct with glass fiber insulation on the exposed side of the assembly was repeated on the unexposed side.

Photographs depicting various stages of the construction process are contained in Appendix B. The appearance of the exposed surface of the assembly prior to the fire test is shown in ILL. 2.

TEST RECORD

FIRE ENDURANCE TEST:

The fire test was conducted in accordance with the Standard of Underwriters Laboratories Inc. for Fire Tests of Building Construction and Materials, UL 263 (ASTM E119, NFPA No. 251).

DESCRIPTION OF TEST ASSEMBLY

The test assembly was constructed as described in the Section of the Report entitled "Construction of Test Assembly" and as shown on ILLS. 1, 1A and 1B.

METHOD

The standard test equipment of Underwriters Laboratories Inc. for wall and partition assemblies was used for the fire endurance test.

The test assembly was placed in front of the vertical furnace and exposed to flames of controlled extent and severity in accordance with the Standard Time-Temperature Curve. The furnace temperatures were measured with 12 thermocouples positioned 6 in. from the exposed face of the assembly and located in the furnace chamber as shown on ILL. 3.

The pressure differential between the furnace chamber and the laboratory was measured at 3 locations. The location of the zero pressure plane was 36 in. above the test frame sill. Above this plane, the pressure within the furnace was greater than the laboratory and below this plane, the pressure within the furnace was less than the laboratory. The two remaining pressure differential locations were 78 in. and 96 in. above the test frame sill. All three air duct penetrations were located above the zero pressure plane. A plot of the pressure magnitudes measured during the test are shown on ILL. 4.

The unexposed surface temperatures of the wall assembly were measured with thermocouples located as shown in ILL. 5. Each thermocouple was covered with a 6 in. by 6 in. dry ceramic fiber pad.

Thermocouples used to measure the temperatures within, on top of, above, and to the side of the each air duct assembly were located as shown in ILL. 6. These thermocouples were attached with tape and were not covered with ceramic fiber pads.

Thermocouples used to measure the surface temperature of the wood blocks adjacent to the duct surfaces were secured against the wood surface with staples. Staples were carefully applied in order to avoid causing a short in the thermocouple. The thermocouples were not covered with ceramic pads.

RESULTS

Character and Distribution of the Fire - The furnace fire was luminous and well distributed during the test and the temperatures recorded in the furnace chamber followed the Standard Time-Temperature Curve as defined in the Standard for Fire Tests of Building Construction and Materials, UL 263 and as shown on ILL. 3.

Observations of Exposed Surface During Test - The following observations were made of the exposed surface during the fire test. All references to dimensions are approximate.

Time, min:s	Observations
:30	The Class I rigid fiberglass air duct had ignited.
:45	The insulated galvanized steel air duct had ignited.
1:00	Heavy flames were issuing from the rigid fiberglass air duct. The insulated galvanized steel air ducts' outer layer of the foil wrap was delaminating. Pieces 1 $in.^2$ to 4 $in.^2$ were falling into the furnace chamber.
1:15	Flames were issuing from the insulation on the insulated galvanized steel duct.
2:00	Both the Class I rigid fiberglass and the glass fiber insulated galvanized steel air duct assemblies were emitting heavy flames. The wall surface was a light gray color.
3:00	Sections of glass fiber insulation located on the bottom surface of the galvanized steel duct had fallen off, leaving exposed 75 percent of the bottom surface of the steel duct.

3:15	The paper surface of the wallboard had ignited.
4:00	The Class I rigid fiberglass air duct had deflected 1 to 1-1/2 in. downward.
4:15	The majority of the rigid fiberglass air duct was consumed.
4:30	A small section of the Class I rigid fiberglass air duct, 6 to 8 in. long remained attached to the wall assembly. The rest of the duct assembly had been consumed or had fallen into the furnace chamber.
4:45	The wall surface was black in color and the paper was peeling and falling away.
5:00	The glass fiber insulation that was wrapped around the north galvanized steel air duct was consumed or had fallen into the furnace chamber.
5:50	All flaming had stopped.
15:00	All charred paper surfacing on the wallboard had fallen.
20:00	The joint tape on the wallboard had begun to delaminate from the wallboard.
40:00	All of the joint tape had delaminated.
53:00	The wallboard joints had opened 3/16 in.
60:00	Test terminated.

Observations of the Unexposed Surface During the Test - The following observations were made of the unexposed surface during the fire test. All references to dimensions are approximate.

Time, min:s	Observations
:15	A light amount of smoke was issuing from the north glass fiber insulated galvanized steel air duct.
:30	Light smoke was issuing from all three air duct assemblies.
2:00	Heavy smoke was issuing from the Class I rigid fiberglass air duct.

6:00	Smoke was still issuing from the Class I rigid fiberglass air duct. Light smoke was issuing from the glass fiber insulated galvanized steel air duct. Light smoke/steam was issuing from the top surface of the south galvanized steel air duct 6 ft from the wall surface.
12:00	Light smoke was issuing from the north glass fiber insulated galvanized steel air duct 10 ft from the wall surface.
15:00	The Class I rigid fiberglass air duct had begun to collapse inward near the sleeve penetration.
17:00	Heavy smoke was issuing from the horizontal joint of the Class I rigid fiberglass air duct located 4 ft from the wall surface.
17:30	The transverse joint of the Class I rigid fiberglass air duct located 4 ft from wall surface and the longitudinal joint began to deteriorate and the duct started to bow downward.
18:00	The transverse joint tape of the Class I rigid fiberglass duct located 4 ft from the wall surface, had delaminated and fallen away from the air duct surface.
18:50	The Class I rigid fiberglass air duct ignited at the horizontal joint, located 4 ft from the wall surface.
19:07	The Class I rigid fiberglass air duct had separated at the transverse joint located 4 ft from the wall surface. The section of flaming air duct beyond the horizontal joint had fallen to the laboratory floor. The 4 ft air duct section extending from the wall surface was burning and collapsed inward.
23:20	Flames had begun to issue from the collapsed Class I rigid fiberglass air duct section extending from the wall surface.
25:00	The remaining section of the Class I rigid fiberglass air duct had separated from the sleeve and had fallen to the laboratory floor. Flames were issuing from the unprotected opening left by the collapsed rigid fiberglass air duct.

25:30	The untreated wood blocks near the Class I rigid fiberglass air duct through-opening ignited.
26:00	The Class I rigid fiberglass air duct through-opening was sealed with sections of gypsum wallboard and ceramic fiber blankets.
26:30	Beginning at the wall surface and extending outward 10 in., the insulation on the bottom of the galvanized steel air duct began to discolor. The top and side foil surface had begun to blister.
32:00	Light amounts of smoke were issuing from the perimeter of the wall assembly.
34:00	Beginning at the wall surface and extending outward 18 in., the surface of the galvanized steel air duct, without insulation, had begun to discolor.
40:00	The top seam of the glass fiber insulation had separated. Sections of the exposed glass fiber insulation were visibly charred.
43:00	The insulation wrap on the galvanized steel air duct glass fiber had appeared to expand outward.
50:00	Slight discoloration was visible on the wall surface adjacent to the glass fiber insulated galvanized steel air duct.
57:00	The wall assembly was giving off some light cracking sounds.
60:00	Test terminated.

Temperatures on the Unexposed Surface of the Wall Assembly - The temperatures that developed at various points on the unexposed surface of the wall assembly were recorded by Thermocouples Nos. 1 through 14 located as shown on ILL. 5. Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test are contained in Appendix A.

<u>Temperatures of the Duct Assemblies</u> - The temperatures that developed within, top surface of, to the side of, and above the air duct assemblies were recorded by Thermocouple Nos. 15 through 68. The location of these thermocouples is shown on ILL. 6. Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test are contained in Appendix A.

Plots of the temperatures recorded within the duct assemblies, located 3 in., 6 ft and 9 ft, 3 in. from the unexposed surface of the wall are shown on ILLS. 8, 9 and 10, respectively.

The limited temperature data on the Class I duct occurred because the transverse joint of the rigid fiberglass duct, located 4 ft from the unexposed surface of the wall, opened and separated at 19 min and the portion of the duct assembly beyond the first joint collapsed and fell to the laboratory floor. The remaining duct assembly section extending from the unexposed surface of the wall collapsed at 25 min. To maintain the pressure differential between the furnace chamber and laboratory the through-opening of the wall assembly was plugged with gypsum board and cera-fiber blankets at 26 min.

The temperatures within the Class I rigid fiberglass duct, 6 ft and 9 ft, 3 in. from the unexposed surface of the wall were plotted for 17 min, 30 sec and temperatures within the rigid fiberglass duct 3 in. from the unexposed surface of the wall were plotted for 25 min.

Temperatures measured within the galvanized steel duct, with and without insulation, were plotted through the full 60 min. The thermocouple location for each duct assembly is shown on ILL. 6.

Plots of the temperatures measured on the top surface of the duct assemblies, 3 in, 6 ft and 9 ft, 3 in. from the unexposed surface of the wall, are shown on ILLS. 11, 12 and 13, respectively.

Thermocouple Nos. 37 and 55 <u>malfunctioned</u> at the start of the test and remained inoperative throughout the test. These thermocouples were on the top surface of the insulated steel duct and on the top surface of the rigid fiberglass duct, 6 ft from the unexposed surface of the wall.

The transverse joint of the Class I rigid fiberglass duct, located 4 ft from the unexposed surface of the wall, opened and separated at 19 min. The portion of the duct assembly beyond this transverse joint collapsed and fell to the laboratory floor. Consequently, the last accurate temperature recorded on the fiberglass duct beyond the transverse joint was obtained at 17 min, 30 s. This temperature was 136°F.

The remaining portion of the Class I fiberglass duct assembly collapsed at 25 min. Consequently, the final accurate temperature recorded on the fiberglass duct 3 in. from the unexposed surface of the wall was obtained at 22 min, 30 s. This temperature was 168.7°F.

The temperatures developed from the radiant heat transfer from each duct assembly were measured by thermocouples located 18 in. and 60 in. from the unexposed surface of the wall and 1 in., 2 in. and 4 in. from the top and side surface of each duct assembly. The thermocouples used to measure these temperatures were secured to the surface of the 6 in. long, 2 by 4 in. exposed untreated wood. The thermocouple locations near each duct assembly is shown on ILL. 6.

The temperatures recorded by Thermocouple Nos. 60 through 62 and 66 through 68, located 60 in. from the unexposed surface of the wall, above and to the side of the rigid fiberglass duct assembly, respectively, were accurate for the first 17 min and 30 s of the fire test. This occurred because the transverse joint of the Class I rigid fiberglass duct located 4 ft from the unexposed surface of the wall, opened and separated at 19 min. and the remaining portion of the duct assembly fell to the laboratory floor. Consequently, the final accurate temperatures for Thermocouple Nos. 60 through 62 and 66 through 68 were recorded at 17 min, 30 s. Within this group of thermocouples, the highest temperature was 145°F as recorded by Thermocouple No. 61 at 17 min, 30 s. Thermocouple No. 61 was located 60 in. from the unexposed surface of the wall and centered 2 in. above the top duct surface. The temperatures recorded by Thermocouple Nos. 57 through 59 and 63 through 65, located 18 in. from the unexposed surface of the wall, above and to the side of the Class I rigid fiberglass duct assembly, respectively, were accurate for the first 22 min, 30 s of the fire test. Thereafter, the last relevant temperatures for Thermocouple Nos. 57 through 59 and 63 through 65 were recorded at 22 min, 30 s. Within this group of thermocouples, the highest temperature was 363°F as recorded by Thermocouple No. 64. Thermocouple No. 64 was located 18 in. from the unexposed surface, centered at the mid-height, and 2 in. from the side surface of the duct.

OBSERVATIONS AFTER TEST:

The appearance of the exposed and unexposed surfaces after the test are shown in ILLS. 14 and 15, respectively.

On the exposed surface, all wallboard remained attached to the studs. The wallboard contained numerous cracks and displayed a maximum joint separation of 5/8 in. The Class I rigid fiberglass air duct had fallen from its supports and was consumed by the furnace fire. The glass fiber insulation used to insulate the north galvanized steel air duct was also consumed.

Both galvanized steel air ducts remained in place. The galvanized steel ducts without insulation distorted less than the galvanized steel duct with insulation.

On the unexposed side of the wall assembly, the gypsum wallboard remained in place with no joint separation or cracks observed. The Class I rigid fiberglass air duct collapsed at 19 min, 5 s and dropped to the laboratory floor. Two galvanized steel ducts were intact and remained in place. The glass fiber insulation that was wrapped around the north galvanized steel air duct was charred through its entire depth for the first 8 ft extending away from the wall surface. The charred depth of the remaining portion was 75 percent of the total thickness. The foil facing had numerous blisters and 1/8 in. wide cracks throughout its surface for the first 4 ft extending from the wall surface. The remaining length of foil facing had numerous blisters. The galvanized steel air ducts, with and without insulation, remained structurally intact. Upon removal of the glass fiber insulation from the north duct assembly, it was noted that the galvanized steel air duct was discolored along its entire length. The south galvanized steel air duct, without insulation, was discolored approximately 3 ft extending from the surface of the wall assembly.

S U M M A R Y

In consideration of the fact-finding character of the investigation, the foregoing Report is to be construed as information only and should not be regarded as conveying any conclusion or recommendations on the part of Underwriters Laboratories Inc. regarding the ability of the construction or performance of the product for Recognition by any code or Standard or for any other purpose.

WALL ASSEMBLY FIRE PERFORMANCE:

The fire resistant test was conducted on the wall assembly in accordance with Standard UL 263 (ASTM E119, NFPA 251, ANSI A2.1). The wall assembly was of gypsum wallboard and steel stud construction containing three types of duct assemblies two galvanized steel ducts and one Class I rigid fiberglass duct. All three duct assemblies penetrated the wall assembly and had open air drops on each side. The duct assemblies did not contain fire dampers.

Based on measurements at locations other than at the duct assembly penetrations, the wall assembly complied with the temperature transmission requirements of Standard UL 263 for a 1 hr fire resistance rating.

A plot of the maximum individual and average temperatures recorded on the unexposed surface of the test assembly is shown on ILL. 7.

Temperature measurements of the duct assemblies at various locations are described separately.

PRESSURE DIFFERENTIALS:

A plane of neutral pressure between the furnace chamber and the surrounding laboratory volume existed within the furnace. Above this plane, the pressure differential within the furnace was positive with respect to laboratory atmospheric pressure. Below the neutral pressure plane, the pressure differential was such that the pressure plane within the furnace was negative with respect to the laboratory atmospheric pressure.

The location of the neutral pressure plane was 36 in. above the sill of the assembly. All three air duct assemblies were located above the neutral plane, in the positive pressure area of the furnace.

The magnitude of the pressure differentials at the location of each duct assembly during the test are shown on ILL. 4.

TEMPERATURES WITHIN THE AIR DUCT:

The temperatures within each air duct assembly were measured at distances of 3 in., 6 ft and 9 ft, 3 in. from the unexposed surface of the wall. The thermocouple locations on each assembly are shown on ILL. 6. Plots comparing maximum temperatures reached at each location for each duct assembly are shown on ILLS. 8, 9 and 10, respectively.

Through 15 min of the fire exposure period, the temperatures recorded within the insulated galvanized steel air duct were generally higher than the uninsulated and Class I rigid glassfiber air duct assemblies. The lowest temperatures were measured within the uninsulated galvanized steel duct. After 60 min of fire exposure, the temperatures recorded within the uninsulated galvanized steel air duct continued to be lower than the insulated galvanized steel duct. Comparison with the Class I rigid fiberglass air duct assembly was not made beyond the time when joint separation occurred (17 min, 30 s).

Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test and at each location are contained in Appendix A.

TEMPERATURES ON THE UNEXPOSED SURFACE OF THE AIR DUCTS:

The temperatures on the top surface of each duct assembly were measured at distances of 3 in., 6 ft, and 9 ft, 3 in. from the unexposed surface of the wall. The thermocouple location on each assembly is shown on ILL. 6.

The maximum temperature measured nearest the wall assembly on the top surface of the uninsulated galvanized steel air duct was 499°F at 22 min, 30 sec. The corresponding maximum temperature measured for the insulated galvanized steel air duct was 176°F at 60 min. A maximum temperature of 293°F was recorded on the Class I glass fiber duct at 25 min, just prior to the collapse of the duct at the steel sleeve.

The maximum temperature measured furthest from the wall assembly on the top surface of the uninsulated galvanized steel duct was 175°F at 47 min, 30 sec. The corresponding maximum temperature measured for the insulated galvanized steel air duct and for the Class I rigid fiberglass duct was 178°F at 2 min, 30 sec and 294°F at 17 min, 30 sec (just prior to collapse of duct portion beyond 4 ft from wall), respectively.

Plots comparing maximum temperatures reached at each location on each duct assembly are shown on ILLS. 11, 12 and 13, respectively.

Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test and at each location are contained in Appendix A.

RADIANT TEMPERATURE OF THE AIR DUCTS:

Temperatures developed from the radiant heat transfer from each duct assembly were measured by thermocouples located 18 in. and 60 in. from the unexposed surface of the wall and 1 in., 2 in. and 4 in. from the top and side surface of each duct assembly. The thermocouples were secured to the surface of the 2 by 4 in. untreated wood blocks, 6 in. long. The location of these thermocouples for each duct assembly is shown on ILL. 6.

A comparison of the radiant temperatures for the three duct assemblies indicates that the greatest temperature rise occurred on the untreated wood adjacent to the galvanized steel air duct assembly without insulation. The Class I rigid fiberglass duct assembly produced the least radiant temperature rise prior to the changes in temperatures affected by the partial or complete collapse of the Class I glass fiber duct assembly.

A comparison of the radiant temperature rise for the galvanized steel duct assemblies, with and without insulation, indicates that the greatest temperature rise occurred with the galvanized steel duct assembly without insulation. The maximum temperatures recorded were 479°F from the uninsulated duct and 251°F from the insulated galvanized steel duct.

Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test and at each location are contained in Appendix A.

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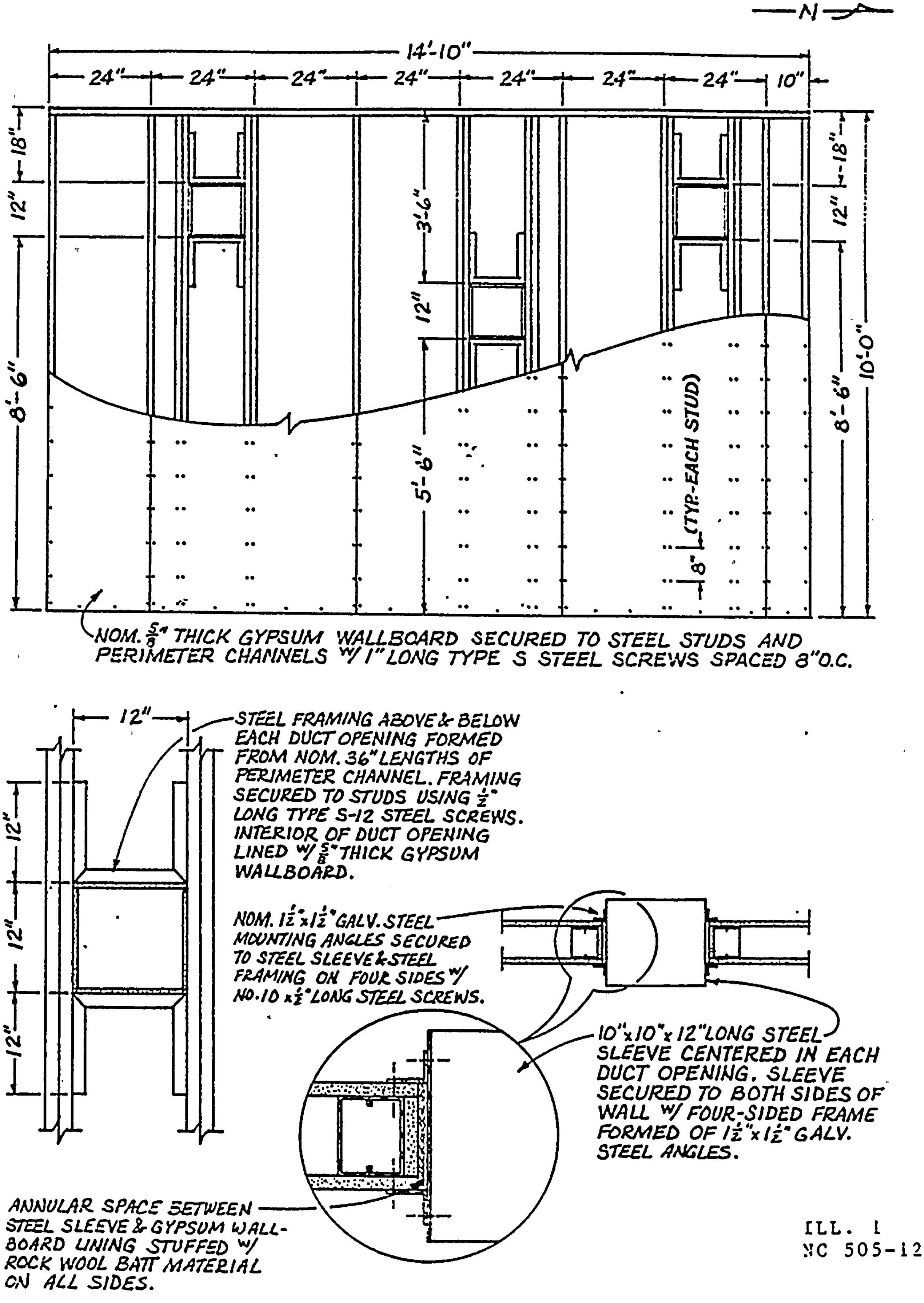
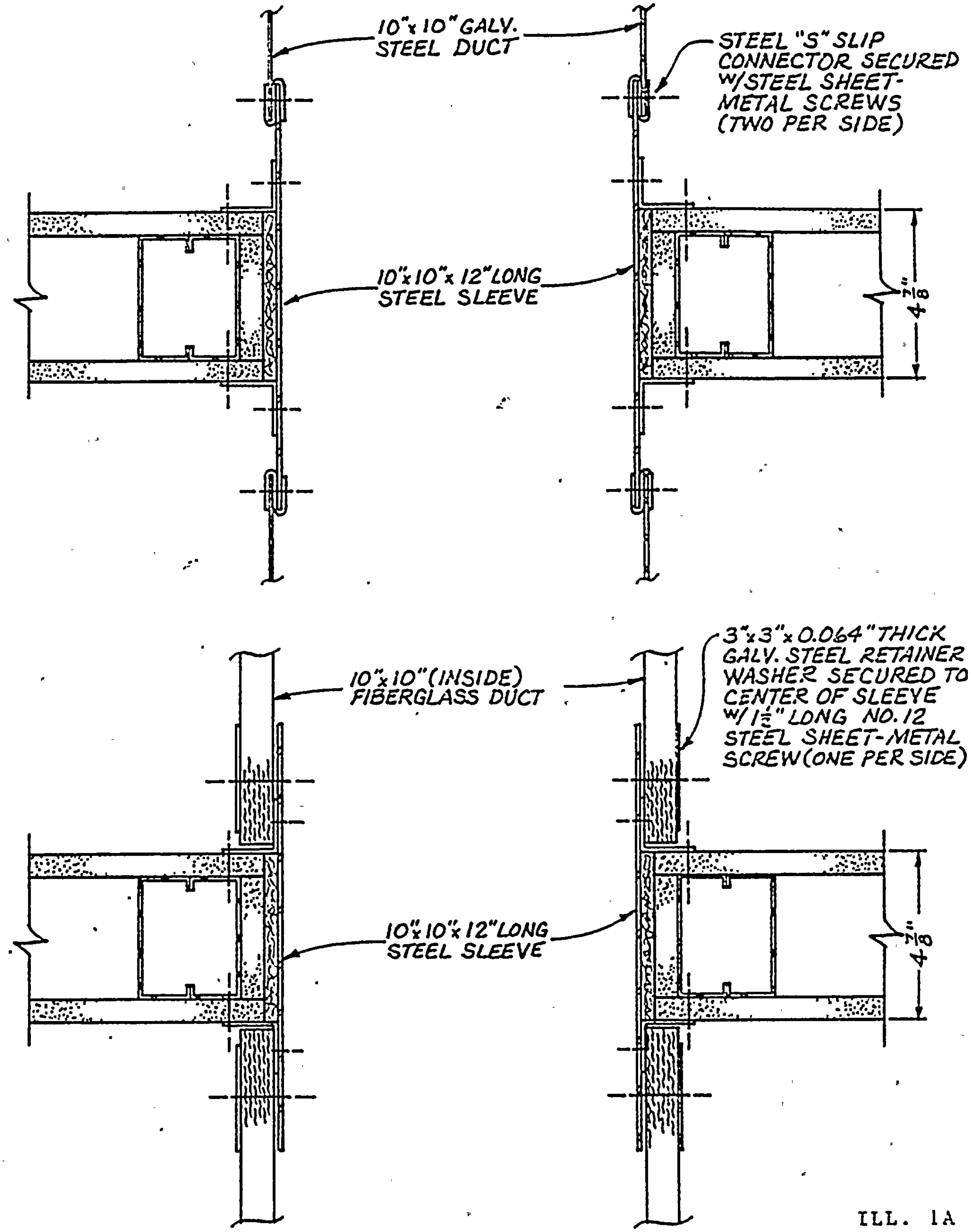
TP/KR:jrr
REPT4

WALL CONSTRUCTION DETAILS



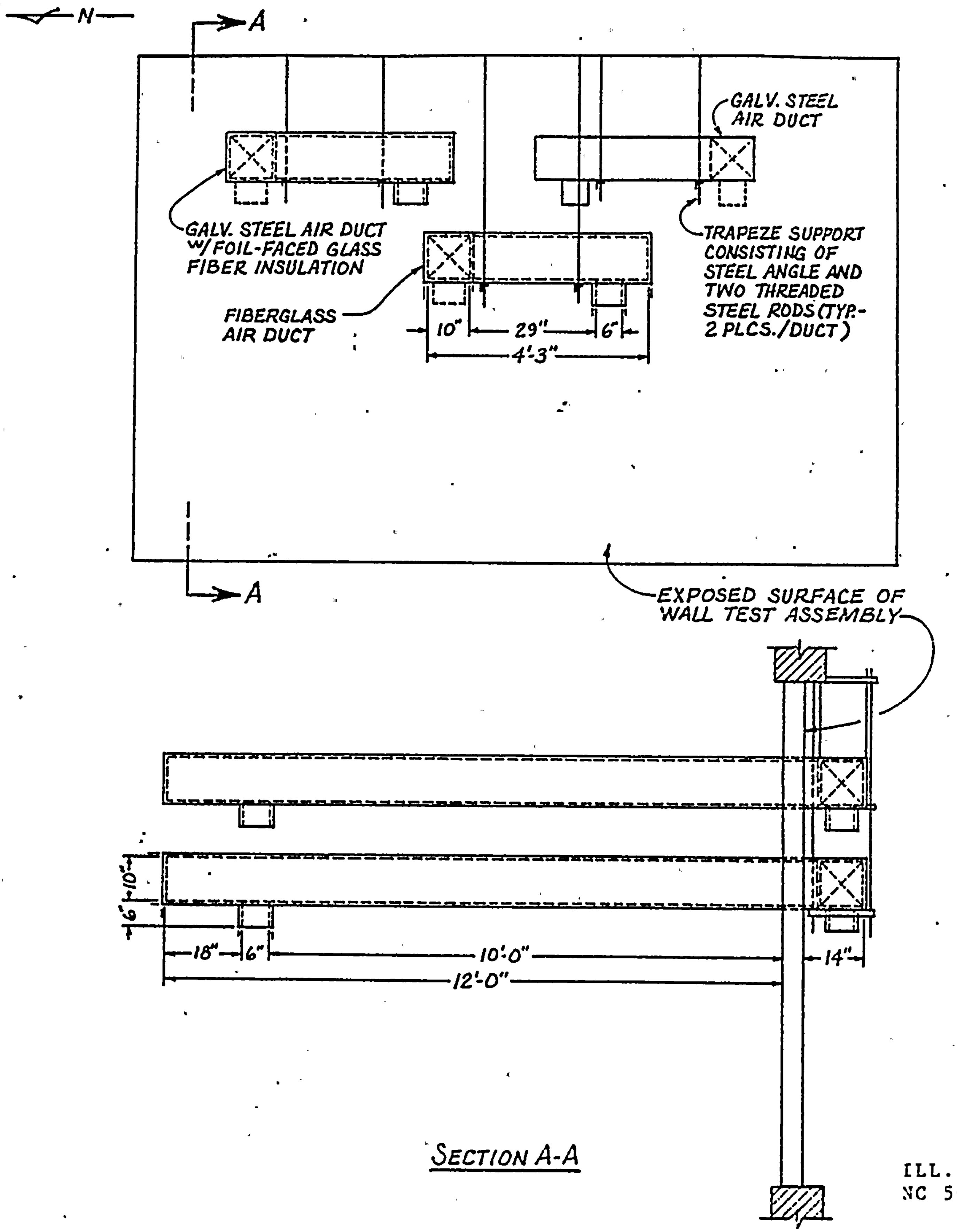
ILL. 1
NC 505-12

AIR DUCT/SLEEVE CONNECTION DETAILS



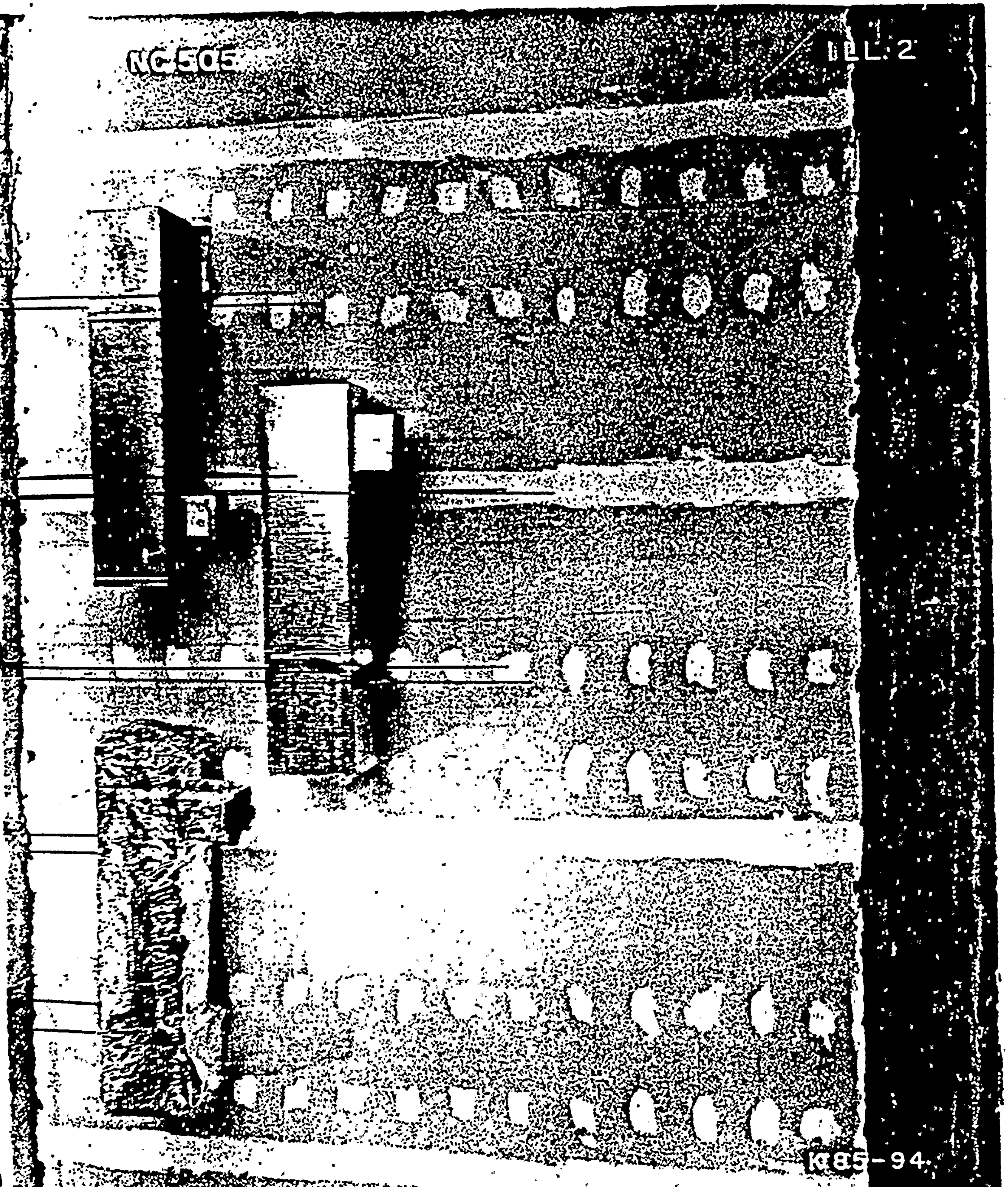
ILL. 1A
NC 505-12

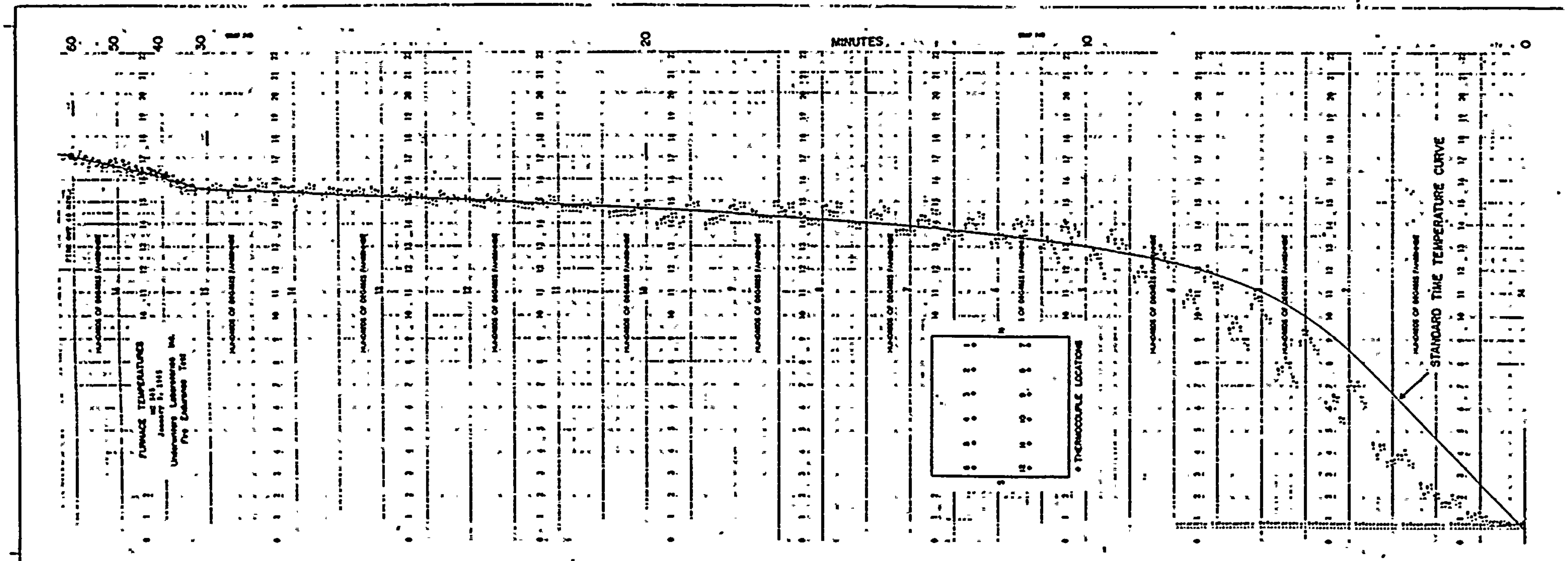
DUCT INSTALLATION DETAILS



SECTION A-A

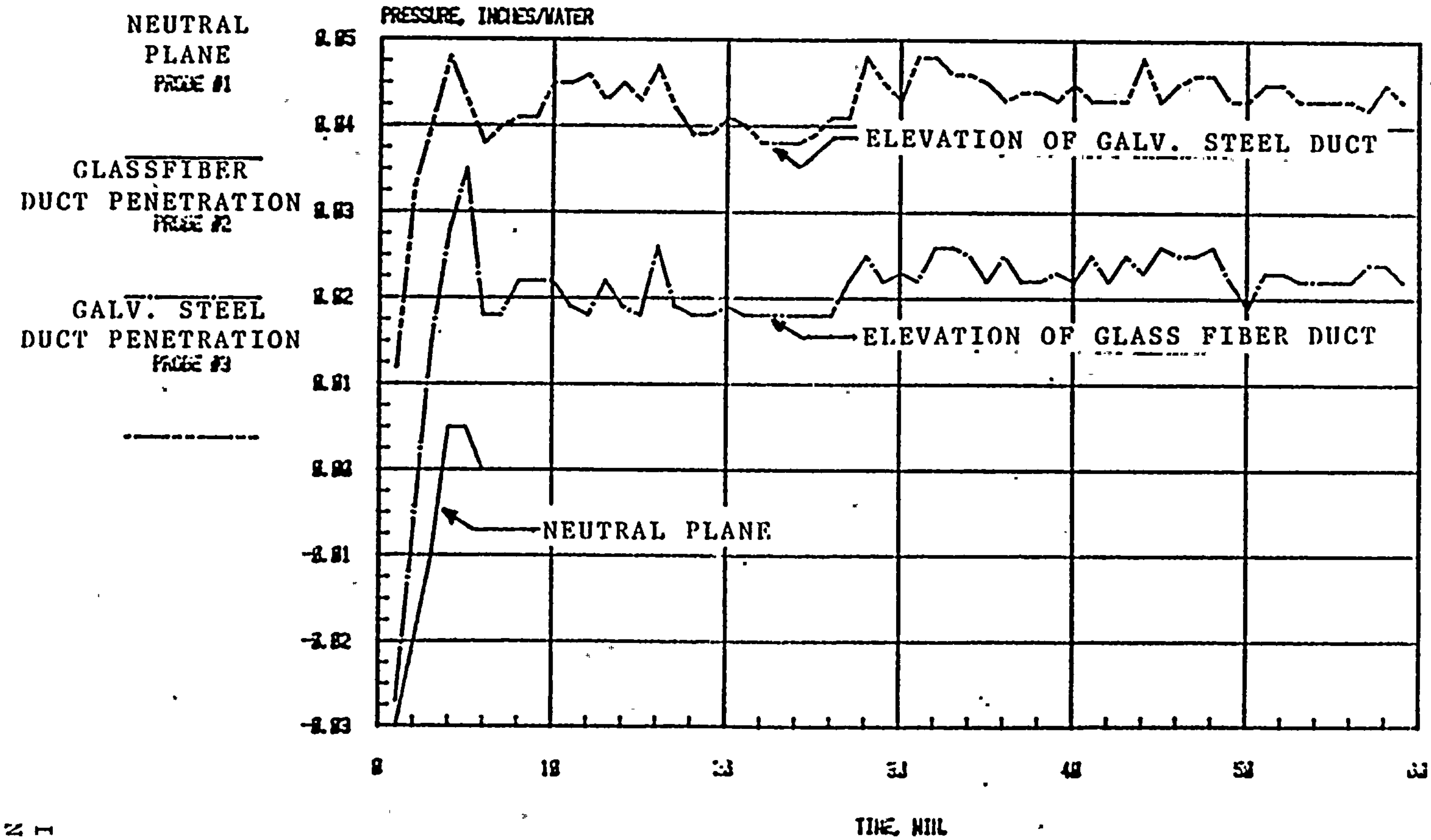
ILL. 1B
NC 505-12


NC 505
ILL. 2
K85-94

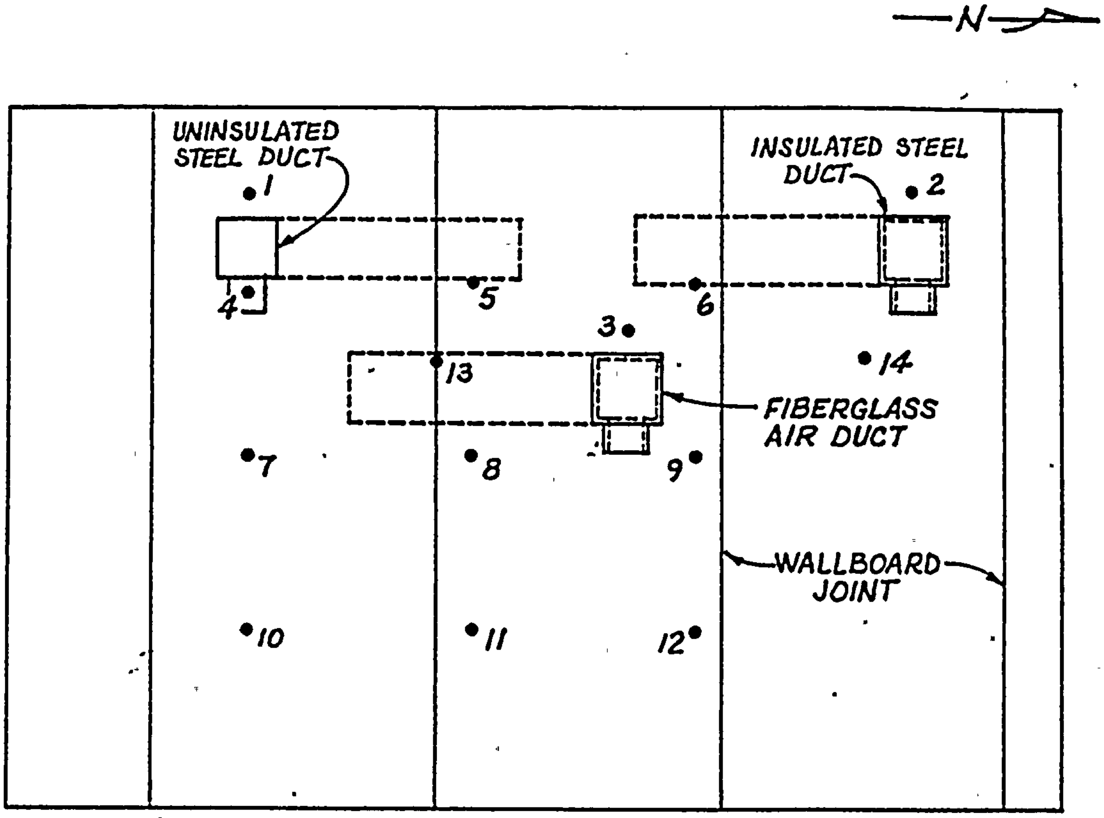

MINUTES
STANDARD TIME TEMPERATURE CURVE
THERMOCOUPLE LOCATIONS
FURNACE TEMPERATURES
Underwriters' Laboratories Inc.
Fire Endurance Test

ILL.3

FURNACE PRESSURE

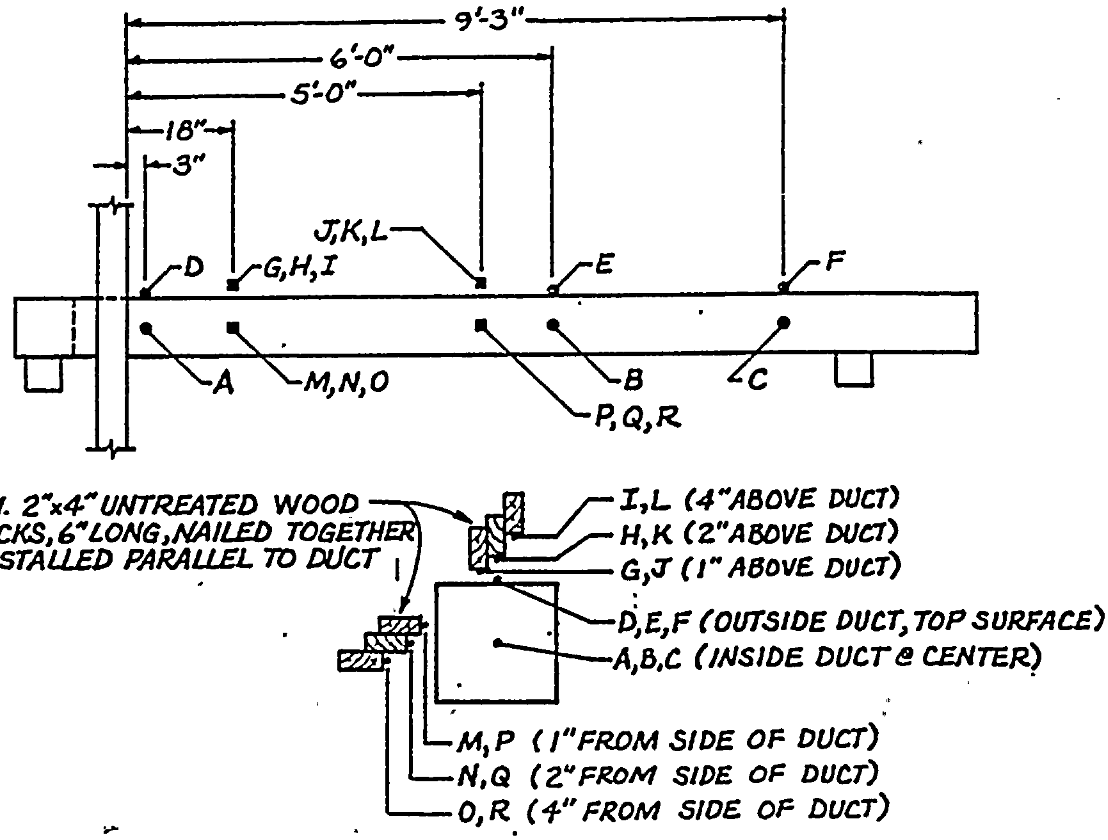


ILL. 4
NC 505-12



UNEXPOSED SURFACE THERMOCOUPLES

ILL. 5
NC 505-12



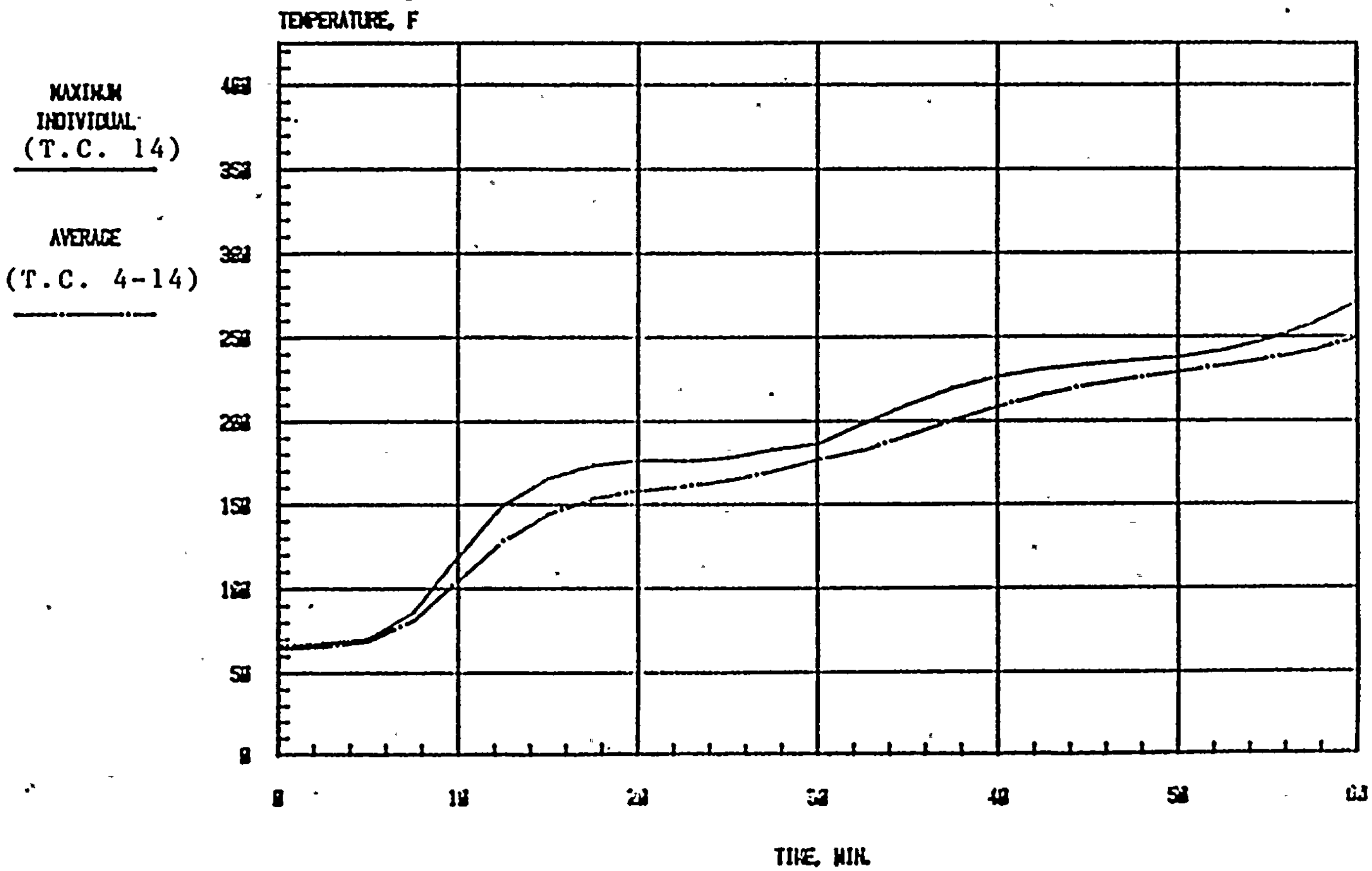
THERMOCOUPLE LOCATION	THERMOCOUPLE NOS.		
	INSULATED STEEL DUCT	STEEL DUCT W/O INSULATION	FIBERGLASS AIR DUCT
A	15	33	51
B	16	34	52
C	17	35	53
D	36	18	54
E	37	19	55
F	38	20	56
G	21	39	57
H	22	40	58
I	23	41	59
J	24	42	60
K	25	43	61
L	26	44	62
M	27	45	63
N	28	46	64
O	29	47	65
P	30	48	66
Q	31	49	67
R	32	50	68

ILL. 6
NC 505-12

DUCT THERMOCOUPLE LOCATIONS

UNEXPOSED SURFACE

AVERAGE AND MAXIMUM WALL TEMPERATURES

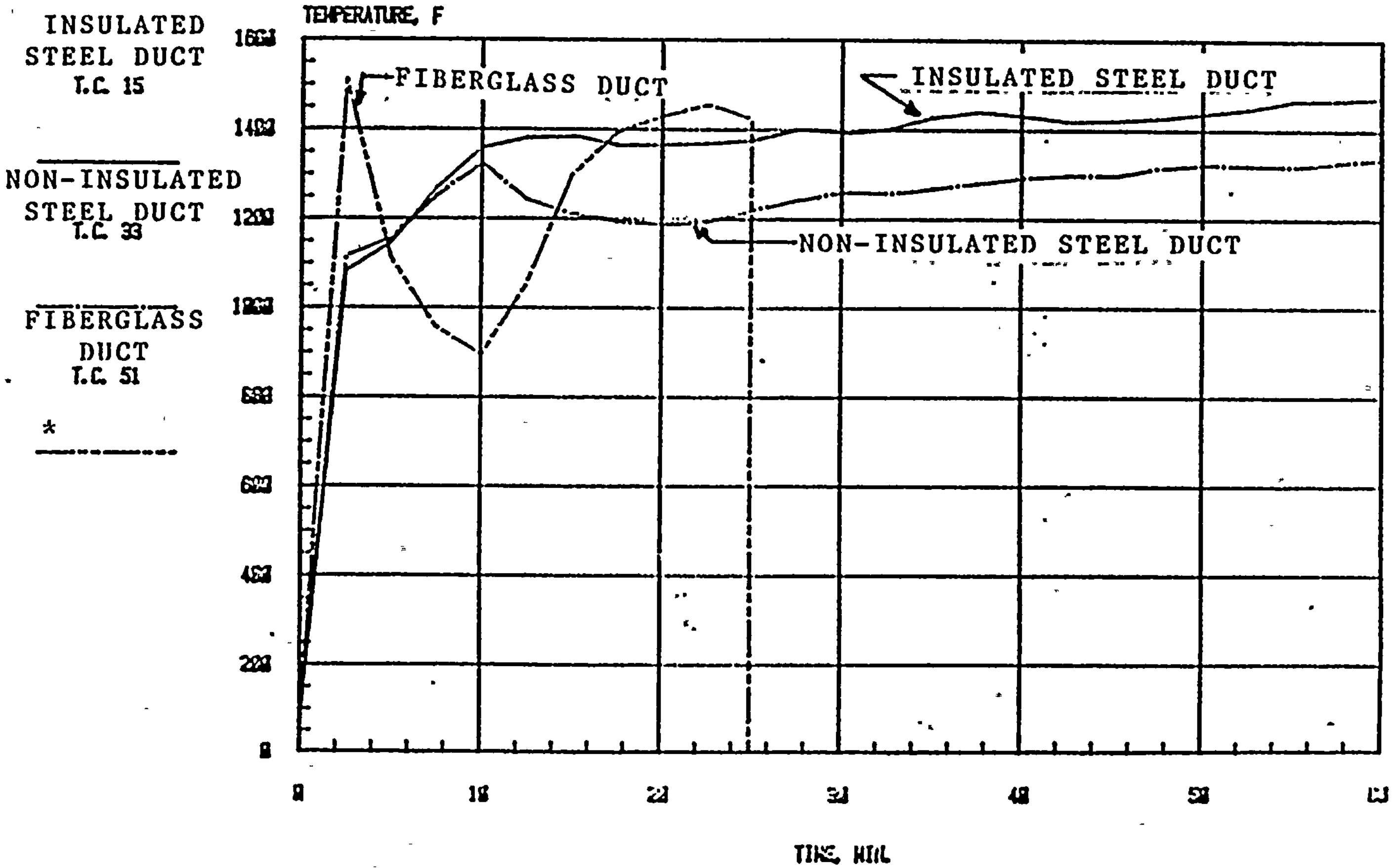


ILL. 7
NC 505-12

TEMPERATURES WITHIN DUCT ASSEMBLIES

THERMOCOUPLES LOCATED 3 IN. FROM

UNEXPOSED SIDE OF WALL ASSEMBLY



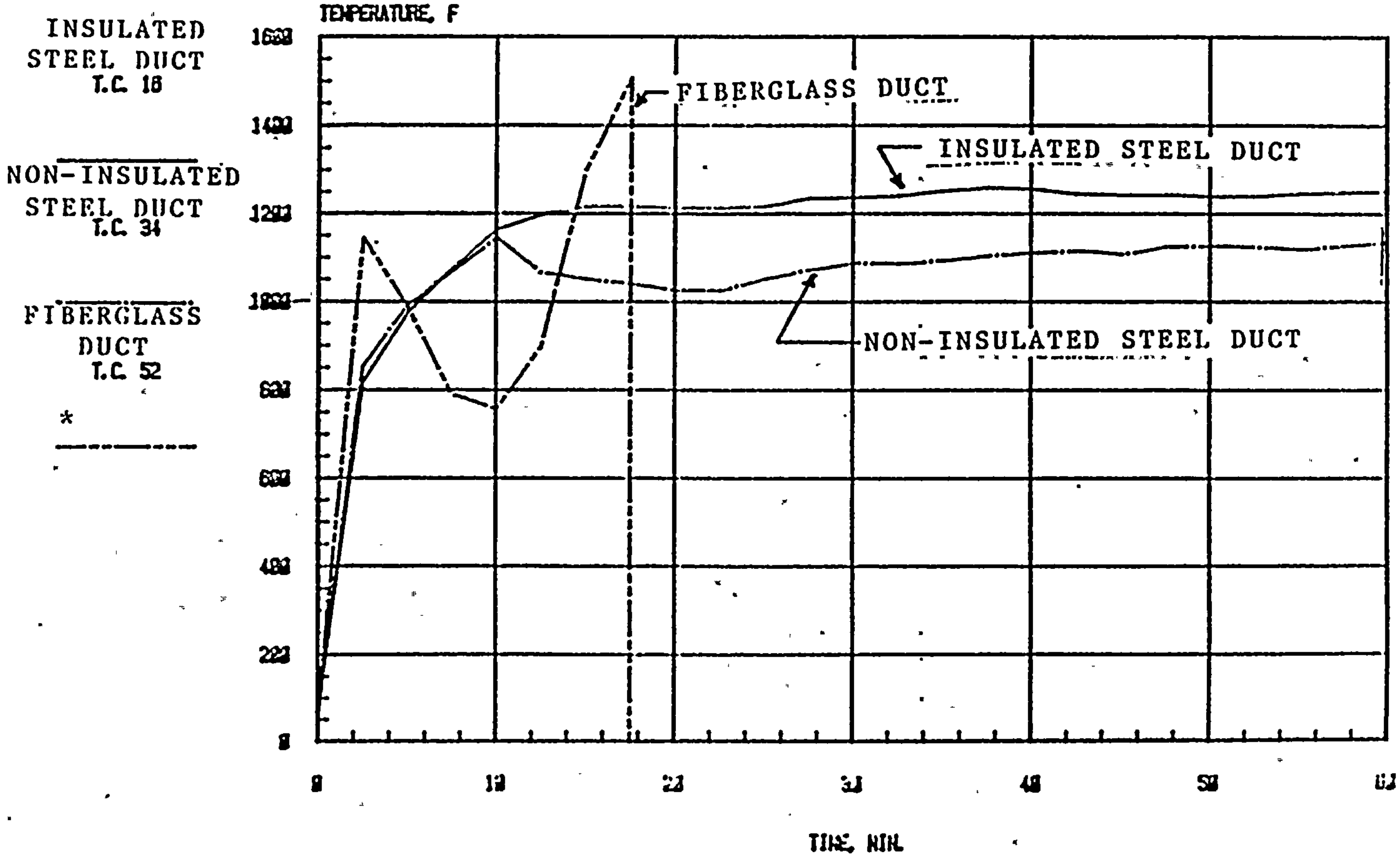
*SECTION OF FIBERGLASS DUCT IN AREA OF T.C. 51 COLLAPSED AT 25 MIN.

ILL. 8
XC 505-12

TEMPERATURES <u>WITHIN</u> DUCT ASSEMBLIES

THERMOCOUPLES LOCATED 6 FT. FROM

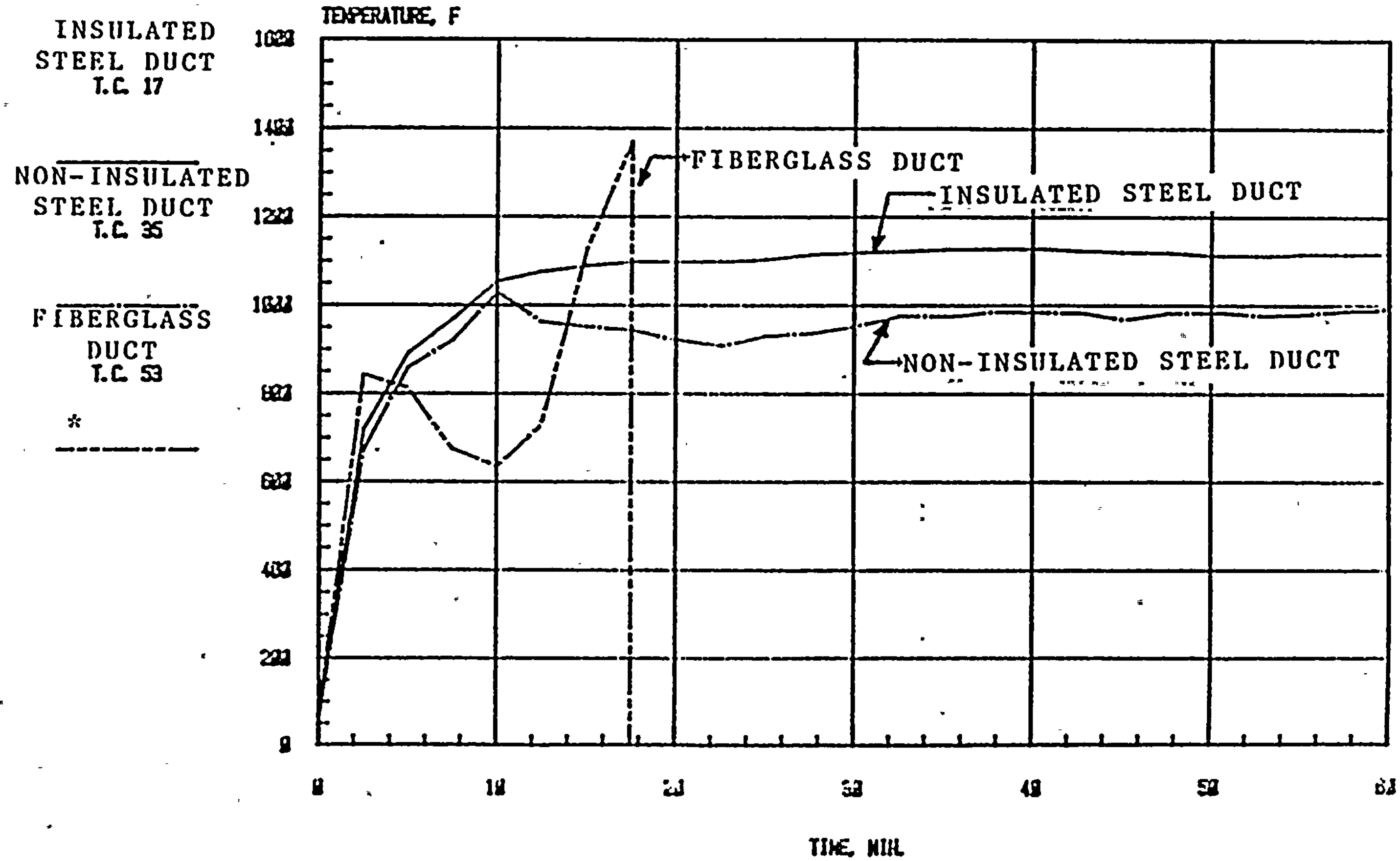
UNEXPOSED SIDE OF WALL ASSEMBLY



*SECTION OF FIBERGLASS DUCT IN AREA OF T.C. 52 COLLAPSED AT 19 MIN.

ILL. 9
NC 505-12

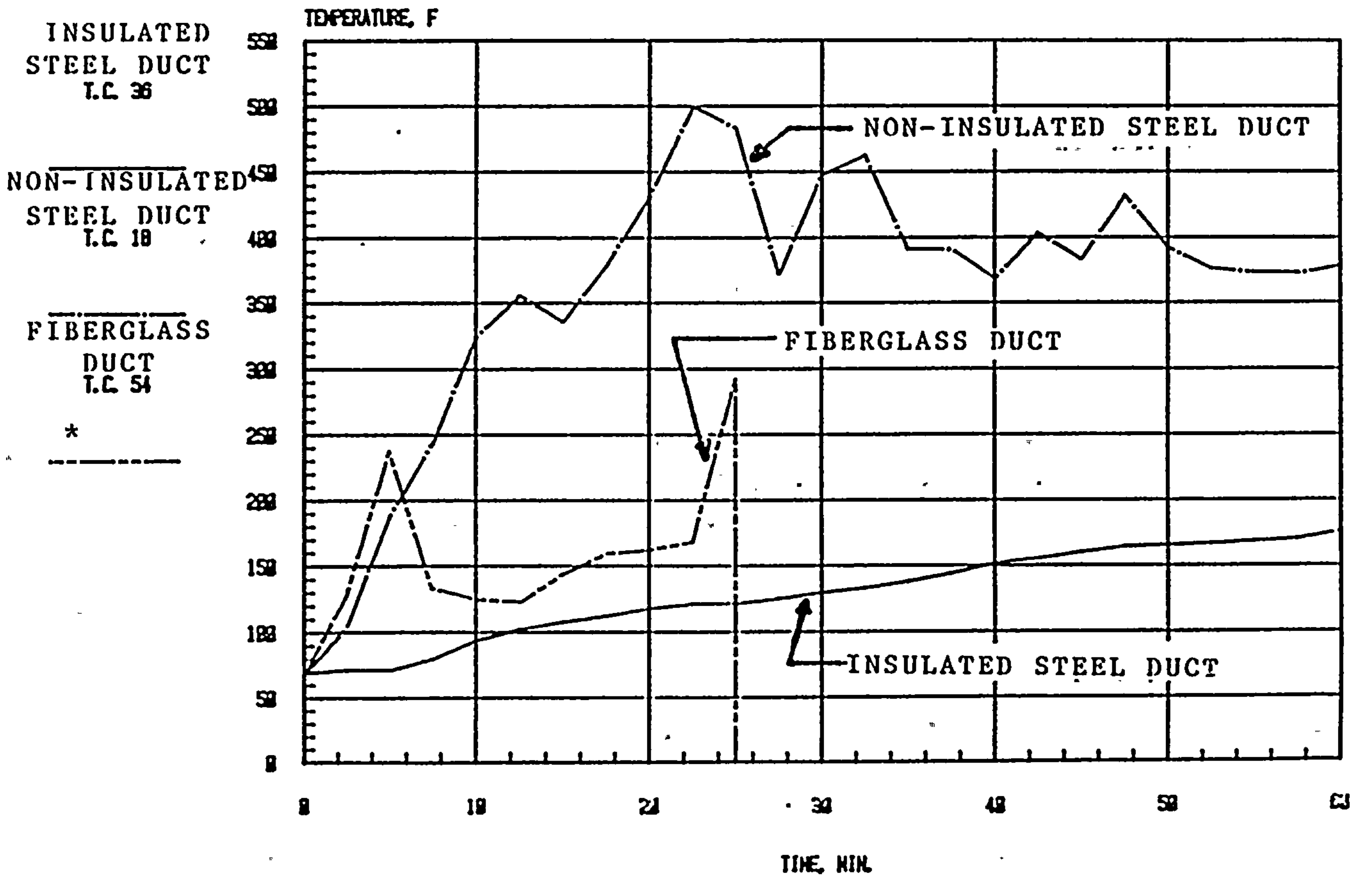
TEMPERATURES WITHIN DUCT ASSEMBLIES
THERMOCOUPLES LOCATED 9 FT. 3 IN. FROM
UNEXPOSED SIDE OF WALL ASSEMBLY



*SECTION OF FIBERGLASS DUCT IN AREA OF T.C. 53 COLLAPSED AT 25 MIN.

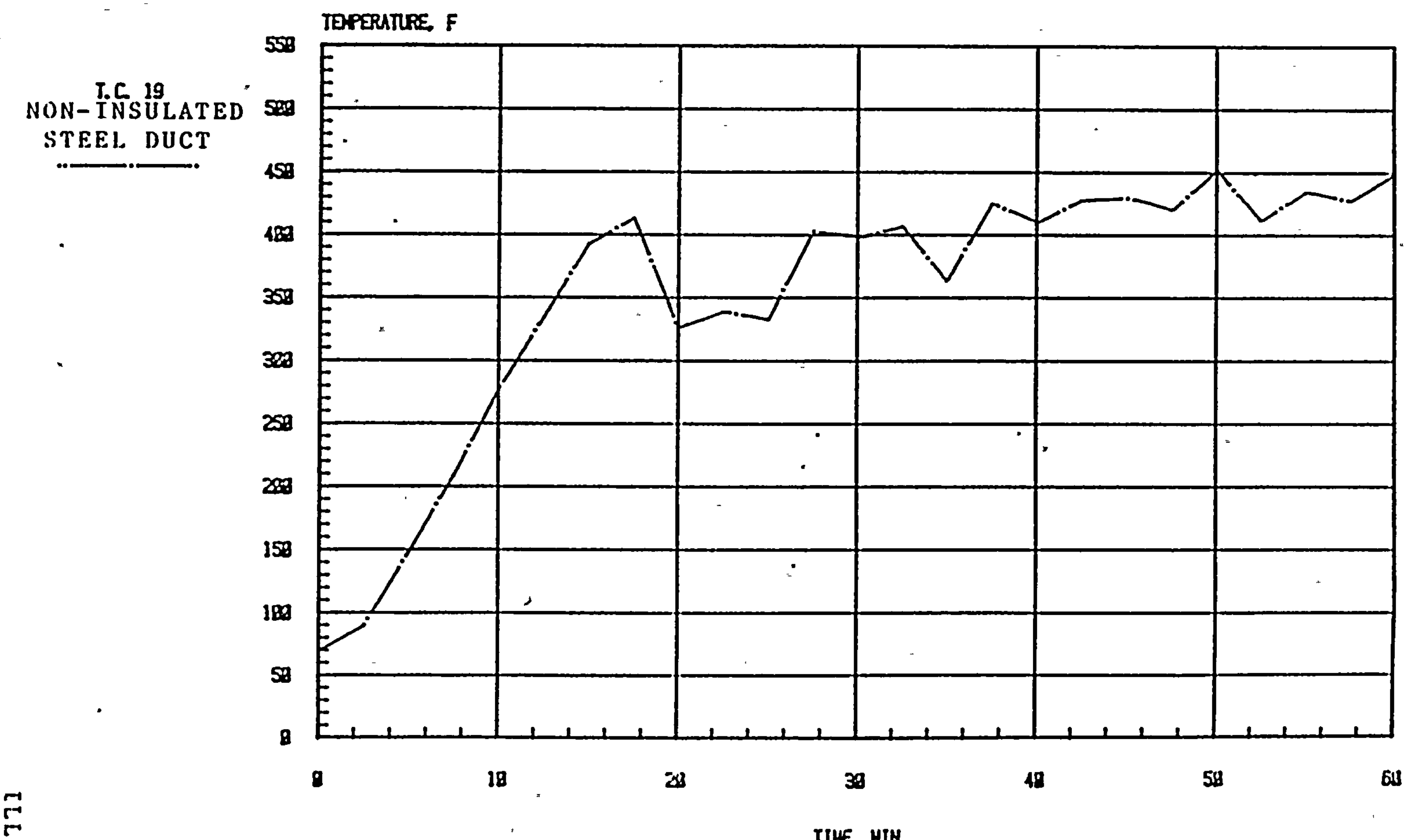
ILL. 10
NC 505-12

TEMPERATURES ON TOP SURFACE OF DUCT ASSEMBLIES
THERMOCOUPLES LOCATED 3 IN. FROM
UNEXPOSED SIDE OF WALL ASSEMBLY



*SECTION OF FIBERGLASS DUCT IN THE AREA OF T.C. 54 COLLAPSED AT 25 MIN.

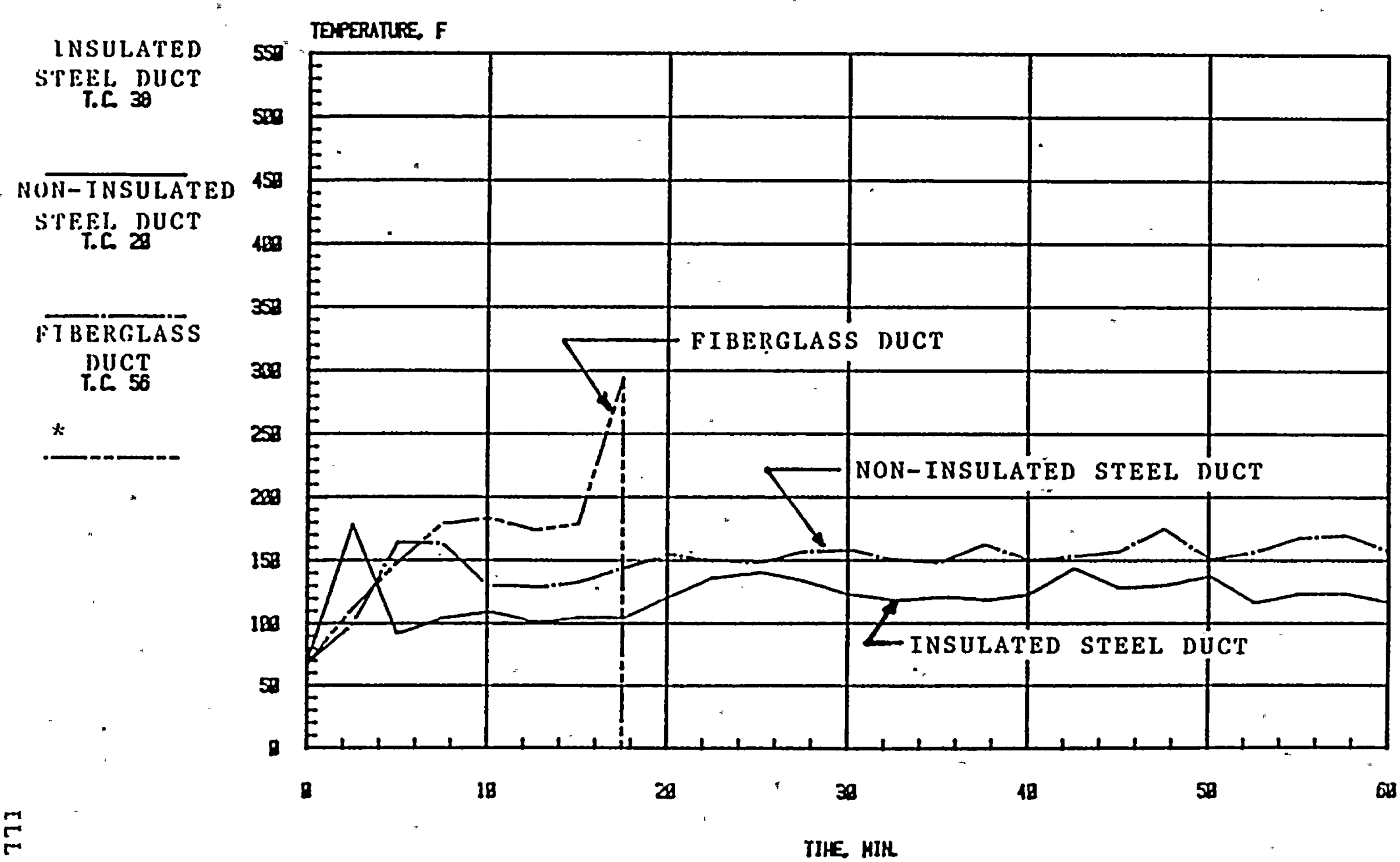
TEMPERATURE ON TOP SURFACE OF NON-INSULATED
STEEL DUCT ASSEMBLY
THERMOCOUPLE LOCATED 6 FT. FROM
UNEXPOSED SIDE OF WALL ASSEMBLY*



*T.C. 37 & 55 LOCATED ON THE TOP SURFACES OF THE INSULATED GALV. STEEL AIR DUCT & FIBERGLASS AIR DUCT, RESPECTIVELY, MALFUNCTIONED AT THE START OF TEST & REMAINED INOPERABLE THROUGHOUT THE TEST

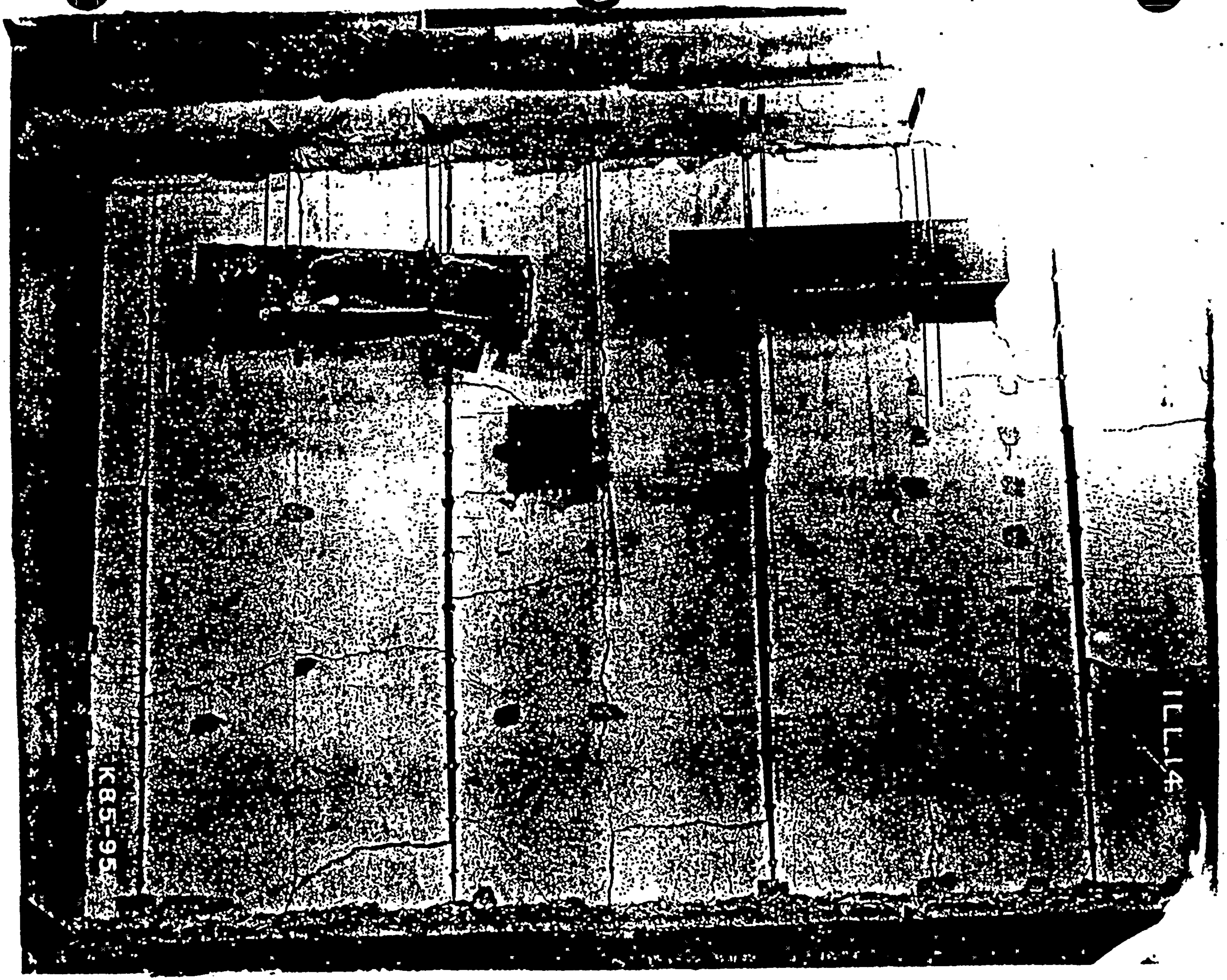
ILL. 12
NC 505-12

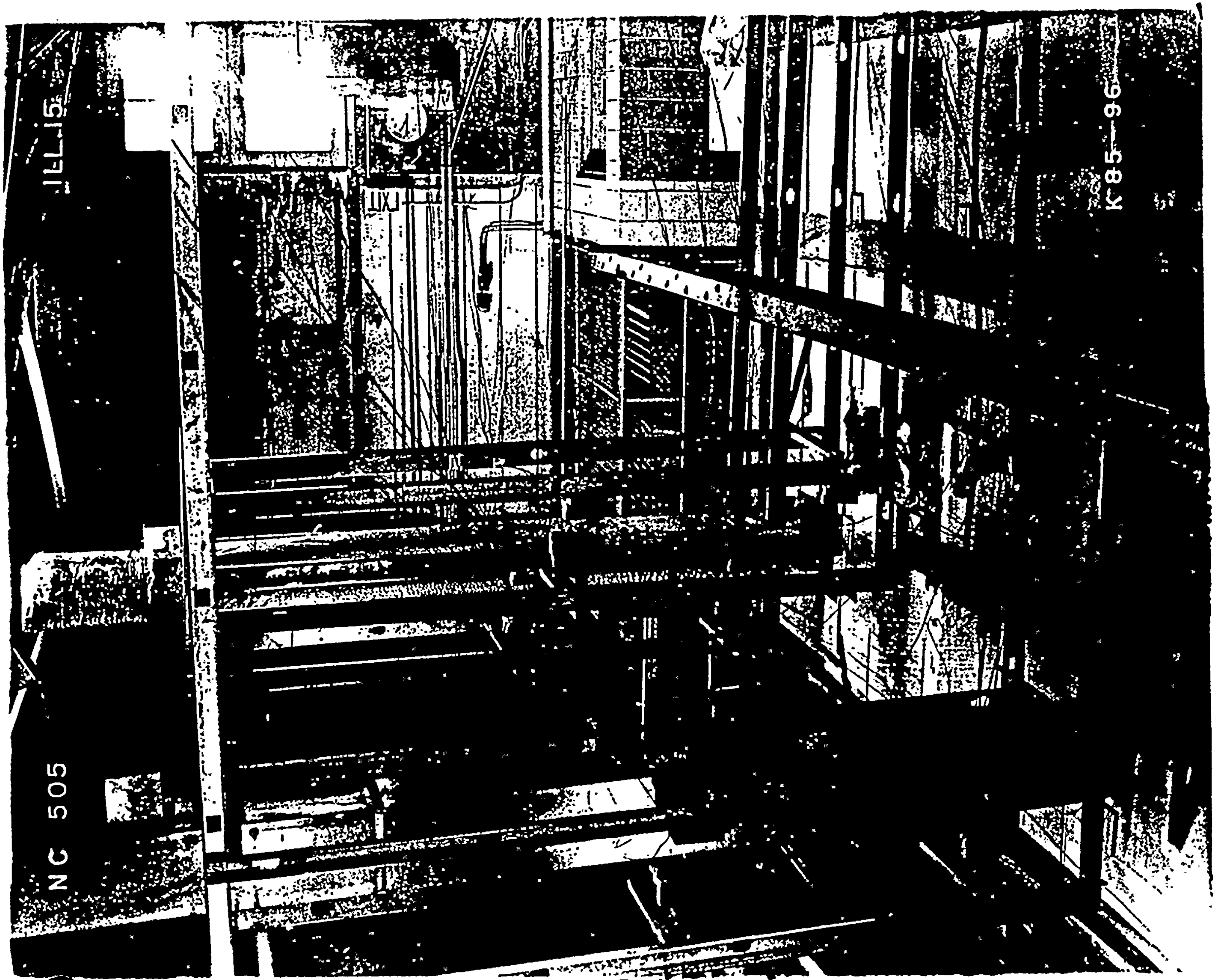
TEMPERATURES ON TOP SURFACE OF DUCT ASSEMBLIES
THERMOCOUPLES LOCATED 9 FT. 3 IN. FROM
UNEXPOSED SIDE OF WALL ASSEMBLY



*SECTION OF FIBERGLASS DUCT IN THE AREA OF T.C. 56 COLLAPSED AT 19 MIN.

ILL. 13
NC 505-12


K85-95
ILL-14


ILL.15
NC 505
K85-96

APPENDIX A

TABULAR TEMPERATURE TEST DATA

The following tables contain the temperature data recorded at 2 min, 30 s intervals during the fire test.

ILL.	Description
A2	Thermocouple Index
A3-A5	Temperatures measured on unexposed surface of wall assembly.
A6-A9	Temperatures measured on insulated steel duct.
A10-A13	Temperatures measured on steel duct without insulation.
A14-A17	Temperatures measured on rigid fiberglass duct.

THERMOCOUPLE INDEX

UNEXPOSED SURFACE THERMOCOUPLES 1-14

	Insulated Steel Duct	Steel Duct Without Insulation	Fiberglass Duct
Inside Duct - 3 in. from wall	15	33	51
Inside Duct - 6 ft from wall	16	34	52
Inside Duct - 9 ft, 3 in. from wall	17	35	53
Outside Duct, Top Surface, 3 in. from wall	36	18	54
Outside Duct, Top Surface, 6 ft from wall	37	19	55
Outside Duct, Top Surface, 9 ft, 3 in. from wall	38	20	56
Outside Duct, w/wood 1 in. above top, 18 in. from wall	21	39	57
Outside Duct, w/wood 2 in. above top, 18 in. from wall	22	40	58
Outside Duct, w/wood 4 in. above top, 18 in. from wall	23	41	59
Outside Duct, w/wood 1 in. above top, 60 in. from wall	24	42	60
Outside Duct, w/wood 2 in. above top, 60 in. from wall	25	43	61
Outside Duct, w/wood 4 in. above top, 60 in. from wall	26	44	62
Outside Duct, w/wood 1 in. from side, 18 in. from wall	27	45	63
Outside Duct, w/wood 2 in. from side, 18 in. from wall	28	46	64
Outside Duct, w/wood 4 in. from side, 18 in. from wall	29	47	65
Outside Duct, w/wood 1 in. from side, 60 in. from wall	30	48	66
Outside Duct, w/wood 2 in. from side, 60 in. from wall	31	49	67
Outside Duct, w/wood 4 in. from side, 60 in. from wall	32	50	68

FILE NC505-12 ILL. NO. A-3 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	1	2	3	4	5
0: 0	65.0	66.5	65.4	63.6	65.4
2:30	67.0	67.4	66.5	64.5	66.5
5: 0	71.4	70.1	69.2	69.0	70.1
7:30	80.6	78.5	77.4	85.8	84.8
10: 0	106.0	99.6	97.5	119.5	112.9
12:30	135.5	124.6	120.1	150.2	136.9
15: 0	157.3	143.9	137.6	166.1	150.4
17:30	169.4	155.3	147.7	173.9	156.6
20: 0	175.5	161.9	153.1	176.7	158.8
22:30	178.6	164.6	157.9	176.2	159.9
25: 0	181.2	166.2	167.6	178.3	164.6
27:30	183.9	169.9	176.3	183.2	170.8
30: 0	188.0	174.3	179.2	186.6	174.7
32:30	191.2	178.5	187.8	198.5	179.1
35: 0	205.8	191.2	198.5	209.9	188.8
37:30	218.3	202.9	207.7	219.7	197.4
40: 0	227.7	213.8	215.0	226.8	203.3
42:30	234.6	221.7	220.0	231.1	212.3
45: 0	238.6	226.2	223.4	233.9	217.3
47:30	239.9	228.6	225.8	236.1	221.[illegible]
50: 0	239.8	229.8	228.4	238.2	224.5
52:30	239.5	230.8	233.4	240.1	227.3
55: 0	239.1	232.0	237.0	242.2	232.4
57:30	239.1	234.4	239.7	245.2	237.4
60: 0	239.5	236.0	241.8	250.1	243.0

FILE NC505-12 ILL. NO. A-4 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	6	7	8	9	10
0: 0	65.1	63.3	63.9	64.6	[illegible]
2:30	66.1	64.4	64.8	65.5	65.4
5: 0	70.5	68.0	68.4	69.1	67.8
7:30	86.0	81.3	81.8	81.2	76.7
10: 0	112.9	106.1	107.6	105.1	96.8
12:30	136.2	129.5	131.1	127.8	118.6
15: 0	149.8	145.2	146.0	143.6	137.1
17:30	156.4	154.0	153.8	152.2	149.7
20: 0	159.4	158.5	157.7	156.2	156.2
22:30	162.1	160.4	159.2	158.1	159.6
25: 0	166.9	162.8	163.9	161.8	161.6
27:30	173.3	167.6	169.8	167.5	165.7
30: 0	175.5	175.0	174.0	173.9	174.4
32:30	184.0	178.3	177.1	177.0	177.9
35: 0	194.5	188.4	186.6	186.1	185.3
37:30	204.1	198.7	195.4	195.5	195.5
40: 0	213.0	207.5	203.8	204.5	203.[illegible]
42:30	219.5	214.9	211.4	212.4	210.[illegible]
45: 0	224.2	220.7	217.3	218.7	[illegible]
47:30	228.0	224.9	221.8	223.[illegible]	221.[illegible]
50: 0	231.4	228.3	225.3	226.[illegible]	225.4
52:30	234.9	231.7	228.6	229.9	229.6
55: 0	238.1	236.0	231.9	232.7	23[illegible].5
57:30	242.4	240.0	236.1	236.4	233.8
60: 0	249.2	244.2	242.1	242.1	243.3

FILE NC505-12 ILL. NO. A-5 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	11	12	13	14
0: 0	65.2	65.8	67.0	66.5
2:30	66.1	66.6	68.0	67.4
5: 0	68.9	69.4	70.3	69.0
7:30	78.8	78.7	80.8	75.8
10: 0	100.9	99.9	103.5	91.9
12:30	123.3	122.3	125.7	111.9
15: 0	140.7	140.4	140.9	130.6
17:30	151.3	151.7	149.7	144.3
20: 0	156.3	157.0	154.8	153.3
22:30	158.9	159.7	158.2	158.4
25: 0	162.0	162.7	162.0	163.1
27:30	165.8	167.2	168.1	170.5
30: 0	174.3	175.7	182.0	181.2
32:30	177.5	179.3	190.4	187.9
35: 0	186.0	189.2	198.7	192.5
37:30	195.4	199.1	206.5	199.2
40: 0	203.3	208.1	214.0	207.9
42:30	210.3	215.4	220.5	217.0
45: 0	215.8	221.1	225.6	224.6
47:30	220.4	225.6	229.4	230.9
50: 0	224.9	230.0	243.2	238.[illegible]
52:30	229.0	233.9	237.7	242.2
55: 0	233.8	237.4	242.5	248.8
57:30	238.3	241.9	249.1	258.[illegible]
60: 0	245.1	249.2	266.6	271.1

FILE NC505-12 ILL. NO. A-6 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	15	16	17	36	*37
0: 0	67.9	67.8	68.1	69.6	69.9
2:30	1084.5	820.1	720.1	71.7	163.0
5: 0	1148.1	976.7	892.8	71.3	70.8
7:30	1270.0	1077.0	969.6	79.8	71.3
10: 0	1360.3	1164.4	1055.5	93.9	72.6
12:30	1381.8	1197.8	1076.7	102.6	72.6
15: 0	1385.0	1216.2	1089.8	108.1	73.2
17:30	1364.0	1214.5	1098.4	112.7	74.4
20: 0	1366.5	1211.5	1098.1	118.1	77.9
22:30	1369.7	1212.3	1099.6	121.4	77.1
25: 0	1376.8	1217.2	1104.3	121.8	76.9
27:30	1400.2	1235.7	1116.1	125.4	73.2
30: 0	1392.6	1237.4	1120.7	130.0	72.8
32:30	1401.4	1240.7	1123.5	133.5	71.4
35: 0	1427.9	1251.7	1127.5	138.3	72.5
37:30	1440.4	1258.5	1128.4	144.4	71.9
40: 0	1430.4	1254.3	1129.0	152.3	74.5
42:30	1418.5	1243.6	1122.9	155.8	72.1
45: 0	1421.9	1241.1	1119.5	160.7	73.2
47:30	1427.2	1241.3	1118.0	164.9	73.4
50: 0	1437.9	1237.8	1111.7	166.[illegible]	73.3
52:30	1448.5	1238.7	1111.1	167.3	73.9
55: 0	1466.6	1246.0	1115.9	169.1	72.[illegible]
57:30	1468.7	1249.0	1115.4	170.7	72.3
60: 0	1472.7	1251.1	1118.1	176.3	73.0

*T.C. 37, located on top surface of insulated steel duct, 6 ft from unexposed surface of wall, malfunctioned at the start of test and remained inoperable throughout the test.

FILE NC505-12 ILL. NO. A-7 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	38	21	22	23	24
0: 0	69.6	69.6	69.5	69.2	70.8
2:30	178.4	74.5	73.1	73.6	72.7
5: 0	92.0	98.6	88.3	90.0	80.0
7:30	104.4	110.6	103.6	102.4	86.5
10: 0	109.3	136.6	125.5	137.4	159.1
12:30	101.0	139.1	141.8	159.8	186.0
15: 0	105.0	146.5	161.7	175.2	210.2
17:30	104.4	150.8	173.9	182.7	214.4
20: 0	121.3	163.8	175.9	184.5	195.5
22:30	136.7	178.7	189.3	181.6	175.5
25: 0	140.8	138.8	176.7	166.1	176.9
27:30	133.5	153.8	187.6	190.7	199.2
30: C	122.8	170.2	197.9	198.5	209.1
32:30	118.0	161.6	199.2	199.3	202.2
35: 0	121.0	171.3	205.7	203.7	207.9
37:30	118.3	174.0	213.3	209.8	207.3
40: 0	123.4	178.8	219.5	215.9	218.5
42:30	143.9	185.3	221.4	218.7	213.9
45: 0	128.3	188.5	226.2	224.3	217.8
47:30	130.8	191.1	224.2	223.0	218.3
50: 0	137.8	198.6	231.6	226.3	217.9
52:30	116.5	199.1	233.6	224.2	207.3
55: 0	124.8	198.0	240.1	230.6	205.[illegible]
57:30	123.3	211.4	248.8	236.6	192.7
60: 0	116.1	204.2	251.8	235.5	200.1

FILE NC505-12 ILL. NO. A-8 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	25	26	27	28	29
0: 0	70.5	70.3	69.4	67.5	67.4
2:30	75.4	73.3	71.0	68.5	68.2
5: 0	88.3	87.9	73.8	70.9	69.4
7:30	100.4	99.1	82.1	75.6	71.5
10: 0	144.5	113.1	100.7	89.1	77.6
12:30	153.5	124.1	105.4	95.3	85.0
15: 0	156.6	135.8	113.9	106.9	91.2
17:30	164.4	159.1	118.8	109.9	95.6
20: 0	158.6	153.8	121.0	108.9	99.4
22:30	158.8	163.1	128.3	116.3	103.2
25: 0	157.6	155.1	103.1	107.8	104.1
27:30	153.2	145.7	118.5	119.2	108.4
30: 0	160.5	151.0	127.1	125.3	109.4
32:30	159.3	137.7	131.1	130.4	117.0
35: 0	160.7	156.9	137.4	135.1	118.5
37:30	159.5	140.9	148.6	146.4	126.9
40: 0	166.4	157.4	154.1	153.0	130.0
42:30	169.1	160.9	159.9	154.9	133.1
45: 0	167.1	149.3	163.8	158.2	136.4
47:30	168.6	158.2	168.4	160.7	138.6
50: 0	171.4	162.8	170.2	167.3	141.3
52:30	162.0	155.8	179.1	17[illegible]	145.[illegible]
55: 0	168.1	154.2	184.5	180.9	147.1
57:30	167.7	156.7	181.3	181.1	151.1
60: 0	167.2	154.6	185.2	185.3	154.4

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	30	31	32
0: 0	70.2	68.1	67.9
2:30	70.2	68.7	68.2
5: 0	71.0	69.4	68.8
7:30	73.1	70.4	69.4
10: 0	75.2	72.7	70.9
12:30	79.7	76.6	73.5
15: 0	88.7	82.8	78.2
17:30	101.2	87.7	82.5
20: 0	87.2	90.6	86.4
22:30	85.9	93.2	89.5
25: 0	88.6	97.5	93.6
27:30	89.2	97.4	91.4
30: 0	91.8	98.7	91.7
32:30	93.3	99.3	92.1
35: 0	90.7	101.0	93.1
37:30	95.6	103.6	95.5
40: 0	95.4	105.6	96.6
42:30	93.1	107.3	97.8
45: 0	98.5	106.1	98.6
47:30	98.3	109.5	99.7
50: 0	102.9	111.1	101.1
52:30	104.4	112.2	101.3
55: 0	105.6	115.8	103.9
57:30	108.9	118.6	104.2
60: 0	111.1	121.0	105.4

FILE NC505-12 ILL. NO. A-10 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	33	34	35	18	19
0: 0	69.2	69.1	69.1	68.5	68.9
2:30	1117.9	856.1	673.9	103.1	89.6
5: 0	1157.8	993.1	860.5	187.0	147.9
7:30	1252.5	1070.1	922.2	243.0	208.8
10: 0	1374.8	1143.9	1028.3	324.3	277.4
12:30	1242.3	1065.1	961.2	355.8	334.7
15: 0	1210.0	1049.2	950.8	335.6	392.9
17:30	1193.0	1038.8	943.1	378.6	413.5
20: 0	1187.4	1024.1	921.0	431.3	326.5
22:30	1194.5	1024.2	907.6	499.4	338.9
25: 0	1220.9	1051.4	931.9	483.1	332.3
27:30	1243.3	1071.7	937.4	372.2	403.0
30: 0	1260.8	1087.7	953.2	448.1	397.8
32:30	1257.0	1085.3	977.2	462.7	407.1
35: 0	1269.1	1093.0	974.8	390.9	363.2
37:30	1281.1	1103.6	985.5	390.7	425.1
40: 0	1292.9	1110.5	994.1	368.3	409.9
42:30	1299.2	1114.6	983.5	403.3	428.0
45: 0	1298.3	1105.3	963.1	381.9	[illegible]
47:30	1316.0	1124.2	983.1	432.1	[illegible]
50: 0	1323.3	1125.5	984.1	391.9	412.4
52:30	1319.5	1121.8	976.4	375.6	411.7
55: 0	1318.8	1116.8	980.0	372.8	434.7
57:30	1329.0	1127.1	988.1	372.4	427.2
60: 0	1336.9	1134.3	991.8	378.7	448.6

FILE NC505-12 ILL. NO. A-11 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	20	39	40	41	42
0: 0	68.8	70.1	69.7	69.9	71.0
2:30	99.3	98.2	86.8	89.8	84.5
5: 0	164.2	142.4	115.2	110.1	115.8
7:30	163.1	163.2	131.2	122.1	129.8
10: 0	129.9	218.5	165.5	141.3	164.8
12:30	128.6	251.8	187.6	146.5	170.2
15: 0	133.3	241.7	191.5	153.6	158.2
17:30	144.2	252.4	196.8	154.0	166.4
20: 0	154.8	248.2	197.6	155.2	167.9
22:30	149.4	269.0	209.4	162.1	165.2
25: 0	148.3	248.9	204.1	161.5	157.9
27:30	157.2	308.0	232.8	172.8	158.2
30: 0	158.3	295.6	242.1	184.5	163.0
32:30	150.1	336.3	253.3	183.7	169.2
35: 0	148.0	341.0	274.0	201.9	177.1
37:30	162.6	350.4	288.3	206.0	177.0
40: 0	150.3	375.3	297.9	210.4	179.2
42:30	153.5	347.5	284.4	204.8	179.3
45: 0	157.[illegible]	370.2	307.6	212.0	186.3
47:30	175.1	363.2	312.5	218.2	188.2
50: 0	151.2	376.2	317.6	220.5	187.3
52:30	156.5	373.2	315.5	219.3	194.4
55: 0	168.0	399.1	328.6	224.4	189.5
57:30	169.9	407.8	339.8	229.3	195.0
60: 0	156.9	393.5	330.6	222.5	195.1

FILE NC505-12 ILL. NO. A-12 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	43	44	45	46	47
0: 0	70.3	70.1	69.8	68.2	68.1
2:30	83.8	85.0	81.4	75.3	72.1
5: 0	106.7	107.7	103.4	92.0	79.8
7:30	119.6	117.2	125.3	107.5	86.9
10: 0	141.2	139.2	194.0	149.5	103.5
12:30	146.6	139.5	323.0	256.7	131.1
15: 0	146.0	139.8	348.8	278.4	138.6
17:30	148.9	136.4	363.9	287.1	138.8
20: 0	150.1	136.7	357.7	287.6	140.8
22:30	149.3	128.3	368.2	295.7	144.2
25: 0	146.0	123.7	176.1	159.8	112.2
27:30	144.0	120.4	336.1	238.7	126.0
30: 0	150.6	127.9	371.2	292.3	134.0
32:30	155.1	137.5	388.1	307.0	146.2
35: 0	161.9	143.8	399.3	328.2	146.7
37:30	160.8	139.2	412.2	335.7	155.3
40: 0	176.7	165.4	424.3	345.3	158.6
42:30	163.5	143.1	436.4	357.7	163.8
45: 0	179.3	160.2	445.7	368.1	165.6
47:30	184.9	172.2	457.9	375.0	166.[illegible]
50: 0	168.9	145.7	466.9	383.6	165.3
52:30	176.9	151.8	466.9	387.0	173.7
55: 0	274.8	148.6	469.4	392.4	173.9
57:30	189.1	163.6	479.0	397.6	175.3
60: 0	179.7	154.3	491.6	406.1	182.1

FILE NC505-12 ILL. NO. A-13 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	48	49	50
0: 0	69.8	68.4	68.2
2:30	80.1	73.8	71.0
5: 0	94.4	80.3	75.1
7:30	99.4	86.1	78.5
10: 0	127.8	100.8	86.0
12:30	128.6	103.2	88.8
15: 0	139.9	108.5	91.3
17:30	126.4	106.7	91.8
20: 0	132.9	112.5	94.8
22:30	120.5	107.9	93.9
25: 0	109.2	107.6	92.0
27:30	112.8	109.8	93.0
30: 0	113.1	110.7	93.5
32:30	128.7	112.7	95.8
35: 0	122.2	111.5	95.1
37:30	130.4	115.6	96.9
40: 0	121.6	116.7	96.7
42:30	132.5	118.3	99.3
45: 0	131.2	118.0	99.1
47:30	130.1	118.2	100.2
50: 0	129.4	119.3	101.2
52:30	128.2	116.6	100.3
55: 0	127.4	118.3	101.0
57:30	133.9	120.1	101.9
60: 0	134.5	121.5	102.4

FILE NC505-12 ILL. NO. A-14 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	51	52	53	54	*55
0: 0	66.9	67.1	67.1	67.3	70.6
2:30	1510.1	1144.3	842.7	128.0	2.3
5: 0	1111.7	986.1	812.7	237.5	130.7
7:30	957.6	790.0	674.1	132.9	36.3
10: 0	894.6	757.5	635.5	124.3	13.5
12:30	1052.2	897.3	730.3	122.5	24.6
15: 0	1297.7	1300.2	1124.3	144.1	5.6
17:30	1394.5	1508.3	1370.2	159.6	53.0
20: 0	1431.2	176.2	117.6	162.7	248.2
22:30	1455.4	66.4	73.0	168.7	66.9
25: 0	1423.4	61.6	72.0	292.9	54.0
27:30	1356.7	64.0	70.7	87.1	61.2
30: 0	1346.5	64.0	70.1	86.2	60.8
32:30	1352.8	63.7	69.4	84.6	63.1
35: 0	1384.7	63.3	69.9	82.8	63.5
37:30	1407.4	63.6	69.6	82.8	63.2
40: 0	1421.2	63.6	69.6	80.5	64.5
42:30	1419.6	63.4	69.2	82.8	64.2
45: 0	1436.2	63.2	70.2	81.3	65.0
47:30	1455.2	63.8	69.2	84.6	63.6
50: 0	1474.6	64.1	69.4	82.4	64.1
52:30	1495.7	63.5	69.7	83.5	65.2
55: 0	1522.9	63.3	69.5	85.8	65.6
57:30	1539.0	63.7	69.8	86.5	65.8
60: 0	1546.0	63.6	69.7	84.3	66.3

*T.C. 55, located on top surface of fiberglass duct, 6 ft from unexposed surface of wall, malfunctioned at the start of test and remained inoperable throughout the test.

FILE NC505-12 ILL. NO. A-15 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	56	57	58	59	60
0: 0	68.1	68.6	68.6	68.6	68.4
2:30	111.7	76.7	75.2	79.6	71.5
5: 0	148.7	103.2	101.4	102.6	87.1
7:30	179.3	122.4	114.1	113.5	93.2
10: 0	183.6	113.4	113.9	124.5	108.4
12:30	173.8	120.6	116.0	116.4	105.4
15: 0	179.4	134.3	131.0	139.1	123.3
17:30	294.3	176.4	157.2	123.0	133.8
20: 0	78.3	157.5	160.5	168.9	326.9
22:30	75.4	161.7	158.5	167.7	360.5
25: 0	74.6	696.5	761.4	664.3	142.3
27:30	72.3	131.2	151.1	94.0	119.4
30: 0	71.6	118.6	144.4	94.0	110.1
32:30	71.5	108.9	121.1	82.7	94.9
35: 0	71.2	99.9	113.5	81.5	92.0
37:30	71.8	99.3	119.6	85.9	89.5
40: 0	71.7	94.9	111.5	81.6	85.3
42:30	71.2	92.0	107.3	78.7	85.1
45: 0	71.6	92.1	106.6	79.3	[illegible]
47:30	70.8	86.6	102.6	81.3	84.9
50: 0	71.5	89.0	105.9	80.4	82.5
52:30	71.8	91.1	102.6	79.9	81.7
55: 0	71.7	92.0	106.2	82.1	80.8
57:30	71.4	91.6	108.0	81.6	81.7
60: 0	72.0	91.2	103.7	80.3	80.4

FILE NC505-12 ILL. NO. A-16 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	61	62	63	64	65
0: 0	68.8	69.1	68.0	67.1	66.9
2:30	71.9	73.8	69.2	67.9	67.7
5: 0	87.5	82.1	75.5	71.1	69.4
7:30	95.5	89.0	91.2	80.3	73.4
10: 0	101.5	92.3	109.8	91.8	77.4
12:30	99.8	89.4	112.5	96.4	81.8
15: 0	113.6	100.4	140.2	111.8	86.1
17:30	145.4	127.1	537.2	262.9	127.0
20: 0	326.7	314.1	675.1	339.3	152.9
22:30	362.2	349.2	721.1	363.2	163.0
25: 0	165.6	148.8	634.4	636.1	442.5
27:30	140.0	128.1	207.1	184.9	142.9
30: 0	125.7	115.9	174.9	158.1	121.3
32:30	114.7	106.9	151.3	137.0	114.8
35: 0	106.8	101.5	133.4	118.6	104.8
37:30	106.3	100.6	128.1	119.9	106.7
40: 0	101.1	94.6	123.9	112.1	104.8
42:30	98.4	95.4	124.3	123.2	108.2
45: 0	96.4	91.6	117.5	111.9	105.7
47:30	97.4	94.3	116.1	116.5	107.4
50: 0	95.1	92.0	113.6	115.5	109.3
52:30	93.1	90.1	115.2	116.1	111.2
55: 0	91.6	88.6	114.3	113.4	110.6
57:30	91.8	89.4	115.7	118.9	113.9
60: 0	90.4	87.0	114.1	111.6	110.4

FILE NC505-12 ILL. NO. A-17 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	66	67	68
0: 0	68.2	67.0	66.6
2:30	69.5	68.2	67.5
5: 0	71.2	69.2	67.9
7:30	74.2	71.1	68.5
10: 0	75.7	72.2	69.8
12:30	76.3	73.1	70.2
15: 0	80.0	75.3	72.2
17:30	110.8	84.7	75.8
20: 0	290.0	271.3	271.0
22:30	455.4	444.2	502.2
25: 0	166.3	176.4	166.8
27:30	140.0	146.5	135.8
30: 0	125.9	130.4	120.5
32:30	117.6	122.5	110.6
35: 0	109.1	114.2	103.8
37:30	105.2	109.9	99.4
40: 0	101.6	106.9	97.2
42:30	99.9	103.5	95.7
45: 0	99.3	101.9	[illegible]
47:30	97.8	100.3	94.2
50: 0	97.0	99.6	92.6
52:30	96.8	99.1	92.1
55: 0	96.0	98.7	90.5
57:30	95.3	96.7	91.0
60: 0	94.9	97.7	90.9

FILE NC505-12 | ILL. NO. A-3 | ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	1	2	3	4	5
0: 0	65.0	66.5	65.4	63.6	65.4
2:30	67.0	67.4	66.5	64.5	66.5
5: 0	71.4	70.1	69.2	69.0	70.1
7:30	80.6	78.5	77.4	85.8	84.8
10: 0	106.0	99.6	97.5	119.5	112.9
12:30	135.5	124.6	120.1	150.2	136.9
15: 0	157.3	143.9	137.6	166.1	150.4
17:30	169.4	155.3	147.7	173.9	156.6
20: 0	175.5	161.9	153.1	176.7	158.8
22:30	178.6	164.6	157.9	176.2	159.9
25: 0	181.2	166.2	167.6	178.3	164.6
27:30	183.9	169.9	176.3	183.2	170.8
30: 0	188.0	174.3	179.2	186.6	174.7
32:30	191.2	178.5	187.8	198.5	179.1
35: 0	205.8	191.2	198.5	209.9	188.8
37:30	218.3	202.9	207.7	219.7	197.4
40: 0	227.7	213.8	215.0	226.8	205.5
42:30	234.6	221.7	220.0	231.1	212.3
45: 0	238.6	226.2	223.4	233.9	217.5
47:30	239.9	228.6	225.8	236.1	221.1
50: 0	239.8	229.8	228.4	238.2	224.3
52:30	239.5	230.8	233.4	240.1	227.5
55: 0	239.1	232.0	237.0	242.2	232.4
57:30	239.1	234.4	239.7	245.2	237.4
60: 0	239.5	236.0	241.8	250.1	243.0

FILE NC505-12 ILL. NO. A-4 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	6	7	8	9	10
0: 0	65.1	63.3	63.9	64.6	[illegible]
2:30	66.1	64.4	64.8	65.5	65.4
5: 0	70.5	68.0	68.4	69.1	67.8
7:30	86.0	81.3	81.8	81.2	76.7
10: 0	112.9	106.1	107.6	105.1	96.8
12:30	136.2	129.5	131.1	127.8	118.6
15: 0	149.8	145.2	146.0	143.6	137.1
17:30	156.4	154.0	153.8	152.2	149.7
20: 0	159.4	158.5	157.7	156.2	156.2
22:30	162.1	160.4	159.2	158.1	159.6
25: 0	166.9	162.8	163.9	161.8	161.6
27:30	173.3	167.6	169.8	167.5	165.7
30: 0	175.5	175.0	174.0	173.9	174.4
32:30	184.0	178.3	177.1	177.0	177.9
35: 0	194.5	188.4	186.6	186.1	185.3
37:30	204.1	198.7	195.4	195.5	195.5
40: 0	213.0	207.5	203.8	204.5	206.2
42:30	219.5	214.3	211.4	212.4	[illegible]
45: 0	224.2	220.7	217.3	218.7	[illegible]
47:30	228.0	224.9	221.8	223.3	[illegible]
50: 0	231.4	228.3	225.3	226.8	[illegible]
52:30	234.9	231.7	228.6	229.9	[illegible]
55: 0	238.1	236.0	231.0	232.7	[illegible]
57:30	242.4	240.0	236.1	235.4	239.3
60: 0	249.2	244.2	242.1	242.1	243.3

FILE NC505-12 ILL. NO. A-5 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	11	12	13	14
0: 0	65.2	65.8	67.0	66.5
2:30	66.1	66.6	68.0	67.4
5: 0	68.9	69.4	70.3	69.0
7:30	78.8	78.7	80.8	75.8
10: 0	100.9	99.9	103.5	91.9
12:30	123.3	122.3	125.7	111.9
15: 0	140.7	140.4	140.9	130.6
17:30	151.3	151.7	149.7	144.3
20: 0	156.3	157.0	154.8	153.3
22:30	158.9	159.7	158.2	158.4
25: 0	162.0	162.7	162.0	163.1
27:30	165.8	167.2	168.1	170.5
30: 0	174.3	175.7	182.0	181.2
32:30	177.5	179.3	190.4	187.9
35: 0	186.0	189.2	198.7	192.5
37:30	195.4	199.1	206.5	199.2
40: 0	203.3	208.1	214.0	207.8
42:30	210.3	215.4	220.5	217.0
45: 0	215.8	221.1	225.6	224.6
47:30	220.4	225.6	229.4	230.9
50: 0	224.9	230.0	233.2	236.4
52:30	229.0	233.9	237.7	242.2
55: 0	233.8	237.4	242.6	248.8
57:30	238.3	241.9	249.1	258.1
60: 0	245.1	249.2	266.6	271.1

FILE NC505-12 ILL. NO. A-6 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	15	16	17	36	*37
0: 0	67.9	67.8	68.1	69.6	69.9
2:30	1084.5	820.1	720.1	71.7	163.0
5: 0	1148.1	976.7	892.8	71.3	70.8
7:30	1270.0	1077.0	969.6	79.8	71.3
10: 0	1360.3	1164.4	1055.5	93.9	72.6
12:30	1381.8	1197.8	1076.7	102.6	72.6
15: 0	1385.0	1216.2	1089.8	108.1	73.2
17:30	1364.0	1214.5	1098.4	112.7	74.4
20: 0	1366.5	1211.5	1098.1	118.1	77.9
22:30	1369.7	1212.3	1099.6	121.4	77.1
25: 0	1376.8	1217.2	1104.3	121.8	76.9
27:30	1400.2	1235.7	1116.1	125.4	73.2
30: 0	1392.6	1237.4	1120.7	130.0	72.8
32:30	1401.4	1240.7	1123.5	133.5	71.4
35: 0	1427.9	1251.7	1127.5	138.3	72.5
37:30	1440.4	1258.5	1128.4	144.4	71.9
40: 0	1430.4	1254.3	1129.0	152.3	74.5
42:30	1418.5	1243.6	1122.9	155.8	72.1
45: 0	1421.9	1241.1	1119.3	160.7	73.2
47:30	1427.2	1241.3	1118.0	164.9	73.4
50: 0	1437.9	1237.8	1111.7	166.1	73.6
52:30	1448.5	1238.7	1111.1	167.3	73.9
55: 0	1466.6	1246.0	1115.9	169.1	72.2
57:30	1468.7	1249.0	1115.4	170.7	72.3
60: 0	1472.7	1251.1	1118.1	176.3	73.0

*T.C. 37, located on top surface of insulated steel duct, 6 ft from unexposed surface of wall, malfunctioned at the start of test and remained inoperable throughout the test.

FILE NC505-12 ILL. NO. A-7 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	38	21	22	23	24
0: 0	69.6	69.6	69.5	69.2	70.8
2:30	178.4	74.5	73.1	73.6	72.7
5: 0	92.0	98.6	88.3	90.0	80.0
7:30	104.4	110.6	103.6	102.4	86.5
10: 0	109.3	136.6	125.5	137.4	159.1
12:30	101.0	139.1	141.8	159.8	186.0
15: 0	105.0	146.5	161.7	175.2	210.2
17:30	104.4	150.8	173.9	182.7	214.4
20: 0	121.3	163.8	175.9	184.5	195.5
22:30	136.7	178.7	189.3	181.6	175.5
25: 0	140.8	138.8	176.7	166.1	176.9
27:30	133.5	153.8	187.6	190.7	199.2
30: 0	122.8	170.2	197.9	198.5	209.1
32:30	118.0	161.6	199.2	199.3	202.2
35: 0	121.0	171.3	205.7	203.7	207.9
37:30	118.3	174.0	213.3	209.3	207.3
40: 0	123.4	178.8	219.5	215.9	213.3
42:30	143.9	185.3	221.4	218.7	218.8
45: 0	128.3	188.5	226.2	224.3	217.8
47:30	130.8	191.1	224.2	223.0	216.8
50: 0	137.8	198.6	231.6	226.5	217.9
52:30	116.5	199.1	233.6	224.2	207.3
55: 0	123.8	198.0	240.1	230.6	205.7
57:30	123.3	211.4	248.6	236.8	198.7
60: 0	116.1	204.2	251.8	235.5	200.1

FILE NC505-12 ILL. NO. A-8 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	25	26	27	28	29
0: 0	70.5	70.3	69.4	67.5	67.4
2:30	75.4	73.3	71.0	68.5	68.2
5: 0	88.3	87.9	73.8	70.9	69.4
7:30	100.4	99.1	82.1	75.6	71.5
10: 0	144.5	113.1	100.7	89.1	77.6
12:30	153.5	124.1	105.4	95.3	85.0
15: 0	156.6	135.8	113.9	106.9	91.2
17:30	164.4	159.1	118.8	109.9	95.6
20: 0	158.6	153.8	121.0	108.9	99.4
22:30	158.8	163.1	128.3	116.3	103.2
25: 0	157.6	155.1	103.1	107.8	104.1
27:30	153.2	145.7	118.5	119.2	108.4
30: 0	160.5	151.0	127.1	125.3	109.4
32:30	159.3	137.7	131.1	130.4	117.0
35: 0	160.7	156.9	137.4	135.1	118.5
37:30	159.5	140.9	148.6	146.4	126.9
40: 0	166.4	157.4	154.1	153.0	130.0
42:30	169.1	160.9	159.9	154.9	133.[illegible]
45: 0	167.1	149.3	163.8	158.2	136.4
47:30	168.6	158.2	168.4	160.7	138.6
50: 0	171.4	162.8	170.2	167.3	141.3
52:30	168.0	155.8	179.1	174.2	145.1
55: 0	168.1	154.2	184.5	180.9	147.1
57:30	167.7	156.7	181.3	181.1	151.1
60: 0	167.2	154.6	185.2	185.3	154.4

FILE NC505-12 ILL. NO. A-9 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	30	31	32
0: 0	70.2	68.1	67.9
2:30	70.2	68.7	68.2
5: 0	71.0	69.4	68.8
7:30	73.1	70.4	69.4
10: 0	75.2	72.7	70.9
12:30	79.7	76.6	73.5
15: 0	88.7	82.8	78.2
17:30	101.2	87.7	82.5
20: 0	87.2	90.6	86.4
22:30	85.9	93.2	89.5
25: 0	88.6	97.5	93.6
27:30	89.2	97.4	91.4
30: 0	91.8	98.7	91.7
32:30	93.3	99.3	92.1
35: 0	90.7	101.0	93.1
37:30	95.6	103.6	95.5
40: 0	95.4	105.6	96.6
42:30	93.1	107.3	97.8
45: 0	98.5	108.1	98.6
47:30	98.3	109.5	99.7
50: 0	102.9	111.1	101.1
52:30	104.4	112.2	101.3
55: 0	105.6	115.3	103.9
57:30	108.9	118.6	104.2
60: 0	111.1	121.0	105.4

FILE NC505-12 ILL. NO. A-10 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	33	34	35	18	19
0: 0	69.2	69.1	69.1	68.5	69.9
2:30	1117.9	856.1	673.9	103.1	89.6
5: 0	1157.8	993.1	860.5	187.0	147.9
7:30	1252.5	1070.1	922.2	243.0	208.8
10: 0	1374.8	1143.9	1028.3	324.3	277.4
12:30	1242.3	1065.1	961.2	355.8	334.7
15: 0	1210.0	1049.2	950.8	335.6	392.9
17:30	1193.0	1038.8	943.1	378.6	413.5
20: 0	1187.4	1024.1	921.0	431.3	326.5
22:30	1194.5	1024.2	907.6	499.4	338.9
25: 0	1220.9	1051.4	931.9	483.1	332.3
27:30	1243.3	1071.7	937.4	372.2	403.0
30: 0	1260.8	1087.7	953.2	448.1	397.8
32:30	1257.0	1085.3	977.2	462.7	407.1
35: 0	1269.1	1093.0	974.8	390.9	363.2
37:30	1281.1	1103.6	985.5	390.7	425.1
40: 0	1292.9	1110.5	984.1	366.3	409.9
42:30	1299.2	1114.6	983.5	403.6	428.0
45: 0	1298.3	1105.3	968.1	382.9	430.1
47:30	1316.0	1124.2	983.1	432.1	420.1
50: 0	1323.3	1125.5	984.1	391.9	452.7
52:30	1319.5	1121.8	976.4	375.6	411.7
55: 0	1318.8	1116.8	980.0	372.8	434.7
57:30	1329.0	1127.1	988.1	372.4	427.2
60: 0	1336.9	1134.3	991.8	378.7	448.6

FILE NC505-12 ILL. NO. A-11 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	20	39	40	41	42
0: 0	68.8	70.1	69.7	69.9	71.0
2:30	99.3	98.2	86.8	89.8	84.5
5: 0	164.2	142.4	115.2	110.1	115.8
7:30	163.1	163.2	131.2	122.1	129.8
10: 0	129.9	218.5	165.5	141.3	164.8
12:30	128.6	251.8	187.6	146.5	170.2
15: 0	133.3	241.7	191.5	153.6	158.2
17:30	144.2	252.4	196.8	154.0	166.4
20: 0	154.8	248.2	197.6	155.2	167.9
22:30	149.4	269.0	209.4	162.1	165.2
25: 0	148.3	248.9	204.1	161.5	157.9
27:30	157.2	308.0	232.8	172.8	158.2
30: 0	158.3	295.6	242.1	184.5	163.0
32:30	150.1	336.3	253.3	183.7	169.2
35: 0	148.0	341.0	274.0	201.9	177.1
37:30	162.6	350.4	288.3	206.0	177.0
40: 0	150.3	375.3	297.9	210.4	178.2
42:30	153.5	347.5	284.4	204.8	179.3
45: 0	157.2	370.2	307.8	212.0	188.3
47:30	175.1	363.2	312.5	218.2	188.2
50: 0	151.2	376.2	317.6	220.5	187.8
52:30	156.5	373.2	315.5	219.3	194.4
55: 0	168.0	399.1	328.6	224.4	188.5
57:30	169.9	407.8	339.8	229.3	195.0
60: 0	156.9	393.5	330.6	222.5	195.1

FILE NC505-12 ILL. NO. A-12 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	43	44	45	46	47
0: 0	70.3	70.1	69.8	66.2	68.1
2:30	83.8	85.0	81.4	75.3	72.1
5: 0	106.7	107.7	103.4	92.0	79.8
7:30	119.6	117.2	125.3	107.5	86.9
10: 0	141.2	139.2	194.0	149.5	103.5
12:30	146.6	139.5	323.0	256.7	131.1
15: 0	146.0	139.8	348.8	278.4	138.6
17:30	148.9	136.4	363.9	287.1	138.8
20: 0	150.1	136.7	357.7	287.6	140.8
22:30	149.3	128.3	368.2	295.7	144.2
25: 0	146.0	123.7	176.1	159.8	112.2
27:30	144.0	120.4	336.1	248.7	126.0
30: 0	150.6	127.9	371.2	292.3	134.0
32:30	155.1	137.5	388.1	307.0	146.2
35: 0	161.9	143.8	399.3	328.2	146.7
37:30	160.8	139.2	412.2	335.7	155.3
40: 0	176.7	165.4	424.3	345.8	158.6
42:30	163.5	143.1	436.4	357.7	163.6
45: 0	179.3	160.2	445.7	368.[illegible]	165.6
47:30	184.9	172.2	457.9	375.0	166.3
50: 0	168.9	145.7	466.9	363.6	163.3
52:30	176.9	151.8	466.9	387.0	173.7
55: 0	174.8	148.6	469.4	392.4	173.[illegible]
57:30	189.1	163.6	479.0	397.3	175.3
60: 0	179.7	154.3	491.6	406.1	182.1

FILE NC505-12 ILL. NO. A-13 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	48	49	50
0: 0	69.8	68.4	68.2
2:30	80.1	73.8	71.0
5: 0	94.4	80.3	75.1
7:30	99.4	86.1	78.5
10: 0	127.8	100.8	86.0
12:30	128.6	103.2	88.8
15: 0	139.9	108.5	91.3
17:30	126.4	106.7	91.8
20: 0	132.9	112.5	94.8
22:30	120.5	107.9	93.9
25: 0	109.2	107.6	92.0
27:30	112.8	109.8	93.0
30: 0	113.1	110.7	93.5
32:30	128.7	112.7	95.8
35: 0	122.2	111.5	95.1
37:30	130.4	115.6	96.9
40: 0	121.6	116.7	96.7
42:30	132.5	119.3	99.3
45: 0	131.2	118.0	99.1
47:30	130.1	118.2	100.2
50: 0	129.4	119.3	101.2
52:30	128.2	116.6	100.3
55: 0	127.4	118.3	101.0
57:30	133.9	120.1	101.9
60: 0	134.5	121.5	102.4

FILE NC505-12 ILL. NO. A-14 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	51	52	53	54	*55
0: 0	66.9	67.1	67.1	67.5	70.6
2:30	1510.1	1144.3	842.7	128.0	2.3
5: 0	1111.7	986.1	812.7	237.5	130.7
7:30	957.6	790.0	674.1	132.9	36.3
10: 0	894.6	757.5	635.5	124.3	13.5
12:30	1052.2	897.3	730.3	122.5	24.6
15: 0	1297.7	1300.2	1124.3	144.1	5.6
17:30	1394.5	1508.3	1370.2	159.6	53.0
20: 0	1431.2	176.2	117.6	162.7	248.2
22:30	1455.4	66.4	73.0	168.7	66.9
25: 0	1423.4	61.6	72.0	292.9	54.0
27:30	1356.7	64.0	70.7	87.1	61.2
30: 0	1346.5	64.0	70.1	86.2	60.8
32:30	1352.8	63.7	69.4	84.6	63.1
35: 0	1384.7	63.3	69.9	82.8	63.5
37:30	1407.4	63.6	69.6	82.8	63.2
40: 0	1421.2	63.6	69.6	80.3	64.5
42:30	1419.6	63.4	69.2	82.8	64.2
45: 0	1436.2	63.2	70.2	81.3	[illegible]
47:30	1455.2	63.8	69.2	84.6	63.6
50: 0	1474.6	64.1	69.4	82.4	[illegible]
52:30	1495.7	63.5	69.7	83.6	65.2
55: 0	1522.9	63.3	69.5	85.8	65.3
57:30	1539.0	63.7	69.8	86.5	65.8
60: 0	1546.0	63.6	69.7	84.3	66.3

*T.C. 55, located on top surface of fiberglass duct, 6 ft from unexposed surface of wall, malfunctioned at the start of test and remained inoperable throughout the test.

FILE NC505-12 ILL. NO. A-15 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST

84NK29824/NC505

1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	56	57	58	59	60
0: 0	68.1	68.6	68.6	68.6	68.4
2:30	111.7	76.7	75.2	79.6	71.5
5: 0	148.7	103.2	101.4	102.6	87.1
7:30	179.3	122.4	114.1	113.5	93.2
10: 0	183.6	113.4	113.9	124.5	108.4
12:30	173.8	120.6	116.0	116.4	105.4
15: 0	179.4	134.3	131.0	139.1	123.3
17:30	294.3	176.4	157.2	123.0	133.8
20: 0	78.3	157.5	160.5	168.9	326.9
22:30	75.4	161.7	158.5	167.7	360.5
25: 0	74.6	696.5	761.4	664.3	142.3
27:30	72.3	131.2	151.1	94.0	119.4
30: 0	71.6	118.6	144.4	94.0	110.1
32:30	71.5	108.9	121.1	82.7	94.9
35: 0	71.2	99.9	113.5	81.5	92.0
37:30	71.8	99.3	119.6	85.9	89.5
40: 0	71.7	94.9	111.5	81.6	85.3
42:30	71.2	92.0	107.3	79.7	85.1
45: 0	71.5	92.1	106.6	79.6	83.0
47:30	70.8	86.6	102.6	81.3	84.9
50: 0	71.5	89.0	105.9	80.4	82.5
52:30	71.8	91.1	102.6	79.9	81.7
55: 0	71.7	92.0	106.2	87.1	80.3
57:30	71.4	91.6	108.0	81.6	81.7
60: 0	72.0	91.2	103.7	80.3	80.4

FILE NC505-12 ILL. NO. A-16 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	61	62	63	64	65
0: 0	68.8	69.1	68.0	67.1	66.9
2:30	71.9	73.8	69.2	67.9	67.7
5: 0	87.5	82.1	75.5	71.1	69.4
7:30	95.5	89.0	91.2	80.3	73.4
10: 0	101.5	92.3	109.8	91.8	77.4
12:30	99.8	89.4	112.5	96.4	81.8
15: 0	113.6	100.4	140.2	111.8	86.1
17:30	145.4	127.1	537.2	262.9	127.0
20: 0	326.7	314.1	675.1	339.3	152.9
22:30	362.2	349.2	721.1	363.2	163.0
25: 0	165.6	148.8	634.4	636.1	442.5
27:30	140.0	128.1	207.1	184.9	142.9
30: 0	125.7	115.9	174.9	158.1	121.3
32:30	114.7	106.9	151.3	137.0	114.8
35: 0	106.8	101.5	133.4	118.6	104.8
37:30	106.3	100.6	128.1	119.9	106.7
40: 0	101.1	94.6	123.9	112.1	104.4
42:30	98.4	95.4	124.3	123.2	108.2
45: 0	96.4	91.6	117.5	111.9	105.7
47:30	97.4	94.3	116.1	116.5	107.4
50: 0	95.1	92.0	113.6	115.5	109.3
52:30	93.1	90.1	115.2	116.1	111.2
55: 0	91.6	88.6	114.3	113.4	110.3
57:30	91.8	89.4	115.7	118.9	113.9
60: 0	90.4	87.0	114.1	111.6	110.4

FILE NC505-12 ILL. NO. A-17 ISSUED: 4-17-85

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	66	67	68
0: 0	68.2	67.0	66.6
2:30	69.5	68.2	67.5
5: 0	71.2	69.2	67.9
7:30	74.2	71.1	68.5
10: 0	75.7	72.2	69.8
12:30	76.3	73.1	70.2
15: 0	80.0	75.3	72.2
17:30	110.8	84.7	75.8
20: 0	290.0	271.3	271.0
22:30	455.4	444.2	502.2
25: 0	166.3	176.4	166.8
27:30	140.0	146.5	135.8
30: 0	125.9	130.4	120.5
32:30	117.6	122.5	110.6
35: 0	109.1	114.2	103.8
37:30	105.2	109.9	99.4
40: 0	101.8	106.9	97.2
42:30	99.9	103.5	95.7
45: 0	99.5	101.8	94.[illegible]
47:30	97.8	100.3	94.2
50: 0	97.0	99.6	92.6
52:30	96.8	99.1	92.1
55: 0	96.0	98.7	90.5
57:30	95.3	96.7	91.0
60: 0	94.9	97.7	90.9

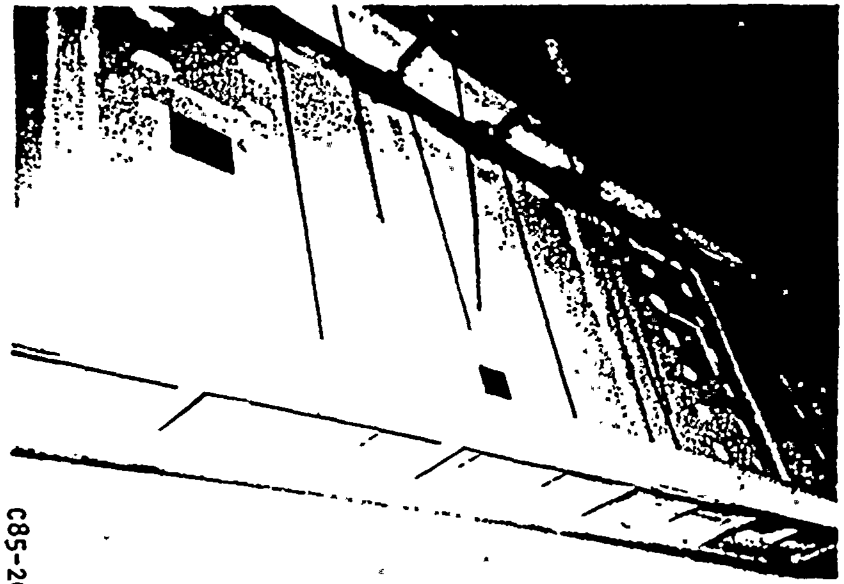
APPENDIX B

TEST RECORD - GENERAL

PICTORIAL HISTORY

STEEL STUDS AND FRAMING ANGLES
FOR AIR DUCT PENETRATIONS

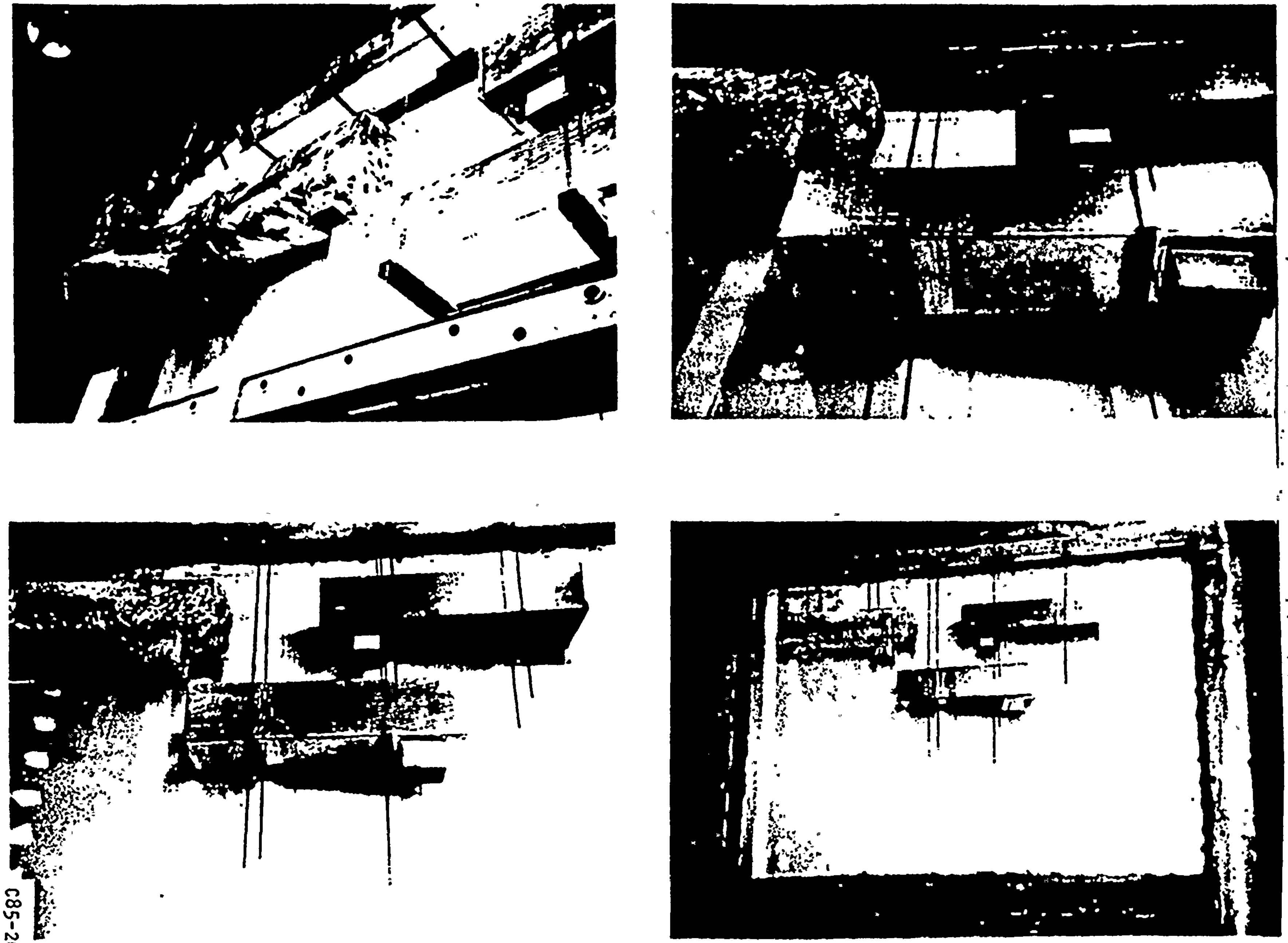
STEEL STUDS AND FRAMING ANGLES
FOR AIR DUCT PENETRATIONS



UNEXPOSED GYPSUM WALLBOARD SURFACE WITH
OPENINGS FOR AIR DUCT PENETRATIONS

STEEL STUDS AND INNER FACE OF EXPOSED
GYPSUM WALLBOARD

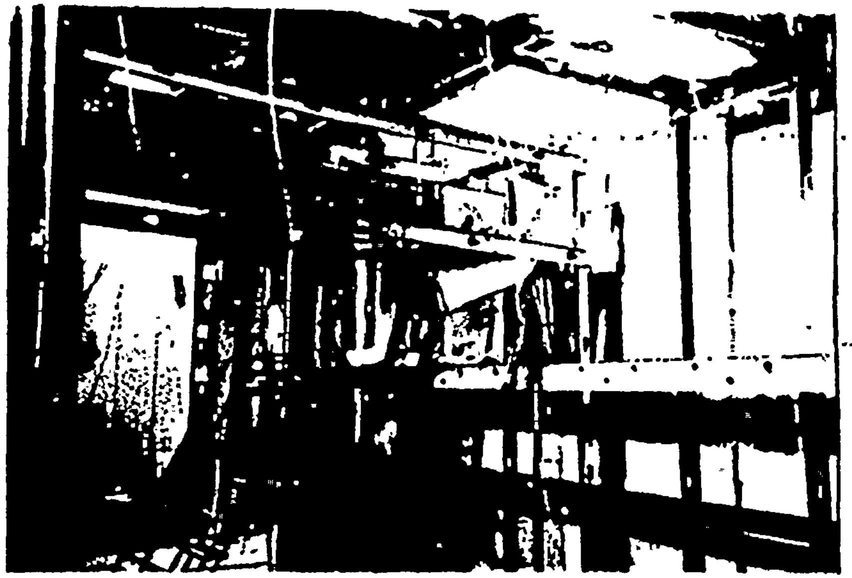
C85-2086



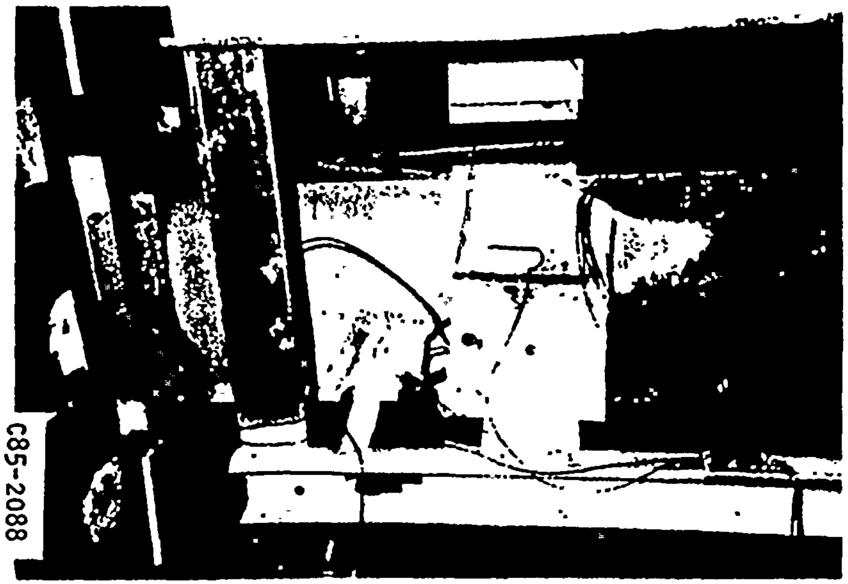
C85-2087

EXPOSED SURFACE OF TEST ASSEMBLY
BEFORE TEST

SMOKE ISSUING FROM RIGID FIBERGLASS AIR DUCT DROP OUTLET ON UNEXPOSED SIDE OF ASSEMBLY. TEST TIME - 2 MIN.



COLLAPSE OF RIGID FIBERGLASS AIR DUCT ON UNEXPOSED SIDE OF ASSEMBLY. TEST TIME - 19 MIN.

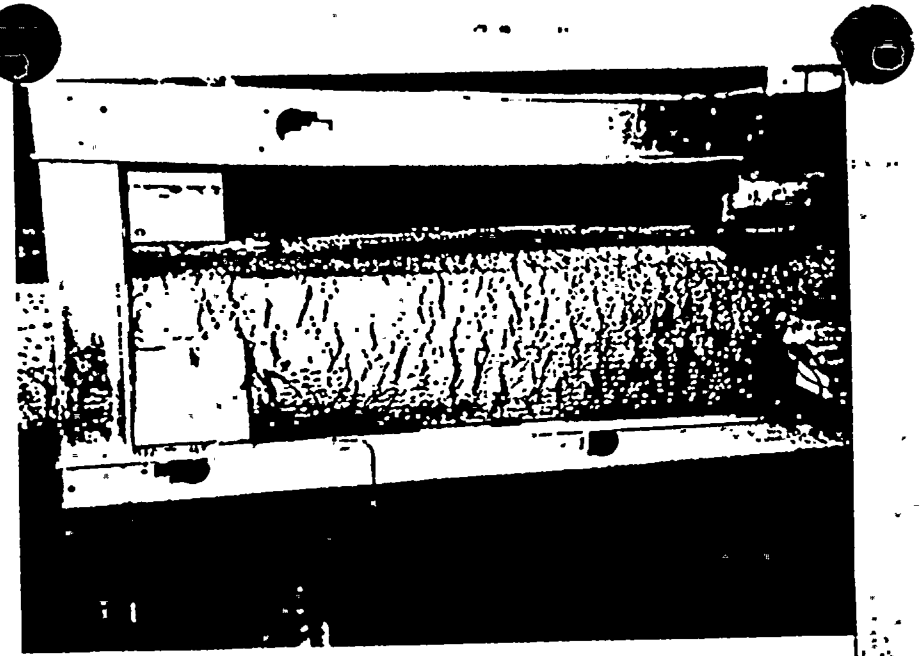


C85-2088

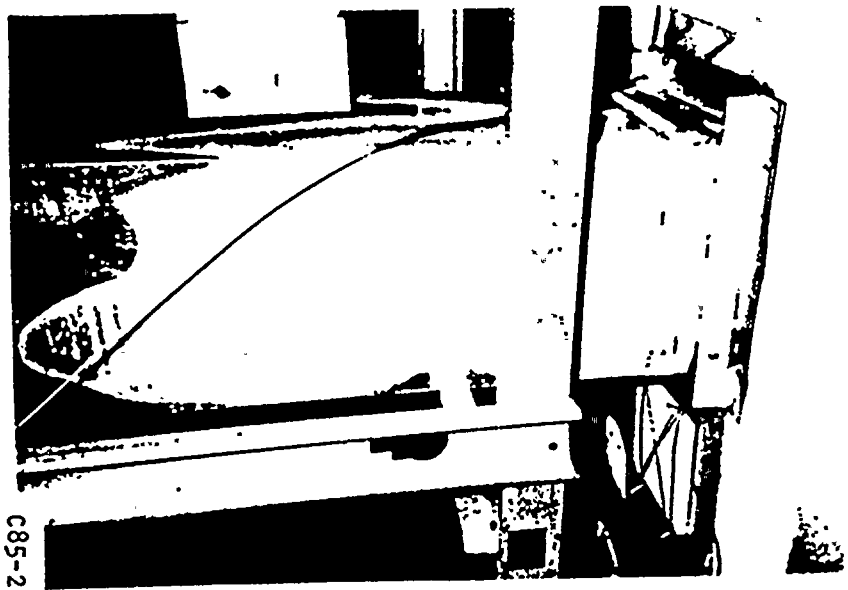
DISCOLORATION OF GALVANIZED STEEL AIR DUCT ON UNEXPOSED SIDE OF ASSEMBLY. TEST TIME - 34 MIN.

DISCOLORATION OF WALL SURFACE AND DETERIORATION OF INSULATED GALV. STEEL AIR DUCT ON UNEXPOSED SIDE OF ASSEMBLY. TEST TIME - 50 MIN.

UNEXPOSED SURFACE AFTER TEST



INSULATED GALVANIZED STEEL AIR DUCT AFTER TEST



GALVANIZED STEEL AIR DUCT AFTER TEST

INSULATED GALVANIZED STEEL AIR DUCT AFTER TEST

C85-2089

APPENDIX R DEVIATION REQUEST

FIRE BARRIER WITHOUT FIRE DAMPERS IN VERTICAL VENTILATION DUCT PENETRATIONS

DEVIATION REQUEST:

We request approval of the following:

Fire dampers are not required to be installed in the following ventilation duct penetrations in fire rated floor/ceiling assemblies between Fire Area R-1A and R-1B or R2A and R-2B.

Penetration	Fire Zone/Fire Zone
X27-6-17	1-5A-S/1-6A
X27-6-18	1-5A-S/1-6A
X27-6-50	1-5A-S/1-6A
X27-6-51	1-5A-S/1-6A
X27-6-83	1-5A-S/1-6A
X28-5-66	1-4A-W/1-5A-W
X29-5-54	1-4A-W/1-5A-W
X29-5-34	1-4A-W/1-5A-S
X34-5-4	2-4A-S/2-5A-W

FIRE AREAS AFFECTED

This deviation request concerns Fire Areas R-1A, R-1B, R-2A, and R-2B.

REASON FOR DEVIATION REQUEST:

The requirements of 10 CFR 50, Appendix R, Section III.G. requires fire rated barriers between fire areas. The guidance documents provided by the NRC indicate these barriers shall be rated for 3-hours fire resistance and ventilation ducts that penetrate such barriers shall have fire dampers installed. The floor/ceiling assemblies identified to be upgraded in PP&L's September 4, 1985 response (PLA-2529) contain ventilation duct penetrations which do not contain fire dampers.

EXISTING ARRANGEMENT:

The following is a description of the floor/ceiling assemblies penetrated by ventilation ducts:

Fire Zone/Fire Zone	Penetration	Duct Size	Zone Sprinklered	Zone Without Duct Opening	Figure Reference
R-1A to R-1B					
1-5A-S/1-6A	X-27-6-17	26" Dia.	1-5A-S	1-6A	(1A,1B,1C)
1-5A-S/1-6A	X-27-6-18	32" Dia.	1-5A-S	Both	2A, 2B,
1-5A-S/1-6A	X-27-6-50	30" x 20"	1-5A-S	1-5A-S	3A,3B,3C
1-5A-S/1-6A	X-27-6-51	30" x 20"	1-5A-S	1-5A-S	3A,3B,3C
1-5A-S/1-6A	X-27-6-83	20" x 8"	1-5A-S	1-6A	4
1-4A-W/1-5A	X-28-5-66	22" x 22"	1-4A-W	Both	5A,5B,5C
1-4A-W/1-5A-S	X-29-5-34	36" Dia.	1-4A-W	Both	6A,6B,6C,6D
1-4A-W/1-5A-S	X-29-5-54	22" x 22"	1-4A-W	Both	7A, 7B
R-2A to R-2B					
2-4A-S/2-5A-W	X-34-5-4	40" x 28"	Both	Both	8A,8B,8C

The maximum combustible loading within either Reactor Building is 45 minutes (In-Situ and transient).

See attached figures for details.

JUSTIFICATION:

The National Fire Protection Association's "Fire Protection Handbook" (14th edition, page 7-69) states:

"In the gauges commonly used, some sheet metal ducts may protect an opening in a building construction assembly for up to 1-hour, if properly hung and adequately fire stopped. Therefore, ducts passing through fire barriers having a rating of up to 1-hour fire resistance can be assumed to present no extraordinary hazard. If the wall, partition, ceiling, or floor is required to have a fire resistance rating of more than 1-hour, a fire damper is required . . ."

It is our position that these ducts adequately mitigate the chimney effects and provide at least an equivalent 1-hour five resistance. The basis for this position is as follows:

(1) The minimum duct thickness is 18 gauge and a typical 3-hour fire damper utilizes 24 gauge blades.

(2) The ducts, as a maximum, have an opening on only one side of the floor/ceiling assembly. Figures are attached which depict the lack of openings.

(3) In each case, automatic sprinkler protection is provided on the lower floor elevation.

A 1-hour equivalent rating provides a sufficient fire resistance to contain the expected 45 minute fire. Except for the ventilation duct penetrations, which are the subject of this request, and unprotected structural steel (See Deviation Request No. 6), the floor/ceiling assemblies will be upgraded to a rating of 3-hours.

dk/k019c:krp

[illegible]

[illegible]

[illegible]

[illegible]

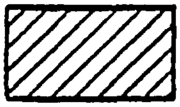
APPENDIX R DEVIATION REQUESTS

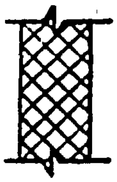
REQUEST NO. 12

FIGURES

LEGEND

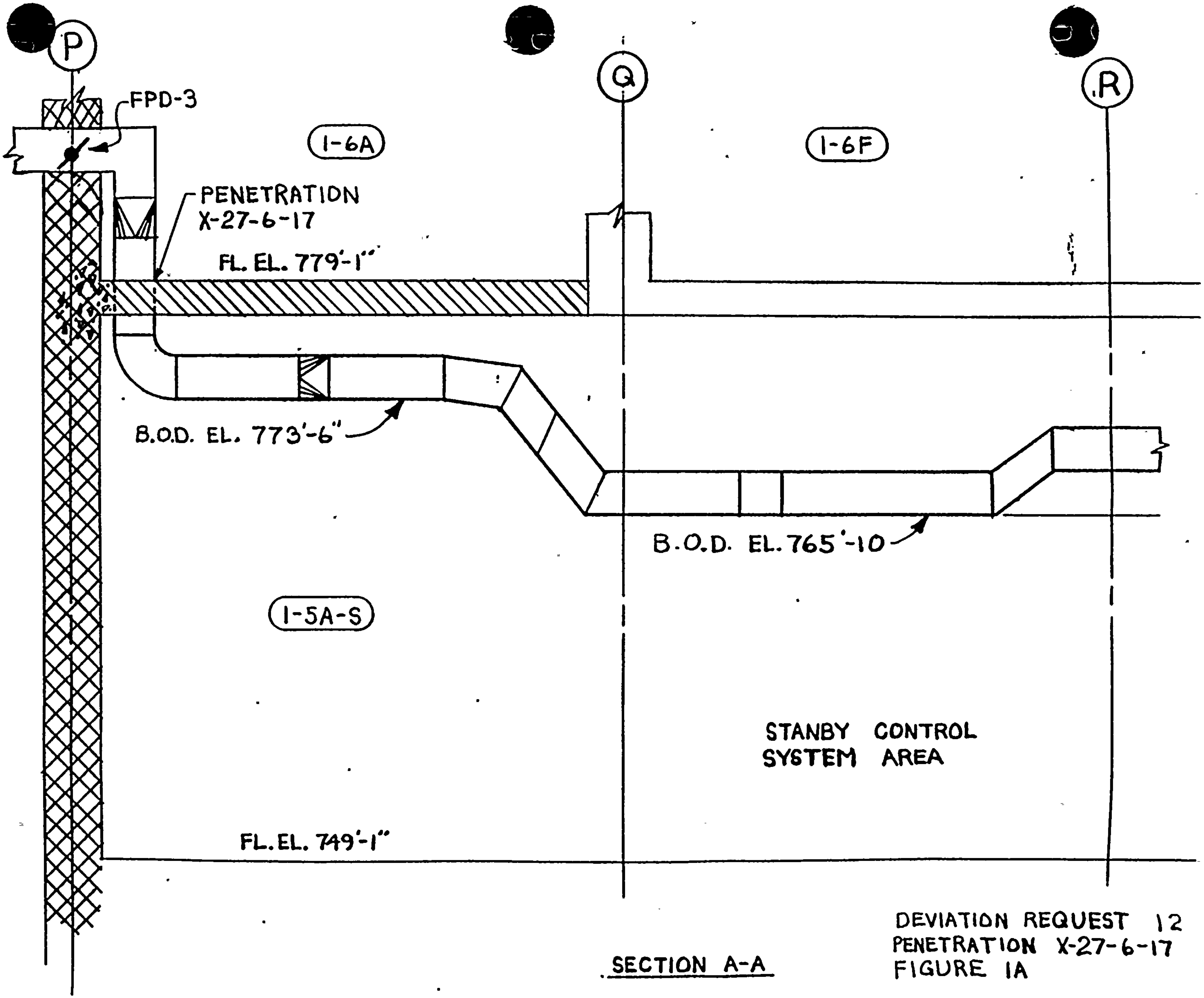
X-XX-X FIRE ZONE IDENTIFICATION

 INDICATES FLOOR IS FIRE RATED

 INDICATES FIRE RATED WALL

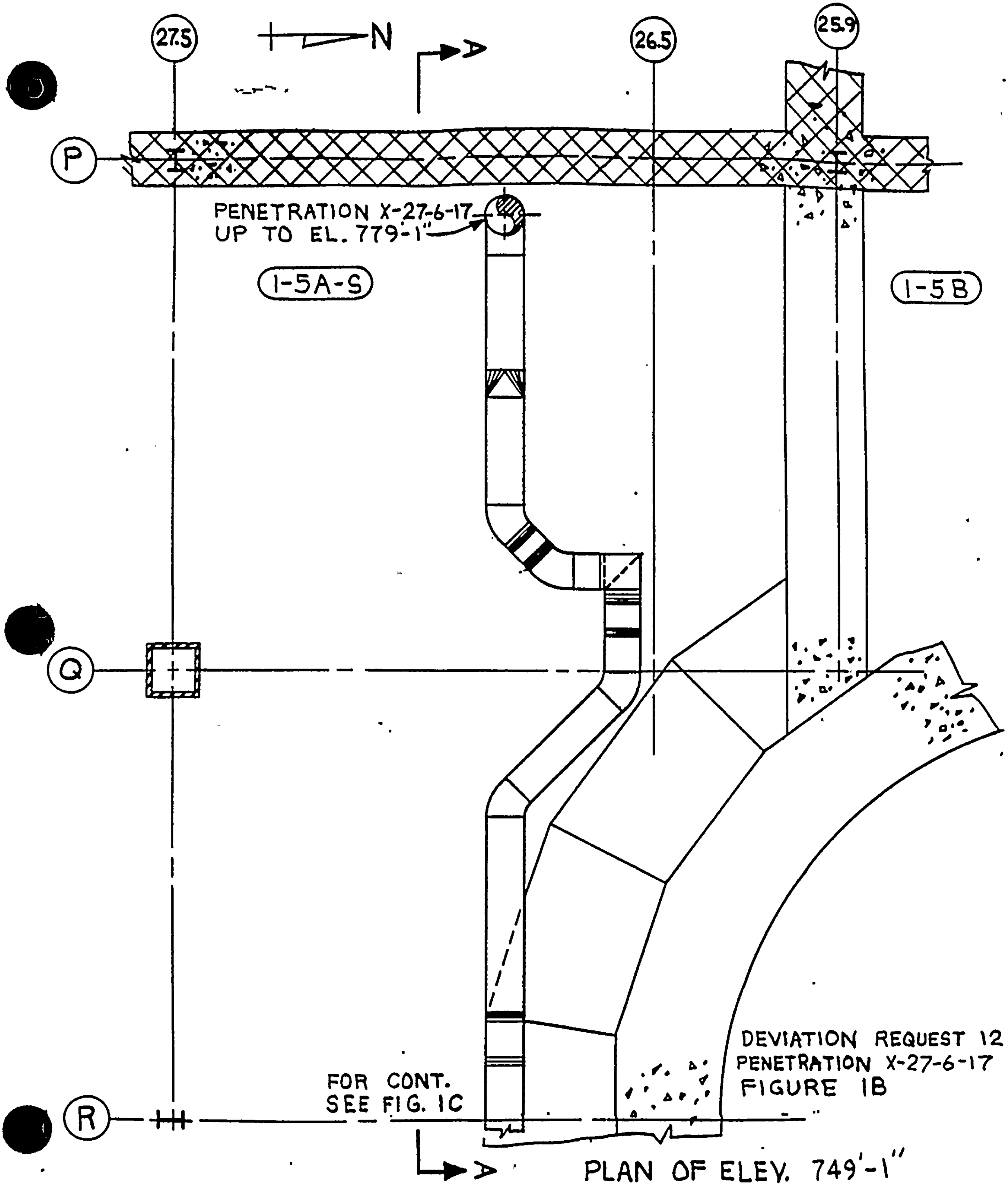
FPD 3 INDICATES 3 HOUR FIRE DAMPER


OR
 INDICATES OPENING IN DUCTWORK



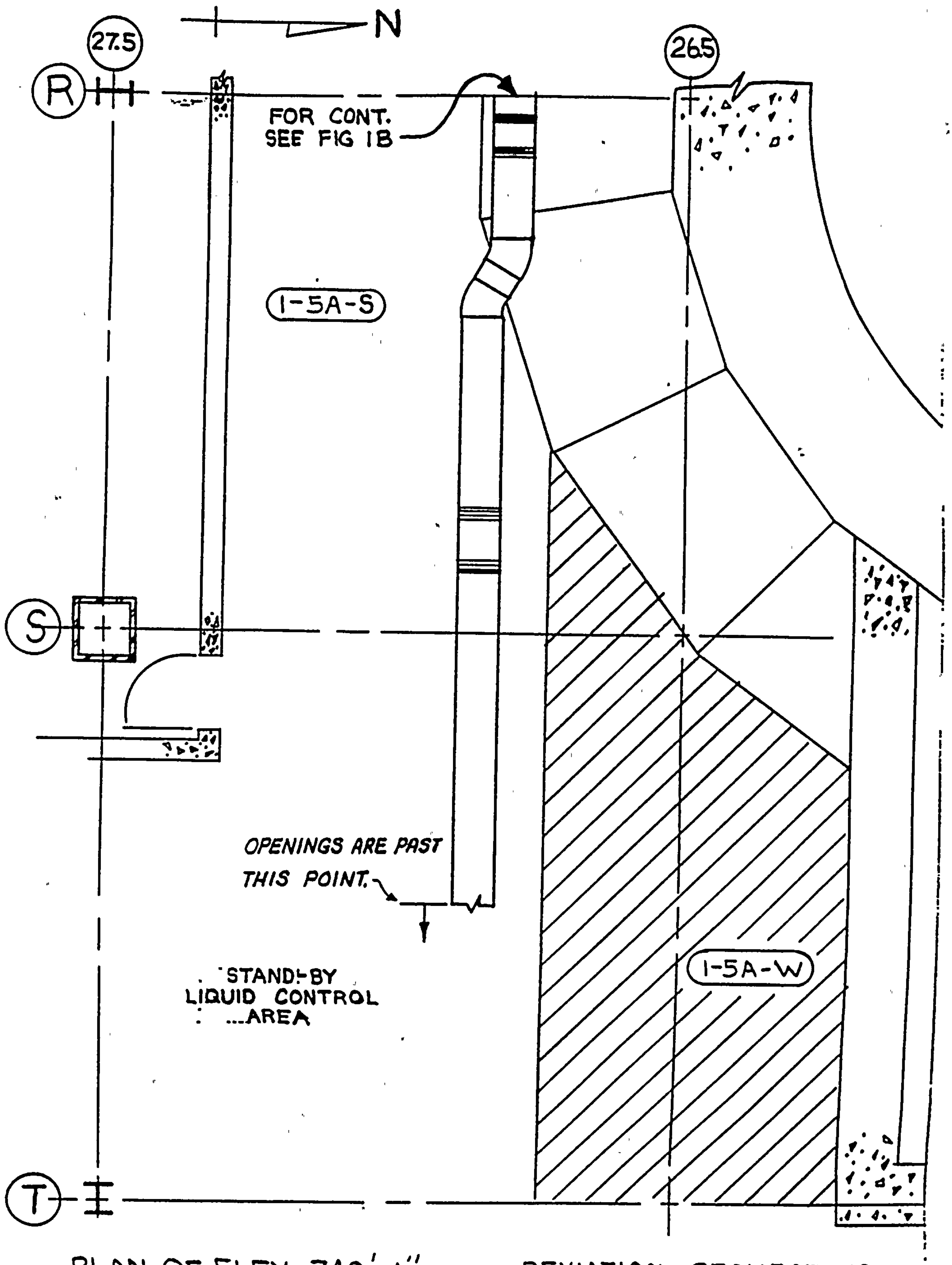
SECTION A-A

DEVIATION REQUEST 12
PENETRATION X-27-6-17
FIGURE 1A



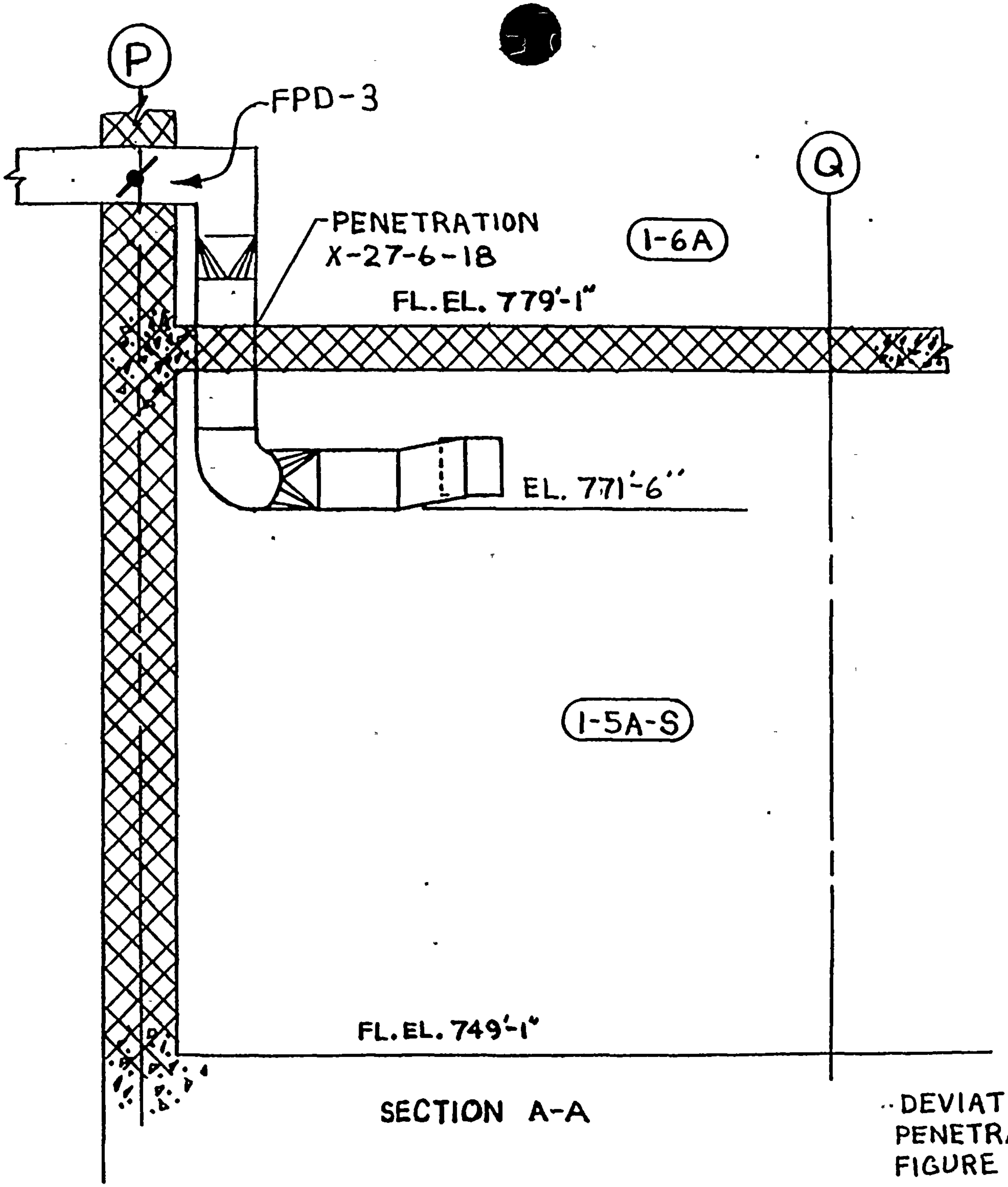
DEVIATION REQUEST 12
PENETRATION X-27-6-17
FIGURE 1B

PLAN OF ELEV. 749'-1"



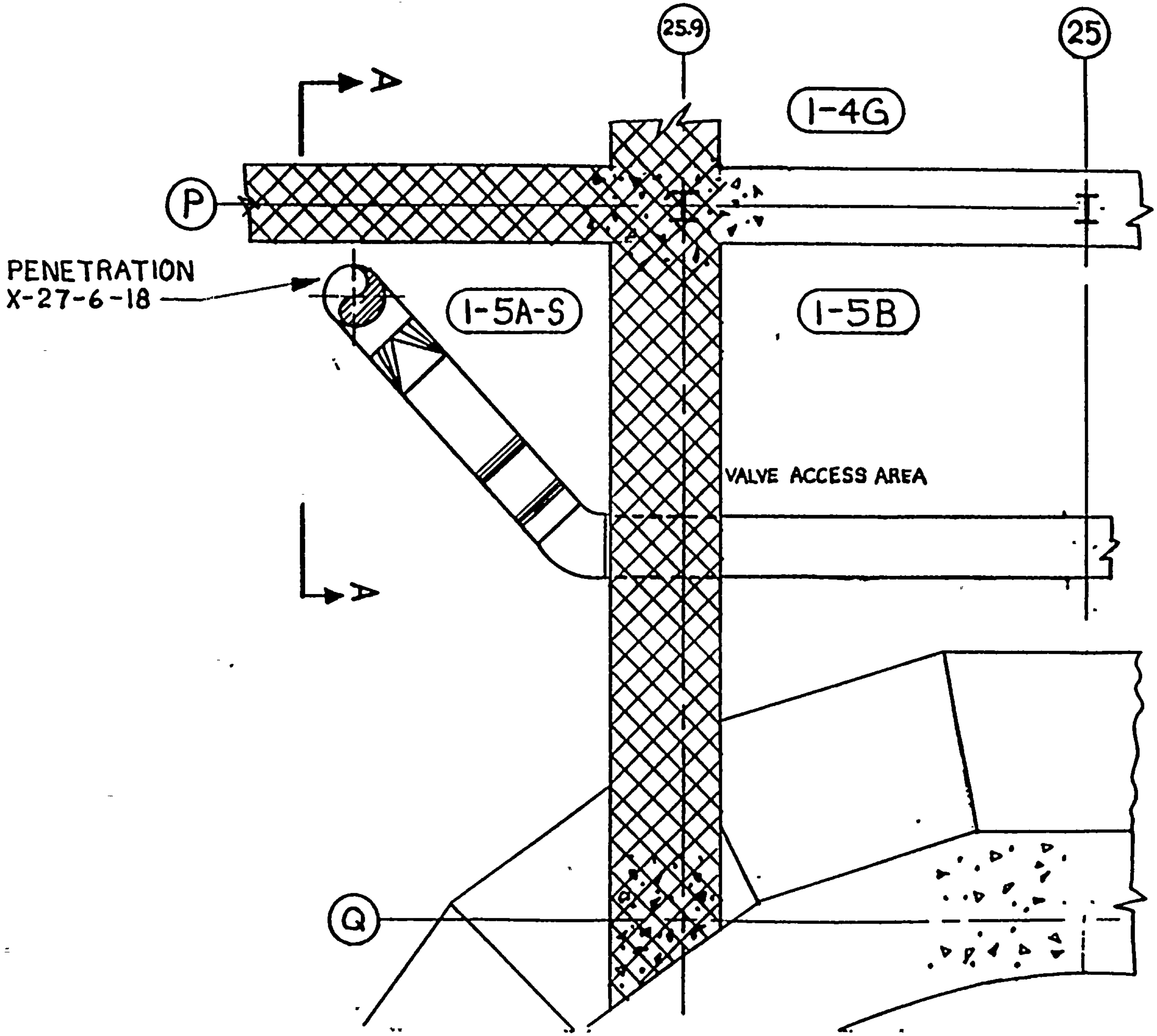
PLAN OF ELEV. 749'-1"

DEVIATION REQUEST 12
PENETRATION X-27-6-17
FIGURE 1C



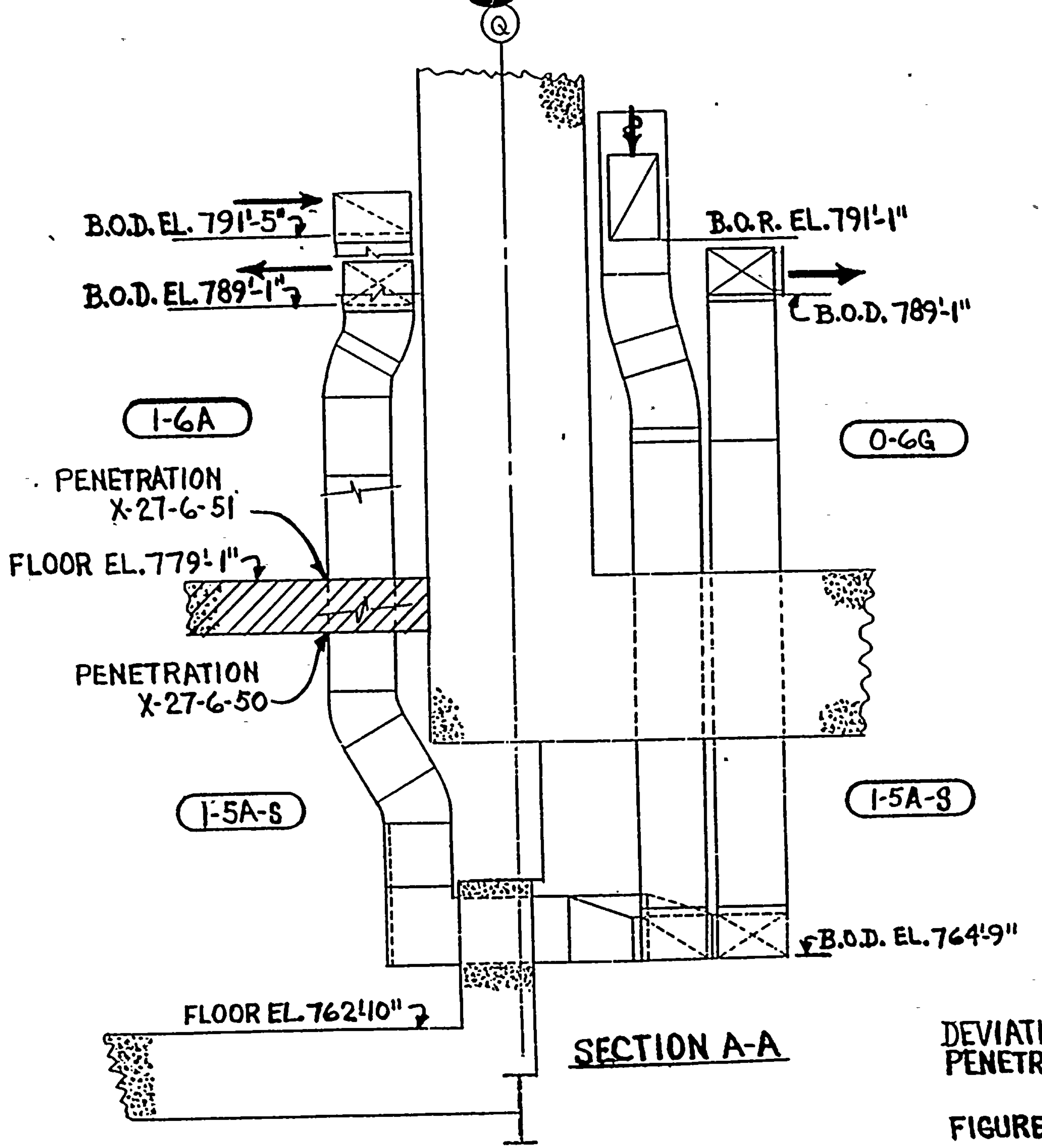
SECTION A-A

DEVIATION REQUEST 12
PENETRATION X-27-6-18
FIGURE 2A



DEVIATION REQUEST 12
PENETRATION X-27-6-18
FIGURE 2B

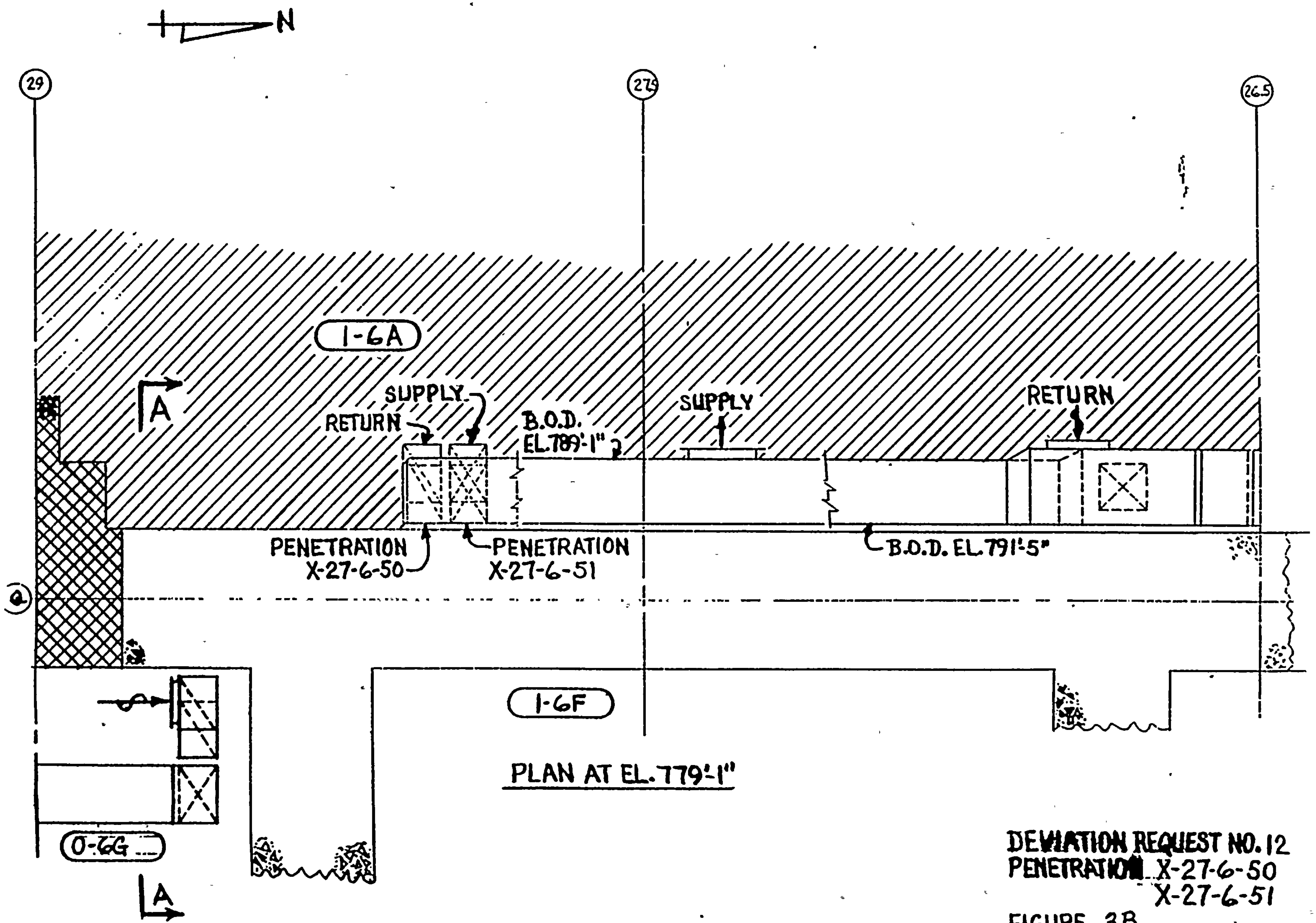
PLAN OF ELEV. 749'-1"



SECTION A-A

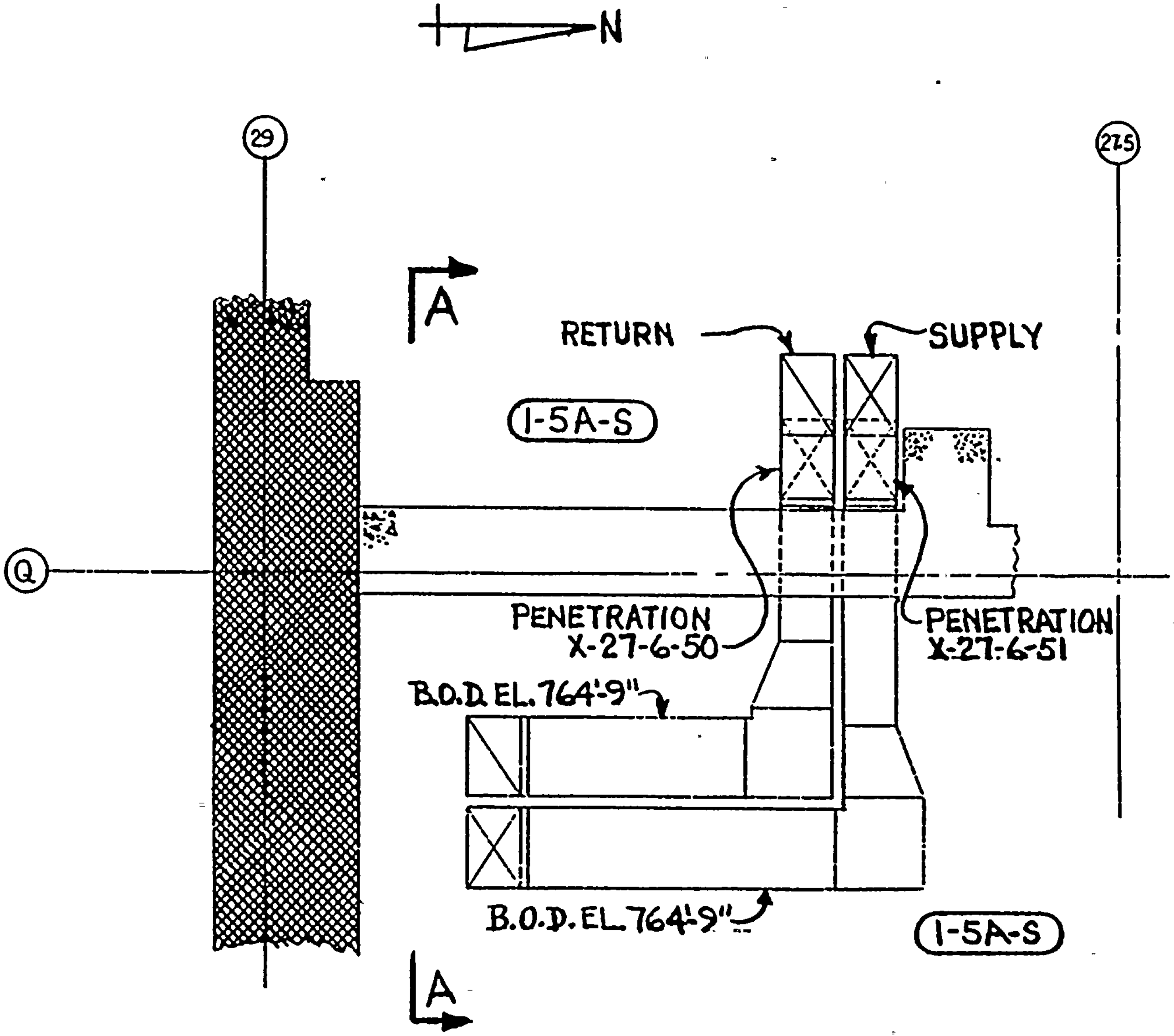
DEVIATION REQUEST NO. 12
PENETRATION X-27-6-50
X-27-6-51

FIGURE 3A



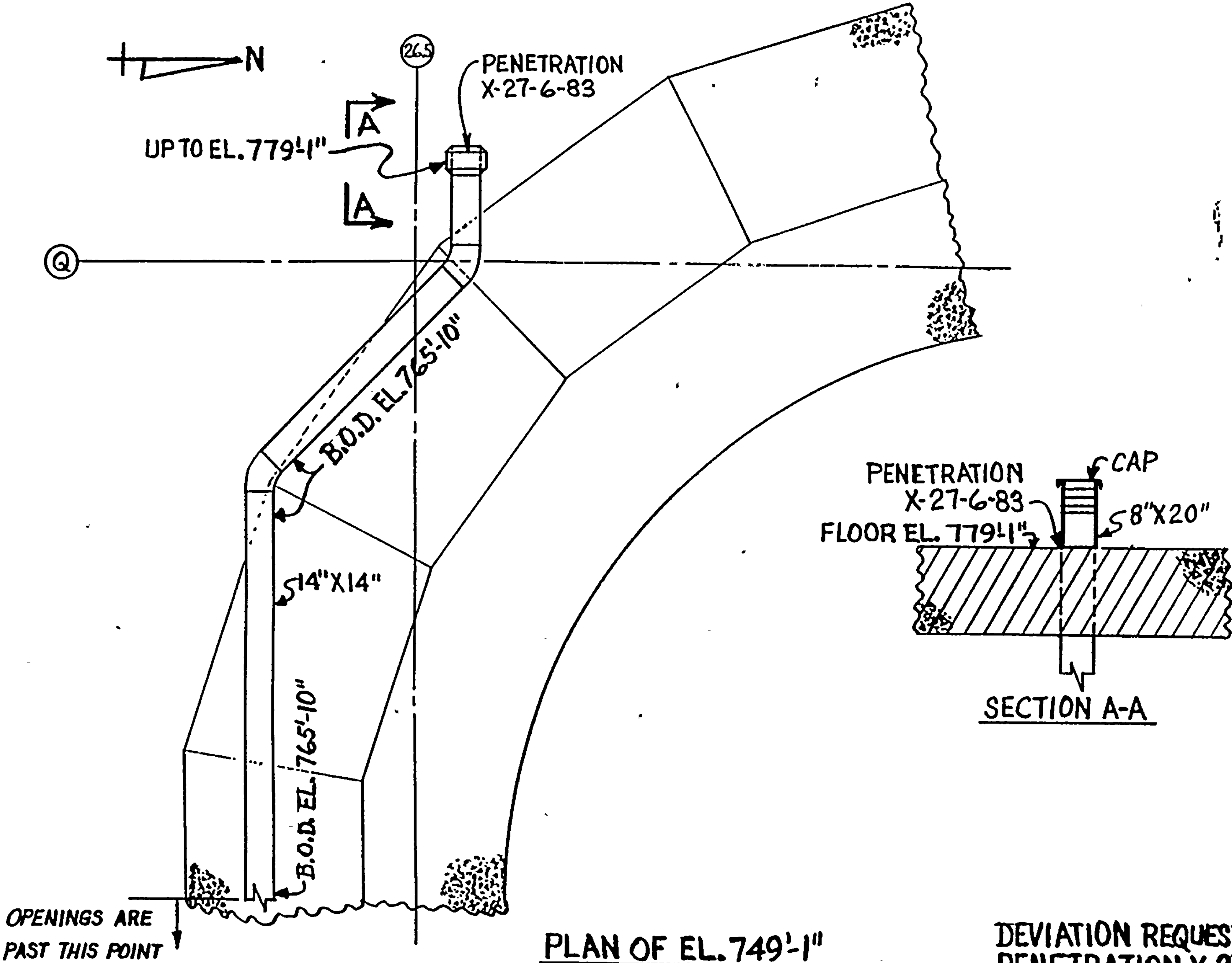
DEVIATION REQUEST NO. 12
PENETRATION X-27-6-50
X-27-6-51

FIGURE 3B

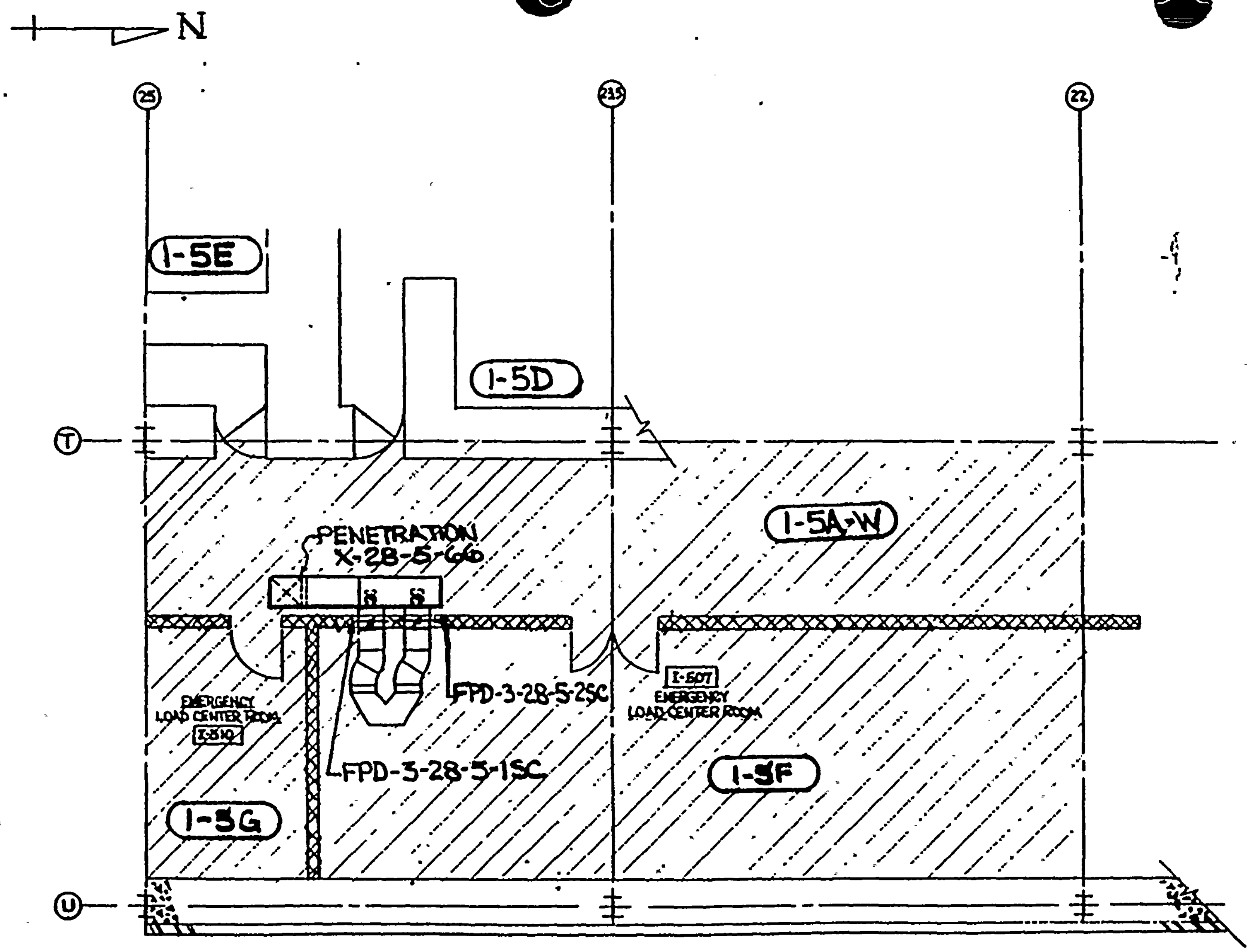


PLAN AT EL. 749'-1"

DEVIATION REQUEST NO. 1
PENETRATION X-27-6-50
X-27-6-51
FIGURE 3C

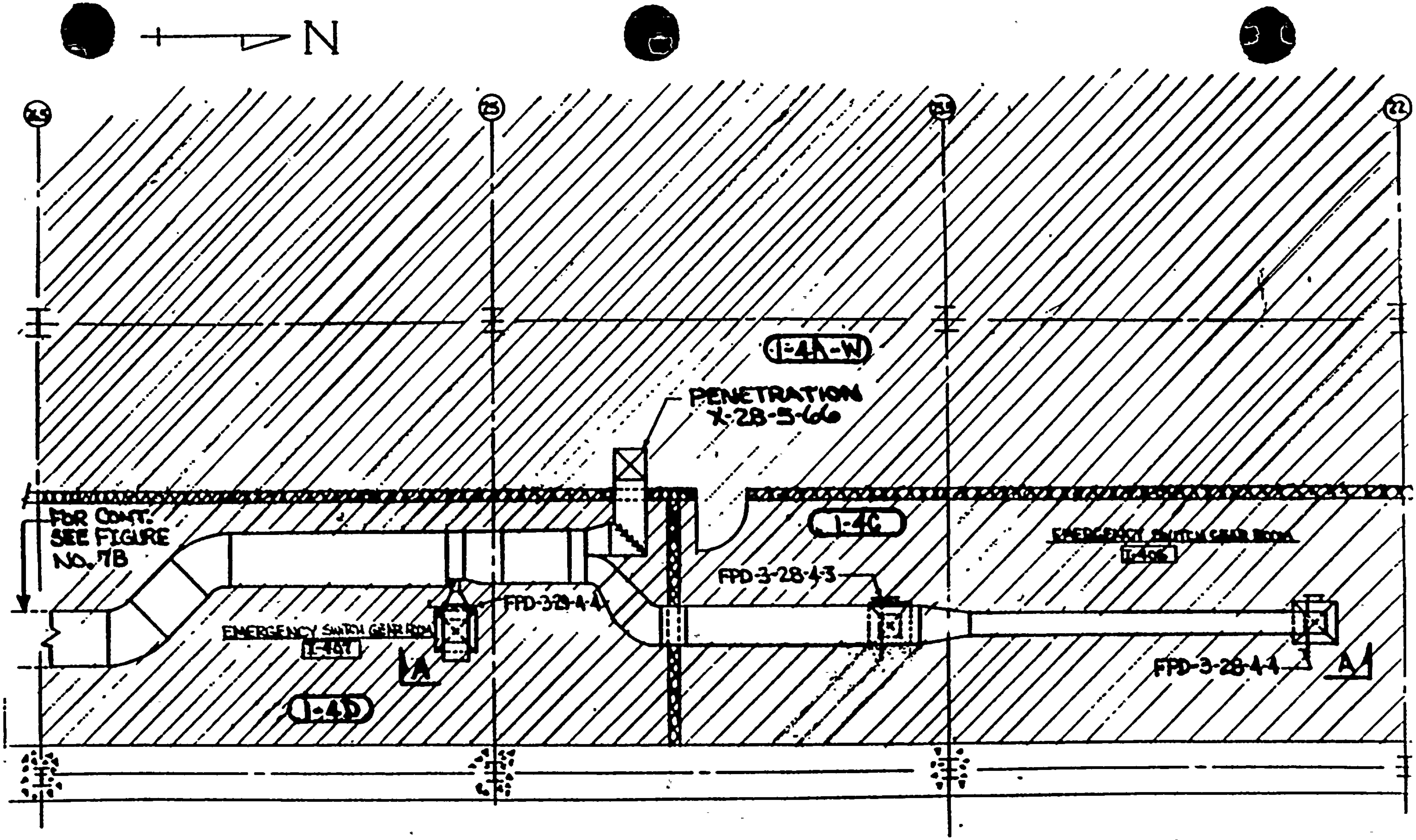


DEVIATION REQUEST NO. 12
PENETRATION X-27-6-83
FIGURE 4



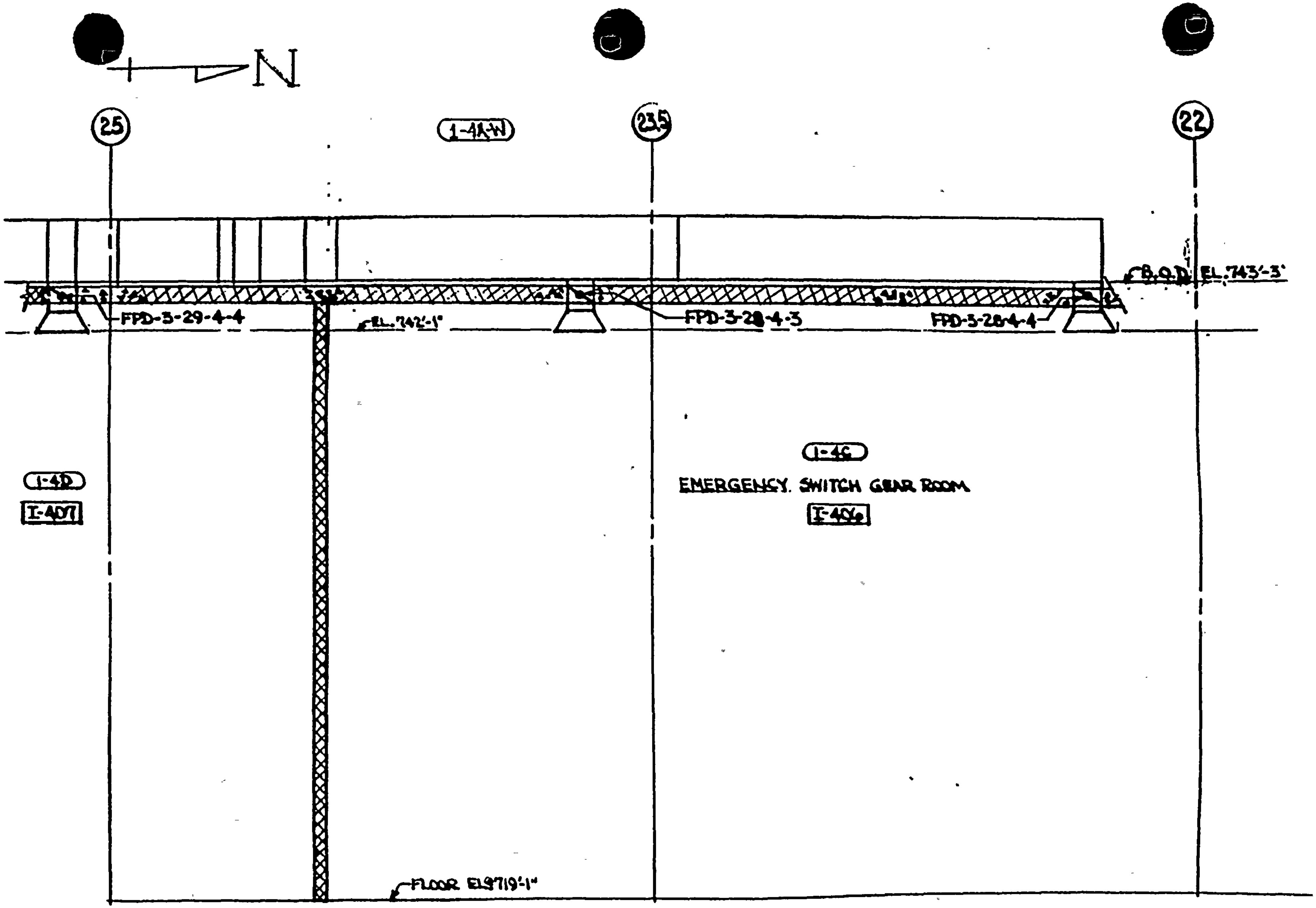
PLAN @ EL. 749'-1"

DEVIATION REQUEST NO. 12
PENETRATION X-28-5-66
FIGURE 5A



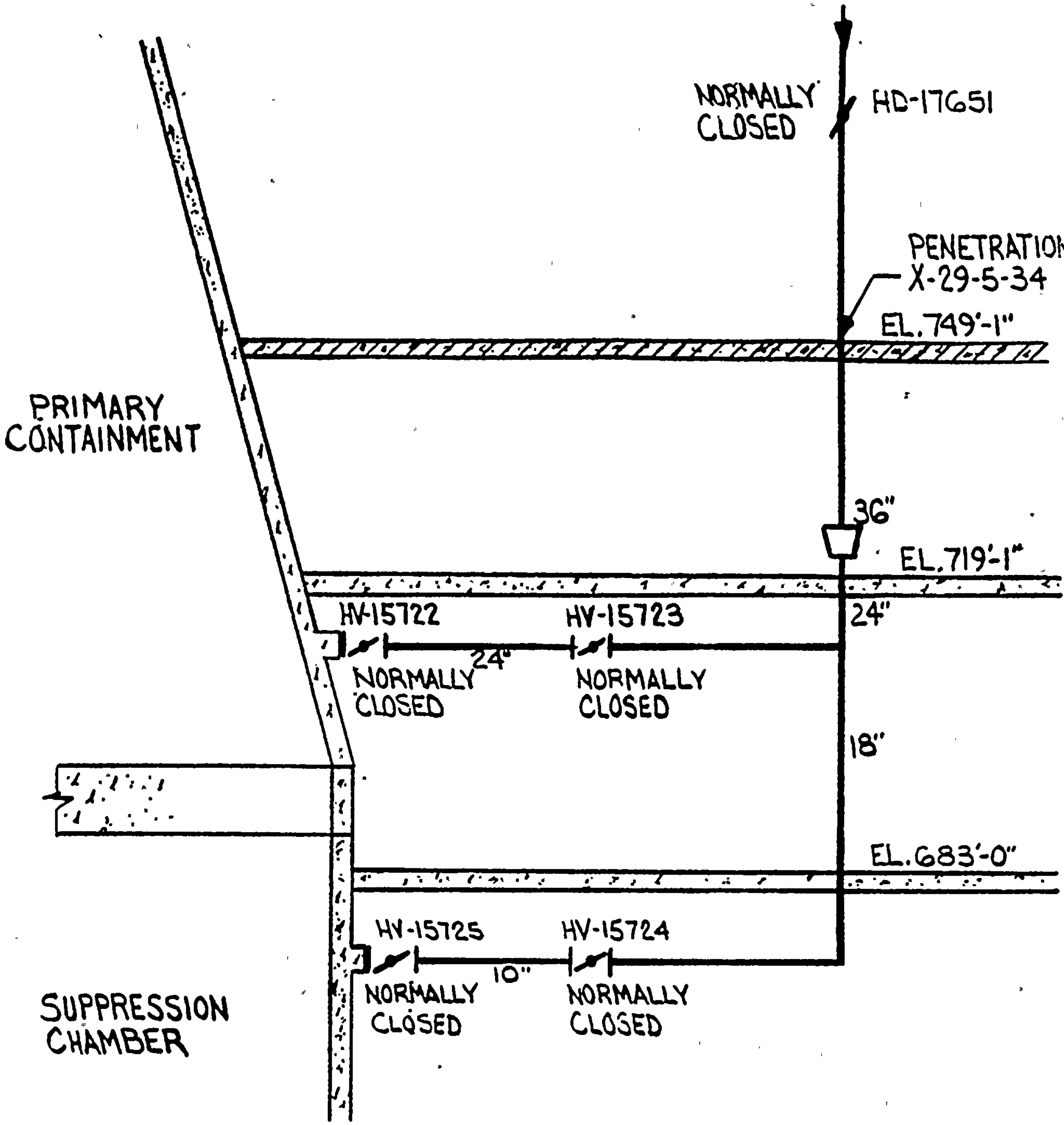
PLAN @ EL. 719'-1"

DEVIATION REQUEST NO. 12
PENETRATION X-28-5-66
FIGURE 5B



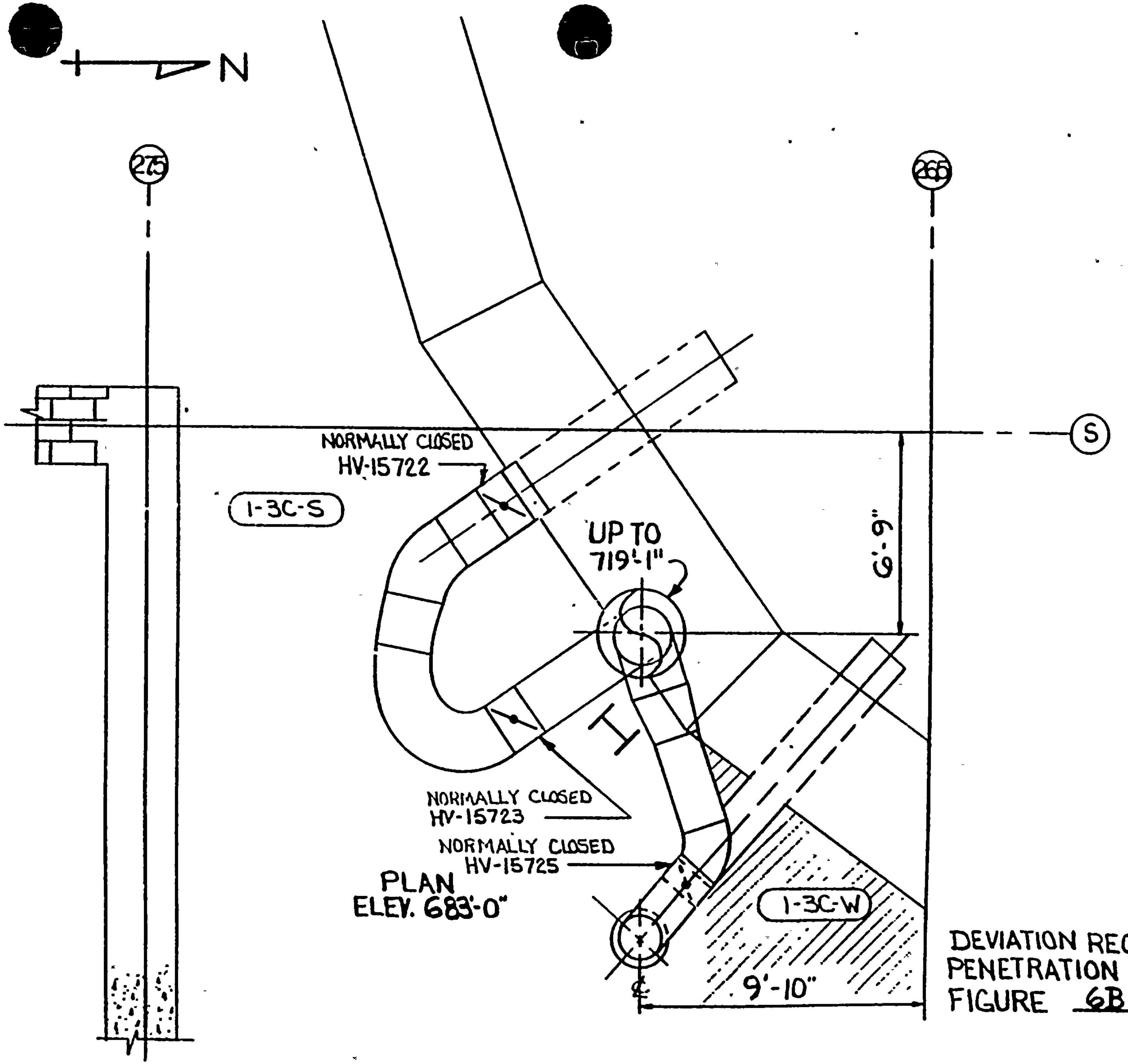
SECTION "A-A"

DEVIATION REQUEST NO. 12
PENETRATION X-28-5-66
FIGURE 5C

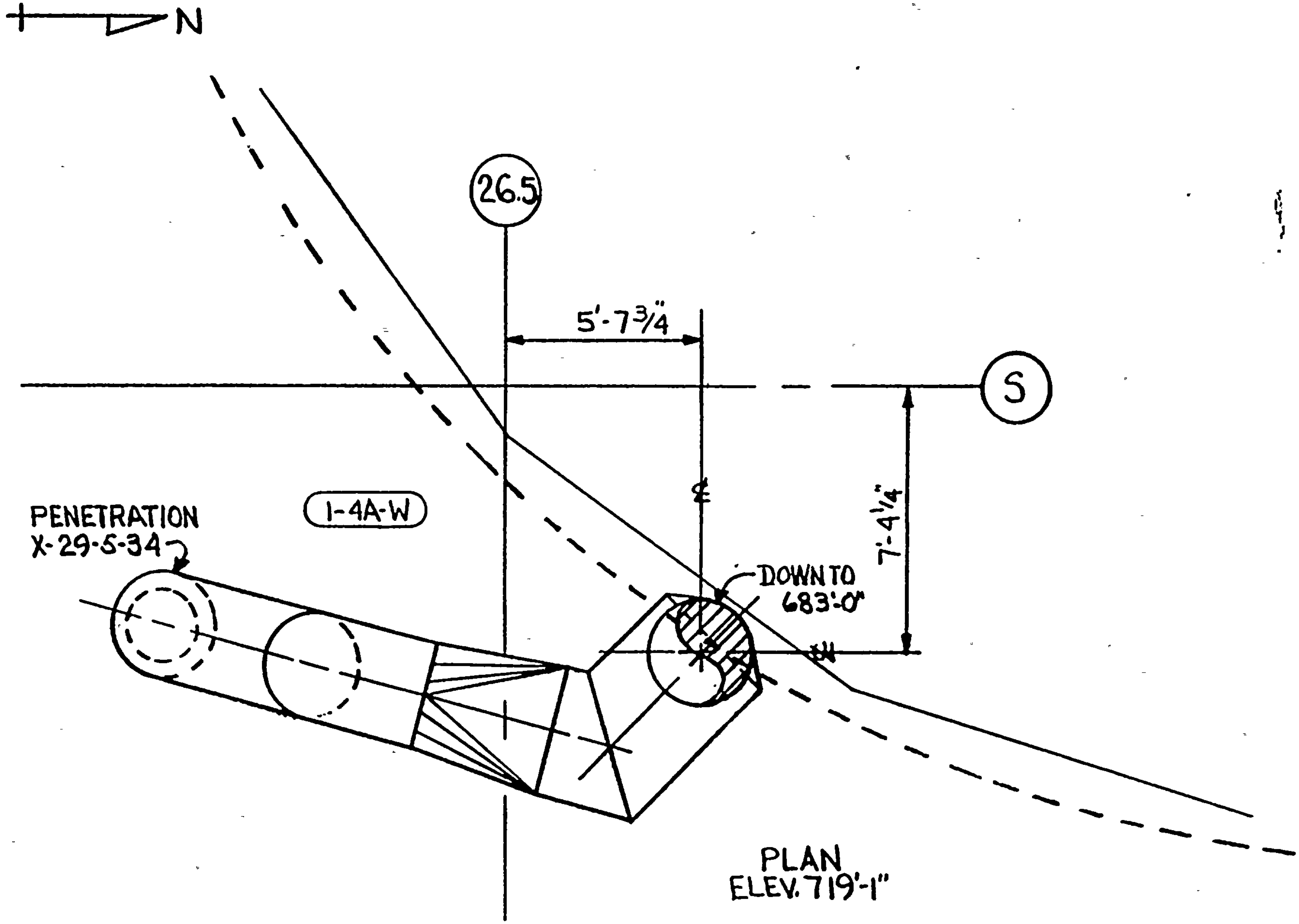


CONTAINMENT ATMOS. CONTROL
UNIT 1

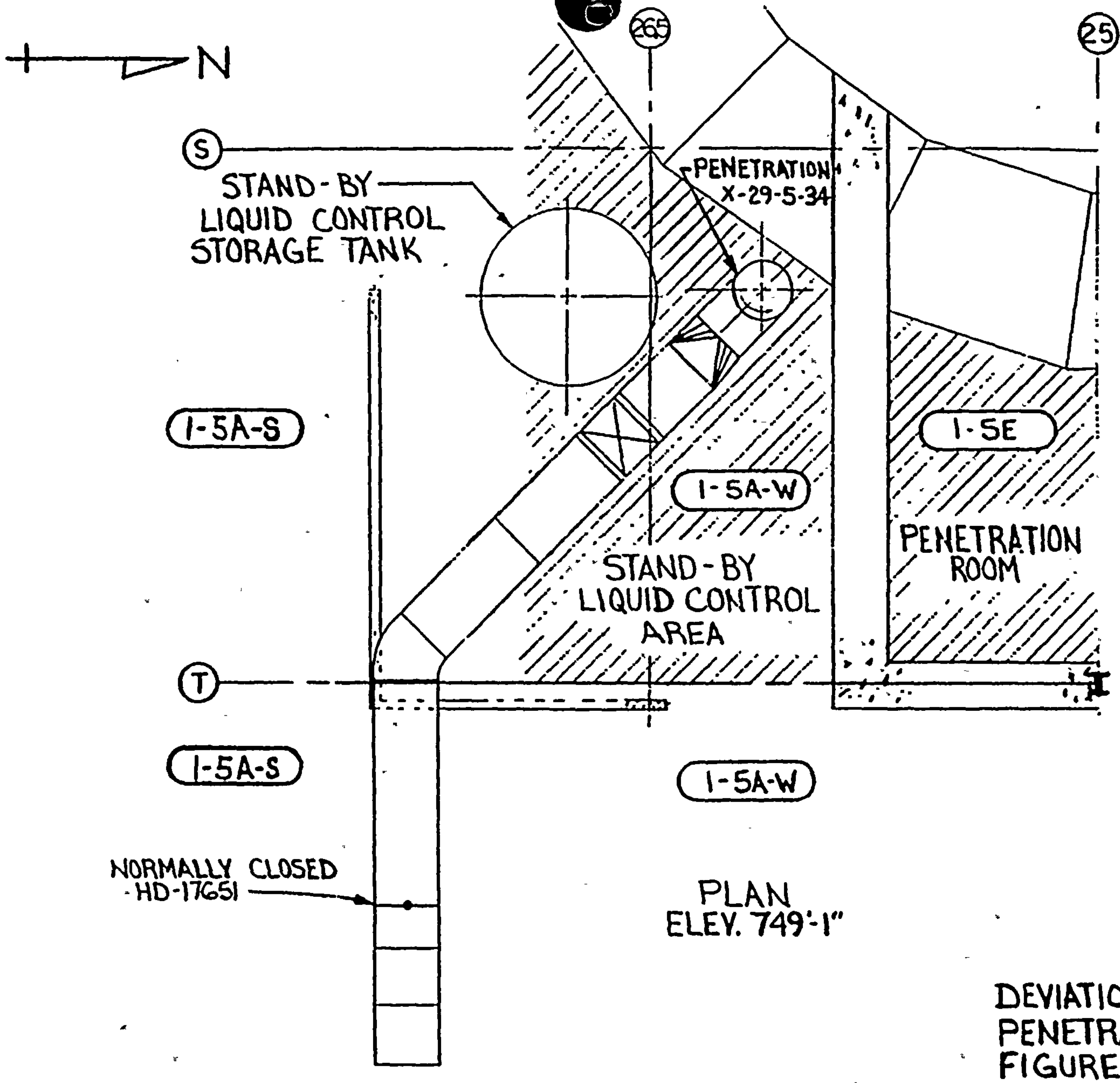
DEVIATION REQUEST NO. 12
PENETRATION 29-5-34
FIGURE 6A



DEVIATION REQUEST NO. 12
PENETRATION 29-5-34
FIGURE 6B

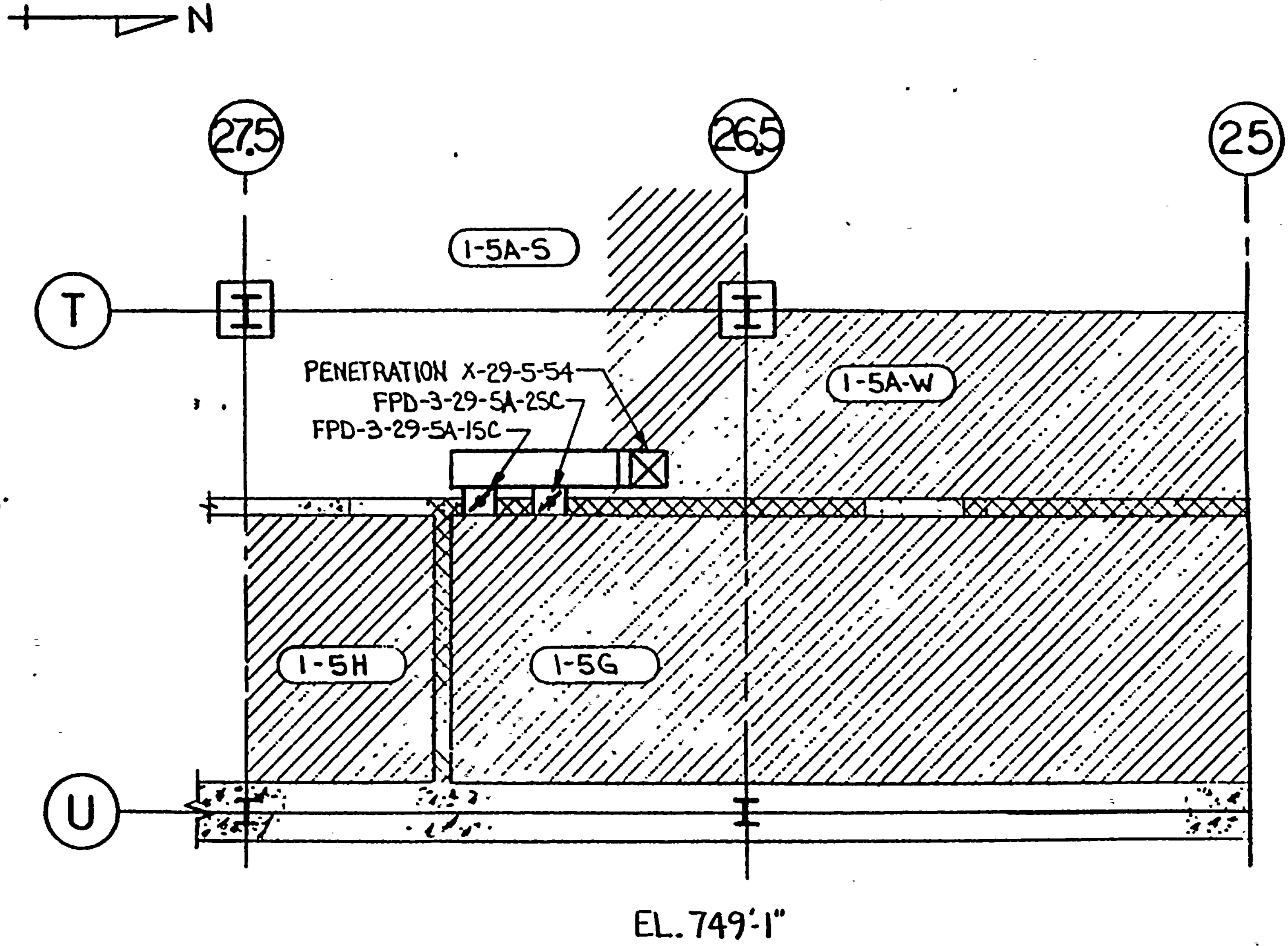


DEVIATION REQUEST NO. 12
PENETRATION 29-5-34
FIGURE 6C

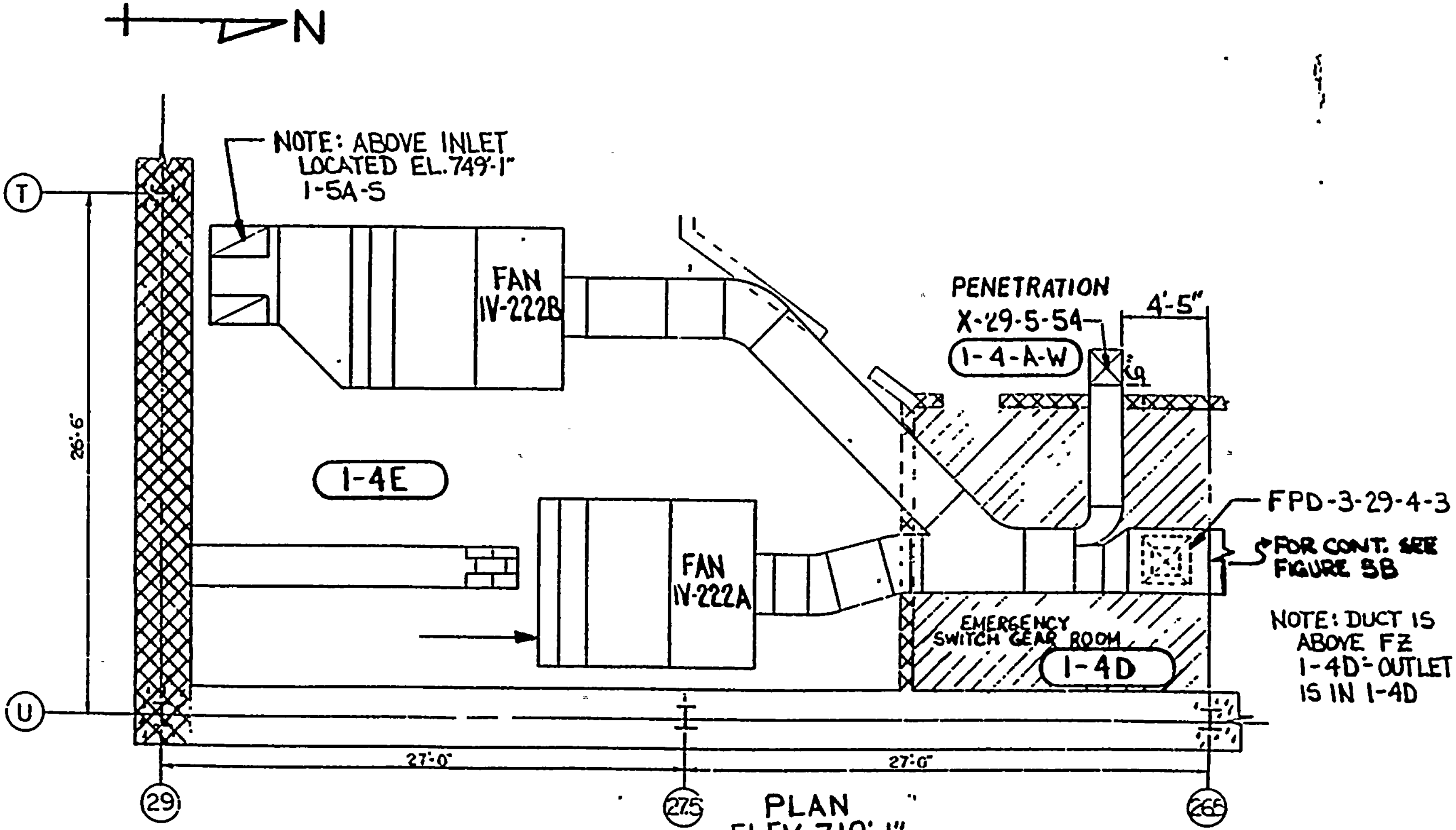


PLAN
ELEV. 749'-1"

DEVIATION REQUEST NO. 12
PENETRATION 29-5-34
FIGURE 6D

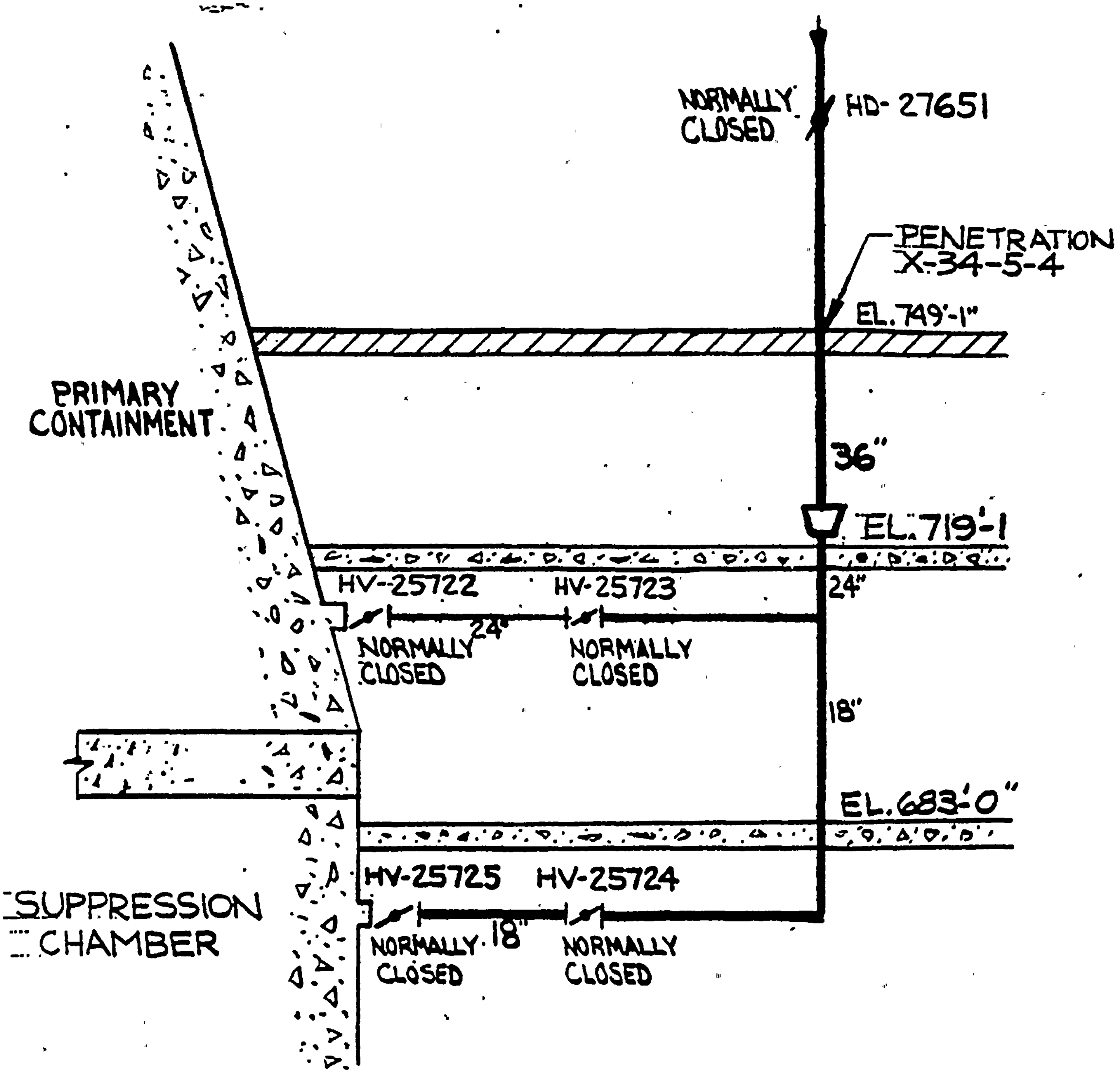


DEVIATION REQUEST NO. 12
PENETRATION 29-5-54
FIGURE 7A



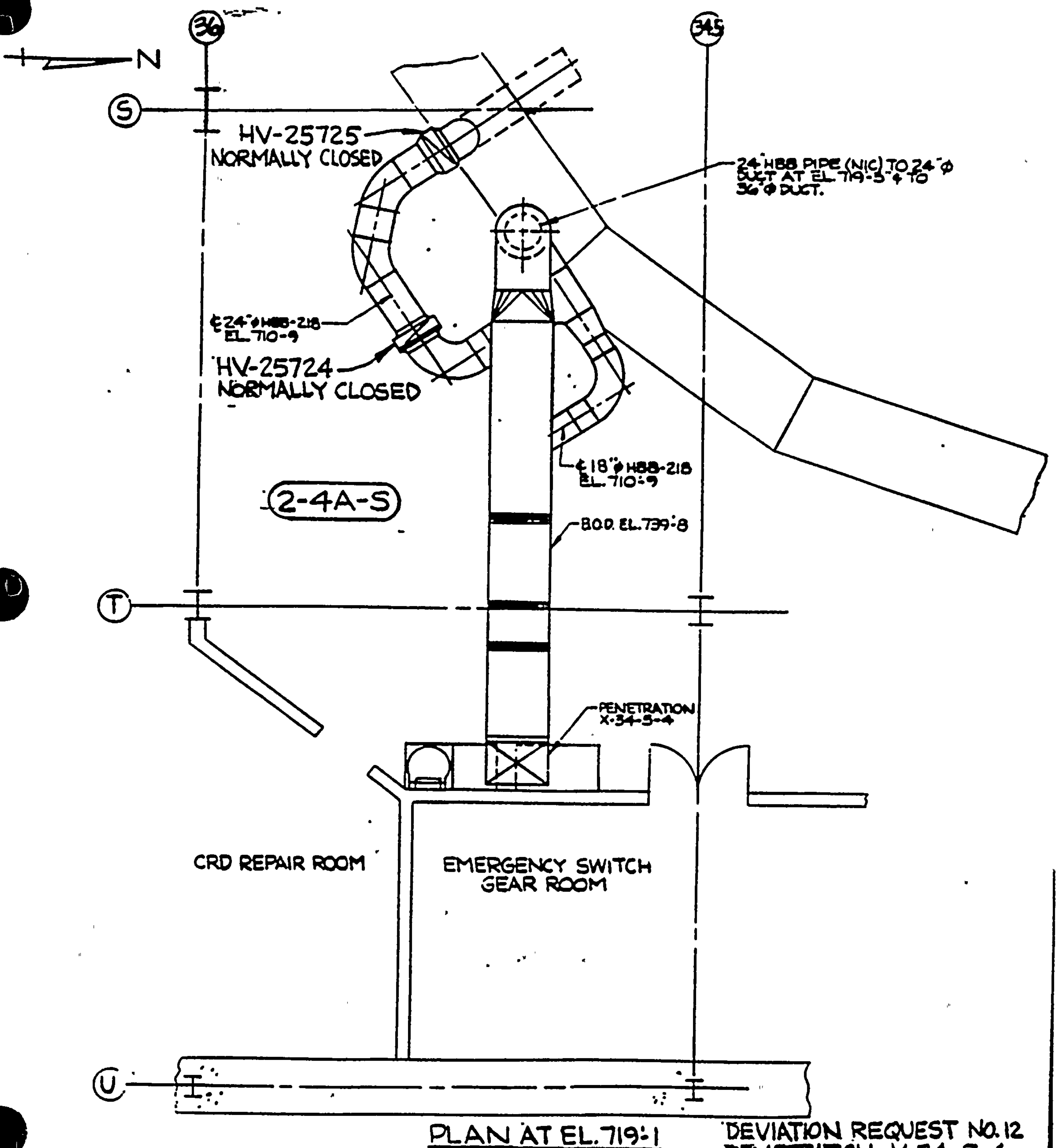
PLAN
ELEV. 719'-1"

DEVIATION REQUEST NO. 12
PENETRATION 29-5-54
FIGURE 7B



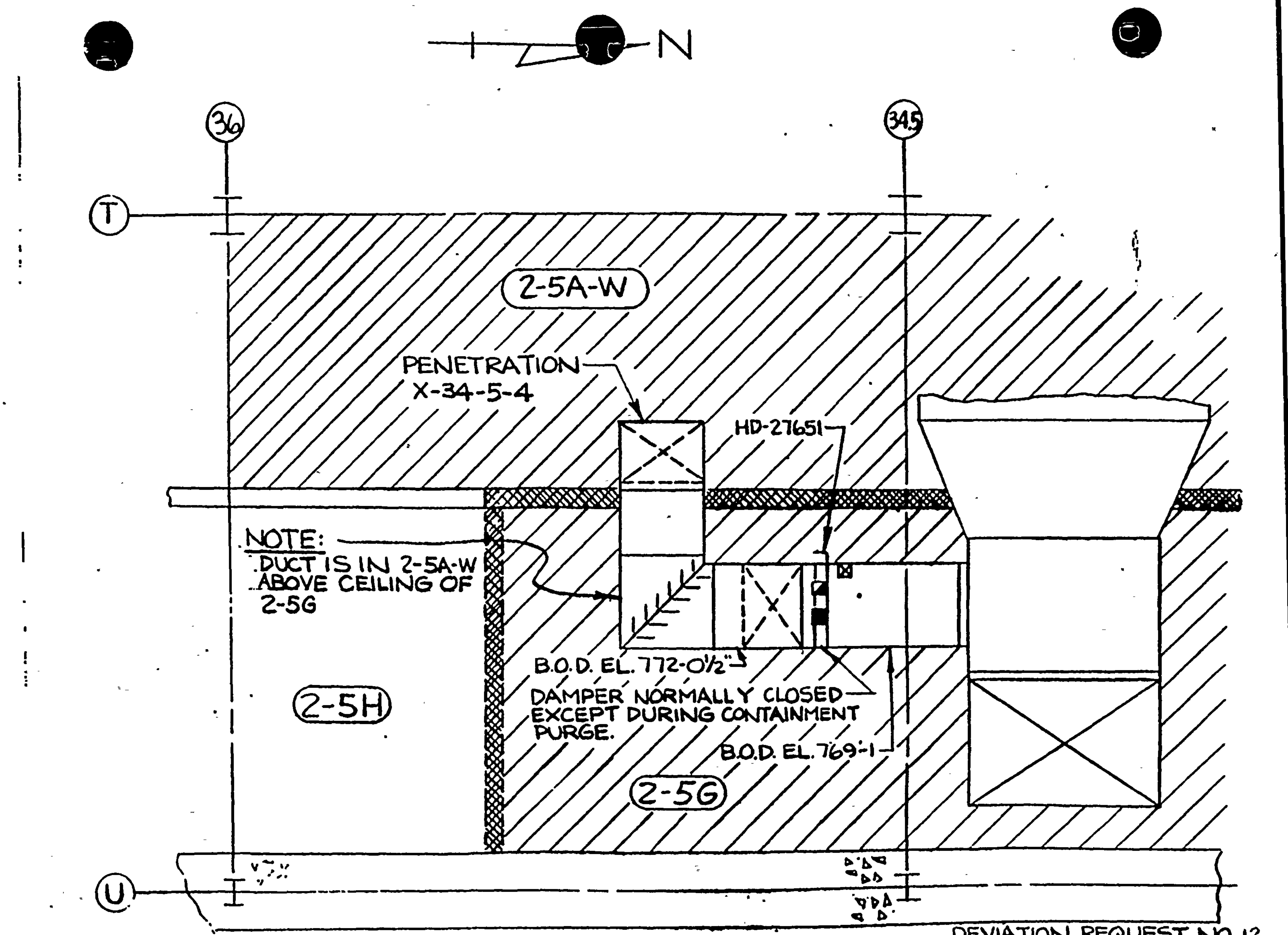
CONTAINMENT ATMOS. CONTROL
UNIT 2

DEVIATION REQUEST NO.12
PENETRATION X-34-5-4
FIGURE 8A



PLAN AT EL. 719-1

DEVIATION REQUEST NO. 12
PENETRATION X-34-5-4
FIGURE 8B



PLAN AT EL. 749'-1"

DEVIATION REQUEST NO. 12
PENETRATION X-34-5-4
FIGURE 8C

APPENDIX R DEVIATION REQUEST

ESSENTIAL REDUNDANT RACEWAY PROTECTION

EXEMPTION REQUEST:

We request approval of the following:

a) Protection of redundant safe shutdown cable in a Fire Zone may be accomplished through the use of one or a combination of methods identified in 10 CFR 50, Appendix R, Section III.G.2a, b, and c.

b) When different shutdown paths are used in different Fire Zones within a Fire Area, the raceways required to ensure availability of a path in a particular Fire Zone need only be protected in that Fire Zone or wrap around area.

c) Fire suppression need only be provided above essential safe shutdown raceway protected by a 1-hour fire rated barrier and the suppression can terminate at a fire zone boundary or if:

   1) the raceway barrier changes to a fire barrier rated at 3 hours.

   2) the raceway no longer requires protection. (i.e., the raceway exits in a wrap-around area.)

   3) The fire suppression is located 50 feet beyond the location of the raceway protected with a 1-hour fire rated wrap.

FIRE AREAS AFFECTED:

This deviation request applies to Fire Areas R-1A, R-1B, R-2A and R-2B in the Unit 1 and Unit 2 Reactor Buildings.

REASON FOR DEVIATION REQUEST:

The requirements of 10 CFR 50, Appendix R allows redundant safe shutdown raceway to be protected by the following methods:

III.G.2 a. Separation of cables and equipment and associated non-safety circuits of redundant trains by a fire barrier having a 3-hour rating. Structural steel forming a part of or supporting such fire barriers shall be protected to provide fire resistance equivalent to that required of the barrier.

III.G.2 b. Separation of cables and equipment and associated non-safety circuits of redundant trains by a horizontal distance of more than 20 feet with no intervening combustible or fire hazards. In

addition, fire detectors and an automatic fire suppression system shall be installed in the fire area; or

III.G.2 c. Enclosure of cable and equipment and associated non-safety circuits of one redundant train in a fire barrier having a 1-hour rating. In addition, fire detectors and an automatic fire suppression system shall be installed in the fire area.

NRC guidance documents indicate that fire suppression and fire wrapping (barrier) shall be complete inside fire area boundaries. When a combination of the methods listed above are utilized within a fire area (or fire zone), configurations are created which may conflict with guidance documents.

EXISTING CONDITIONS:

The 3-hour barrier method (III.G.2.a) and the 1-hour barrier with fire suppression and fire detection method (III.G.2.c) are used to protect redundant (essential) raceways at Susquehanna SES. The choice of methods depends on the availability of fire suppression.

PP&L's response to the NRC's concern on unrated fire zone boundaries contained two assumptions. First a 50 foot wide wrap-around area will be used to divide fire areas. Both divisions of redundant safe shutdown raceways are protected in a wrap-around area, but only one division would be protected in each horizontally adjacent zone (i.e., 1-4A-W would have Division I and II protected, 1-4A-N would have only Division I protected and 1-4A-S would have only Division II protected.) This is the subject of Deviation Request No. 4. Second, it was assumed that a fire would only spread to the next adjacent fire zones. Therefore, different safe shutdown paths could be protected in fire zones remote from each other. This is the subject of Deviation Request No. 7. In both cases fire barrier wrapping and fire suppression would not be provided throughout a fire area.

Automatic sprinkler protection is provided to protect essential redundant safe shutdown raceway wrapped with a 1-hour fire rated barrier and is extended either to the fire zone boundary or a maximum 50 feet beyond the location of the 1-hour fire wrapped raceway (see attached figure).

The attached figures provide additional details.

JUSTIFICATION:

It is our position that since it is acceptable to utilized the protection methodology described in either Appendix R, III G.2.a, b, or c on an individual basis, then utilizing a combination of those methods within a fire area is justifiable.

When a combination of these methods is used throughout a fire zone or fire area it is possible that, the 1-hour or 3-hour rated wraps would not be complete throughout the zone or area.

Limiting protection as a result of wrap-around area concept is justified, as documented by Deviation Request No. 4.

The limiting of protection as a result of utilizing different safe shutdown paths in different fire zones within the same Fire Area is justified, as documented by Deviation Request No. 7.

Since the maximum fire loading within any fire zone of either reactor building does not exceed 45 minutes, automatic sprinkler protection which extends either to the Fire Zone boundary or for a horizontal distance of 50 feet on either side of the essential minority raceway is adequate to protect essential safety shutdown raceways wrapped with a 1-hour rated fire barrier.

dk/j006c:krp

APPENDIX R DEVIATION REQUEST

REQUEST NO. 13

FIGURES

REQUEST NO. 13

FIGURE #1

SPRINKLER PROTECTION PROVIDED TO PROTECT ESSENTIAL SAFE SHUTDOWN RACEWAY WRAPPED WITH 1-HOUR FIRE RATED BARRIER

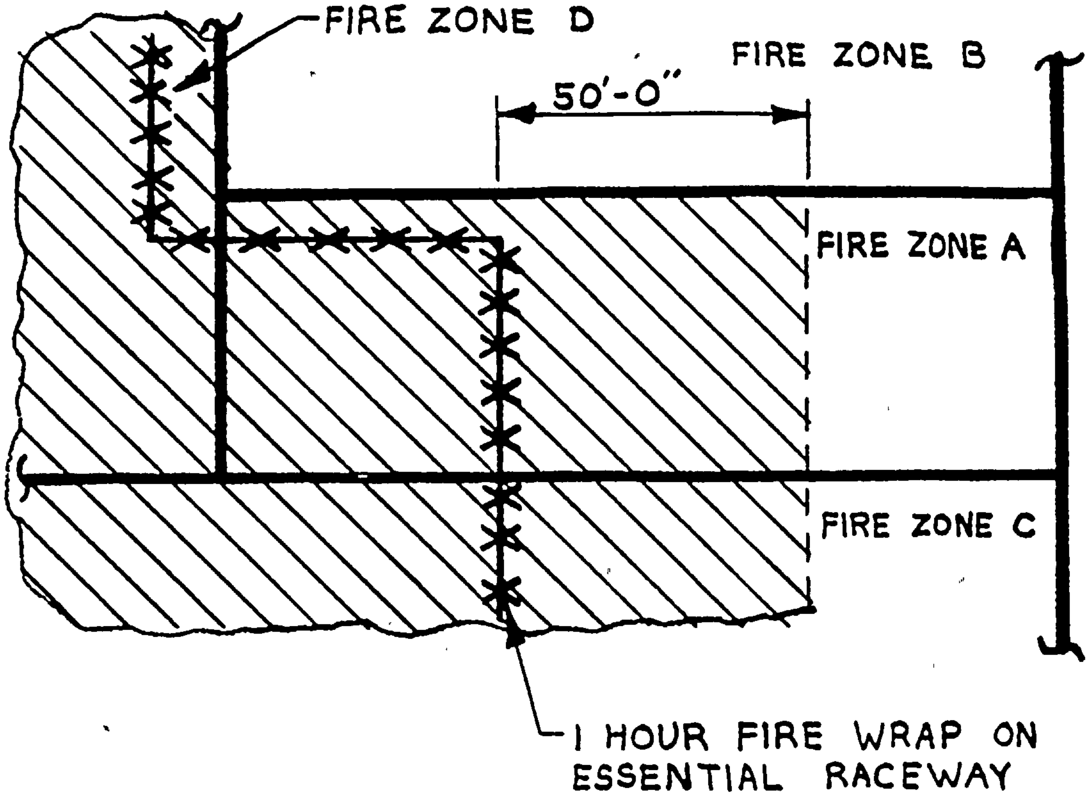
Fire Area	Fire Zone	Protection Within Zone
R-1A	1-3 B-W	Full
	1-3B-S	Full
	1-3A	Part
	1-4A-S	Full
	1-4A-W	Full
	1-5A-S	Full
R-1B	1-2B	Full
	1-3B-N	Part
	1-3B-W	Full
	1-4A-N	Part
	1-4A-W	Full
R-2A	2-3B-S	Full
	2-3B-W	Full
	2-4A-S	Part
	2-4A-W	Full
		Full
	2-5A-W	Full
R-2B	2-3B-N	Part
	2-3B-W	Full
	2-4A-W	Full
	2-4A-N	Full
	2-4B	Full
	2-5A-W	Full
	2-5A-N	Full

NOTE: Part indicates:

a) Sprinkler protection is not provided throughout the entire fire zone
and
b) Protection is extended 50 feet beyond the 1-hour wrapped raceway
or
c) The wrapping changes to a 3-hour fire rated wrap.
or
d) The essential raceway leave the "wrap-around" area, and protection is not required.

dk/k019i:mg

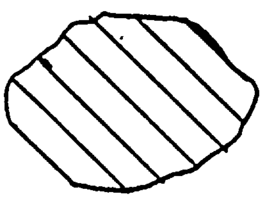
[illegible]



TYPICAL

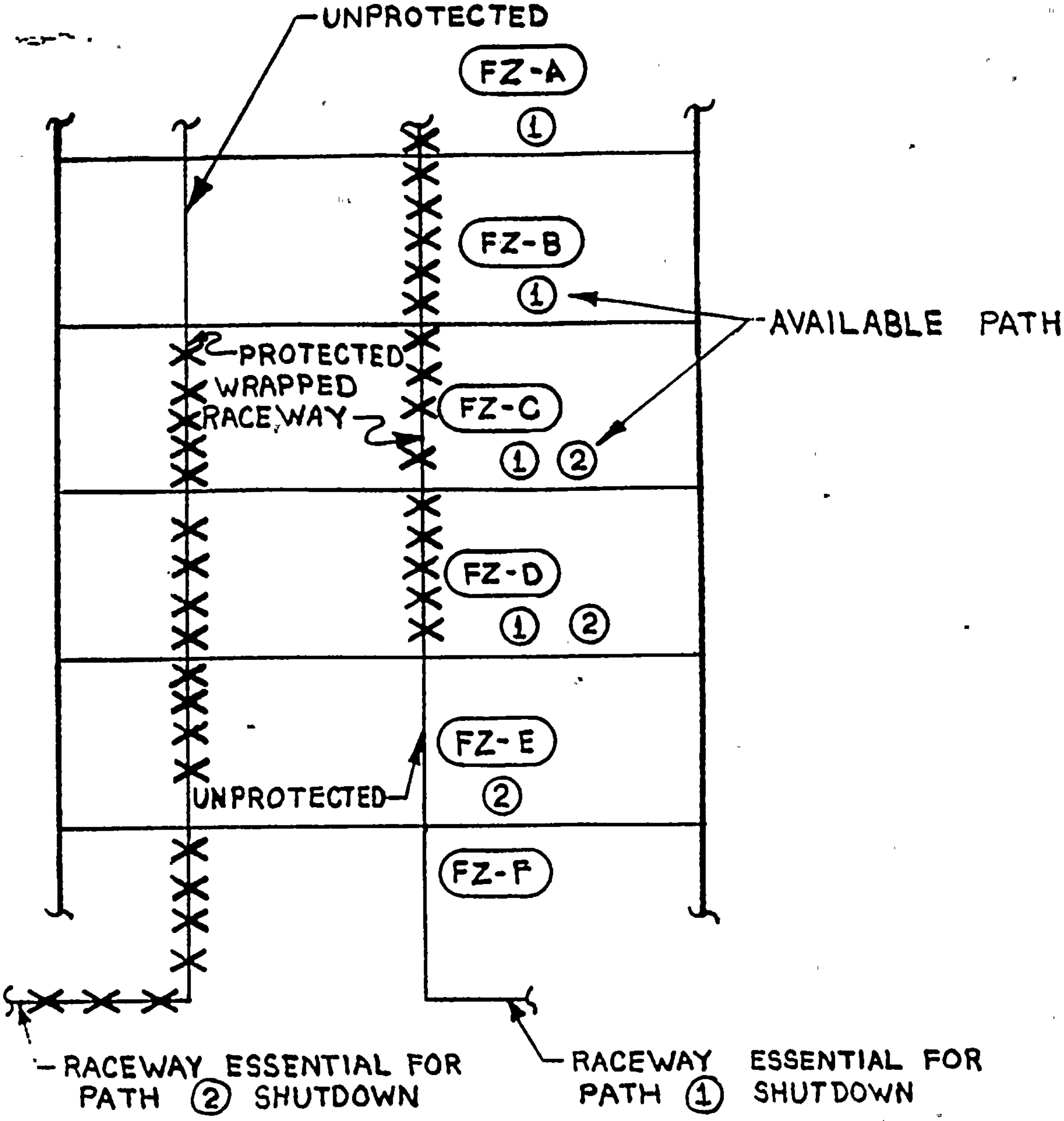
SPRINKLER PROTECTION WHEN A 1 HOUR FIRE WRAP IS USED.

PLAN VIEW



INDICATES AREA COVERED BY SPRINKLER PROTECTION

REQUEST NO. 13
FIGURE 2

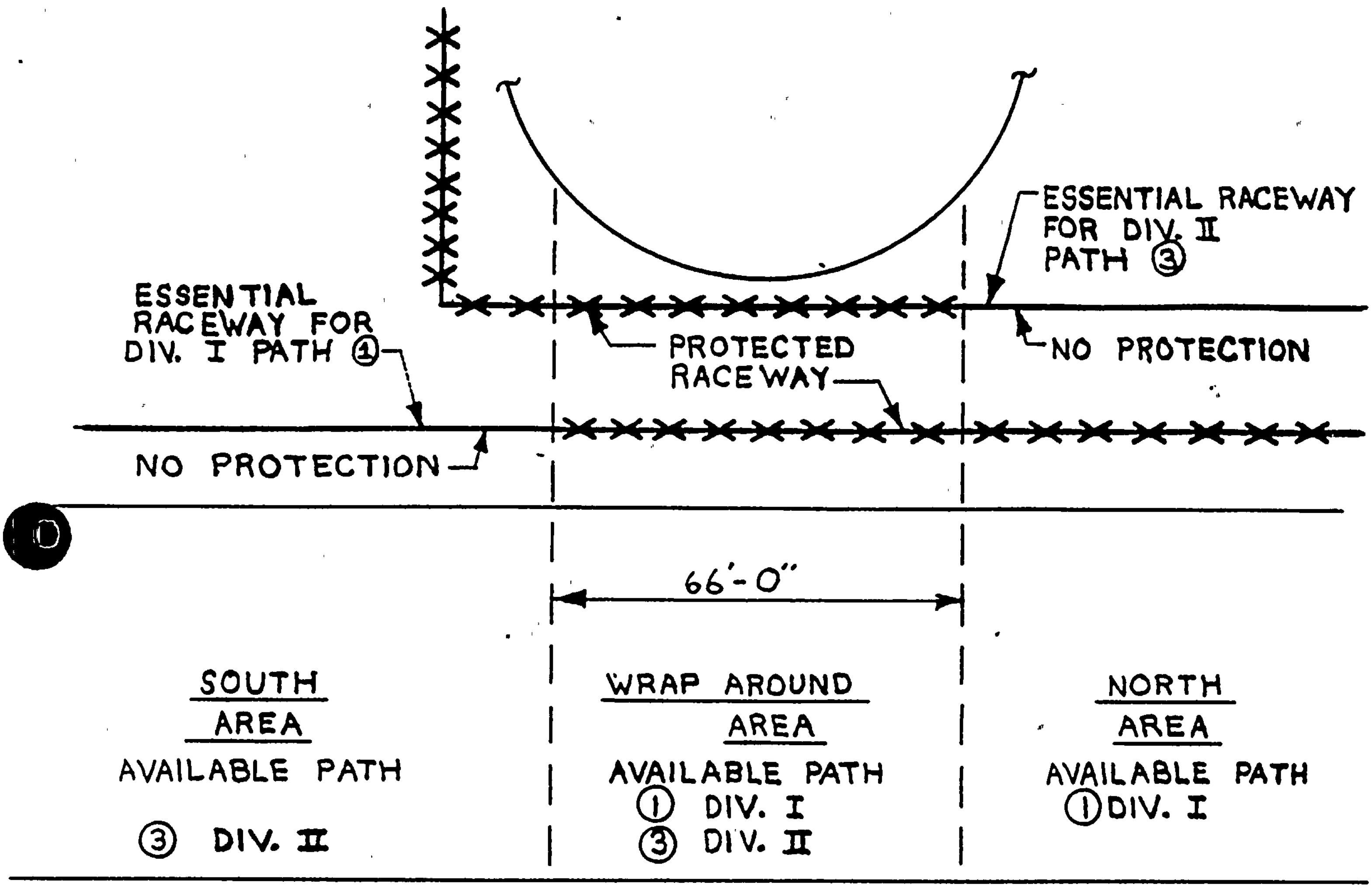


PLAN VIEW

TYPICAL

CONFIGURATION WHEN FIRE ZONES DO NOT USE THE SAME SHUTDOWN PATH

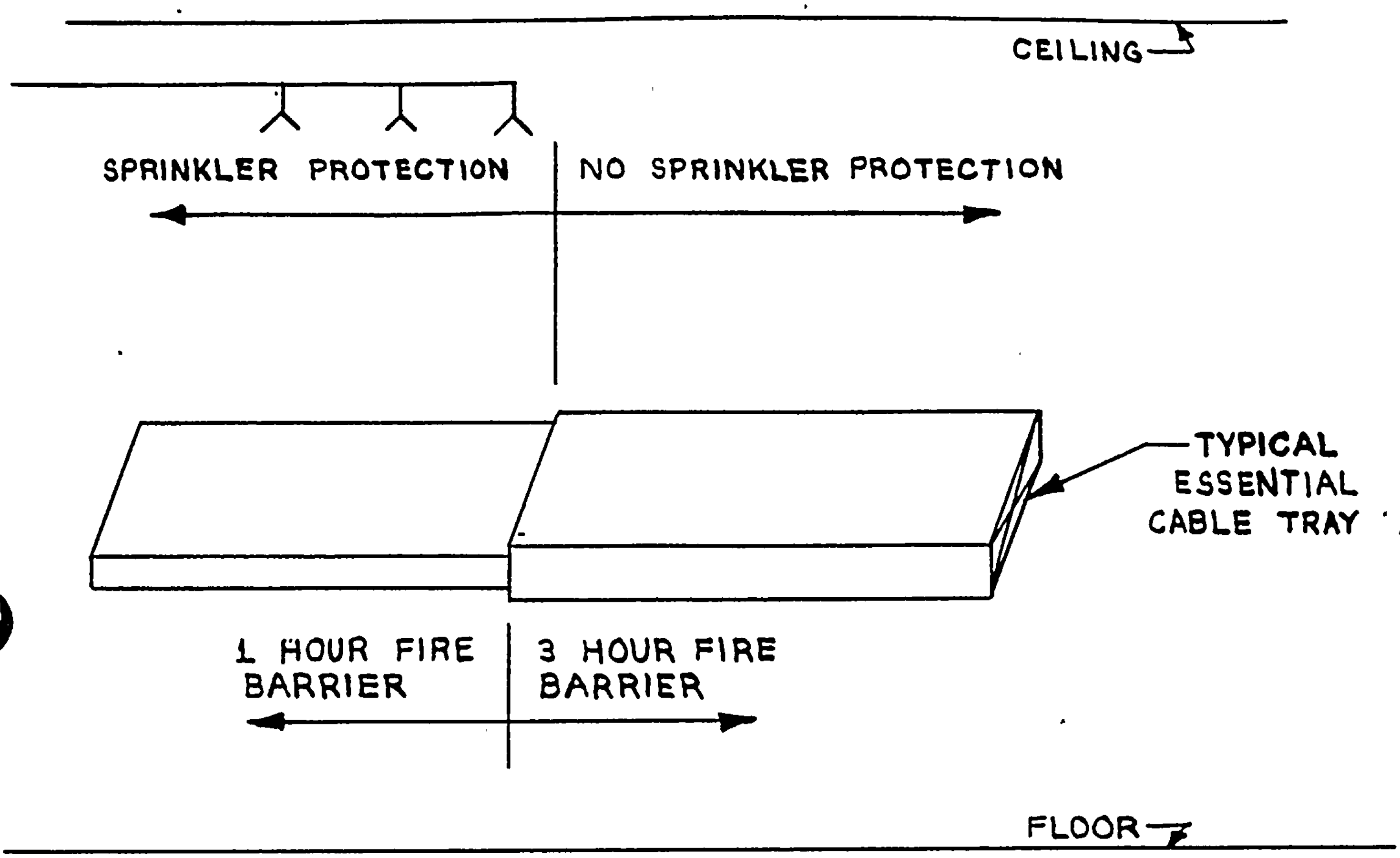
REQUEST NO. 13
FIGURE 3



TYPICAL
WRAP AROUND AREA PROTECTION

REQUEST NO. 13
FIGURE 4

TYPICAL PROTECTION CONFIGURATIONS



TYPICAL ELEVATION VIEW

TYPICAL

1 HOUR WITH FIRE SUPPRESSION (PART)
AND
3 HOUR WITHOUT FIRE SUPPRESION (PART)

REQUEST NO. 13
FIGURE 5

APPENDIX R DEVIATION REQUEST

REACTOR BUILDING FIRE ZONES WITHOUT FIRE DETECTION

DEVIATION REQUEST:

We request approval of the following:

Fire detection need not be provided in Fire Zones which do not contain safe shutdown raceway or do not represent an exposure hazard to safe shutdown equipment even if a fire zone within the same area contains essential redundant safe shutdown raceway. The provision of automatic sprinkler protection in lieu of fire detection is acceptable in Fire Zones 1-1C and 2-1C.

FIRE AREA AFFECTED:

This deviation applies to Unit #1 and #2 Reactor Buildings, Fire Areas: R-1A, R-1B, R-2A and R-2B.

REASON FOR DEVIATION REQUEST:

The requirements of 10 CFR 50, Appendix R, Section III.G.2 require fire detection. The NRC guidance indicates fire detection should be provided throughout a fire area. Fire detection has not been provided in the Reactor Building Fire Zones listed below under Existing Arrangement.

EXISTING ARRANGEMENT:

The following zones do not have fire detection:

Fire Area	Fire Zone	Reason
R-1A	1-2C	No electric detection - Automatic sprinklers provided
	1-4E	No safe shutdown cables-very low combustible loadings
	0-6H	Cask Storage Pit
	1-7B	No safe shutdown cables-very low combustible loadings
	1-6F	Spent fuel pool
R-1B	1-1I	Stairwell-no safe shutdown raceway or combustibles
	1-1J	Stairwell-no safe shutdown raceway or combustibles
	1-6F	Spent fuel pool
	0-6G	No safe shutdown cables-very low combustible loadings
R-2A	2-2C	Same as 1-2C
	2-4E	Same as 1-4E
	2-1I	Same as 1-1I
	2-6F	Same as 1-6F
R-2B	2-1J	Same as 1-1J

JUSTIFICATION:

Fire zones 1-2C and 2-2C have been provided with automatic sprinkler protection. Detection of a fire is provided via the sprinkler flow alarm when heat activates a sprinkler head. The remainder of the fire zones listed above do not contain safe shutdown raceway or equipment. None of the zones listed above represent a fire hazard which impacts on adjacent fire zones.

The NRC requested additional detection for Fire Zones 1-7B and 1-6F in FSAR Question 281.17. There was no additional detection requested for Fire Zones 1-2C, 1-4E or 0-6H. Our response to the staff and our Fire Protection Review Report both indicated that additional smoke detection would be provided in zones which contain or present a fire exposure hazard to safe shutdown equipment. The Fire Zones delineated in this request do not present an exposure fire hazard to safe shutdown equipment.

dk/j006c:krp

APPENDIX R DEVIATION REQUEST

CONTROLSTRUCTURE
FIRE AREA WITHOUT FIRE SUPPRESSION

DEVIATION REQUEST:

We request approval of the following:

Automatic fire suppression is not required for the protection of 1-hour wrapped essential redundant safe shutdown raceway in Fire Areas CS-11 and CS-20.

FIRE AREA AFFECTED:

This deviation applies to Fire Areas CS-11 (Fire Zone 0-28A-I) and CS-20 (Fire Zone 0-28A-II).

REASON FOR DEVIATION REQUEST:

The requirements of 10CFR50, Appendix R, Section III G.2.C require fire suppression, if a one-hour fire rate barrier for cable is provided. Fire areas CS-11 and CS-20 are not provided with automatic fire suppression.

EXISTING CONDITIONS:

Fire Areas CS-11 and CS-20 contain essential safe shutdown raceway protected by a one hour barrier. The combustible loading in each area is less than 1 minute. All cables are in conduits. No cable trays which could add to the combustible loading are located in either fire area.

JUSTIFICATION:

Fire Areas CS-11 and CS-20 are identical in function and hazard to Zone 0-28B which was the subject of a request for variance.(PLA-1013, 2-9-82). The NRC concluded in SER Supplement #4 that the approach in question was acceptable for Zone 0-28B.

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APPENDIX R DEVIATION REQUEST

SWITCHGEAR ROOM COOLER FANS INSUFFICIENT SPATIAL SEPARATION

DEVIATION REQUEST:

We request approval of the following:

The Switchgear Room Cooling Fans, 1V222A (Division I) and 1V222B (Division II) for Unit 1 (Fire Zone 1-4A-S) and 2V222A (Division I) and 2V222B (Division II) for Unit 2 (Fire Zone 2-4A-S) are required safe shutdown equipment.

The Division I and II equipment are located within 6 feet of each other. Automatic fire detection and suppression equipment are located within each zone above the equipment. Both zones are located on mezzanines 20 feet above the main floor with access only by ladder. Transient combustibles are precluded by the congestion of equipment, ducts, conduits, and pipes in an area with only a 5' - 9" height clearance and accessible only by ladder. The combustible loading in the each zone is low.

This combination of protection constitutes an adequate level of safety and is an acceptable deviation from the staff's guidelines.

FIRE AREA AFFECTED:

The Unit #1 fans are located in fire zone 1-4A-S located in Fire Area R-1A. The identical Unit 2 fans are located in fire zone 2-4A-S located in Fire Area R-2B.

REASON FOR DEVIATION REQUEST:

The requirements of 10 CFR 50, Appendix R, Section III G.2.b requires redundant safe shutdown equipment to be separated by 20-feet (with no intervening combustibles) and fire suppression and detection must be provided. Redundant switchgear room cooling fans are located less than 20 feet from each other.

EXISTING ARRANGEMENT:

Switchgear Room Cooling Fans 1V222A (Division I) and 1V222B (Division II) are located in fire zone 1-4A-S on a mezzanine above fire zone 1-4E. Fire Zone 1-4A-S in the area of these fans and 1-4E have low combustible loading. Fire Zone 1-4A-S has automatic sprinkler protection and fire detection above the equipment. The mezzanine is 20-feet above the main floor of Fire Zone 1-4A-S (Elevation 719'1"). Transient combustibles in this area are precluded by the congestion of equipment, ducts, conduits, and pipes in area with only 5'9" clear height and accessible only by ladder. See Figures 1 and 2 for details.

Unit 2 conditions are identical. The fans are 2V222A (Division I) and 2V222B (Division II). The fire zones are 2-4A-S and 2-4E. See Figures 3 and 4 for details.

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The redundant fans are separated by six feet.

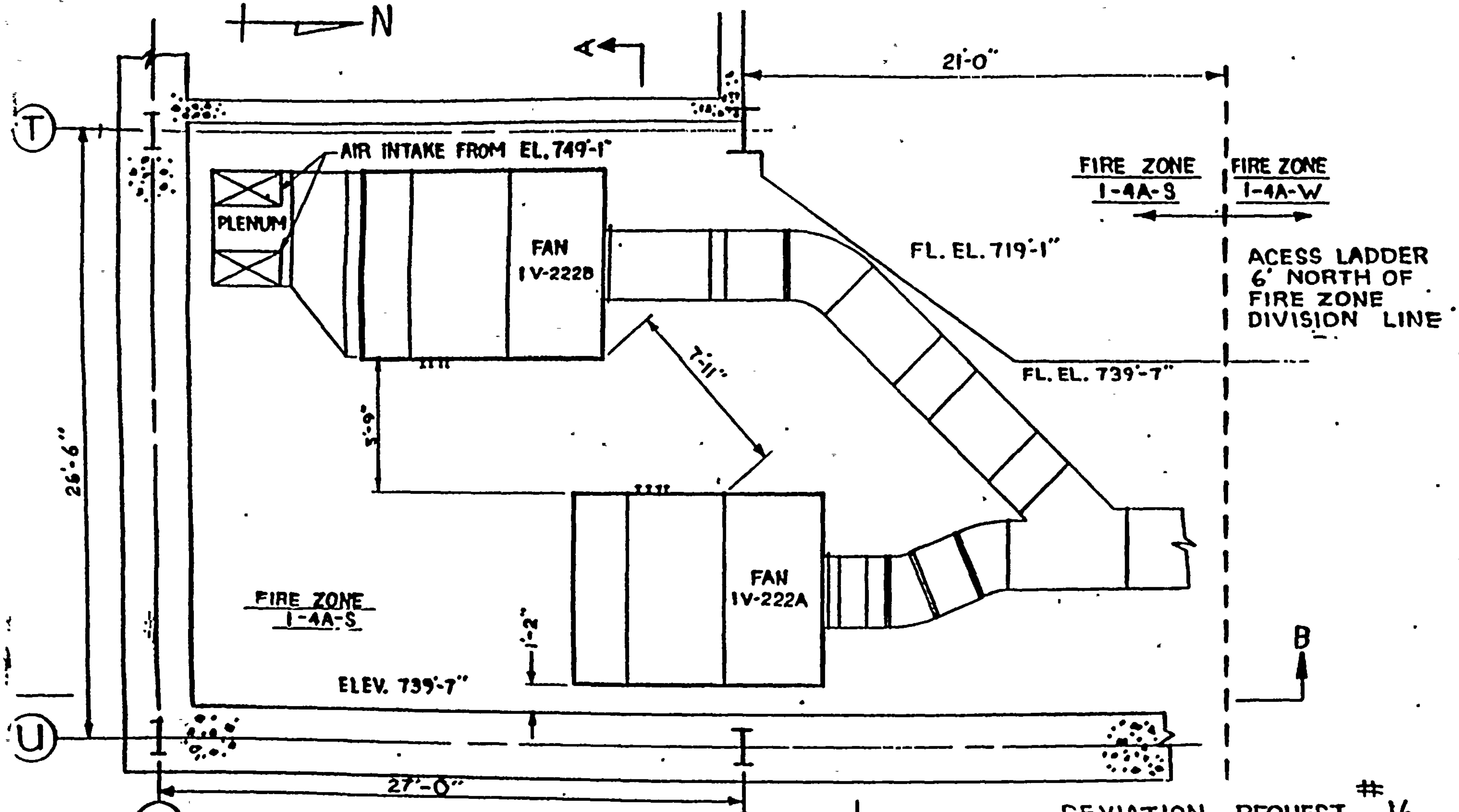
JUSTIFICATION:

The existing fire suppression, fire detection, and 6 foot spatial separation are adequate measures to protect equipment located in a inaccessible location with low combustible loadings.

APPENDIX R DEVIATION REQUEST

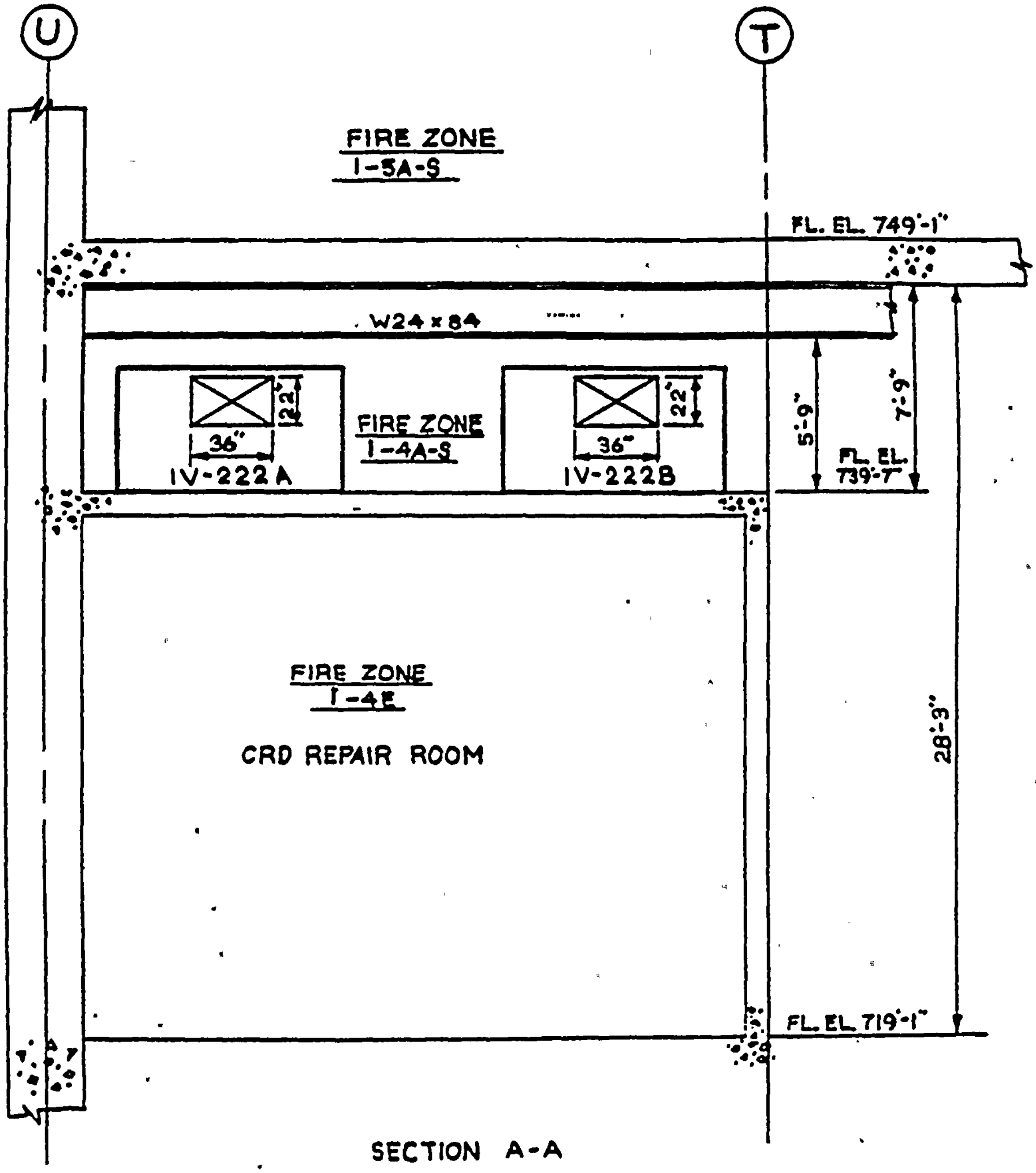
REQUEST NO. 16

FIGURES



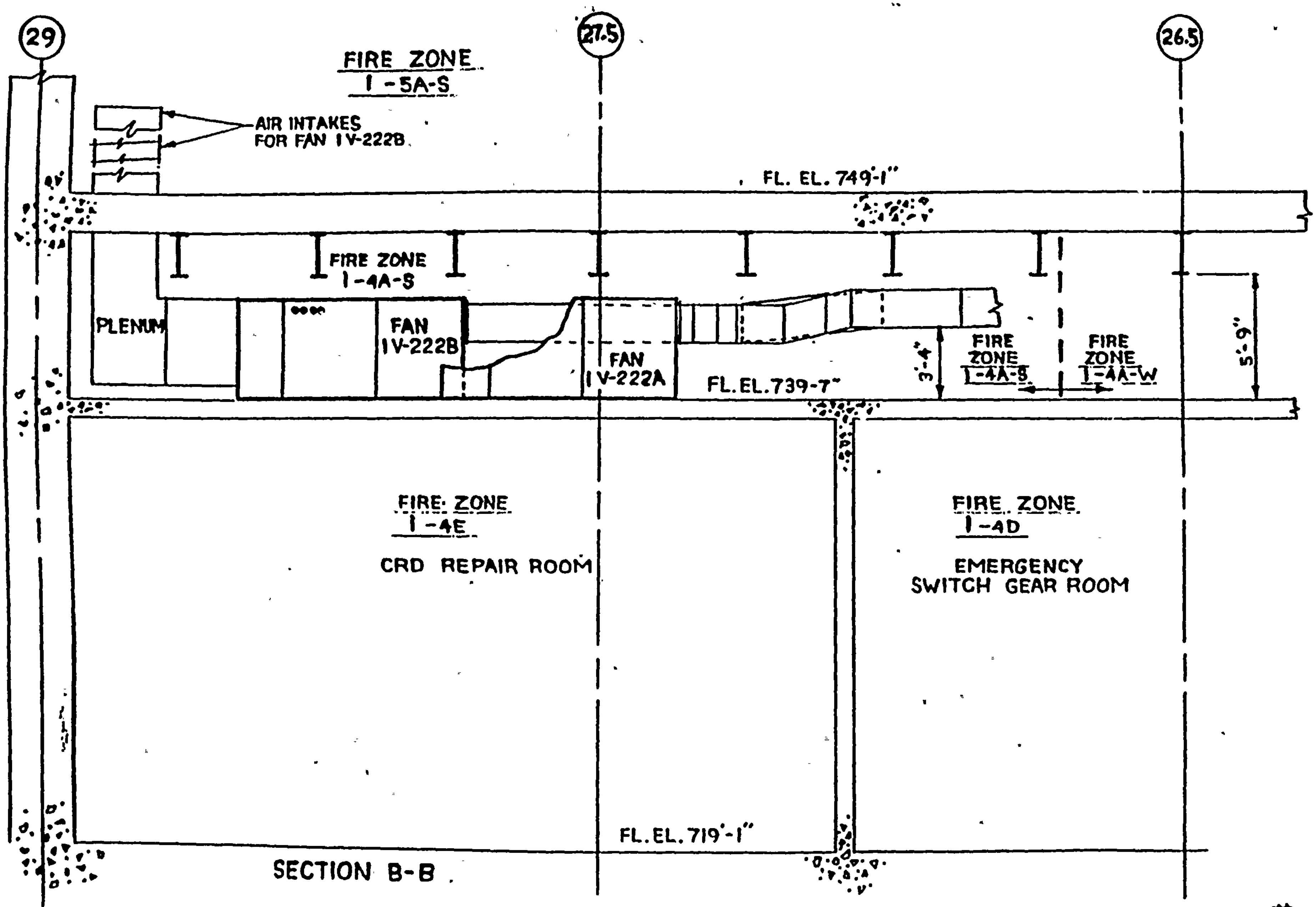
PLAN

DEVIATION REQUEST #16
FIGURE 1
UNIT 1



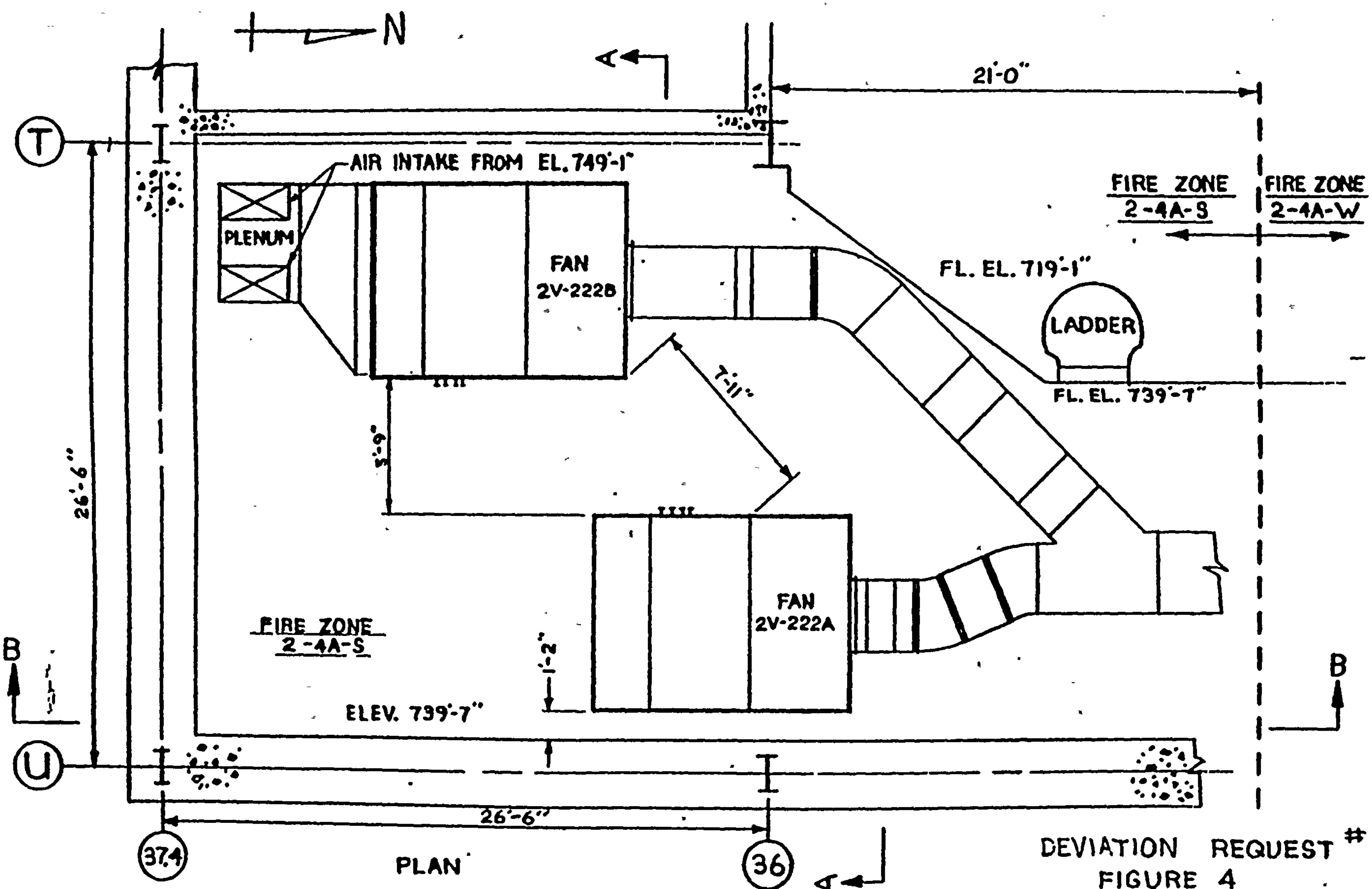
SECTION A-A

DEVIATION REQUEST #16
FIGURE 2
UNIT 1

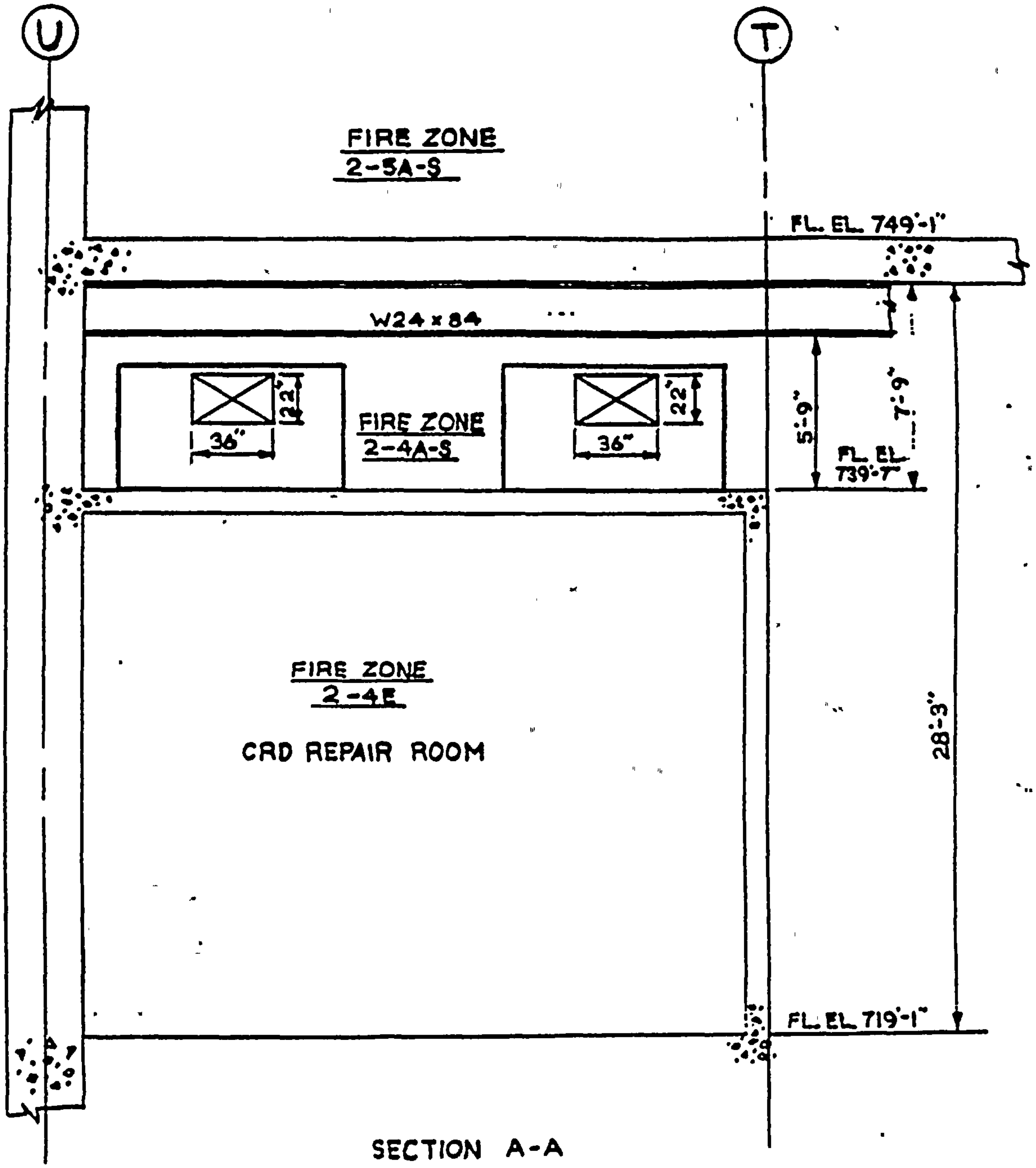


SECTION B-B

DEVIATION REQUEST #16
FIGURE 3
UNIT #1

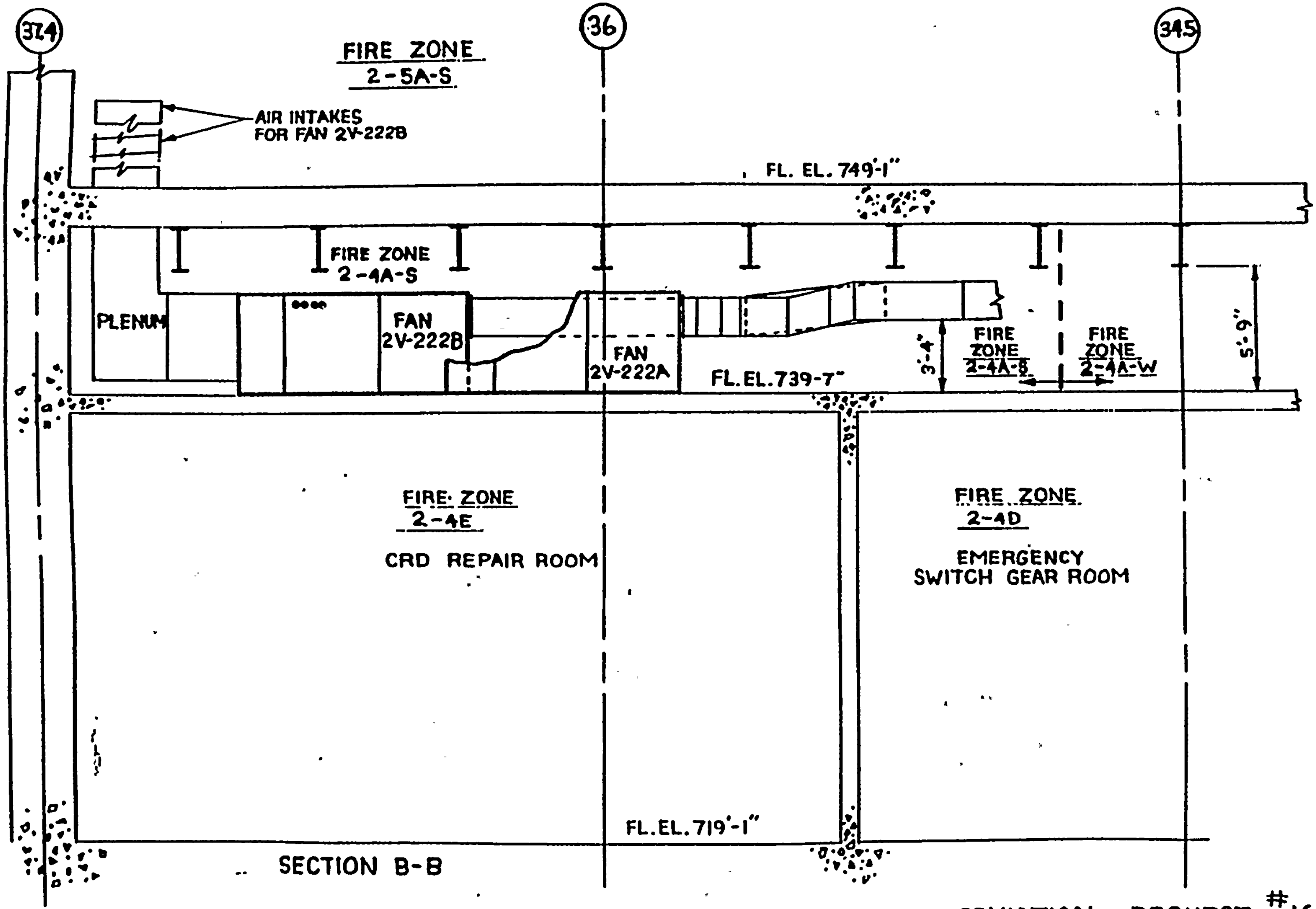


DEVIATION REQUEST # 16
FIGURE 4
UNIT # 2



SECTION A-A

DEVIATION REQUEST #16
FIGURE 5
UNIT 2



SECTION B-B

DEVIATION REQUEST #16
FIGURE 6
UNIT #2

APPENDIX R DEVIATION REQUEST

KAOWOOL SYSTEM AS AN ACCEPTABLE 1-HOUR FIRE BARRIER WRAP

DEVIATION REQUEST

We request approval of the following:

A Kaowool fire barrier wrap system along with an automatic suppression system is acceptable for use as a 1-hour fire barrier in plant areas where the installation currently exist.

FIRE AREAS AFFECTED:

Kaowool has been installed in the following plant areas:

Fire Area	Fire Zones with Kaowool
R-1A	1-3B-S
	1-3B-W
	1-4A-S, W
	1-5A-S
R-1B	1-3A
	1-3B-N
	1-3B-W
	1-4A-W
	1-4A-N
CS-10	0-27-C
CS-3	0-25E

REASON FOR DEVIATION REQUEST:

The requirements of 10CFR50, Section II.G.2.C, allows the use of a 1-hour fire barrier wrap. NRC guidance letter 85-01, Section 3.2.1 indicates that the "Kaowool System", which had been accepted by the NRC, failed to meet the 325°F temperature limit. This system has been installed at Susquehanna SES.

EXISTING ARRANGEMENTS:

All fire zones in which Kaowool has been installed have automatic fire suppression installed a minimum of 50' on either side of the wrapped raceway. Fire detection is also provided in these fire zones.

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JUSTIFICATION:

Kaowool was installed as a barrier wrap at Susquehanna SES prior to fuel load on Unit 1 (July, 1982). In Generic Letter 85-01, the staff has stated that conduit and cable tray enclosure materials accepted by the NRC as a 1-hour barrier prior to Appendix R (e.g. some Kaowool and 3M materials) and already installed by the licensee need not be replaced even though they may not have met the 325^{o} criteria." The existing Kaowool installations at Susquehanna SES were previously approved by the NRC. Each installation is protected by an automatic fire suppression system. While another barrier design may be preferable and has been utilized at Susquehanna SES, Kaowool provides a sufficient level of protection for raceways when fire suppression is provided so as to not warrant its replacement in areas of the plant where it is currently installed.

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APPENDIX R DEVIATION REQUEST

FIRE PROTECTION SYSTEMS
DEVIATIONS FROM NFPA REQUIREMENTS

DEVIATION REQUEST:

We request approval of the following:

The use of small orifice sprinkler heads in preaction sprinkler systems protecting the essential safe shutdown raceway is acceptable.

FIRE AREAS AFFECTED:

This deviation applies to Fire Areas R-1A, R-1B, R-2A, and R-2B.

REASON FOR DEVIATION REQUEST:

Generic Letter 85-01 indicates fire suppression must comply with NFPA requirements in order to meet 10 CFR 50 Appendix R requirements. Certain sprinkler systems installed at Susquehanna SES do not comply with NFPA 13, Section 3-16.5.2a.

NFPA 13 (1985) Section 3-16.5.2a states:

> "(a) Small orifice sprinklers shall not be used on dry-pipe, preaction or combine dry-pipe and pre-action systems."

EXISTING ARRANGEMENT:

Preaction sprinkler systems in the following fire zones utilize 3/8 inch orifices rather than 1/2 inch standard orifices.

Unit 1		Unit 2	
Fire Area	Fire Zone	Fire Area	Fire Zone
R-1A	1-4A-S	R-2A	2-3B-S
	1-4A-W		2-3B-W
	1-3B-S		2-4A-W
	1-3B-W		2-4A-S
	1-5AS		2-4B
			2-5A-W
R-1B	1-2B	R-2B	2-3B-W
	1-3B-W		2-3B-N
	1-3B-N		2-4A-W
	1-4A-W		2-4A-N
	1-4A-N		2-5A-W
			2-5A-N

JUSTIFICATION:

The maximum combustible loading within reactor building is 45 min. (in situ and transient).

In 1981 and 1982, sprinkler systems were retrofitted to provide protection for essential safe shutdown raceway. These systems utilize a preaction systems to minimize damage to safety related equipment. The systems were designed to provide .15 gpm/sq. ft. over the entire area of application, or 2,500 sq. ft., (whichever is smallest). If 1/2 inch orifice heads had been used, large individual head densities would have resulted at areas close to the supply valve. The smaller orifice heads were utilized to minimize the impact on the existing drainage system.

The time delay to evacuate the low pressure supervisory air in the preaction system is minimal.

The use of small orifice sprinkler nozzles does not impact the ability of these preaction systems to properly protect these areas.

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APPENDIX R DEVIATION REQUEST

INCOMPLETE FIRE SUPPRESSION AND FIRE DETECTION IN DIESEL GENERATOR FIRE AREAS

DEVIATION REQUEST:

We request approval of the following:

Existing fire protection in Fire Areas D-1 and D-3, consisting of automatic suppression and detection in the basement (EL 660' - 0") and ground floor (EL677' - 0") only, is adequate to protect essential redundant safe shutdown equipment located within the fire areas. Specifically, no automatic suppression or detection is required for the top floor (EL 710' - 9").

FIRE AREA AFFECTED:

This deviation covers Diesel Generator Fire Areas D-1 (0-41A) and D-3 (0-41C). Fire areas D-2 and D-4 do not contain essential redundant safe shutdown raceway and, therefore, are not in deviation.

REASON FOR DEVIATION REQUEST:

The requirements of 10CFR50, Appendix R, Sections III.G.2 require fire detection, and fire suppression when redundant safe shutdown raceway exist within a fire area. NRC guidance indicates fire detection and suppression should be provided throughout a fire area. Portions of the Diesel Generator Buildings do not satisfy these requirements.

EXISTING ARRANGEMENT

Fire Areas D-1 and D-3 contain essential safe shutdown equipment. Automatic suppression and fire detection is provided for the basement (EL 660'0") and the ground floor (El. 677'0") of each Fire Area.. The top floor of each Fire Area (El. 710'9"), neither of which contain essential safe shutdown equipment, are not provided with fire suppression or fire detection.

JUSTIFICATION:

The top floor (El. 710'9") of each Fire Area contains fan equipment only, have minimal combustibles, and do not contain any redundant safe shutdown raceway and consequently do not present a hazard to redundant safe shutdown raceway located in the basement elevations.

dk/j006c:krp

APPENDIX R DEVIATION REQUEST

PENETRATION SEALS - CONDUITS

DEVIATION REQUEST:

We request approval of the following:

It is acceptable to seal new and existing conduits at Susquehanna SES which penetrate fire rated barriers in the following manner:

A. All conduit ends which terminate more than 6 inches from a wall and terminate either as open ends (i.e., cable drops) or into boxes (or cabinets) with ventilation openings are provided with a non-fire rated seal to prevent the passage of air and hot gases.

B. All conduit ends which terminate in enclosed boxes such as junction boxes, are not sealed since the junction box, etc., would prevent flow of hot gases and air.

FIRE ZONE AFFECTED:

The requirements for fire rated seals (PP&L Specification C1027) and general sealing of conduits (Drawing E-49) are applied throughout the facility, therefore, this deviation applies to all safety related fire area boundaries.

REASON FOR DEVIATION REQUEST:

The requirements of 10CFR50, Appendix R, Section III.G.2 require fire areas to have rated fire boundaries. In Generic Letter 85-01, Section 8.8 the NRC indicated requirements for sealing conduits as they passed through fire rated boundaries. The conduits passing through fire rated barriers at Susquehanna SES are protected in a different, but equivalent manner.

EXISTING ARRANGEMENT:

Conduits at Susquehanna SES are sealed in the following manner: (See attached Figure 1)

A. When both ends of the conduit terminate within 6 inches of the barrier a full fire rated seal is provided in the conduit. Such seals coincide with the fire barrier.

B. All conduit ends which terminate more than 6 inches from a wall and terminate either as open ends (i.e., cable drops) or into boxes (or cabinets) with ventilation openings are provided with a non-fire rated seal to prevent the passage of air and hot gases.

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C. All conduits which terminate in enclosed boxes such as junction boxes, are not sealed. The junction box, etc., prevents flow of hot gases and air.

JUSTIFICATION:

Conduits which terminate within 6 inches on both sides of the fire barrier are adequately filled with a fire rated penetration seal which coincides with the fire barrier. When the conduit extends more than 6 inches, then it is not possible using our existing procedures to place a 9 inch fire rated penetration seal which coincides with the barrier. Protection of the penetration in this situation relies on fire not breaching the conduit for the distance between the non-coincidence fire seal and the fire barrier, and the non-coincidence seal preventing transfer of hot gases and smoke.

As an alternative to a fire rated seal at one end of a conduit, (which extends more than 6 inches from a fire barrier) all conduit ends at Susquehanna SES are treated in a manner which prevents transfer of hot gases and smoke through the conduits. The treatment of both ends of all conduits ensures that, when conduits penetrate fire barriers, the conduit end not exposed to a fire will prevent passage of hot gases and smoke. Therefore, a fire rated seal at one end is not required.

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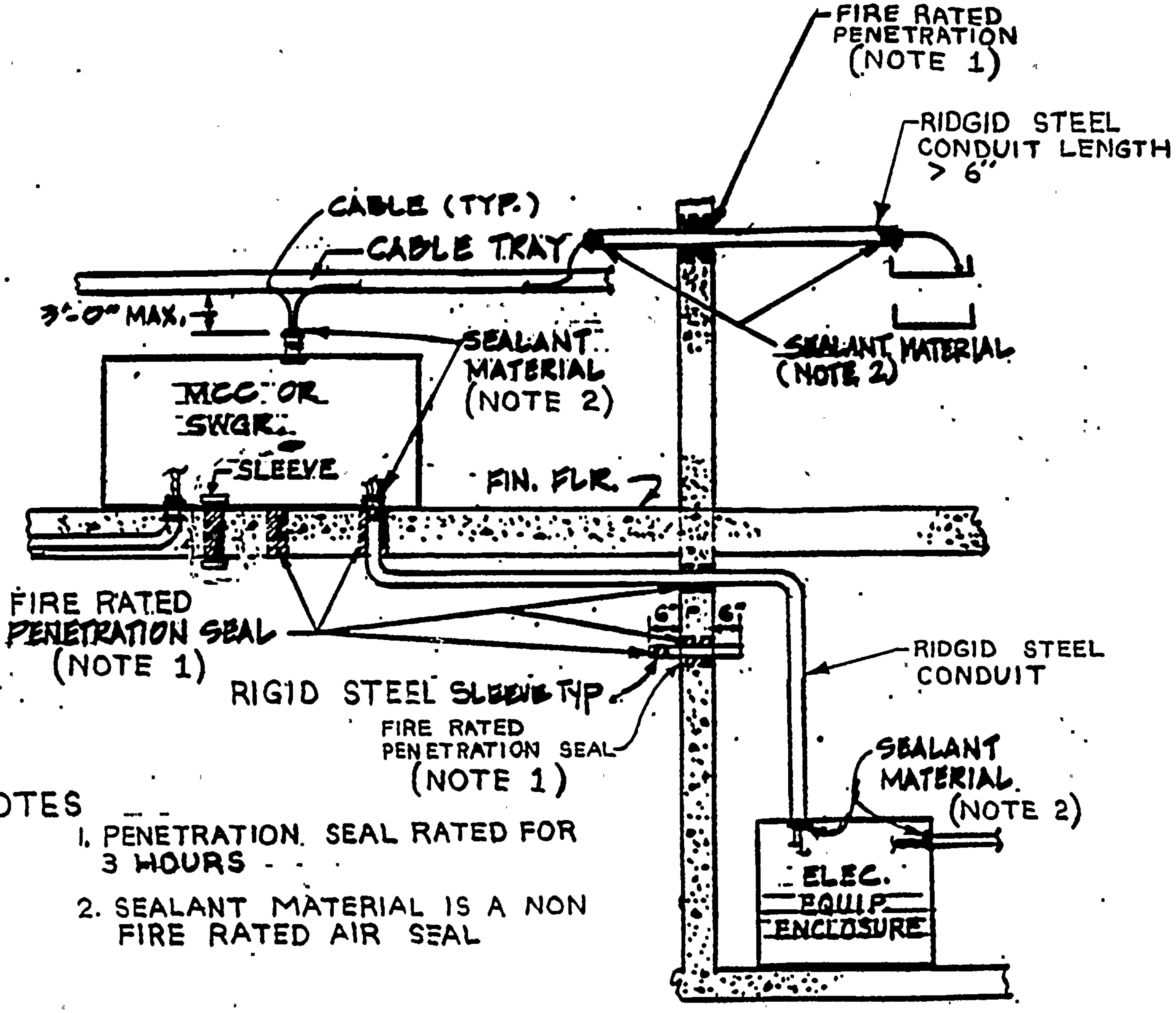
APPENDIX R DEVIATION REQUEST

REQUEST NO. 20

FIGURE

TYPICAL INTERNAL CONDUIT SEALING DETAILS



NOTES

1. PENETRATION SEAL RATED FOR 3 HOURS
2. SEALANT MATERIAL IS A NON FIRE RATED AIR SEAL

DEVIATION REQUEST No 20

FIGURE # 1

APPENDIX R DEVIATION REQUEST

CONTROL STRUCTURE
FIRE ZONES WITHOUT FIRE DETECTION OR FIRE SUPPRESSION

DEVIATION REQUEST:

We request approval of the following:

The fire detection and fire suppression as described herein for Fire Zones 0-21A, 0-22A, 0-22C, 0-23, 0-24A, 0-24B, 0-24C, 0-24D, 0-24E, 0-24F, 0-24G, 0-25A and 0-25E provide an acceptable level of protection and as such Fire Area CS-3 satisfies the requirements of 10 CFR 50, Appendix R.

FIRE AREA AFFECTED:

This exemption covers Fire Area CS-3.

REASON FOR DEVIATION REQUEST:

10CFR50, Appendix R, Section III.G.2, requires fire detection and suppression throughout a fire area. Fire detection and suppression is not provided throughout the Fire Area CS-3 at Susquehanna SES.

EXISTING ARRANGEMENT:

The following list identifies the Fire Zones which comprise Fire Area CS-3 and the protection features provided.

Zone	Safety Related Equipment/ Raceway	Detection	Suppression	Redundant Safe Shutdown Raceway
0-21A	No	No	No	No
0-22A	No	Part	Part	No
0-22C	No	No	No	No
0-23	No	Part	No	No
0-24A	No	Yes	CO_2	No
0-24B	No	Yes	CO_2 (Part)	No
0-24C	No	Yes	CO_2	No
0-24D	Yes	Yes	CO_2 Halon	No

Zone	Safety Related	Detection	Suppression	Redundant Safe Shutdown Raceway
0-24E	Yes	Yes	CO_2 Halon	No
0-24F	No	Yes	CO_2 (Part)	No
0-24G	Yes	Yes	CO_2 Halon	Yes
0-25A	Yes	Yes	Sprinklers	No
0-25E	Yes	Yes	Sprinklers	Yes

All safety related fire zones are provided with fire detection and fire suppression. In addition, all safety related fire zones have fire rated walls, and except for exposed support steel in the floor/ceiling assemblies, all safety-related zone have fire rated floors and ceilings.

The essential raceway in this fire area have been provided with a one hour barrier, automatic fire suppression, and fire detection as outlined above.

JUSTIFICATION:

The fire zones which contain essential safe shutdown raceway have been properly protected in accordance with 10 CFR 50 Appendix R, Section III.G.2.C. The other fire zones within this fire area which have not been provided with either complete fire detection and fire suppression do not contain sufficient combustibles to present a hazard to either safety related equipment or essential safe shutdown raceway.

dk/j006c:krp

APPENDIX R DEVIATION REQUEST

CONTROL STRUCTURE
FIRE AREA CS-10
PARTIAL FIRE SUPPRESSION

DEVIATION

We request approval of the following:

Fire protection provided in Fire Area CS-10 is adequate to protect essential safe shutdown raceway in the Fire Area. Specifically, the Fire Area, with the exception of fire Zone 0-27D is provided with fire detection and suppression capability throughout the Fire Area. Fire Zone 0-27D, although not provided with fire suppression capability is separated from the remainder of the Fire Area by barriers with a minimum rating of 2 hours and contains a combustible loading of less than 2 hours.

FIRE AREA AFFECTED

This deviation request applies to Fire Zone 0-27D in Fire Area CS-10.

REASON FOR DEVIATION REQUEST

The requirements of 10 CFR 50 Appendix R Section III.G.2. requires fire suppression throughout a fire area. Fire Zone 0-27D, which is part of Fire Area CS-10, has not been provided with fire suppression.

EXISTING ARRANGEMENT

Fire Zone 0-27D (Fire Area CS-10), is not provided with fire suppression. The other fire zones within Fire Area CS-10 are provided with fire detection and fire suppression. The walls separating Fire Zone 0-27D and the remainder of Fire Area CS-10 are rated at a minimum of 2 hours, which is in excess of the combustible loading in Fire Zone 0-27D. No safety related equipment is located in Fire Zone 0-27D.

JUSTIFICATION

Safe shutdown raceways within Fire Area CS-10 are adequately protected and passive fire rated construction exists between essential safe shutdown raceway and Fire Zone 0-27D.

APPENDIX R DEVIATION REQUEST

CONTROL STRUCTURE
FIRE AREA CS-9
PARTIAL FIRE SUPPRESSION

DEVIATION REQUEST

We request approval of the following:

Fire protection provided in Fire Area CS-9 is adequate to protect the identified hazard. Specifically, the Fire Area is constantly manned by operations personnel who would detect and react to a fire, the area is provided with partial suppression, manual suppression is available, and the capability to achieve safe shutdown through alternative equipment is provided by the remote shutdown panel located outside the fire area.

FIRE AREA AFFECTED

This deviation applies to Fire Area CS-9 (Main Control Room).

REASON FOR THE DEVIATION REQUEST

Dedicated shutdown capability in accordance with Appendix R, Section III.G.3 has been provided for use in the event of a fire in the control room. The above was provided since separation of redundant trains of safe shutdown equipment within the control room does not satisfy the requirements of 10CFR50, Appendix R, Section III.G.2. Complete Fire suppression has not been provided throughout the Control Room (Fire Area CS-9).

EXISTING CONDITIONS

The following conditions exist in Fire Zone CS-9:

ZONE	PROTECTION	SAFETY RELATED EQUIPMENT
0-26A	None	None
0-26E	None	None
0-26F	None	Yes
0-26G	Manual Spurt CO_2 under floor (Fixed Piping)	Yes
0-26H	Manual Spurt CO_2 under floor (Fixed Piping)	Yes
0-26I	Manual Spurt CO_2 under floor (Fixed Piping)	Yes
0-26J	None	Yes
0-26K	Automatic Sprinkler Protection	Yes
0-26L	Automatic Sprinkler Protection	Yes
0-26M	Manual Spurt CO_2 (Fixed Piping)	Yes
0-26N	Manual Spurt CO_2 (Fixed Piping)	Yes
0-26P	Manual Spurt CO_2	Yes

	(Fixed Piping)	
0-26R	Manual Spurt CO_2 (Fixed Piping)	Yes

The release of CO_2 is controlled manually to minimize the effects of a CO_2 discharge on plant operation. Manual control stations are provided both inside and outside the fire area. Areas with constant occupancy (0-26G, H, and I) are provided with under floor protection only.

Complete automatic sprinkler protection has been provided for Fire Zones 0-26K and 0-26L.

Fire Zones 0-26F and J are vestibules and contain minimal safety related cables below the raised floor.

Fire Zones 0-26A and 0-26E do not contain safety related equipment.

Portable extinguishers are available for use in the fire area. A hose station is available within the control structure for use in the fire area.

JUSTIFICATION It has been demonstrated during the performance of startup and test procedures ST28.1 and ST28.2 that full shutdown is achievable without reliance on the Control Room. The existing protection provided in Fire Area CS-9 is adequate to protect the identified cable hazards. It is expected that since the control room is constantly manned by operations personnel, any fire would be detected and extinguished prior to activation of a suppression system. The addition of more suppression capability would not enhance, to a significant degree, the protection of safe shutdown functions.

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SUSQUEHANNA STEAM ELECTRIC STATION - UNITS 1 & 2

FIRE PROTECTION PROGRAM - CONCERN #2

DOCKETS NO. 50-387
50-388

APPENDIX B - TABLE: FIRE AREAS VS DEVIATION REQUESTS

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TABLE

FIRE AREAS VS. DEVIATION REQUEST

FIRE AREA	APPLICABLE DEVIATION REQUEST
Reactor Building Unit 1	
R-1A	3, 4, 5, 6, 7, 12, 13, 14, 16, 18, 20
R-1B	3, 4, 5, 6, 7, 8, 12, 13, 14, 18, 20
R-1C	In Compliance
Reactor Building Unit 2	
R-2A	3, 4, 5, 6, 7, 9, 12, 13, 14, 16, 18, 20
R-2B	3, 4, 5, 6, 7, 12, 13, 14, 18, 20
R-2C	In Compliance
Control Structure	
CS-1	In Compliance
CS-2	In Compliance
CS-3	20, 21
CS-4	20
CS-5	20
CS-6	20
CS-7	20
CS-8	20
CS-9	1, 2, 6, 20, 23
CS-10	6, 20, 22
CS-11	15, 20
CS-12	20
CS-13	20
CS-14	20
CS-15	8, 20
CS-16	20
CS-17	8, 20
CS-18	20
CS-19	20
CS-20	15, 20
CS-21	20
CS-22	20
CS-23	20
CS-24	8, 20
CS-25	20
CS-26	20
CS-27	20
CS-28	20

NOTE: Deviation Request Numbers 11 and 17 may apply to all fire areas.

TABLE

FIRE AREAS VS. DEVIATION REQUEST

FIRE AREA	APPLICABLE DEVIATION REQUEST
Diesel Generator Bldg.	
D-1	19, 20
D-2	20
D-3	19, 20
D-4	20
ESSW Pump H.	
E-1	20
E-2	20

NOTE: Deviation Request Numbers 11 and 17 may apply to all fire areas.

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SUSQUEHANNA STEAM ELECTRIC STATION

UNITS 1 & 2

FIRE PROTECTION PROGRAM

APPENDIX R

SUMMARY REPORT

FOR

CONCERN #4A - Analysis of Associated Circuits Within Fire Zones Outside the Control Room

DOCKET NOS. 50-387
50-388

SUSQUEHANNA STEAM ELECTRIC STATION - UNITS 1 & 2
FIRE PROTECTION PROGRAM - CONCERN #4A
DOCKET NOS. 50-387
50-388

SUMMARY REPORT

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SUSQUEHANNA STEAM ELECTRIC STATION - UNITS 1 & 2
FIRE PROTECTION PROGRAM - CONCERN #4A
DOCKET NOS. 50-387
50-388

SUMMARY REPORT

CONCERN #4A Analysis of Associated Circuits Within Fire Zones Outside The Control Room

1.0 INTRODUCTION

As a result of audits performed in the first quarter of 1985 on the Fire Protection Program at Susquehanna Steam Electric Station (SSES), the NRC, in a letter dated April 18, 1985, issued a statement of their concerns related to the SSES Fire Protection Program. Subsequently, PP&L issued PLA-2482 dated June 11, 1985 which provided a description of each of the NRC concerns, a description of PP&L's method of resolution of the NRC concerns, and a description of PP&L's deliverables to the NRC. All of these items were discussed with and agreed to by the NRC staff.

Concern #4A addresses the possibility of a majority division component preventing the operation of a minority division system. For the purposes of this report, the minority division is defined as that division which was chosen to be protected from fire. In response to this concern, PP&L reviewed all safe shutdown systems and all systems that interconnect with safe shutdown systems. It was determined that in several safe shutdown systems operation of the minority division depends upon one majority division component. To resolve Concern #4A, PP&L made an investigation to determine if the majority division components had been protected when required. PP&L also reviewed all systems connected to the Reactor Pressure Vessel (RPV) to determine if the spurious operation of a "majority" component could cause a loss of coolant from the RPV.

2.0 METHODOLOGY UTILIZED

Majority components were investigated by the following methodology:

1. Identified all safe shutdown systems that require components from both divisions for operation.

2. Determined the routing of essential cabling required for the operation and control of each majority division component and identified the fire zones through which this essential cabling passes.

3. Identified all fire zones that contain essential cabling for a majority division component that is required for a safe shutdown path* in the zone.

4. Determined if the cabling identified in step 3 was protected or, need not be protected due to the existence of an alternate safe shutdown path that does not rely on the particular safe shutdown system.

5. Identified all systems connected to the RPV that have components in both divisions and evaluated the capability of the majority division component to cause a loss of coolant from the RPV.

6. Identified all systems that interconnect with safe shutdown systems and reviewed for potential effects of majority division components.

3.0 ASSUMPTIONS & NRC GUIDANCE

3.1 The analysis was performed in accordance with the following NRC guidance:

a. 10 CFR 50, Appendix R Section III.G.

b. Generic Letters 83-33 and 85-01.

c. NRC letter to PP&L dated April 18, 1985 which states:

The licensee's separation criteria is adequate to assure that the "minority" division is not associated electrically with the "majority" division. However, the methodology is not adequate to identify systems interactions that could associate the "majority" division with the "minority" division shutdown capability for the area.

4.0 RESULTS OF THE ANALYSIS

4.1 Safe Shutdown Systems

It was determined that the only majority division components that can affect the operation of a minority system are containment isolation valves. The results of the analysis for these valves are shown on Table 1 at the end of this section. Both the inboard and ouboard isolation valves were analyzed even though in most cases one valve would be a minority system component.

The results of the anlaysis indicate that there are fire zones in which majority components must be protected if the associated system is required for safe shutdown. Table 1 identifies the raceways that must be protected to insure that the required components will remain operable in the event of fire.

*Safe Shutdown Paths for each fire zone in both the Unit-1 and Unit-2 Reactor Building are identified in Appendix B of the Summary Report for NRC Concern #1.

4.2 Interconnecting Systems

Interconnecting systems can only defeat a safe shutdown system by flow diversion. All potential flow diversion paths for each safe shutdown system were identified and evaluated. It was concluded that flow diversion will not defeat the operation of any safe shutdown system. Potential flow diversion paths that could defeat system operation are either so small that any flow through them would be insignificant or they are blocked by a check valve or a normally closed manual valve. It can therefore be concluded that spurious operation of a majority division component in an interconnecting system cannot defeat the operation of a minority division safe shutdown system. Appendix A to this report provides sample documentation of flow diversion paths.

4.3 Loss of Coolant From The Reactor Pressure Vessel

In an effort unrelated to Concern #4A, PP&L conducted a study of all potential loss of coolant (LOC) paths from the RPV. This study shows that there are no cases where a majority division component can cause a loss of coolant through a minority division system.

5.0 Corrective Actions

Those raceways in fire zone 1-4A-S and 1-5A-S identified in Table 1 will be protected. Revision 2 to our response to Concern No. 1 has concluded that path 4 must be made available in these fire zones. The revision also showed that a safe shutdown path is available in the remaining fire zones identified in table 1.0 without paths 2 or 4.

6.0 SCHEDULE

Any modifications committed to in this report will be accomplished in accordance with the schedule listed below. The commitment date is tied to the end of outage referenced. Actual dates provided are for outage time frame reference only.

UNIT	COMPLETED BY	REFERENCE DATE
Modification in Unit #1 & Common	End of Unit #1 3rd Refueling Outage	October 23, 1987
Modification in Unit #2	End of Unit #2 2nd Refueling Outage	April 29, 1988

7.0 COMPENSATORY MEASURES

Those compensatory measures currently in place will remain in place until all identified modifications are completed.

8.0 CONCLUSION

Upon completion of the identified modifications, the NRC's concerns related to Concern #4A, "Analysis of Associated Circuits within Fire Zones Outside the Control Room", will be resolved.

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[illegible]
[illegible]
[illegible]

TABLE - 1 (continued)

VALVE	DESCRIPTION	MAJORITY/ MINORITY COMPONENT	NORMALLY OPEN/ NORMALLY CLOSED	ID NO. OF SAFE SHUTDOWN PATH(S) REQUIRING VALVE	FIRE ZONES WHERE PROTECTION IS REQUIRED	RACEWAYS & JUNCTION BOXES REQUIRING PROTECTION	ID NO. OF ALTERNATE PATH(S) AVAILABLE IN FIRE ZONE
HV-1F008	UNIT-1 RHR SHUTDOWN COOLING OUTBOARD ISOLATION VALVE	N/A	N.C.	2,4	NONE		N/A
HV-1F009	UNIT-1 RHR SHUTDOWN COOLING INBOARD ISOLATION VALVE	N/A	N.C.	2,4	1-3A	EVKH01,05,E1K373,375 393,E1KJ55,E1KJ55, E1KF57,58,59,JB0302,0304	3*
					1-4A-S	E1PJ07-15,E1KJ09-15,E1K704	3*
					1-4D	E1PJ34,35,53,54,56,64, E1PJ51,E1KJ31-35,37-39 E1KH27	3&4
HV-2F008	UNIT-2 RHR SHUTDOWN COOLING OUTBOARD ISOLATION VALVE	N/A	N.C.	2,4	NONE		N/A
HV-2F009	UNIT-2 RHR SHUTDOWN COOLING INBOARD ISOLATION VALVE	N/A	N.C.	2,4	2-3A	E2KH05-09,61,E2KG71	3
					2-4A-S	E2KJ08-16,91,92,95, E2PJ07-16,71	3
					2-4A-W	E2KJ17-19	1&3
					2-4D	E2KJ03-37,E2KH30,E2PJ, 34,35,51,53,54,56,57,64	3

*PP&L has previously made a commitment to protect the raceways necessary to make the alternate safe shutdown path available in these zones. See Appendix D of the Summary Report for NRC Concern #1.

TABLE - 1

VALVE	DESCRIPTION	MAJORITY/ MINORITY COMPONENT	NORMALLY OPEN/ NORMALLY CLOSED	ID NO. OF SAFE SHUTDOWN PATH(S) REQUIRING VALVE	FIRE ZONES WHERE PROTECTION IS REQUIRED	RACEWAYS & JUNCTION BOXES REQUIRING PROTECION	ID NO. OF ALTERNATE PATH(S) AVAILABLE IN FIRE ZONE
HV-1F007	UNIT-1 RCIC SYSTEM STEAM SUPPLY INBOARD ISOLATION VALVE	MAJORITY	N.O.	2	1-3B-N	F1K937,F1K958,JB3937	1*
HV-1F008	UNIT-1 RCIC SYSTEM STEAM SUPPLY OUTBOARD ISOLATION VALVE	MINORITY	N.O.	2	NONE		N/A
HV-2F007	UNIT-2 RCIC SYSTEM STEAM SUPPLY INBOARD ISOLATION VALVE	MAJORITY	N.O.	2	2-4C 2-1E	F2K674,F2K676 & JB4156 F2K674	1 1
HV-2F008	UNIT-2 RCIC SYSTEM STEAM SUPPLY OUTBOARD ISOLATION VALVE	MINORITY	N.O.	2	NONE		N/A
HV-1F002	UNIT-1 HPCI SYSTEM STEAM SUPPLY INBOARD ISOLATION VALVE	MAJORITY	N.O.	4	1-3A 1-4A-S 1-5A-S	E1K985 E1K985,E1K990,JB3941 E1K990	3* 3*
HV-1F003	UNIT-1 HPCI SYSTEM STEAM SUPPLY OUTBOARD ISOLATION VALVE	MINORITY	N.O.	4	1-3A	F1KX11	3*
HV-2F002	UNIT-2 HPCI SYSTEM STEAM SUPPLY INBOARD ISOLATION VALVE	MAJORITY	N.O.	4	2-3A 2-4A-S 2-5C	E2K1C1 E2K1C1,E2KK8 & JB4157 E2K1C8	3 3 3
HV-2F003	UNIT-2 HPCI SYSTEM STEAM SUPPLY OUTBOARD ISOLATION VALVE	MINORITY	N.O.	4	NONE		N/A

SUSQUEHANNA STEAM ELECTRIC STATION - UNITS 1 & 2
FIRE PROTECTION PROGRAM - CONCERN #4A
DOCKET NOS. 50-387
50-388

APPENDIX A - SAMPLE DOCUMENTATION

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[illegible]

[illegible]

APPENDIX A

Description of Sample Documentation

This appendix contains examples of the documentation used to evaluate the effects of majority division components on minority division systems. The first example is for the Inboard Containment Isolation Valve on the Steam Supply to the RCIC Turbine. This documentation was developed from electrical schematics, fire protection raceway drawings and safe shutdown paths as reported in Appendix B of the Summary Report for NRC Concern #1. The second example is flow diversion paths for the Unit 1 Core Spray System and Unit 1 Reactor Pressure Vessel. Flow diversion paths are defined as those pipelines that have a potential for diverting coolant flow from its required destination or from the Reactor Pressure Vessel. The documentation of the flow diversion paths for safe shutdown systems was developed by:

1. Identifying the required flow path on the system P&ID.

2. All lines connected to the required flow path are traced from the connection point back to a point where it can be determined that they can or cannot cause flow diversion.

The procedure for the RPV was basically the same except that rather than a required flow path all pipe lines connected to the RPV were identified.

IDENTIFICATION OF FIRE
ZONES AFFECTING
AND
DETERMINATION OF POTENTIAL
EFFECTS OF A FIRE ON

HV-E51-1F007

PP&L Form 2454 (10/83)
Cat. #973401

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Date 10-18 19 8[illegible]
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Approved by

PENNSYLVANIA POWER & LIGHT COMPANY
CALCULATION SHEET

PROJECT ADDITIONAL UNIT # 1 COMPONENTS FOR SAFE SHUTDOWN PATHS

ER No.
CTN 743120
Sht. No. 1 of 1

DEVICE TAG #	SCHEMATIC/SH/REV DWG #	COMPONENT AREA	ELEV
HV-E51 1F007	E-154 SH.4 R11	26	

CABLE #	FROM	TO	SYS
FP1Q1303A	1B246022	PEN 1W105B	RCIC

RACEWAY SECTIONS	FIRE ZONE	[illegible]/MIN. DIVISION	FIRE PROT RACEWAY DWG	REMARKS
F1PJ66	1-4C	I	EF28-4	
65	1-4C			
71	1-4C			
72	1-4C			
73	1-4C			
74	1-4C			
F1PH82	1-4C, 1-4A		EF 28-4, 28-9	
F1PJ49	1-4A		EF 28-9	
48			EF 28-9	
47			EF 28-9	
46			EF 28-4, 28-9	
45			EF 28-4	
44				
43				
42				
41				
33				
32				
31				
91				

PP&L Form 2454 (10/83)
Cat. #973401

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Date 10-18 19 8[illegible]	**CALCULATION SHEET**	CTN 743120
Designed by RA	PROJECT ADDITIONAL UNIT # 1 COMPONENTS FOR SAFE SHUTDOWN PATHS	Sht. No. 1 of 1
Approved by		

DEVICE TAG #	SCHEMATIC/SH/REV DWG #	COMPONENT AREA	ELEV
HV-E51 1F007	E-154 SH.4 R11	26	

CABLE #	FROM	TO	SYS
FP1Q1303B	PEN 1W105B	HV-E51 1F007	RCIC

RACEWAY SECTIONS	FIRE ZONE	MAJ/MIN. DIVISION	FIRE PROT RACEWAY DWG	REMARKS
F1PS11			E-26-3	ROUTED INSIDE
06			E-26-2	CONTAINMENT
05			↓	↓
F1P390				
JB0944				
F1P394				

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PROJECT ADDITIONAL UNIT #1 COMPONENTS FOR SAFE SHUTDOWN PATHS

ER No.
CTN 743120
Sht. No. 1 of 1

DEVICE TAG #	SCHEMATIC/SH/REV DWG #	COMPONENT AREA	ELEV
HV-E51 1F007	E-154 SH.4 R11	26	

CABLE #	FROM	TO	SYS
FK1Q1303C	1B246022	1C201A	RCIC

RACEWAY SECTIONS	FIRE ZONE	MAN/MIN. DIVISION	FIRE PROT RACEWAY DWG	REMARKS
FIK935	1-4A	I	EF 28-4, 28-9	
JB3950	1-4A		EF 28-4	
FIK937	1-3B 1-4A		EF 25-3, 25-9	
JB3937	1-3B		EF 25-3	
FIK958	1-3B		EF 25-3	

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PROJECT ADDITIONAL UNIT # 1 COMPONENTS FOR SAFE SHUTDOWN PATHS

ER No.
CTN 743120
Sht. No. 1 of 1

DEVICE TAG #	SCHEMATIC/SH/REV DWG #	COMPONENT AREA	ELEV
HV-E51 1F007	E-154 SH.4 R11	26	

CABLE #	FROM	TO	SYS
FK1Q1303D	1B246022	1C201A	RCIC

RACEWAY SECTIONS	FIRE ZONE	~~SSD~~/MIN. DIVISION	FIRE PROT RACEWAY DWG	REMARKS
F1K935	1-4A	I	EF 28-4, 28-9	
JB3950	1-4A	I	EF 28-4	
F1K937	1-3B, 1-4A	I	EF 25-3, 25-9	
JB3937	1-3B	I	EF 25-3	
F1K958	1-3B	I	EF 25-3	

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ER No.
CTN 743120
Sht. No. 1 of 1

DEVICE TAG #	SCHEMATIC/SH/REV DWG #	COMPONENT AREA	ELEV
HV-E51 1F007	E-154 SH.4 R11	26	

CABLE #	FROM	TO	SYS
FK1Q1303F	PEN 1W106B	HV-E51 1F007	RCIC

RACEWAY SECTIONS	FIRE ZONE	~~FIRE~~/MIN. DIVISION	FIRE PROT RACEWAY DWG	REMARKS
F1K934			263	ROUTED INSIDE CONTAINMENT

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PROJECT ADDITIONAL UNIT # 1 COMPONENTS FOR SAFE SHUTDOWN PATHS

ER No.
CTN 743120
Sht. No. 1 of 1

DEVICE TAG #	SCHEMATIC/SH/REV DWG #	COMPONENT AREA	ELEV
HV-E51 1F007	E-154 SH.4 R11	26	

CABLE #	FROM	TO	SYS
FK1Q1303E	1B246022	PEN 1W106B	RCIC

RACEWAY SECTIONS	FIRE ZONE	MIN. DIVISION	FIRE PROT RACEWAY DWG	REMARKS
F1K935	1-4A	I	EF 28.4, 28-9	
JB3950	1-4A	I		
F1K936	1-4A	I		

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Cat. #973401

Safe shutdown paths are revised in RE 41802

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CALCULATION SHEET

PROJECT ADDITIONAL UNIT # 1 COMPONENTS FOR SAFE SHUTDOWN PATHS

ER No.
CTN 743120
Sht. No. 1 of 1

DEVICE TAG #	SCHEMATIC/SH/REV DWG #	COMPONENT AREA	ELEV
HV-E51 1F007	E-154 SH.4 R11 * & DCP 83-592C	26	

CABLE #	FROM	TO	SYS
FK1Q1303G	1C201A	1TC623A	R01C

RACEWAY SECTIONS	FIRE ZONE	/MIN. DIVISION	FIRE PROT RACEWAY DWG	REMARKS
F1K958	1-3B	I	EF 25-3	
JB3937	1-3B	I	EF 25-3	
F1K938	1-3B, 1-3A	I, II	EF 27-3	
* JB4501	1-3A	II	EF 27-3	
F1K205	1-3A, 0-24D	↓	EF 12-3 27-3	
JB3940	0-24D		EF 12-3	
F1K942	0-24D		EF 12-3	

FLOW DIVERSION PATHS

CORE SPRAY SYSTEM

Core Spray S[illegible]

Flow Diversion Paths (Unit 1)

Sheet [illegible]6

Prepared By: S. S. Howze — S. S. Howze

Reviewed By: L. S. Weed — L. S. Weed

Flow Path	Description	Potential Flow Diversion	Component(s) that Prevents Flow Diversion	Component W/Potential for Flow Diversion	Division	References	Remarks
16" HBB-104	Suction Line from CST	No	1F002A	N/A	I	M-152	Locked Closed Manual Valve
1" HBB-104	Suction Relief Line	No	PSV-1F032A	N/A	I	M-152	Relieves Pressure Only No Multiple Failure Considered
1 1/2" GBB-101	Discharge Relief Line	No	PSV-1F012A	N/A	I	M-152	Relieves Pressure Only, Minimal Flow No Multiple Failures Considered
2" GBB-101	Condensate Transfer Fill Line	No	CV-1F030A CV-1F029A	N/A	I	M-152	Double Check Valves in Series Restrict Flow
1" Lines	Vent, Drain, Pump Shaft Seal, Instrument Tap, Test & Equalizing Lines	No	See Remarks	N/A	I	M-152	Flow in These Lines is Prevented By Locked Closed Manual Valves, Caps, or Excess Flow Check Valves, and therefore is not a problem

Core Spray [illegible]n

Flow Diversion Paths (Unit 1)

Prepared By: S. S. Howze

Reviewed By: L. S. Weed

Flow Path	Description	Potential Flow Diversion	Component(s) that Prevents Flow Diversion	Component W/Potential for Flow Diversion	Division	References	Remarks
16" HBB-104	Suction Line from CST	No	1F002B	N/A	II	M-152	Locked Closed Manual Valve
3" GBB-102	Condensate Transfer Minimum Flow Fill Line	No	1-52-005	N/A	II	M-152	Check Valve Restricts Flow
1" HBB-104	Suction Relief Line	No	PSV-1F032B	N/A	II	M-152	Relieves Pressure With Minimal Flow Multiple Failures Not Considered
1 1/2" GBB-101	Discharge Relief Line	No	PSV-1F012B	N/A	II	M-152	Relieves Pressure With Minimal Flow Multiple Failures Not Considered
2" GBB-101	Condensate Transfer Filling Line	No	CV-1F030B CV-1F029B	N/A	II	M-152	Double Check Valves in Series Restrict Flow
1" Lines	Vent, Drain, Pump Shaft Seal, Instrument Tap, Test & Equalizing Lines	No	See Remarks	N/A	II	M-152	Flow in These Lines Is Prevented by Locked Closed Manual Valves, Caps, or Excess Flow Check Valves and Therefore is not a Problem

dk/tbd305i

FLOW DIVERSION PATHS

UNIT-1 REACTOR PRESSURE VESSEL

Reactor Vess[illegible]C.

Flow Diversion Paths (Unit 1)

Prepared By: James M. Manoleas

Reviewed By: L. S. Weed

L. S. Weed

Flow Path Description	Potential L.O.C. from R.P.V.	Component that Prevents L.O.C. from R.P.V.	Component W/Potential for L.O.C. from R.P.V.	Division	References	Remarks
N4D, E, F - Feedwater Supply Lines (12" DLA-102 to 24" DLA-102)	No	1F010A	N/A	N/A	M-141	3 feedwater branch outlets tie into a single supply header with a check valve to restrict back-flow from RPV.
N4, A, B, C - Feedwater Supply Lines (12" DLA-104 to 24" DLA-104)	No	1F010B	N/A	N/A	M-141	3 feedwater branch outlets tie into a single supply header with a check valve to restrict back-flow from RPV.
N3A - Main Steam Line 'A' (26" G001)	Yes	N/A	PSV-1F013A,C,E,S (N.C.) (Solenoid valves SV-14113A; C; E; & S, respectively)	II	M-141	Consequences to fuel and vessel resulting from multiple valve openings have been determined to be less severe than a main steamline break. See final resolution Task No. 183E1, 2, 3, 4 Control Room Fire Study.
	No	PSV-1F013G (N.C.) (Solenoid valves SV-14113G1, G2	N/A	II	M-141	These components are required to to perform a safety function. Refer to ADS System.
	No	HV-1F022A (N.O.) (Solenoid valves SV-14123A1, A2)	N/A	I	M-141	These components are required to perform a safety function. Refer to MSIVs.

Reactor Vess[illegible]C.

Flow Diversion Paths (Unit 1)

Prepared By: James M. Manoleas

Reviewed By: L. S. Weed

L. S. Weed

Flow Path Description	Potential L.O.C. from R.P.V.	Component that Prevents L.O.C. from R.P.V.	Component W/Potential for L.O.C. from R.P.V.	Division	References	Remarks
N3A - Main Steam Line 'A' Bypass (2"DBA-108 to 3" DBA-108)	Yes	N/A	HV-1F016 (N.O.) HV-1F019 (N.O.)	I II	M-141	The injection rate of available makeup systems is much greater than the maximum possible loss of coolant rate through this line. Valves normally close on a main steam isolation signal.
N3B - Main Steam Line 'B' (26' G001)	Yes	N/A	PSV-1F013P (N.C.) (Solenoid valve SV-14113P)	II	M-141	Consequences to fuel and vessel resulting from multiple valve openings have been determined to be less severe than a main steamline break. See final resolution Task No. 183E1, 2, 3, 4 Control Room Fire Study.
	No	PSV-1F013J, M (Solenoid valves SV14113J1, J2; M1,M2 respectively)	N/A	II	M-141	These components are required to perform a safety function. Refer to ADS System.
	No	HV-1F022B (N.O.) (Solenoid valves SV-14123B1,B2)	N/A	I	M-141	These components are required to perform a safety function. Refer to MSIVs.
N3B - Main Steam Line 'B' Bypass (2" DBA-109 to 3" DBA-108)	Yes	N/A	See Remarks	I/II	M-141	Same valves as N3A - Main Steam Line 'A' Bypass.

Reactor Vesse[illegible]C.

Flow Diversion Paths (Unit 1)

Prepared By: James M. Manoleas

Reviewed By: L. S. Weed

L. S. Weed

Flow Path Description	Potential L.O.C. from R.P.V.	Component that Prevents L.O.C. from R.P.V.	Component W/Potential for L.O.C. from R.P.V.	Division	References	Remarks
N3B - HPCI Steam Supply Line (10" DBA-102) from Main Steam Line 'B'	No	HV-1F001 (N.C.)	N/A	II	M-155	This component is required to perform a safety function. Refer to HPCI System.
N3C - Main Steam Line 'C' (26" G001)	Yes	N/A	PSV-1F013B,R (N.C.) (Solenoid valves SV-14113B; R, respectively)	I	M-141	Consequences to fuel and vessel resulting from multiple valve openings have been determined to be less severe than a main steamline break. See final resolution Task No. 183E1, 2, 3, 4 Control Room Fire Study.
	No	PSV-1F013L (N.C.) (Solenoid valves SV-14113 L1,L2)	N/A	I	M-141	These components are required to perform a safety function. Refer to ADS System.
	No	HV-1F022C (N.O.) (Solenoid valves SV-14123C1,C2)	N/A	I	M-141	These components are required to perform a safety function. Refer to MSIVs.

Reactor Vessel L.O.C.

Flow Diversion Paths (Unit 1)

Prepared By: James M. Manoleas

Reviewed By: L. S. Weed

L. S. Weed

Flow Path Description	Potential L.O.C. from R.P.V.	Component that Prevents L.O.C. from R.P.V.	Component W/Potential for L.O.C. from R.P.V.	Division	References	Remarks
N3C - RCIC Steam Supply Line (4"DBA-105) from Main Steam Line 'C'	No	HV-1F045 (N.C.)	N/A	I	M-150	This component is required to perform a safety function. Refer to RCIC System.
N3C - Main Steam Line 'C' Bypass (2" DBA-110 to 3" DBA-108)	Yes	N/A	See Remarks	I/II	M-141	Same valves as N3A - Main Steam Line 'A' Bypass.
N3D - Main Steam Line 'D' (26" G001)	Yes	N/A	PSV-1F013D,F, H, (N.C.) (Solenoid valves SV-14113D; F; H; respectively)	I	M-141	Consequences to fuel and vessel resulting from multiple valve openings have been determined to be less severe than a main steamline break. See final resolution Task No. 183E1, 2, 3, 4 Control Room Fire Study.
	No	PSV-1F013K, N (N.C.) (Solenoid valves SV14113K1,K2; N1, N2, respectively)	N/A	I	M-141	These components are required to perform a safety function. Refer to ADS System.
	No	HV-1F022D (N.O.) (Solenoid valves SV-14123D1,D2)	N/A	I	M-141	These components are required to perform a safety function. Refer to MSIVs.
N3D - Main Steam Line 'D' Bypass (2" DBA-111 to 3" DBA-108)	Yes	N/A	See Remarks	I/II	M-141	Same valves as N3A - Main Steam Line 'A' Bypass

Prepared By: James M. Manoleas

Reviewed By: L. S. Weed

L. S. Weed

Flow Path Description	Potential L.O.C. from R.P.V.	Component that Prevents L.O.C. from R.P.V.	Component W/Potential for L.O.C. from R.P.V.	Division	References	Remarks
N5A - Core Spray System Injection Line 'A' (12" DCA-107)	No	HV-1F005A (N.C.)	N/A	I	M-141 & M-152	This component is required to perform a safety function. Refer to Core Spray System.
N5B - Core Spray System Injection Line 'B' (12" DCA-107)	No	HV-1F005B (N.C.)	N/A	II	M-141 & M-152	This component is required to perform a safety function. Refer to Core Spray System.
N7 - Reactor Vent to Drywell Equip. Drain Tank Line (2" DBA-112)	No See Remarks	HV-1F001 (N.C.) HV-1F002 (N.C.)	N/A	I II	M-141	The injection rate of available makeup systems is much greater than the maximum possible loss of coolant rate through this line.
N7 - To Nuclear Boiler Instrumentation (2" DBA-112 to 1" DCA-145)	No	XV-1F041	N/A	N/A	M-141 & M-142	Excess flow check valve restricts flow from RPV.
N9 - Capped Connection	No	Capped 4" Nozzle	N/A	N/A	M-141	No L.O.C. permissible.
N6A - Flanged Connection	No	6" Mating Flange Connection	N/A	N/A	M-141	No L.O.C. permissible.
N6B - RHR Reactor Head Spray Line (6" DCA-111)	No	1F019	N/A	N/A	M-141 & M-151 Sh.1	Check valve restricts backflow from RPV.
N13 - RPV Instrument Line (1" DCA-101)	No	XV-1F009 1-41-014 & 1-41-015	N/A	N/A	M-141	Excess flow check valve and double locked closed manual valves restrict flow from RPV.

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Flow Diversion Paths (Unit 1)

Prepared By: James M. Manoleas

Reviewed By: L. S. Weed

Flow Path Description	Potential L.O.C. from R.P.V.	Component that Prevents L.O.C. from R.P.V.	Component W/Potential for L.O.C. from R.P.V.	Division	References	Remarks
N10 - Instrument Sensing Line (1" DCA-139)	No	XV-1F061	N/A	N/A	M-142	Excess flow check valve restricts flow from RPV.
N10 - Instrument Sensing Line (1" DCA-135)	No	XV-1F057	N/A	N/A	M-142	Excess flow check valve restricts flow from RPV.
N10 - Instrument Sensing Line (1" DCA-135)	No	XV-1F055	N/A	N/A	M-142	Excess flow check valve restricts flow from RPV.
N10 - Standby Liquid Control System Line (1 1/2" DCA-106)	No	CV-1F007	N/A	N/A	M-142 & M-148	Check valve restricts backflow from RPV.
N12A - Instrument Sensing Line (1" DBA-118)	No	XV-1F043A	N/A	N/A	M-142	Excess flow check valve restricts flow from RPV.
N12B - Instrument Sensing Line (1" DBA-118)	No	XV-1F043B	N/A	N/A	M-142	Excess flow check valve restricts flow from RPV.
N11A - Instrument Sensing Line (1" DCA-138)	No	XV-1F047A	N/A	N/A	M-142	Excess flow check valve restricts flow from RPV.
N11B - Instrument Sensing Line (1" DCA-138)	No	XV-1F047B	N/A	N/A	M-142	Excess flow check valve restricts flow from RPV.
N16A - Instrument Sensing Line (1" DCA-140)	No	XV-1F045A	N/A	N/A	M-142	Excess flow check valve restricts flow from RPV.
N16B - Instrument Sensing Line (1" DCA-140)	No	XV-1F045B	N/A	N/A	M-142	Excess flow check valve restricts flow from RPV.

Prepared By: James M. Manoleas

Reviewed By: L. S. Weed

L. S. Weed

Flow Path Description	Potential L.O.C. from R.P.V.	Component that Prevents L.O.C. from R.P.V.	Component W/Potential for L.O.C. from R.P.V.	Division	References	Remarks
N8A - Instrument Sensing Lines (3/4" DCA-144) (Typ. 4 lines) (3/4" DCA-136) (Typ. 2 lines) (3/4" DCA-136) (Typ. 2 lines)	No	XV-1F053A,B,C,D XV-1F051C,D XV-1F051A,B	N/A	N/A	M-142	Excess flow check valves restrict flow from RPV.
N8B - Instrument Sensing Line (3/4" DCA-144) (Typ. 15 lines) (3/4" DCA-144)	No	XV-1F059A,B,C,D, E,F,H,L,M,N,P,R, S,T,U	N/A	N/A	M-142	Excess flow check valves restrict flow from RPV.
	No	XV-1F059G	N/A	N/A	M-142	
N2A,B,C,D,E - Loop B Recirculation Discharge Lines (12" G001 to 28" G001 to 24" DCA-110) to RHR	No	HV-1F050A	N/A	N/A	M-151 Sh.2 & M-143	Check Valve Restricts Flow
N2F,G,H,J,K, - Loop A Recirculation Discharge Lines (12" G001 to 28" G001 to 24" DCA-110) to RHR	No	HV-1F050B	N/A	N/A	M-151 Sh.1 & M-143	Check Valve Restricts Flow.
N1B - Loop B Recirculation Suction Line (28" G001 to 20" DCA-108) to RHR	No	HV-1F009 (N.C.) HV-1F008 (N.C.)	N/A	I II	M-143 & M-151 Sh.2	These components are required to perform a safety function. Refer to RHR system.

Prepared By: James M. Manoleas

Reviewed By: L. S. Weed

Flow Path Description	Potential L.O.C. from R.P.V.	Component that Prevents L.O.C. from R.P.V.	Component W/Potential for L.O.C. from R.P.V.	Division	References	Remarks
N1B - Loop B Recirculation Suction Lines (28" G001 to 4" DCA-102 to 6" DBA-101) to RWCU	Yes	N/A	HV-1F001 (N.O.) HV-1F004 (N.O.)	I II	M-143 & M-144	The injection rate of available makeup systems is much greater than the maximum possible loss of coolant rate through this line.
N1A - Loop A Recirculation Suction Line (28" G001 to 4" DCA-102 to 6" DBA-101) to RWCU	Yes	N/A	HV-1F001 (N.O.) HV-1F004 (N.O.)	I II	M-143 & M-144	See N1B - Loop B Recirculation Suction Line above.
N15 - RWCU Line from RPV (4" DCA-103 to 6" DBA-101)	Yes	N/A	HV-1F001 (N.O.) HV-1F004 (N.O.)	I II	M-144	See N1B - Loop Recirculation Suction Line above.
N15 - Instrument Sensing Line from RWCU (1" DCA-103)	No	XV-1F046	N/A	N/A	M-144	Excess flow check valve restricts flow from RPV.
CRD Exhaust Water Header (1/2" DCD) (Typ. of 185)	No	N/A	SV-120 (ND) SV-121 (ND) SV-122 (ND) SV-123 (ND)	I/II	M-147	These valves are typical for 185 CRDs.
Scram Discharge Volume Drain Line (2" DCB)	No	SV1F009 (XV-1F011; FC)	N/A	I/II	M-147	Valves close on scram and prevent L.O.C. inventory. Refer to CRD System.

Reactor Vess[illegible]C.

Flow Diversion Paths (Unit 1)

Prepared By: James M. Manoleas

Reviewed By: L. S. Weed
L. S. Weed

Flow Path Description	Potential L.O.C. from R.P.V.	Component that Prevents L.O.C. from R.P.V.	Component W/Potential for L.O.C. from R.P.V.	Division	References	Remarks
Scram Discharge Volume Vent	No	SV1F009 (XV-1F010; FC)	N/A	I/II	M-147	Valves close on scram and prevent L.O.C. inventory. Refer to CRD System.
Scram Inlet Line (1/2" DCD)	No	115	N/A	N/A	M-147	Check valve restricts L.O.C. flow path.
Drive Water Header (1/2" DCD)	No	137	N/A	N/A	M-147	Check valve restricts L.O.C. flow path.

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FPRKLN · F0008
ATTACHMENT I
TO DR #11

ATTACHMENT 1

Underwriter's Laboratories Inc.

Fact-Finding Report

on

Air Duct Penetrations Through One Hour

Fire Resistive Wall Assembly

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173pp.

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File NC505-12
Project 84NK29824

April 17, 1985

FACT-FINDING REPORT

on

AIR DUCT PENETRATIONS THROUGH ONE HOUR FIRE RESISTIVE WALL ASSEMBLY

UNDERWRITERS LABORATORIES INC

UNDERWRITERS LABORATORIES INC.

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an independent, not-for-profit organization testing for public safety

File NC505-12
Project 84NK29824

April 17, 1985

FACT-FINDING
REPORT

on

AIR DUCT PENETRATIONS THROUGH ONE HOUR
FIRE RESISTIVE WALL ASSEMBLY

American Iron and Steel Institute
Washington, D.C.

Fact-Finding Investigations are undertaken to develop facts and issue a Report for use by the Applicant in seeking amendments in nationally recognized installation codes and standards. The issuance of this Report in no way implies Listing, Classification, or other Recognition by UL and does not authorize the use of UL Listing or Classification Marks or any other reference to Underwriters Laboratories Inc. on or in connection with the product.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

This Fact-Finding Report describes the performance of air duct penetrations through a 1 hr rated fire resistive wall assembly when the wall assembly was subjected to a fire test conducted in accordance with the requirements of the Standard for Fire Tests of Building Construction and Materials, UL 263 (ASTM E119).

The air duct assemblies which penetrated the wall assembly consisted of two square 10 in. by 10 in. inside dimension galvanized steel ducts and one square 10 in. by 10 in. inside dimension Class I rigid fiberglass duct. The outside surface of one galvanized steel air duct was covered with foil-scrim-kraft faced fiberglass duct insulation on the fire and non-fire side of the wall assembly. All the air duct assemblies had open duct drops on both sides of the wall assembly. None of the air duct assemblies contained fire dampers. The fire resistive wall assembly consisted of 5/8 in. thick gypsum wallboard screw-attached to steel studs which were spaced 24 in. on center.

This investigation was undertaken at the request of the American Iron & Steel Institute (AISI) to develop test data relative to the fire performance of insulated steel air ducts, uninsulated steel air ducts, and Class I rigid fiberglass air ducts, without dampers, penetrating a 1 hr fire resistive wall.

The following objectives were associated with the conduct of this test:

(1) develop fire performance data on the ability of insulated steel, uninsulated steel, and rigid fiberglass air duct systems to remain secure within the wall opening without developing through openings allowing the passage of flame and hot gases through the wall and duct assemblies,

(2) develop data on the influence of the air ducts on the transmission of heat to the unexposed surfaces of the wall and duct assemblies and

(3) the radiation of heat from the surfaces of the duct assemblies to adjacent surfaces.

For this investigation, the measurement of temperatures on the unexposed surface of the wall utilized thermocouples that were covered with 6 by 6 in. ceramic pads as described in Standard UL 263. The thermocouples used to measure the temperatures on the top surface of the duct assemblies were attached with tape and were not covered with ceramic pads so as not to interfere with the measurement of radiant heat from the surface of the duct assemblies to adjacent untreated wood surfaces.

Information developed in this investigation is to be used for submittal by the sponsor to the Air Conditioning Committee of National Fire Protection Association (NFPA) in connection with the development of the Standard for Installation of Air Conditioning and Ventilation Systems, NFPA 90A, which specifies the use of fire dampers in openings in partitions requiring fire resistive ratings of 2 hr or more and does not now contain provisions for the protection of openings in walls and partitions requiring fire resistance ratings of less than 2 hr.

The fire performance included temperatures measured and recorded at various locations within, top surface of, to the side of and above the air duct assemblies, the structural integrity of air duct assemblies, the passage of flames through the air duct assemblies, and the passage of flames through the wall assembly.

Because of the furnace design and the characteristic of rising hot gases, the value of the pressure differential between the furnace chamber and the surrounding laboratory volume changes as the distance from the test frame sill changes. During the fire test, a plane of zero pressure differential between the laboratory and the furnace existed in the furnace chamber. Above this plane, the pressure within the furnace was greater than the laboratory and below this plane, the pressure within the furnace was less than the laboratory. The location of the zero pressure plane was maintained at approximately 36 in. above the test frame sill.

DESCRIPTION OF TEST ASSEMBLY

MATERIALS:

The following is a description of the materials used in the test assembly.

Floor/Ceiling Tracks - The floor/ceiling tracks were fabricated from 0.025 in. thick galvanized steel. The channel shaped tracks were 3-5/8 in. deep with 1 in. long legs.

Steel Studs - The steel studs were fabricated from 0.025 in. thick galvanized steel. The channel shaped studs were 3-5/8 in. deep with 1-1/4 in. long legs and 5/16 in. long stiffeners.

Gypsum Wallboard - The gypsum wallboard was 5/8 in. thick and bore UL's Classification Marking for Fire Resistance Classification.

Steel Sleeves - The steel sleeves were 12 in. long, 10 by 10 in. (O.D.) and fabricated from 0.059 in. thick galvanized steel.

Framing Angles - The framing angles used in mounting the steel sleeves in the wall assemblies had 1-1/2 in. long legs and were fabricated from 0.079 in. thick galvanized steel.

Galvanized Steel Air Duct Insulation - The glass fiber insulation was supplied in rolls, 48 in. wide by 48 in. long. The nominal density of the fiberglass insulation was approximately 1 lb/ft^3. The outside face of the fiberglass insulation was covered with 7 mil thick aluminum foil-scrim-kraft facing.

Galvanized Steel Air Duct Assemblies - The two galvanized steel air duct assemblies were fabricated from 0.022 in. thick material and each duct assembly had a 10 by 10 in. inside dimension.

Rigid Fiberglass Air Duct Assembly - The rigid fiberglass air duct material was fabricated from 4 ft wide by 8 ft long by 1 in. thick boards. The density of the boards was approximately 4 lb/ft^3. The air duct material bore the UL Classification Mark for use in fabrication of a Class I air duct per the requirements of the Standard for Factory-Made Air Ducts and Connectors, UL 181.

Fasteners - All fasteners used in the assembly were steel. The floor tracks were secured to the sill of the test frame with No. 8-32 by 3/4 in. long bolts spaced approximately 16 in. OC.

The steel studs and the floor/ceiling tracks were secured together with Type S-12 by 1/2 in. long pan head screws.

The gypsum wallboard was secured to the steel studs with Type S by 1 in. long bugle head screws. The fasteners were spaced 8 in. OC along the wallboard joints in the field.

WALL ASSEMBLY:

The wall assembly was nominally 15 ft wide by 10 ft high and consisted of 3-5/8 in. deep, 0.025 in. thick, steel studs spaced 24 in. OC. Additional studs were added to accommodate the penetration framing. The studs were covered on the exposed and unexposed sides with a single layer of 5/8 in. thick gypsum wallboard which was screw-attached to each stud.

AIR DUCT ASSEMBLIES:

Three air duct assemblies were included in the test assembly. The air duct assemblies included two galvanized steel air ducts and one rigid fiberglass air duct. The galvanized air ducts were fabricated from 0.022 in. thick steel. The inside dimension of the ducts was 10 by 10 in. A steel sleeve was utilized for each air duct assembly where it penetrated through the wall. One galvanized steel air duct assembly was covered with glass fiber duct insulation on the fire and non-fire side of the wall assembly. The other galvanized steel duct assembly was uninsulated. The horizontal center line of the galvanized steel air duct penetrations, with and without insulation, was 96 in. above the test frame sill. The remaining air duct assembly was fabricated from 1 in. thick rigid fiberglass air duct material with an aluminum foil-scrim-kraft facing. The inside dimensions of the rigid fiberglass air duct assembly was 10 by 10 in. The horizontal center line of the rigid fiberglass air duct penetration was 78 in. above the test frame sill. None of the air duct assemblies contained fire dampers.

Galvanized Steel Air Duct Assemblies - The two galvanized steel duct assemblies were fabricated from 0.022 in. thick material. The duct assemblies were fabricated from several sections to form L-shaped units. Each duct assembly contained a 6 in. square drop outlet which was centered 10 ft, 3 in. from the unexposed surface of the wall assembly and a 6 in. square drop outlet which was centered 12 in. from the end of the duct trunk on the exposed side of the assembly. The ends of each duct assembly were closed and the duct drop outlets were open.

One of the two galvanized steel duct assemblies was wrapped with glass fiber insulation.

Class I Rigid Fiberglass Duct Air Assembly - The Class I rigid fiberglass air duct assembly was fabricated from 4 ft wide by 8 ft long by 1 in. thick boards. The density of the boards was approximately 4 lb/ft^3. One surface of the boards was covered with an 0.008 in. thick aluminum foil-scrim-kraft facing. The 4 ft long edges of the board were cut with kerf edges to provide shiplap construction when joining adjacent pieces. The air duct material bore the UL Classification Mark as Class I material per the requirements of the Standard for Factory-Made Air Ducts and Connectors, UL 181.

The boards were cut to form a 10 in. by 10 in. (I.D.) L-shaped unit. Longitudinal joints and adjacent 4 ft long sections of duct were joined together with staples and pressure sensitive tape in accordance with instructions provided with the rigid fiberglass air duct board material. The duct assembly contained a 6 in. by 6 in. by 6 in. deep drop outlet which was centered 10 ft, 3 in. from the unexposed surface of the wall assembly and a 6 in. square drop outlet which was centered 21 in. from the end of the duct trunk on the exposed side of th wall assembly. The ends of the duct assembly were closed and duct drop outlets were opened.

Duct Support System - On the exposed side of the test assembly, each air duct was supported by means of a trapeze support system. The supports for the air duct systems were spaced 24 in. OC. Each support consisted of two 1/4 in. diameter threaded steel rods spaced a nominal 12 in. OC. The galvanized steel ducts, with and without insulation, were supported by 14 in. long, 1 by 1 by 1/8 in. thick steel angles. The rigid fiberglass duct was supported by 14 in. long, 2 by 2 by 1/8 in. thick steel angles.

On the unexposed side of the test assembly, the air ducts were supported by temporary steel framing.

CONSTRUCTION OF TEST ASSEMBLY:

The test assembly was constructed in a manner similar to that shown on ILLS. 1, 1A and 1B.

The floor/ceiling tracks were secured to the test frame. The steel studs were secured to the floor/ceiling tracks at a spacing of 24 in. OC. The vertical edges of a frame to support the air duct penetration was formed from the studs placed toe-to-toe. The horizontal edges of the frame were formed from 36 in. lengths of floor/ceiling tracks folded into U-shapes as shown on ILLS. 1 and 1A.

A single layer of gypsum wallboard was fastened to the steel framing membrane forming the frames for the air duct penetrations as shown in ILL. 1.

A steel sleeve was inserted through each steel frame. Rockwool batt material was installed between the steel sleeve and the wallboard lining of the frame to seal any openings between the sleeve and the wallboard. The framing angles were fastened to the sleeve and to the steel studs to secure the sleeves in place as shown on ILLS. 1 and 1A.

On the exposed surface of the assemblies, the trapeze air duct supports were hung from the lintel of the test frame. The duct supports were spaced 24 in. OC. The air duct assemblies were installed with the ends sealed and open 6 in. square outlets. One end of each duct assembly contained a 90° elbow which was connected to the steel sleeve as shown on ILL. 1A. The horizontal center line of the galvanized steel air duct assemblies was located 96 in. above the test frame sill. The horizontal center line of the rigid fiberglass duct assembly was located 78 in. above the test frame sill. Glass fiber insulation was wrapped around the galvanized steel air duct located on the north side of the assembly. The insulation extended approximately 4 in. beyond the closed end and was folded over and stapled to itself. A 6 in. overlap was provided along the horizontal and longitudinal joints and were taped with a pressure sensitive tape.

On the unexposed surface, one end of the air duct assembly was connected to the steel sleeve and the remaining end was sealed. A 6 in. square air outlet was provided in each duct assembly. The center of each air outlet was located 10 ft, 3 in. from the unexposed surface of the wall assembly as shown on ILL. 1B. The same procedure of wrapping the north galvanized steel air duct with glass fiber insulation on the exposed side of the assembly was repeated on the unexposed side.

Photographs depicting various stages of the construction process are contained in Appendix B. The appearance of the exposed surface of the assembly prior to the fire test is shown in ILL. 2.

T E S T   R E C O R D

FIRE ENDURANCE TEST:

The fire test was conducted in accordance with the Standard of Underwriters Laboratories Inc. for Fire Tests of Building Construction and Materials, UL 263 (ASTM E119, NFPA No. 251).

DESCRIPTION OF TEST ASSEMBLY

The test assembly was constructed as described in the Section of the Report entitled "Construction of Test Assembly" and as shown on ILLS. 1, 1A and 1B.

METHOD

The standard test equipment of Underwriters Laboratories Inc. for wall and partition assemblies was used for the fire endurance test.

The test assembly was placed in front of the vertical furnace and exposed to flames of controlled extent and severity in accordance with the Standard Time-Temperature Curve. The furnace temperatures were measured with 12 thermocouples positioned 6 in. from the exposed face of the assembly and located in the furnace chamber as shown on ILL. 3.

The pressure differential between the furnace chamber and the laboratory was measured at 3 locations. The location of the zero pressure plane was 36 in. above the test frame sill. Above this plane, the pressure within the furnace was greater than the laboratory and below this plane, the pressure within the furnace was less than the laboratory. The two remaining pressure differential locations were 78 in. and 96 in. above the test frame sill. All three air duct penetrations were located above the zero pressure plane. A plot of the pressure magnitudes measured during the test are shown on ILL. 4.

The unexposed surface temperatures of the wall assembly were measured with thermocouples located as shown in ILL. 5. Each thermocouple was covered with a 6 in. by 6 in. dry ceramic fiber pad.

Thermocouples used to measure the temperatures within, on top of, above, and to the side of the each air duct assembly were located as shown in ILL. 6. These thermocouples were attached with tape and were not covered with ceramic fiber pads.

Thermocouples used to measure the surface temperature of the wood blocks adjacent to the duct surfaces were secured against the wood surface with staples. Staples were carefully applied in order to avoid causing a short in the thermocouple. The thermocouples were not covered with ceramic pads.

RESULTS

Character and Distribution of the Fire - The furnace fire was luminous and well distributed during the test and the temperatures recorded in the furnace chamber followed the Standard Time-Temperature Curve as defined in the Standard for Fire Tests of Building Construction and Materials, UL 263 and as shown on ILL. 3.

Observations of Exposed Surface During Test - The following observations were made of the exposed surface during the fire test. All references to dimensions are approximate.

Time, min:s	Observations
:30	The Class I rigid fiberglass air duct had ignited.
:45	The insulated galvanized steel air duct had ignited.
1:00	Heavy flames were issuing from the rigid fiberglass air duct. The insulated galvanized steel air ducts' outer layer of the foil wrap was delaminating. Pieces 1 in.^{2} to 4 in.^{2} were falling into the furnace chamber.
1:15	Flames were issuing from the insulation on the insulated galvanized steel duct.
2:00	Both the Class I rigid fiberglass and the glass fiber insulated galvanized steel air duct assemblies were emitting heavy flames. The wall surface was a light gray color.
3:00	Sections of glass fiber insulation located on the bottom surface of the galvanized steel duct had fallen off, leaving exposed 75 percent of the bottom surface of the steel duct.

3:15	The paper surface of the wallboard had ignited.
4:00	The Class I rigid fiberglass air duct had deflected 1 to 1-1/2 in. downward.
4:15	The majority of the rigid fiberglass air duct was consumed.
4:30	A small section of the Class I rigid fiberglass air duct, 6 to 8 in. long remained attached to the wall assembly. The rest of the duct assembly had been consumed or had fallen into the furnace chamber.
4:45	The wall surface was black in color and the paper was peeling and falling away.
5:00	The glass fiber insulation that was wrapped around the north galvanized steel air duct was consumed or had fallen into the furnace chamber.
5:50	All flaming had stopped.
15:00	All charred paper surfacing on the wallboard had fallen.
20:00	The joint tape on the wallboard had begun to delaminate from the wallboard.
40:00	All of the joint tape had delaminated.
53:00	The wallboard joints had opened 3/16 in.
60:00	Test terminated.

<u>Observations of the Unexposed Surface During the Test</u> - The following observations were made of the unexposed surface during the fire test. All references to dimensions are approximate.

Time, min:s	Observations
:15	A light amount of smoke was issuing from the north glass fiber insulated galvanized steel air duct.
:30	Light smoke was issuing from all three air duct assemblies.
2:00	Heavy smoke was issuing from the Class I rigid fiberglass air duct.

6:00 Smoke was still issuing from the Class I rigid fiberglass air duct. Light smoke was issuing from the glass fiber insulated galvanized steel air duct. Light smoke/steam was issuing from the top surface of the south galvanized steel air duct 6 ft from the wall surface.

12:00 Light smoke was issuing from the north glass fiber insulated galvanized steel air duct 10 ft from the wall surface.

15:00 The Class I rigid fiberglass air duct had begun to collapse inward near the sleeve penetration.

17:00 Heavy smoke was issuing from the horizontal joint of the Class I rigid fiberglass air duct located 4 ft from the wall surface.

17:30 The transverse joint of the Class I rigid fiberglass air duct located 4 ft from wall surface and the longitudinal joint began to deteriorate and the duct started to bow downward.

18:00 The transverse joint tape of the Class I rigid fiberglass duct located 4 ft from the wall surface, had delaminated and fallen away from the air duct surface.

18:50 The Class I rigid fiberglass air duct ignited at the horizontal joint, located 4 ft from the wall surface.

19:07 The Class I rigid fiberglass air duct had separated at the transverse joint located 4 ft from the wall surface. The section of flaming air duct beyond the horizontal joint had fallen to the laboratory floor. The 4 ft air duct section extending from the wall surface was burning and collapsed inward.

23:20 Flames had begun to issue from the collapsed Class I rigid fiberglass air duct section extending from the wall surface.

25:00 The remaining section of the Class I rigid fiberglass air duct had separated from the sleeve and had fallen to the laboratory floor. Flames were issuing from the unprotected opening left the collapsed rigid fiberglass air duct.

25:30	The untreated wood blocks near the Class I rigid fiberglass air duct through-opening ignited.
26:00	The Class I rigid fiberglass air duct through-opening was sealed with sections of gypsum wallboard and ceramic fiber blankets.
26:30	Beginning at the wall surface and extending outward 10 in., the insulation on the bottom of the galvanized steel air duct began to discolor. The top and side foil surface had begun to blister.
32:00	Light amounts of smoke were issuing from the perimeter of the wall assembly.
34:00	Beginning at the wall surface and extending outward 18 in., the surface of the galvanized steel air duct, without insulation, had begun to discolor.
40:00	The top seam of the glass fiber insulation had separated. Sections of the exposed glass fiber insulation were visibly charred.
43:00	The insulation wrap on the galvanized steel air duct glass fiber had appeared to expand outward.
50:00	Slight discoloration was visible on the wall surface adjacent to the glass fiber insulated galvanized steel air duct.
57:00	The wall assembly was giving off some light cracking sounds.
60:00	Test terminated.

Temperatures on the Unexposed Surface of the Wall Assembly - The temperatures that developed at various points on the unexposed surface of the wall assembly were recorded by Thermocouples Nos. 1 through 14 located as shown on ILL. 5. Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test are contained in Appendix A.

Temperatures of the Duct Assemblies - The temperatures that developed within, top surface of, to the side of, and above the air duct assemblies were recorded by Thermocouple Nos. 15 through 68. The location of these thermocouples is shown on ILL. 6. Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test are contained in Appendix A.

Plots of the temperatures recorded within the duct assemblies, located 3 in., 6 ft and 9 ft, 3 in. from the unexposed surface of the wall are shown on ILLS. 8, 9 and 10, respectively.

The limited temperature data on the Class I duct occurred because the transverse joint of the rigid fiberglass duct, located 4 ft from the unexposed surface of the wall, opened and separated at 19 min and the portion of the duct assembly beyond the first joint collapsed and fell to the laboratory floor. The remaining duct assembly section extending from the unexposed surface of the wall collapsed at 25 min. To maintain the pressure differential between the furnace chamber and laboratory the through-opening of the wall assembly was plugged with gypsum board and cera-fiber blankets at 26 min.

The temperatures within the Class I rigid fiberglass duct, 6 ft and 9 ft, 3 in. from the unexposed surface of the wall were plotted for 17 min, 30 sec and temperatures within the rigid fiberglass duct 3 in. from the unexposed surface of the wall were plotted for 25 min.

Temperatures measured within the galvanized steel duct, with and without insulation, were plotted through the full 60 min. The thermocouple location for each duct assembly is shown on ILL. 6.

Plots of the temperatures measured on the top surface of the duct assemblies, 3 in, 6 ft and 9 ft, 3 in. from the unexposed surface of the wall, are shown on ILLS. 11, 12 and 13, respectively.

Thermocouple Nos. 37 and 59 malfunctioned at the start of the test and remained inoperative throughout the test. These thermocouples were on the top surface of the insulated steel duct and on the top surface of the rigid fiberglass duct, 6 ft from the unexposed surface of the wall.

The transverse joint of the Class I rigid fiberglass duct, located 4 ft from the unexposed surface of the wall, opened and separated at 19 min. The portion of the duct assembly beyond this transverse joint collapsed and fell to the laboratory floor. Consequently, the last accurate temperature recorded on the fiberglass duct beyond the transverse joint was obtained at 17 min, 30 s. This temperature was 136°F.

The remaining portion of the Class I fiberglass duct assembly collapsed at 25 min. Consequently, the final accurate temperature recorded on the fiberglass duct 3 in. from the unexposed surface of the wall was obtained at 22 min, 30 s. This temperature was 168.7°F.

The temperatures developed from the radiant heat transfer from each duct assembly were measured by thermocouples located 18 in. and 60 in. from the unexposed surface of the wall and 1 in., 2 in. and 4 in. from the top and side surface of each duct assembly. The thermocouples used to measure these temperatures were securdd to the surface of the 6 in. long, 2 by 4 in. exposed untreated wood. The thermocouple locations near each duct assembly is shown on ILL. 6.

The temperatures recorded by Thermocouple Nos. 60 through 62 and 66 through 68, located 60 in. from the unexposed surface of the wall, above and to the side of the rigid fiberglass duct assembly, respectively, were accurate for the first 17 min and 30 s of the fire test. This occurred because the transverse joint of the Class I rigid fiberglass duct located 4 ft from the unexposed surface of the wall, opened and separated at 19 min. and the remaining portion of the duct assembly fell to the laboratory floor. Consequently, the final accurate temperatures for Thermocouple Nos. 60 through 62 and 66 through 68 were recorded at 17 min, 30 s. Within this group of thermocouples, the highest temperature was 145°F as recorded by Thermocouple No. 61 at 17 min, 30 s. Thermocouple No. 61 was located 60 in. from the unexposed surface of the wall and centered 2 in. above the top duct surface. The temperatures recorded by Thermocouple Nos. 57 through 59 and 63 through 65, located 18 in. from the unexposed surface of the wall, above and to the side of the Class I rigid fiberglass duct assembly, respectively, were accurate for the first 22 min, 30 s of the fire test. Thereafter, the last relevant temperatures for Thermocouple Nos. 57 through 59 and 63 through 65 were recorded at 22 min, 30 s. Within this group of thermocouples, the highest temperature was 363°F as recorded by Thermocouple No. 64. Thermocouple No. 64 was located 18 in. from the unexposed surface, centered at the mid-height, and 2 in. from the side surface of the duct.

OBSERVATIONS AFTER TEST:

The appearance of the exposed and unexposed surfaces after the test are shown in ILLS. 14 and 15, respectively.

On the exposed surface, all wallboard remained attached to the studs. The wallboard contained numerous cracks and displayed a maximum joint separation of 5/8 in. The Class I rigid fiberglass air duct had fallen from its supports and was consumed by the furnace fire. The glass fiber insulation used to insulate the north galvanized steel air duct was also consumed.

Both galvanized steel air ducts remained in place. The galvanized steel ducts without insulation distorted less than the galvanized steel duct with insulation.

On the unexposed side of the wall assembly, the gypsum wallboard remained in place with no joint separation or cracks observed. The Class I rigid fiberglass air duct collapsed at 19 min, 5 s and dropped to the laboratory floor. Two galvanized steel ducts were intact and remained in place. The glass fiber insulation that was wrapped around the north galvanized steel duct was charred through its entire depth for the first 8 ft extending away from the wall surface. The charred depth of the remaining portion was 75 percent of the total thickness. The foil facing had numerous blisters and 1/8 in. wide cracks throughout its surface for the first 4 ft extending from the wall surface. The remaining length of foil facing had numerous blisters. The galvanized steel air ducts, with and without insulation, remained structurally intact. Upon removal of the glass fiber insulation from the north duct assembly, it was noted that the galvanized steel air duct was discolored along its entire length. The south galvanized steel air duct, without insulation, was discolored approximately 3 ft extending from the surface of the wall assembly.

SUMMARY

In consideration of the fact-finding character of the investigation, the foregoing Report is to be construed as information only and should not be regarded as conveying any conclusion or recommendations on the part of Underwriters Laboratories Inc. regarding the ability of the construction or performance of the product for Recognition by any code or Standard or for any other purpose.

WALL ASSEMBLY FIRE PERFORMANCE:

The fire resistant test was conducted on the wall assembly in accordance with Standard UL 263 (ASTM E119, NFPA 251, ANSI A2.1). The wall assembly was of gypsum wallboard and steel stud construction containing three types of duct assemblies two galvanized steel ducts and one Class I rigid fiberglass duct. All three duct assemblies penetrated the wall assembly and had open air drops on each side. The duct assemblies did not contain fire dampers.

Based on measurements at locations other than at the duct assembly penetrations, the wall assembly complied with the temperature transmission requirements of Standard UL 263 for a 1 hr fire resistance rating.

A plot of the maximum individual and average temperatures recorded on the unexposed surface of the test assembly is shown on ILL. 7.

Temperature measurements of the duct assemblies at various locations are described separately.

PRESSURE DIFFERENTIALS:

A plane of neutral pressure between the furnace chamber and the surrounding laboratory volume existed within the furnace. Above this plane, the pressure differential within the furnace was positive with respect to laboratory atmospheric pressure. Below the neutral pressure plane, the pressure differential was such that the pressure plane within the furnace was negative with respect to the laboratory atmospheric pressure.

The location of the neutral pressure plane was 36 in. above the sill of the assembly. All three air duct assemblies were located above the neutral plane, in the positive pressure area of the furnace.

The magnitude of the pressure differentials at the location of each duct assembly during the test are shown on ILL. 4.

TEMPERATURES WITHIN THE AIR DUCT:

The temperatures within each air duct assembly were measured at distances of 3 in., 6 ft and 9 ft, 3 in. from the unexposed surface of the wall. The thermocouple locations on each assembly are shown on ILL. 6. Plots comparing maximum temperatures reached at each location for each duct assembly are shown on ILLS. 8, 9 and 10, respectively.

Through 15 min of the fire exposure period, the temperatures recorded within the insulated galvanized steel air duct were generally higher than the uninsulated and Class I rigid glassfiber air duct assemblies. The lowest temperatures were measured within the uninsulated galvanized steel duct. After 60 min of fire exposure, the temperatures recorded within the uninsulated galvanized steel air duct continued to be lower than the insulated galvanized steel duct. Comparison with the Class I rigid fiberglass air duct assembly was not made beyond the time when joint separation occurred (17 min, 30 s).

Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test and at each location are contained in Appendix A.

TEMPERATURES ON THE UNEXPOSED SURFACE OF THE AIR DUCTS:

The temperatures on the top surface of each duct assembly were measured at distances of 3 in., 6 ft, and 9 ft, 3 in. from the unexposed surface of the wall. The thermocouple location on each assembly is shown on ILL. 6.

The maximum temperature measured nearest the wall assembly on the top surface of the uninsulated galvanized steel air duct was 499°F at 22 min, 30 sec. The corresponding maximum temperature measured for the insulated galvanized steel air duct was 176°F at 60 min. A maximum temperature of 293°F was recorded on the Class I glass fiber duct at 25 min, just prior to the collapse of the duct at the steel sleeve.

The maximum temperature measured furthest from the wall assembly on the top surface of the uninsulated galvanized steel duct was 175°F at 47 min, 30 sec. The corresponding maximum temperature measured for the insulated galvanized steel air duct and for the Class I rigid fiberglass duct was 178°F at 2 min, 30 sec and 294°F at 17 min, 30 sec (just prior to collapse of duct portion beyond 4 ft from wall), respectively.

Plots comparing maximum temperatures reached at each location on each duct assembly are shown on ILLS. 11, 12 and 13, respectively.

Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test and at each location are contained in Appendix A.

RADIANT TEMPERATURE OF THE AIR DUCTS:

Temperatures developed from the radiant heat transfer from each duct assembly were measured by thermocouples located 18 in. and 60 in. from the unexposed surface of the wall and 1 in., 2 in. and 4 in. from the top and side surface of each duct assembly. The thermocouples were secured to the surface of the 2 by 4 in. untreated wood blocks, 6 in. long. The location of these thermocouples for each duct assembly is shown on ILL. 6.

A comparison of the radiant temperatures for the three duct assemblies indicates that the greatest temperature rise occurred on the untreated wood adjacent to the galvanized steel air duct assembly without insulation. The Class I rigid fiberglass duct assembly produced the least radiant temperature rise prior to the changes in temperatures affected by the partial or complete collapse of the Class I glass fiber duct assembly.

A comparison of the radiant temperature rise for the galvanized steel duct assemblies, with and without insulation, indicates that the greatest temperature rise occurred with the galvanized steel duct assembly without insulation. The maximum temperatures recorded were 479°F from the uninsulated duct and 251°F from the insulated galvanized steel duct.

Tables containing the temperatures recorded at 2 min, 30 s intervals throughout the test and at each location are contained in Appendix A.

Report by:

THOMAS PLENS
Senior Engineering Assistant
Fire Protection Department

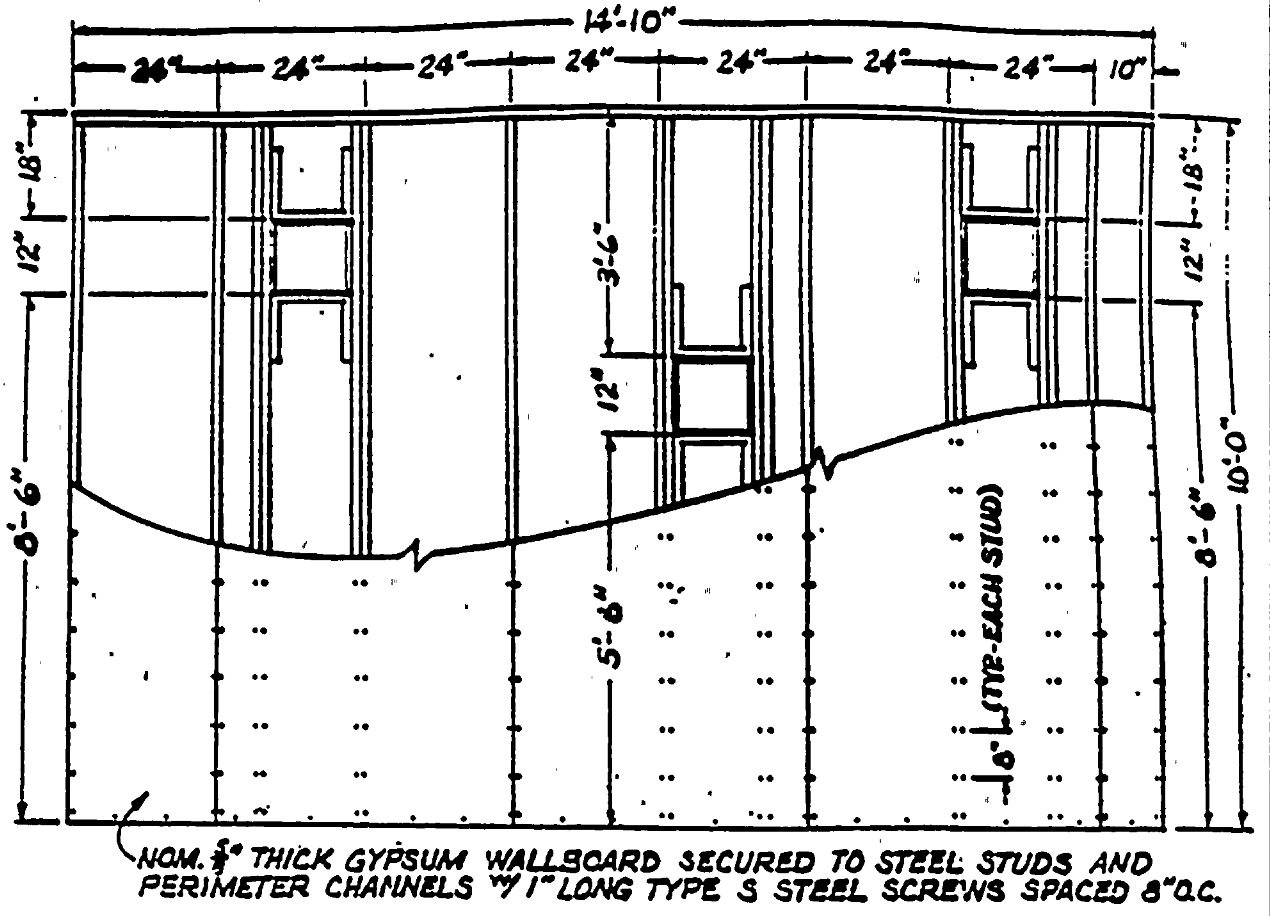
KENNETH RHODES
Engineering Group Leader
Fire Protection Department

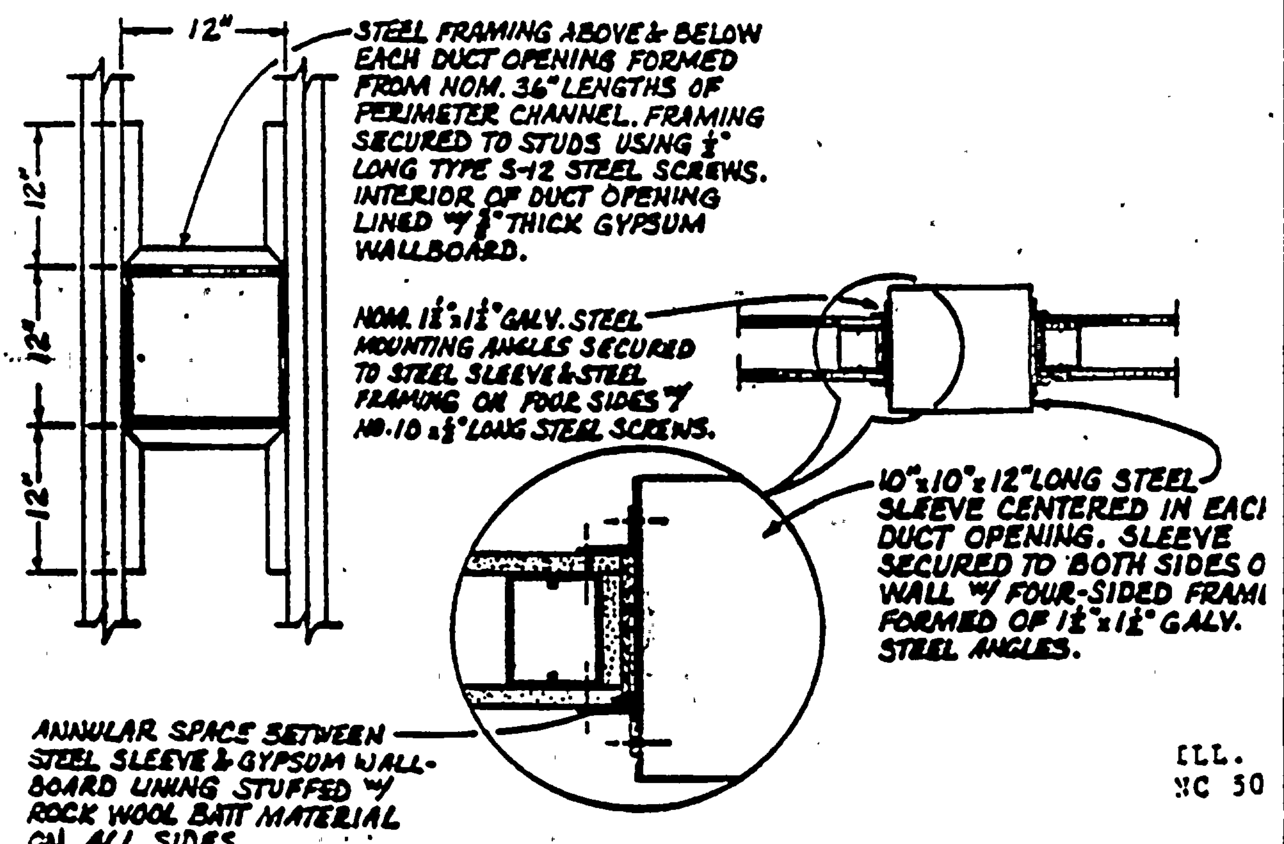
Reviewed by:

J. BEYREIS
Managing Engineer
Fire Protection Department

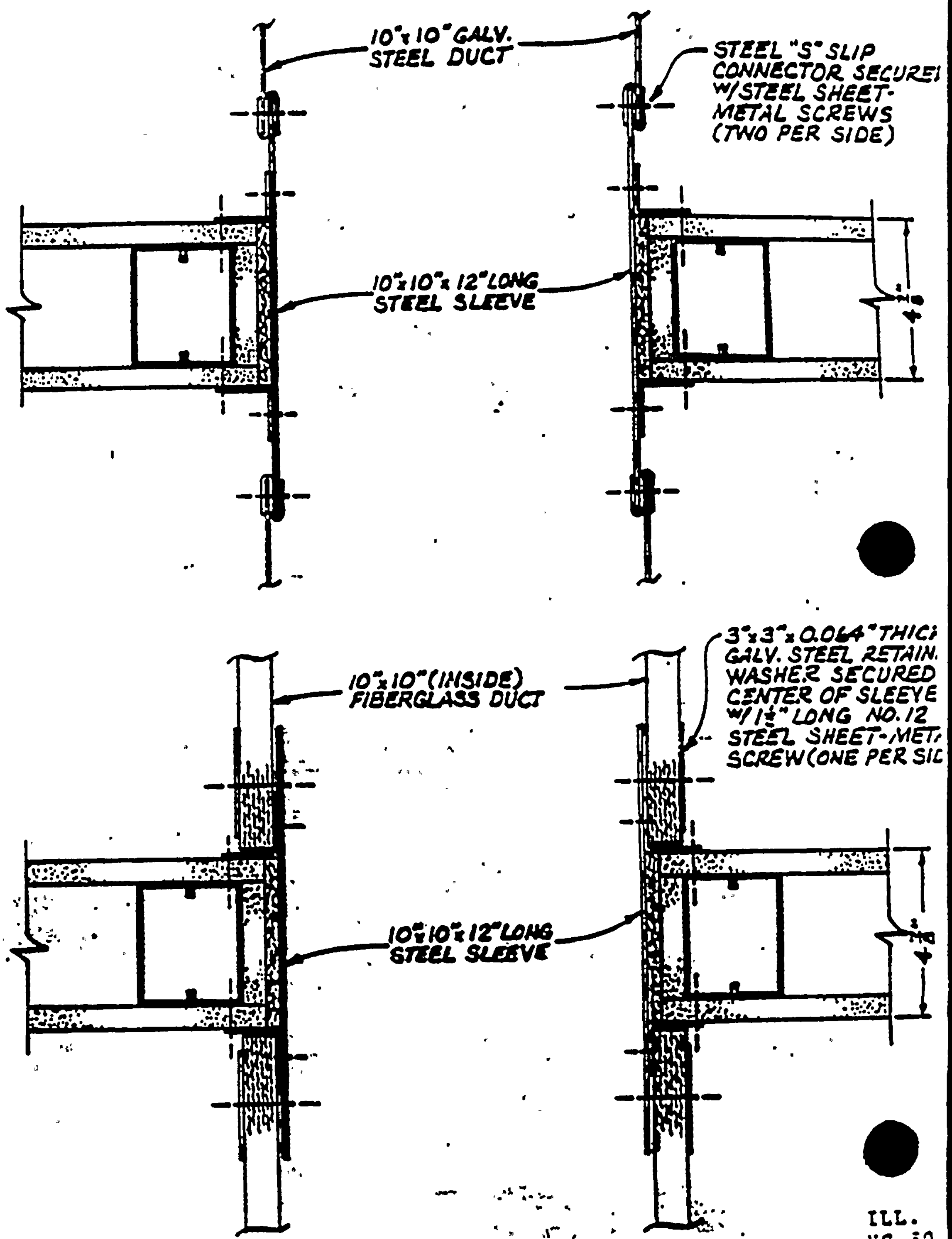
TP/KR:jrr
REPT4

WALL CONSTRUCTION DETAILS





AIR DUCT/SLEEVE CONNECTION DETAILS



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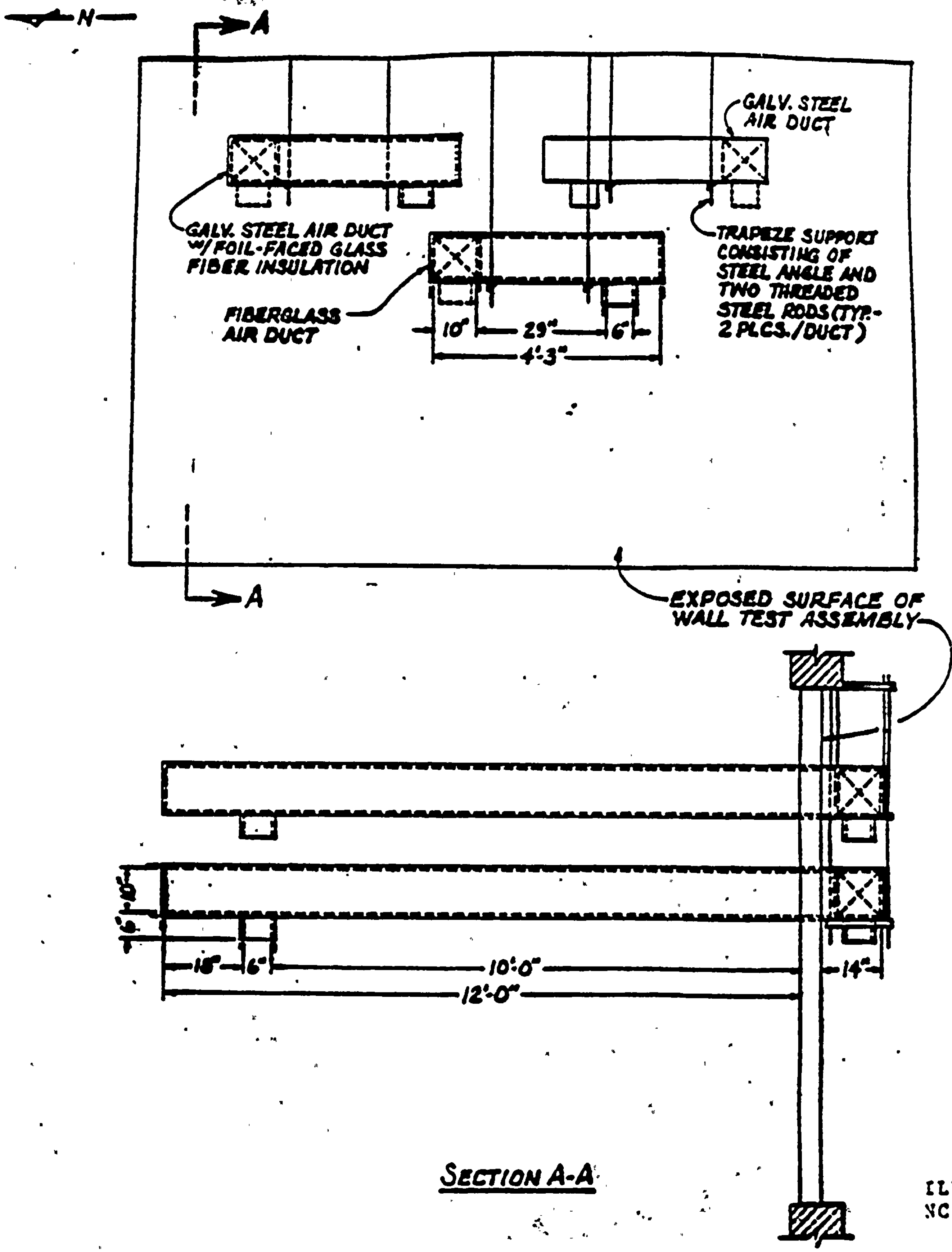
DUCT INSTALLATION DETAILS



SECTION A-A

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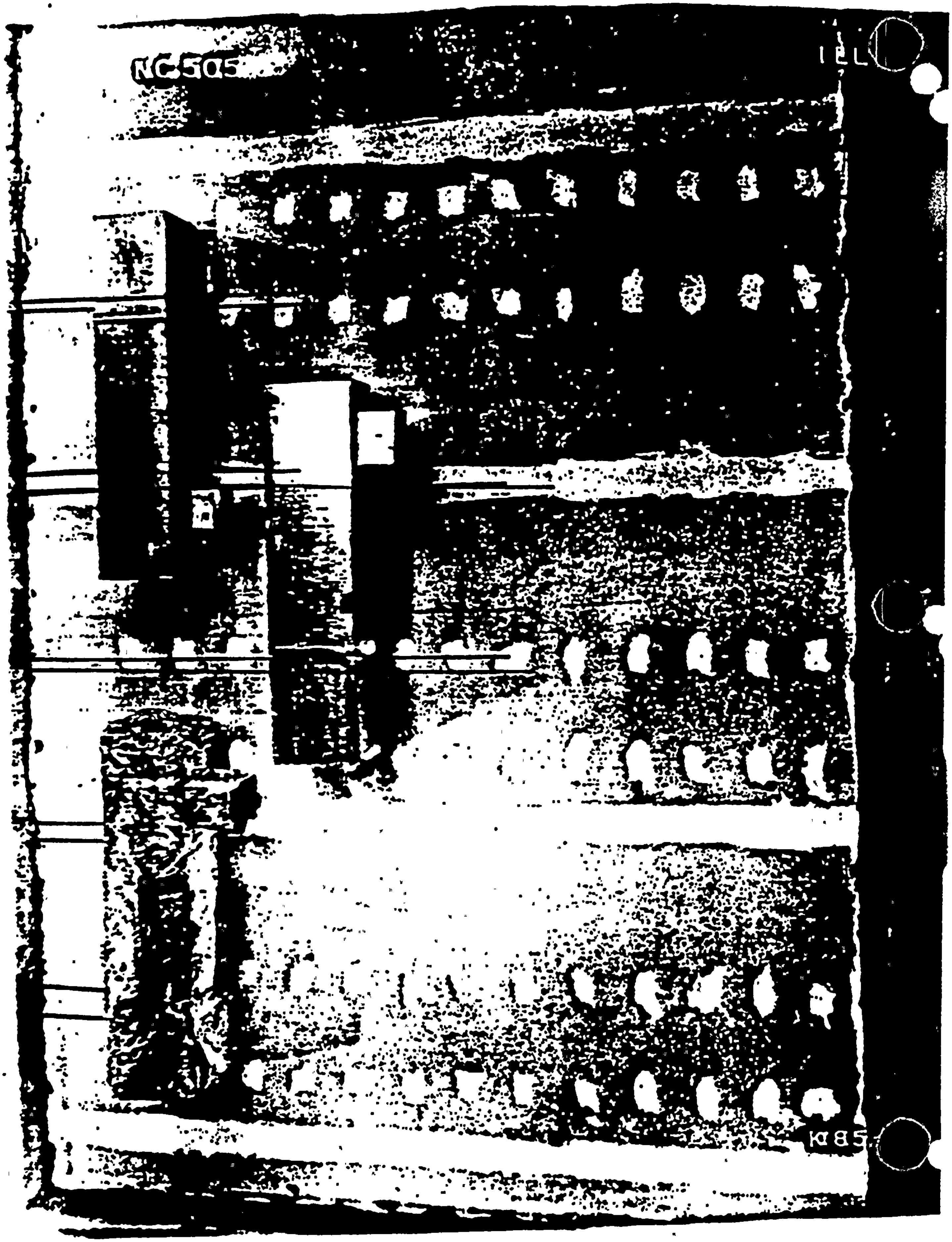
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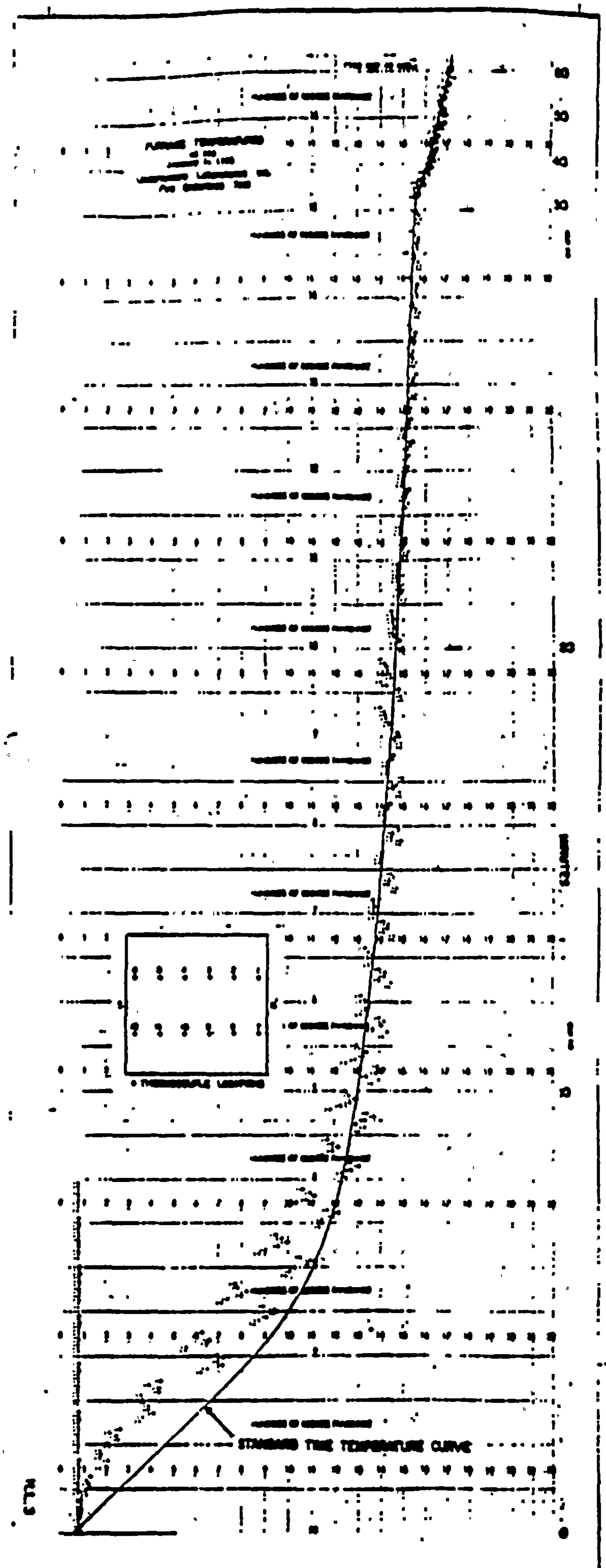
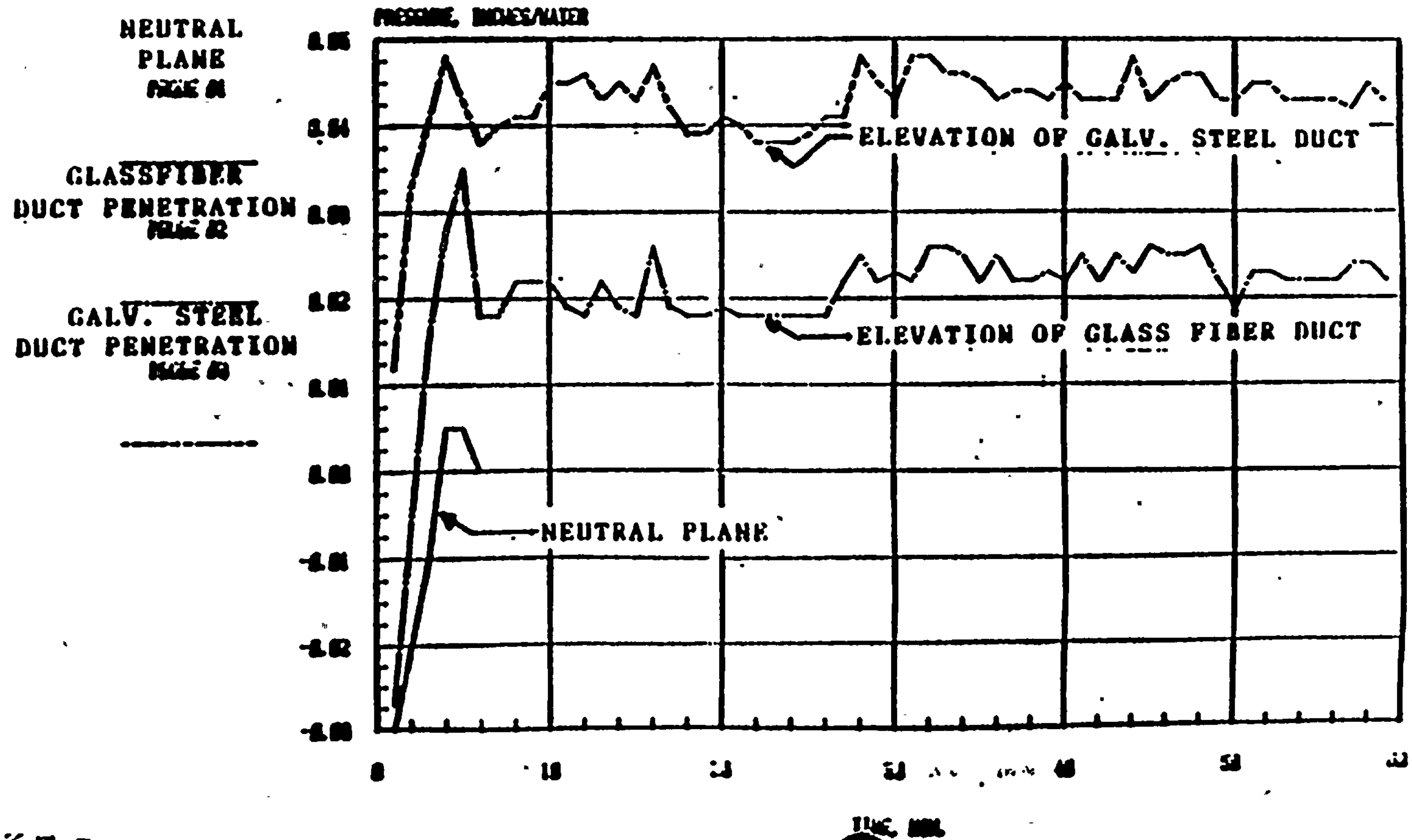
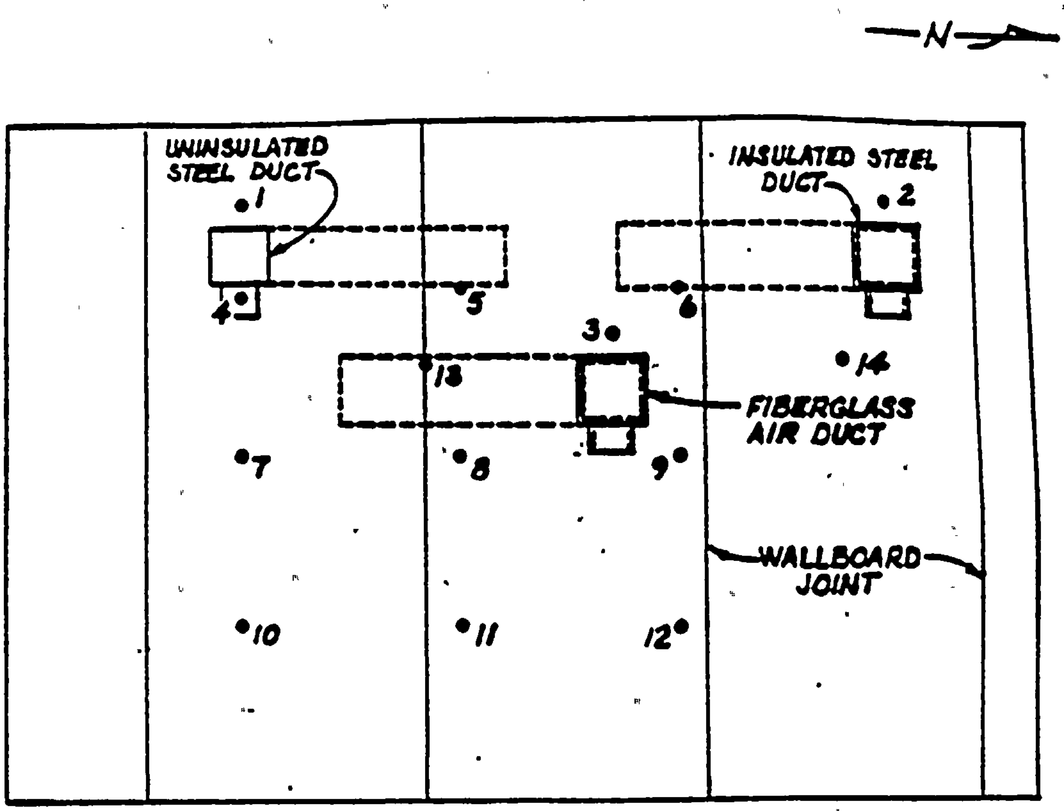

STANDARD TIME TEMPERATURE CURVE

FURNACE PRESSURE

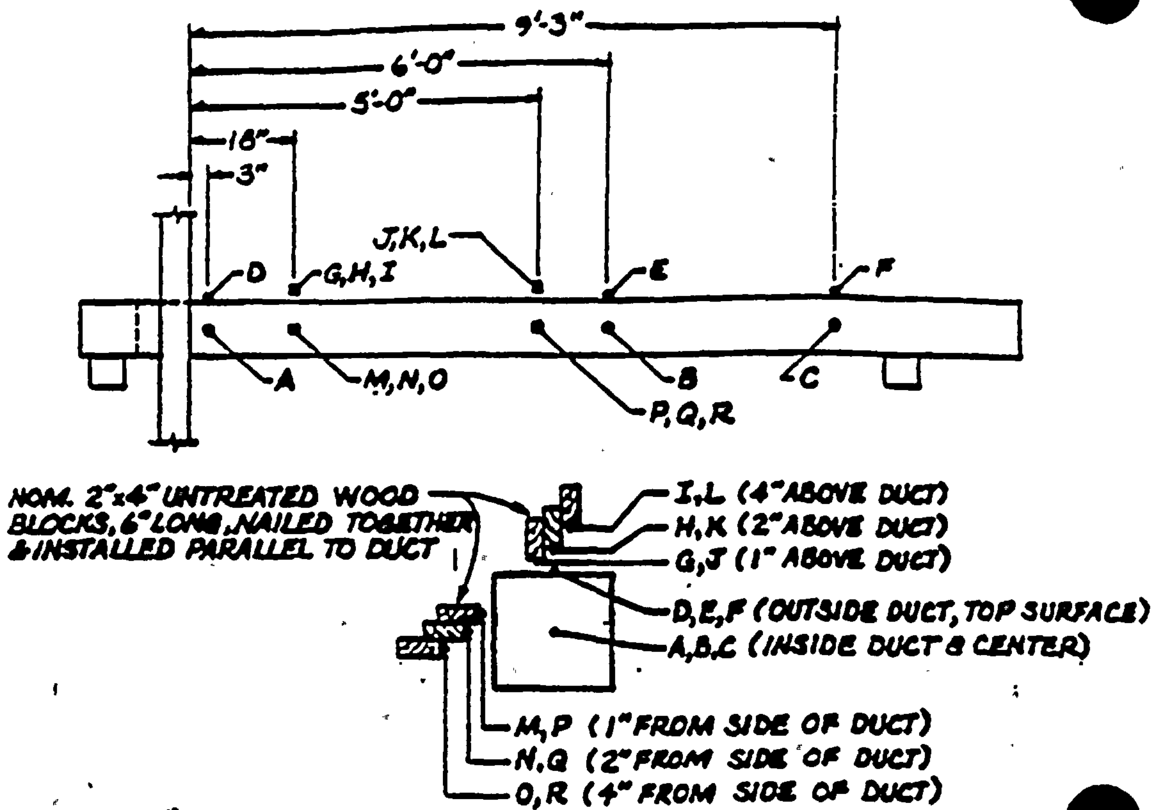


ILL. NC 30



UNEXPOSED SURFACE THERMOCOUPLES

ILL
NC



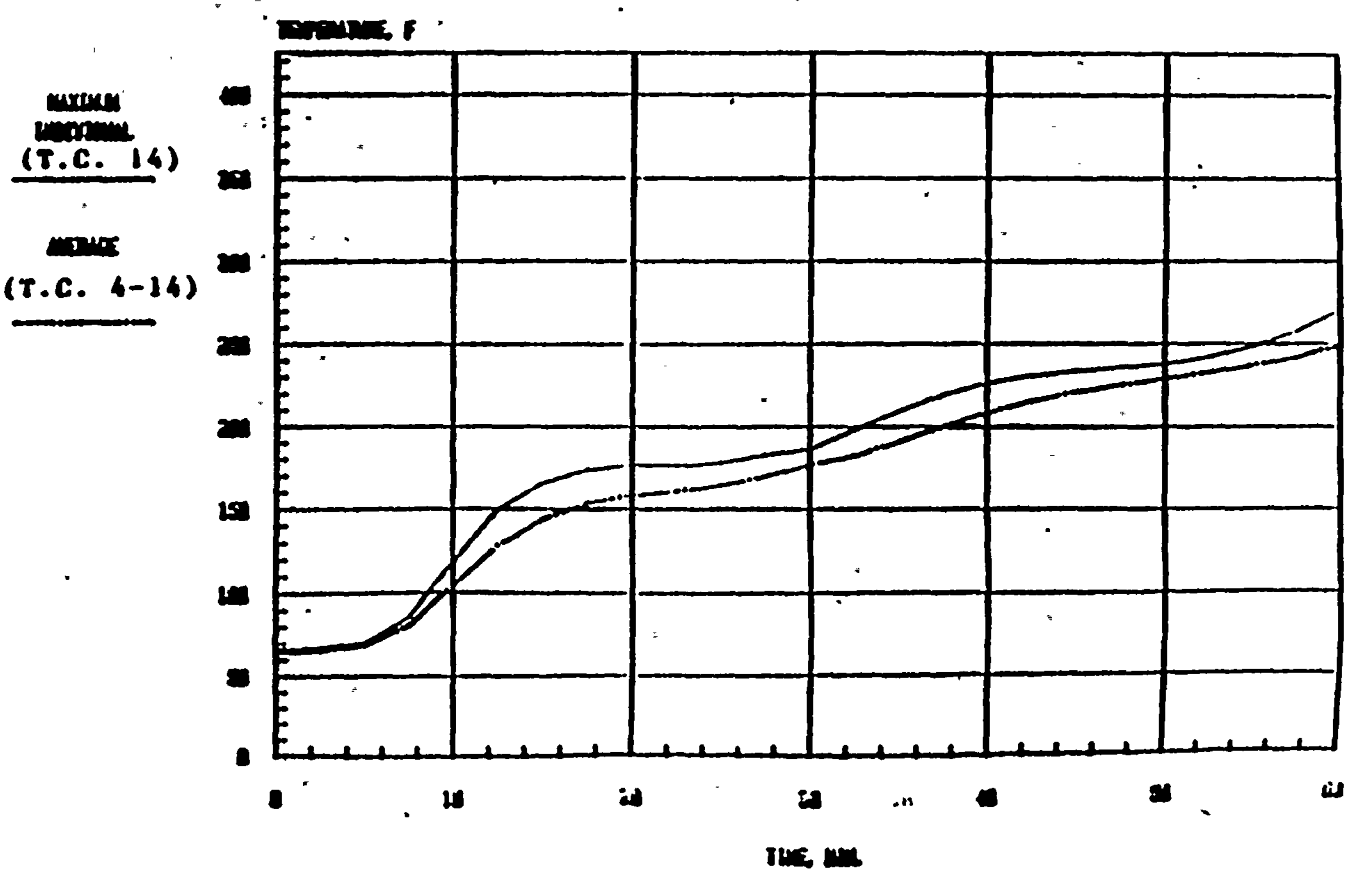
THERMOCOUPLE LOCATION	THERMOCOUPLE NOS. INSULATED STEEL DUCT	STEEL DUCT W/O INSULATION	FIBERGLASS AIR DUCT
A	15	33	51
B	16	34	52
C	17	35	53
D	36	18	54
E	37	19	55
F	38	20	56
G	21	39	57
H	22	40	58
I	23	41	59
J	24	42	60
K	25	43	61
L	26	44	62
M	27	45	63
N	28	46	64
O	29	47	65
P	30	48	66
Q	31	49	67
R	32	50	68

NC 3

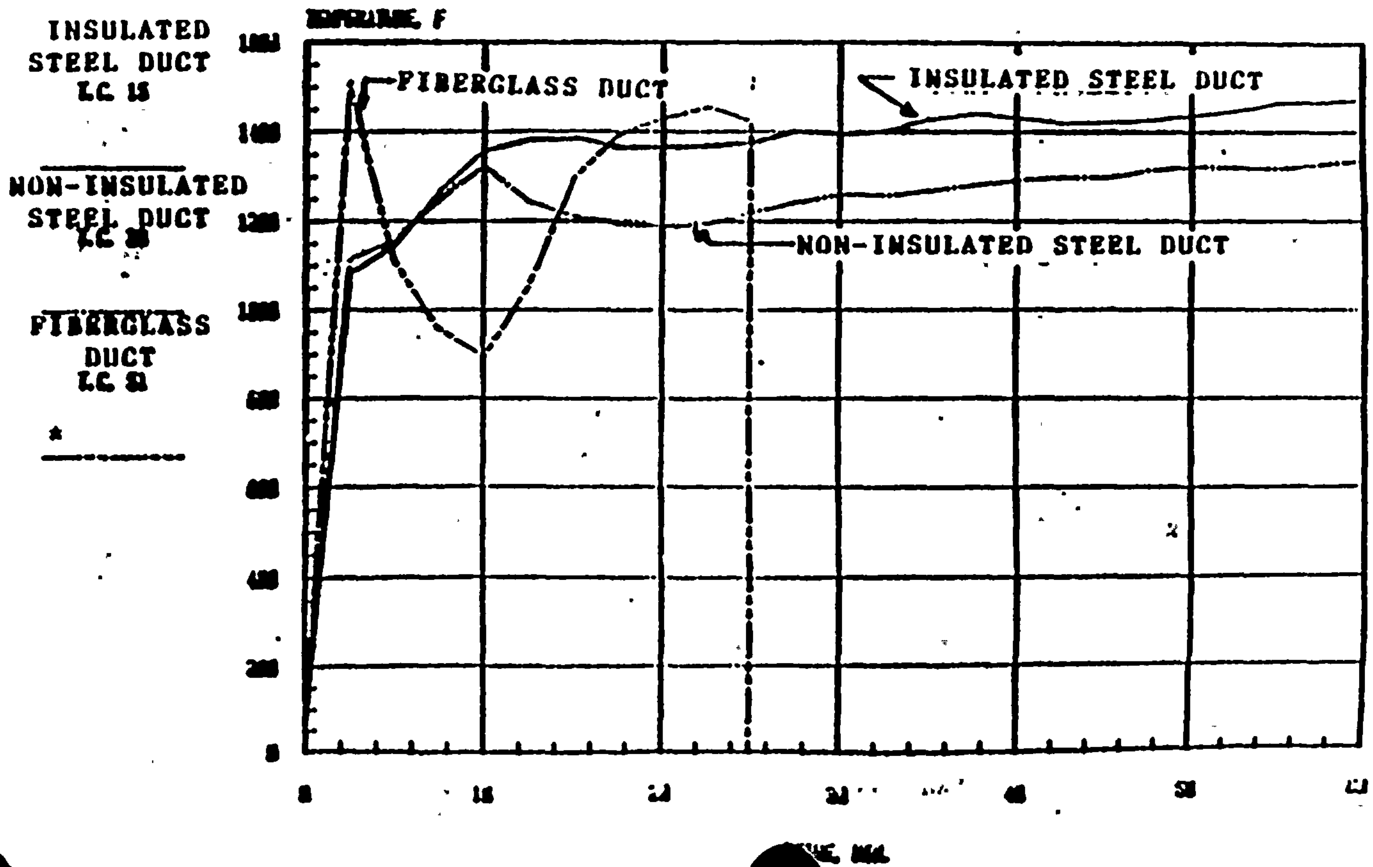
DUCT THERMOCOUPLE LOCATIONS

UNEXPOSED SURFACE

AVERAGE AND MAXIMUM WALL TEMPERATURES



TEMPERATURES WITHIN DUCT ASSEMBLIES
THERMOCOUPLES LOCATED 3 IN. FROM
UNEXPOSED SIDE OF WALL ASSEMBLY

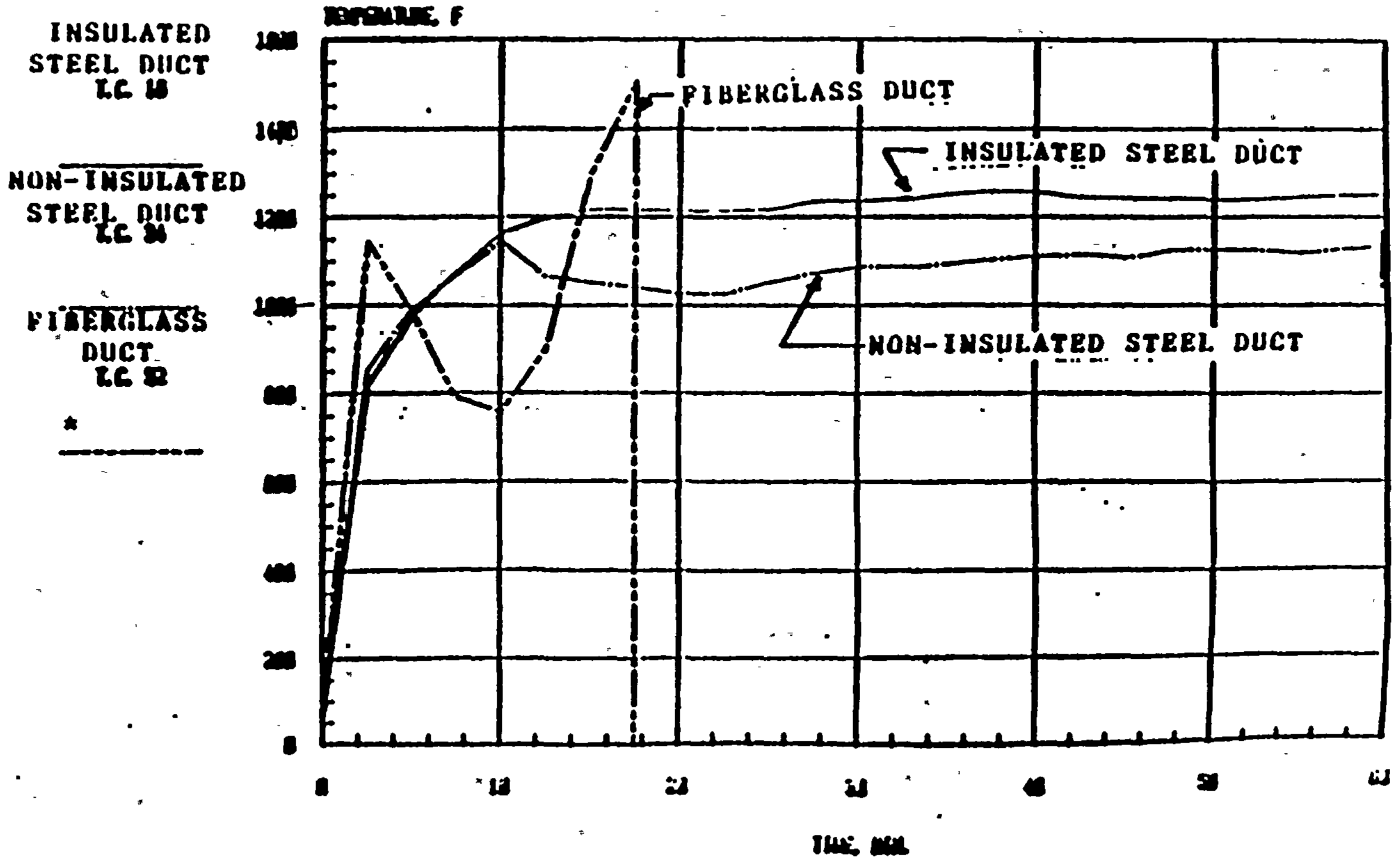


*SECTION OF FIBERGLASS DU[illegible] IN AREA OF T.C. 51 COLLAPSED

TEMPERATURES WITHIN DUCT ASSEMBLIES

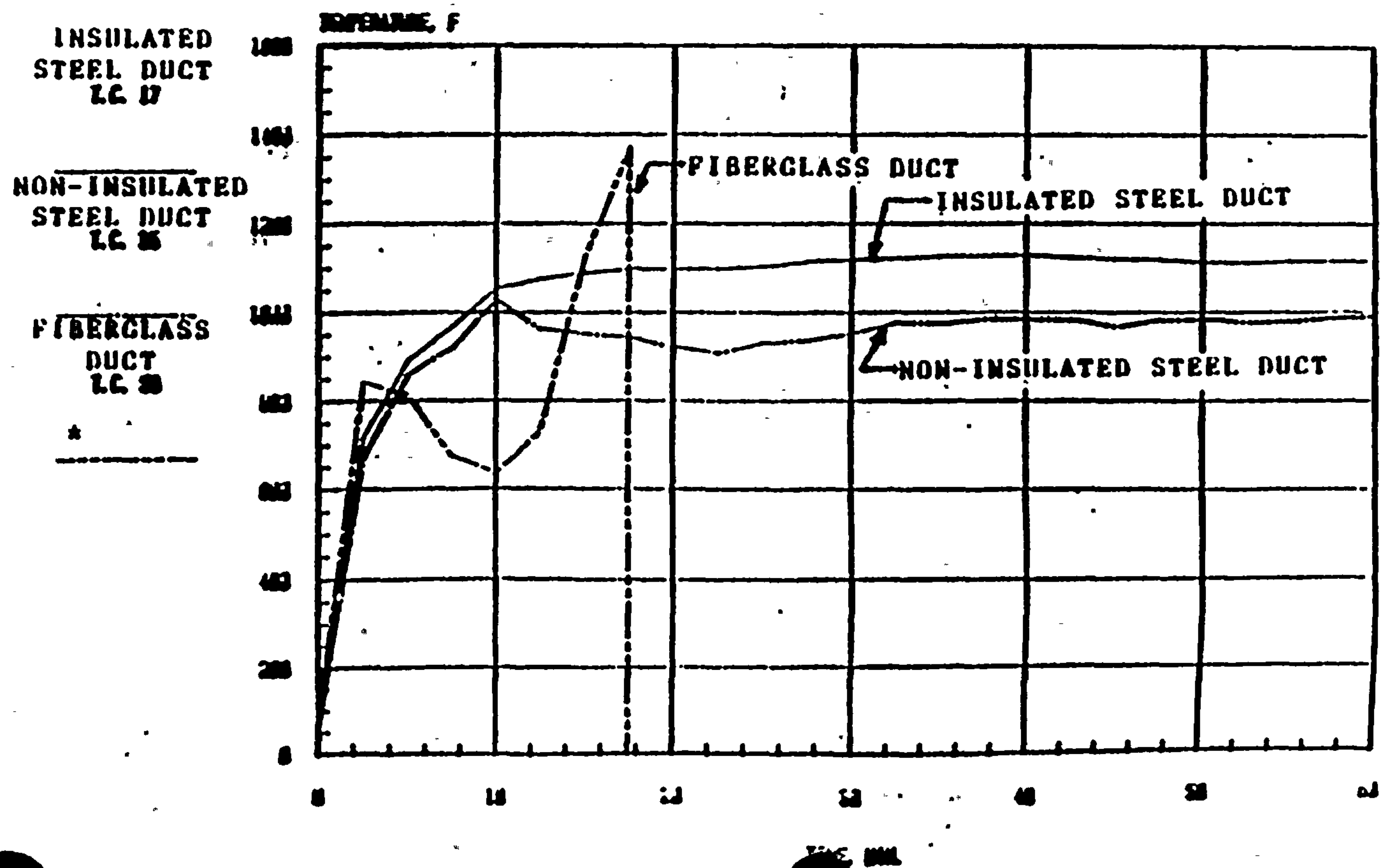
THERMOCOUPLES LOCATED 6 FT. FROM

UNEXPOSED SIDE OF WALL ASSEMBLY



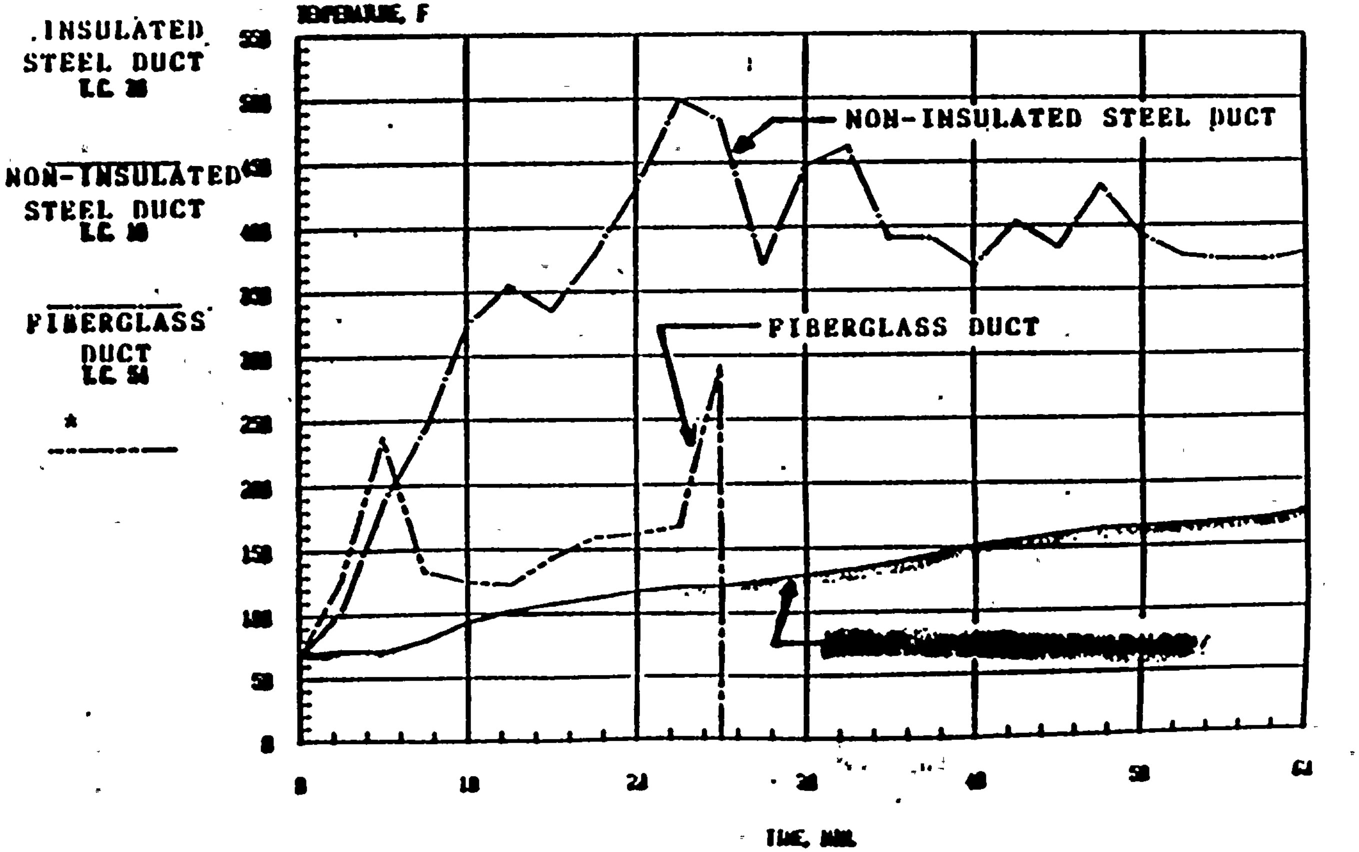
*SECTION OF FIBERGLASS DUCT IN AREA OF T.C. 52 COLLAPSED AT 19 MIN.

TEMPERATURES WITHIN DUCT ASSEMBLIES
THERMOCOUPLES LOCATED 9 FT. 3 IN. FROM
UNEXPOSED SIDE OF WALL ASSEMBLY



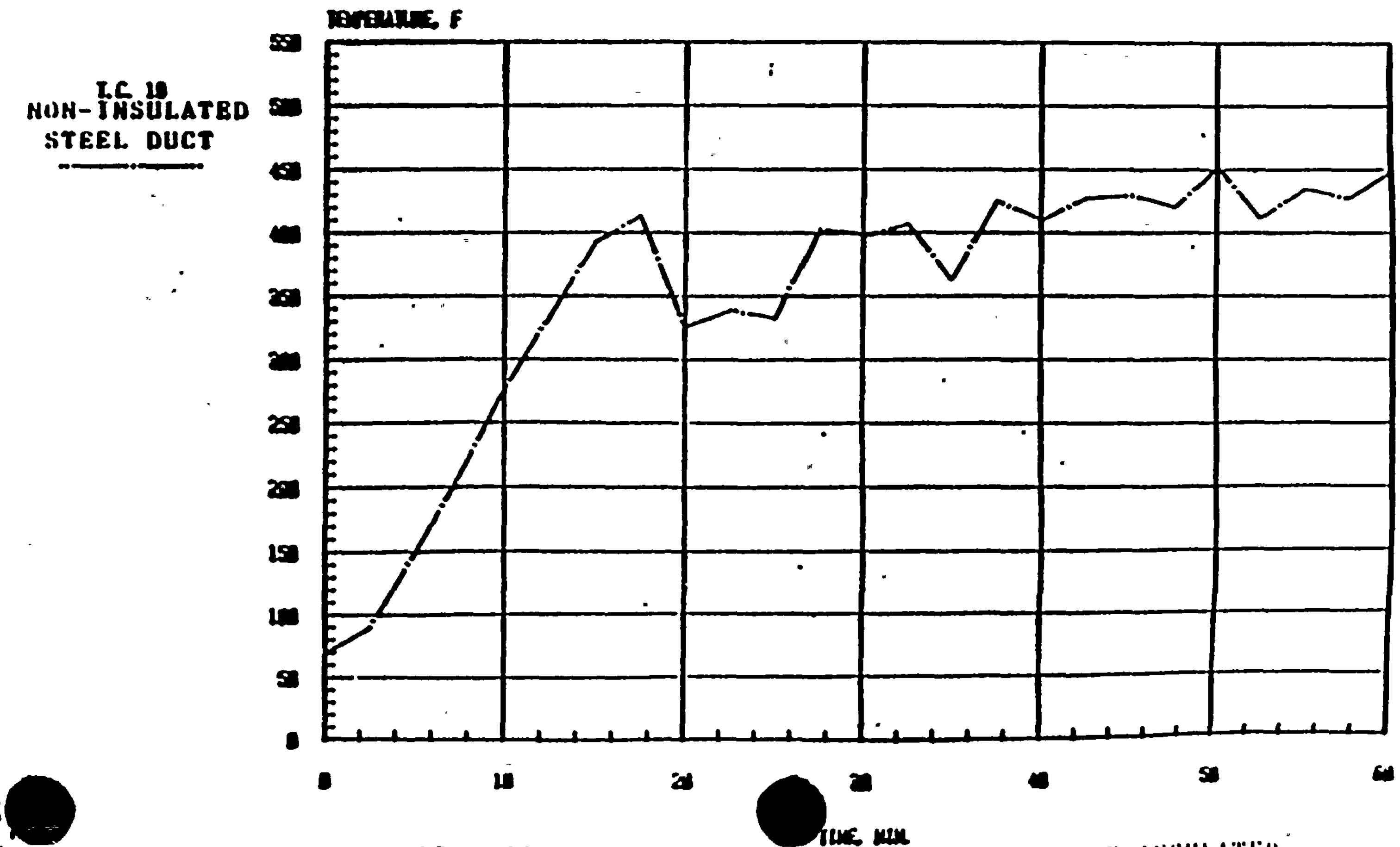
*SECTION OF FIBERGLASS DUC[illegible] AREA OF T.C. 53 COLLAPSED AT 25 MIN.

TEMPERATURES ON TOP SURFACE OF DUCT ASSEMBLIES
THERMOCOUPLES LOCATED 3 IN. FROM
UNEXPOSED SIDE OF WALL ASSEMBLY



*SECTION OF FIBERGLASS DUCT IN THE AREA OF T.C. 54 COLLAPSED AT 25 MIN.

TEMPERATURE ON TOP SURFACE OF NON-INSULATED
STEEL DUCT ASSEMBLY
THERMOCOUPLE LOCATED 6 FT. FROM
UNEXPOSED SIDE OF WALL ASSEMBLY*

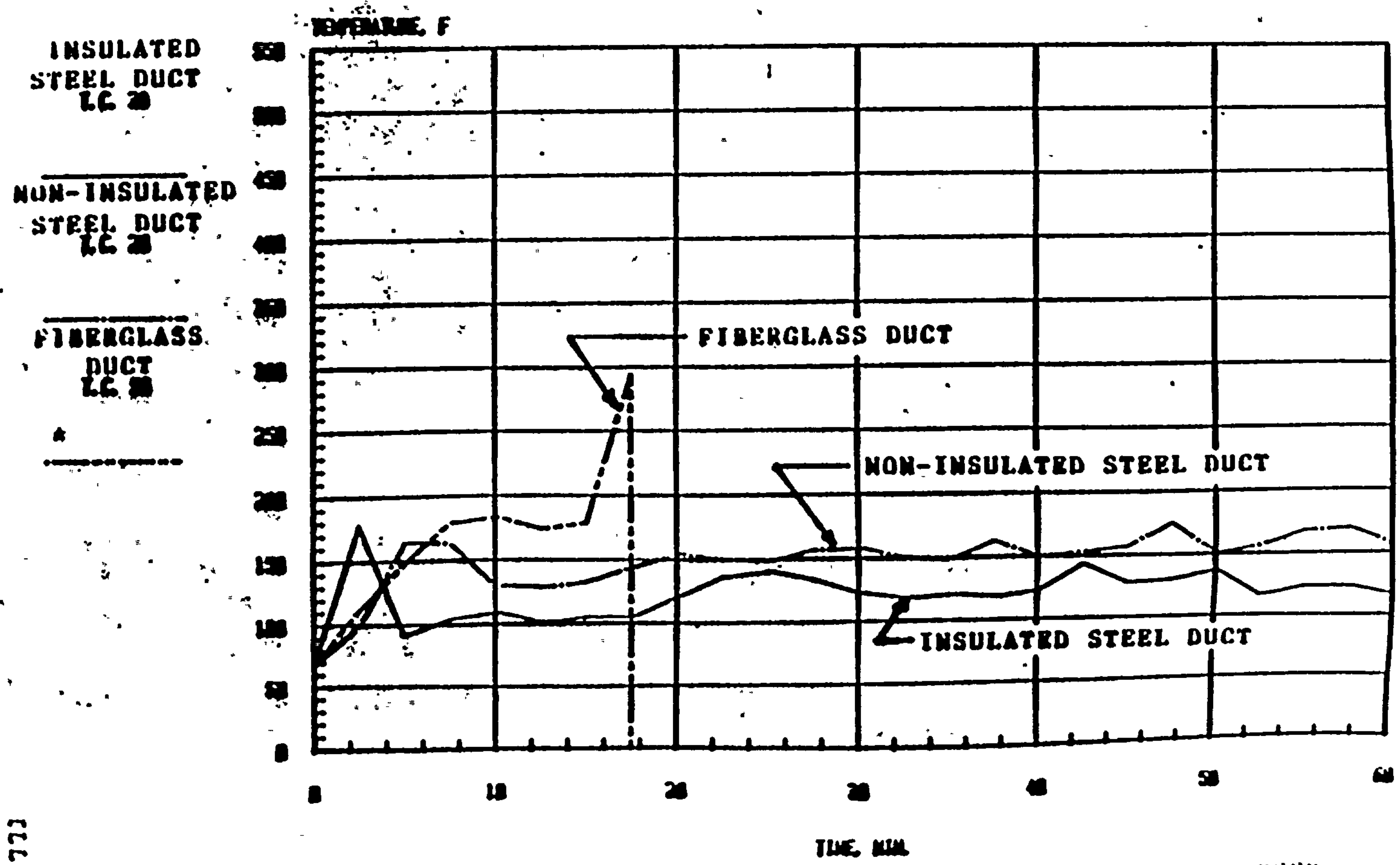


*T.C. 37 & 55 LOCATED ON T TOP SURFACES OF THE INSULATED

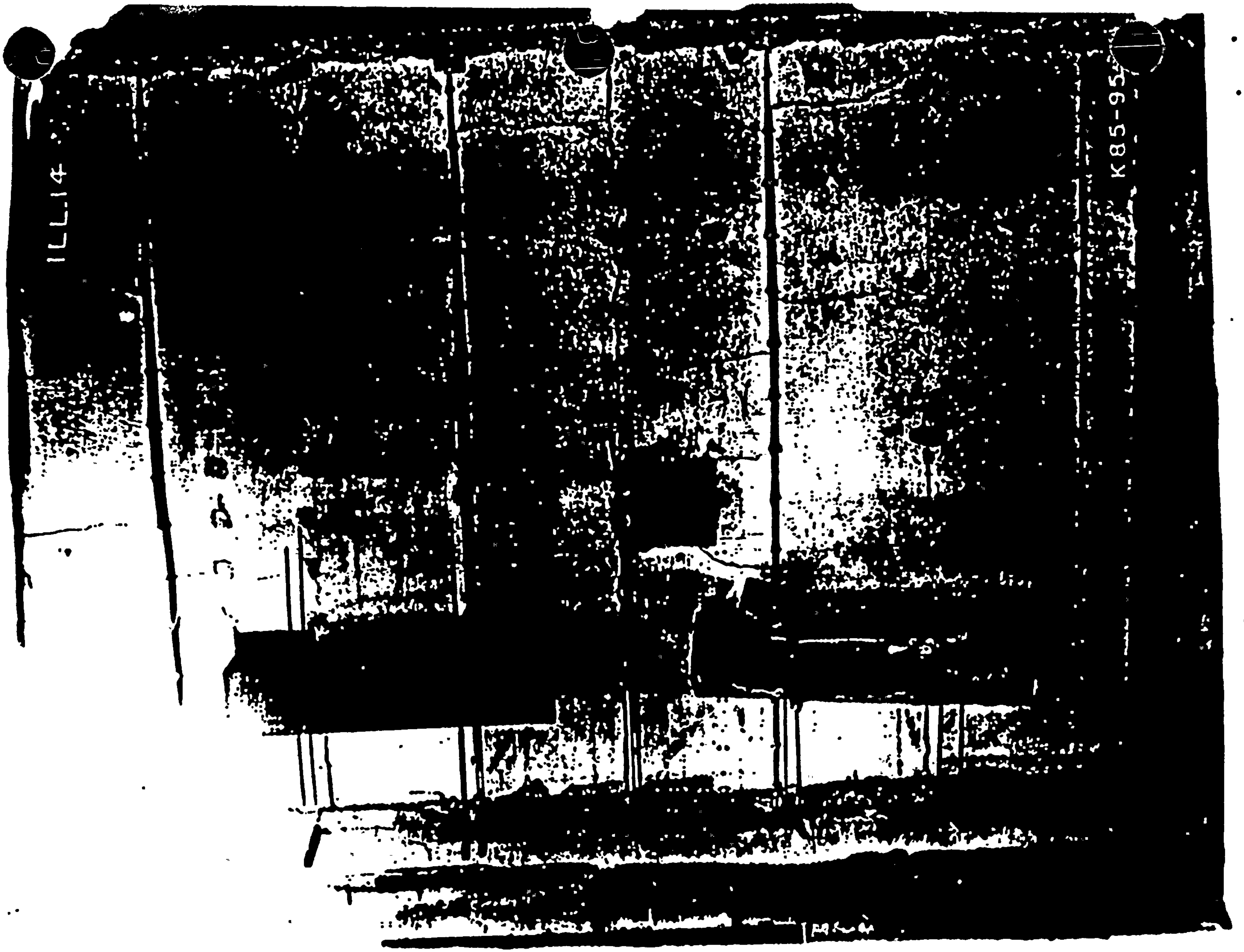
TEMPERATURES ON TOP SURFACE OF DUCT ASSEMBLIES

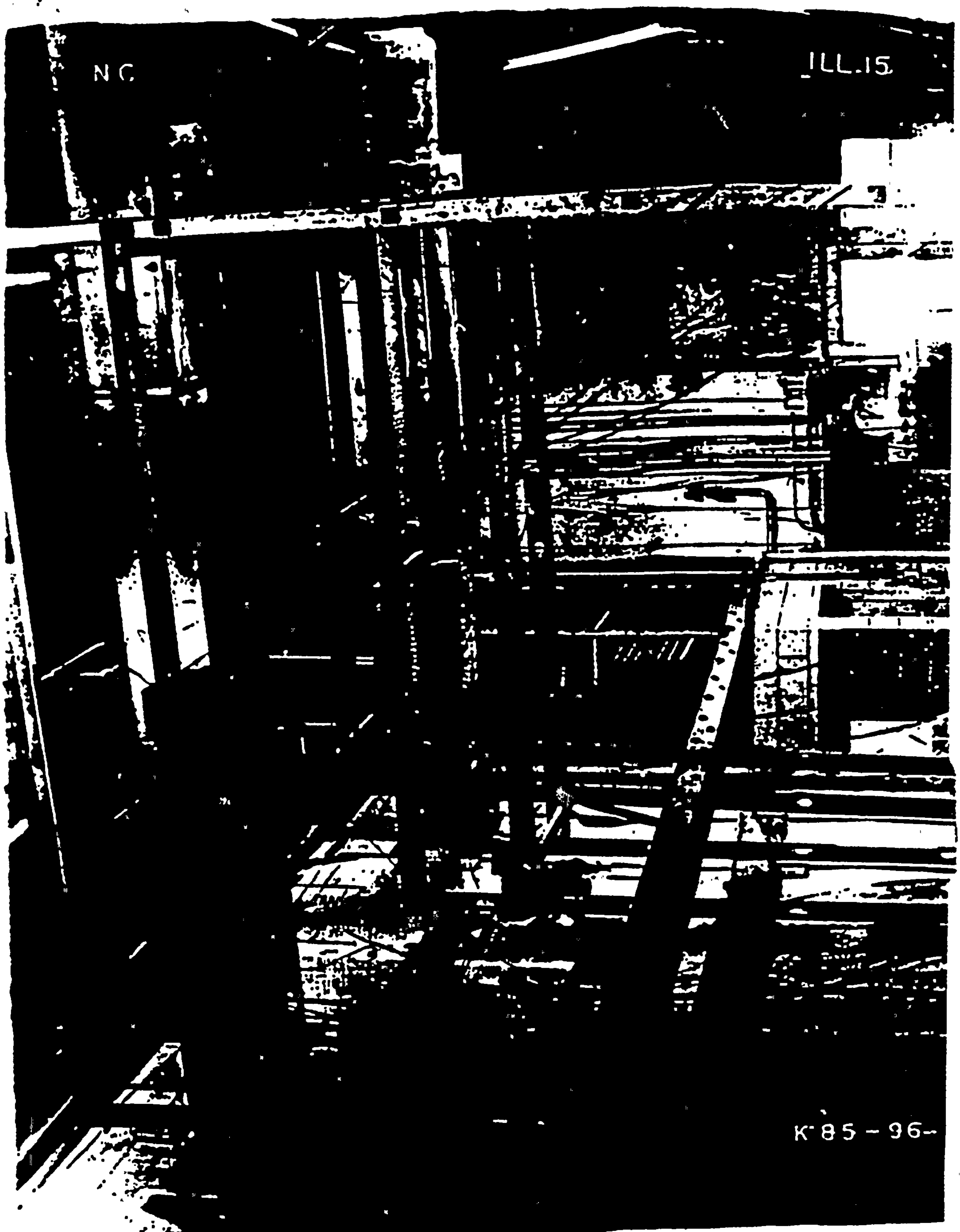
THERMOCOUPLES LOCATED 9 FT. 3 IN. FROM

UNEXPOSED SIDE OF WALL ASSEMBLY



...N OF FIBERGLASS ... IN THE AREA OF T.C. 56 COLLAPSED


ILL.14
K85-95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ILL.15
K-85-96-

APPENDIX A

TABULAR TEMPERATURE TEST DATA

The following tables contain the temperature data recorded at 2 min, 30 s intervals during the fire test.

ILL.	Description
A2	Thermocouple Index
A3-A5	Temperatures measured on unexposed surface of wall assembly.
A6-A9	Temperatures measured on insulated steel duct.
A10-A13	Temperatures measured on steel duct without insulation.
A14-A17	Temperatures measured on rigid fiberglass duct.

THERMOCOUPLE INDEX

UNEXPOSED SURFACE THERMOCOUPLES 1-14

	Insulated Steel Duct	Steel Duct Without Insulation	Fiberglass Duct
Inside Duct - 3 in. from wall	15	33	51
Inside Duct - 6 ft from wall	16	34	52
Inside Duct - 9 ft, 3 in. from wall	17	35	53
Outside Duct, Top Surface, 3 in. from wall	36	18	54
Outside Duct, Top Surface, 6 ft from wall	37	19	55
Outside Duct, Top Surface, 9 ft, 3 in. from wall	38	20	56
Outside Duct, w/wood 1 in. above top, 18 in. from wall	21	39	57
Outside Duct, w/wood 2 in. above top, 18 in. from wall	22	40	58
Outside Duct, w/wood 4 in. above top, 18 in. from wall	23	41	59
Outside Duct, w/wood 1 in. above top, 60 in. from wall	24	42	60
Outside Duct, w/wood 2 in. above top, 60 in. from wall	25	43	61
Outside Duct, w/wood 4 in. above top, 60 in. from wall	26	44	62
Outside Duct, w/wood 1 in. from side, 18 in. from wall	27	45	63
Outside Duct, w/wood 2 in. from side, 18 in. from wall	28	46	64
Outside Duct, w/wood 4 in. from side, 18 in. from wall	29	47	65
Outside Duct, w/wood 1 in. from side, 60 in. from wall	30	48	66
Outside Duct, w/wood 2 in. from side, 60 in. from wall	31	49	67
Outside Duct, w/wood 4 in. from side, 60 in. from wall	32	50	68

FILE NC505-12 ILL. NO. A-3 ISSUED: 4.

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FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	1	2	3	4
0: 0	65.0	66.3	65.4	63.6
2:30	67.0	67.4	66.5	64.5
5: 0	71.4	70.1	69.2	69.0
7:30	80.6	78.5	77.4	85.8
10: 0	106.0	99.6	97.5	119.5
12:30	135.5	124.6	120.1	150.2
15: 0	157.3	143.9	137.6	166.1
17:30	169.4	155.3	147.7	173.9
20: 0	175.5	161.9	153.1	176.7
22:30	178.6	164.6	157.9	176.2
25: 0	181.2	166.2	167.6	178.3
27:30	183.9	169.9	176.3	193.2
30: 0	188.0	174.3	179.2	196.6
32:30	191.[illegible]	178.5	187.8	198.8
35: 0	205.8	191.2	198.5	209.9
37:30	218.3	202.9	207.7	219.7
40: 0	227.7	213.8	[illegible]	[illegible]
42:30	[illegible]	221.[illegible]	[illegible]	[illegible]
45: 0	233.5	228.[illegible]	[illegible]	[illegible]
47:30	239.0	228.6	[illegible]	[illegible]
50: 0	239.8	229.8	225.3	236.[illegible]
52:30	239.5	230.8	228.4	[illegible]
55: 0	239.1	232.0	233.4	240.[illegible]
57:30	239.1	234.4	[illegible]	242.[illegible]
60: 0	239.5	236.0	239.7	245.[illegible]
			241.8	250.[illegible]

FILE NC505-12 ILL. NO. A-4 ISSUED: 4-17-[illegible]

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	6	7	8	9	[illegible]
0: 0	65.1	53.3	55.9	64.3	[illegible]
2:30	66.1	64.4	64.8	65.5	55[illegible]
5: 0	70.5	68.0	68.4	69.1	57[illegible]
7:30	86.0	81.3	81.8	81.2	79[illegible]
10: 0	112.9	106.1	107.6	105.1	9[illegible]
12:30	136.2	129.5	131.1	127.8	11[illegible]
15: 0	149.8	145.2	146.0	143.6	13[illegible]
17:30	156.4	154.0	153.8	152.2	14[illegible]
20: 0	159.4	158.5	157.7	156.2	15[illegible]
22:30	162.1	160.4	159.2	158.1	15[illegible]
25: 0	166.9	162.8	163.9	161.8	16[illegible]
27:30	173.3	167.6	169.8	167.5	16[illegible]
30: 0	175.5	175.0	174.0	173.9	17[illegible]
32:30	184.0	175.3	177.1	177.0	17[illegible]
35: 0	194.5	188.4	186.6	186.1	18[illegible]
37:30	204.1	198.7	195.4	195.5	[illegible]
[illegible]: 0	214.0	207.5	205.2	204.5	[illegible]
[illegible]:30	[illegible]	214.8	[illegible]	212.[illegible]	[illegible]
[illegible]: 0	224.[illegible]	220.[illegible]	217.6	[illegible]	[illegible]
47:30	229.0	224.8	221.3	223.[illegible]	[illegible]
50: 0	[illegible]	225.3	225.3	226.[illegible]	[illegible]
52:30	234.9	231.7	229.8	229.[illegible]	[illegible]
55: 0	238.1	236.[illegible]	231.[illegible]	[illegible]	[illegible]
57:30	242.4	240.0	236.1	233.4	[illegible]
60: 0	249.2	244.2	242.1	242.1	24[illegible]

FILE NC305-12 ILL. NO. A-5 ISSUED: 4-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	11	12	13
0: 0	65.2	65.8	67.0
2:30	66.1	66.6	68.0
5: 0	68.9	69.4	70.3
7:30	78.8	78.7	80.8
10: 0	100.9	99.9	103.5
12:30	123.3	122.3	125.7
15: 0	140.7	140.4	140.9
17:30	151.3	151.7	149.7
20: 0	156.3	157.0	154.8
22:30	158.9	159.7	158.2
25: 0	162.0	162.7	162.0
27:30	165.8	167.2	168.1
30: 0	174.3	175.7	182.0
32:30	177.5	179.3	190.4
35: 0	186.3	189.2	198.7
37:30	195.4	199.1	206.5
40: 0	203.3	208.1	214.0
42:30	210.1	215.4	220.5
45: 0	215.8	221.1	225.3
47:30	220.4	225.5	229.[illegible]
50: 0	224.[illegible]	230.0	233.[illegible]
52:30	229.0	233.9	237.[illegible]
55: 0	233.3	237.[illegible]	242.[illegible]
57:30	238.3	241.3	249.1
60: 0	245.1	249.2	266.6

FILE NC505-12 ILL. NO. A-6 ISSUED: 4-17

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHANNELS: TIME	15	16	7	38	*
0: 0	67.9	67.8	68.1	[illegible]	
2:30	1084.5	820.1	720.1	71.7	18.
5: 0	1148.1	976.7	892.8	71.3	7
7:30	1270.0	1077.0	969.6	79.8	7
10: 0	1360.3	1164.4	1055.5	93.9	7
12:30	1381.8	1192.8	1076.7	102.6	7
15: 0	1385.0	1216.2	1089.8	108.1	7
17:30	1364.0	1214.5	1098.4	112.7	7
20: 0	1366.5	1211.5	1098.1	118.1	7
22:30	1369.7	1212.3	1099.6	121.4	7
25: 0	1376.8	1217.2	1104.3	121.8	7
27:30	1400.2	1235.7	1116.1	125.4	7
30: 0	1392.5	1237.4	1120.7	130.0	[illegible]
32:30	1401.4	1240.7	1123.5	133.[illegible]	[illegible]
35: 0	1427.9	1251.7	1127.5	138.[illegible]	[illegible]
37:30	1440.8	1258.5	1128.4	144.4	[illegible]
40: 0	1430.4	1254.3	1129.6	152.3	[illegible]
42:30	1419.5	1243.6	1122.9	155.3	[illegible]
45: 0	1421.[illegible]	1241.[illegible]	[illegible]	16[illegible]	[illegible]
47:30	1427.2	1241.3	1119.0	164.3	[illegible]
50: 0	1437.[illegible]	1237.6	1111.[illegible]	[illegible]	
52:30	1448.5	1238.7	1111.1	167.[illegible]	[illegible]
55: 0	1456.3	1246.0	1113.9	169.1	
57:30	1468.7	1249.0	1113.4	170.[illegible]	
60: 0	1472.7	1251.1	1118.1	176.3	7

*T.C. 37, located on top surface of insulated steel duct, 6 ft from unexposed surface of wall, malfunctioned at the start of test and remained inoperable throughout the test.

FILE NC505-12 ILL. NO. A-7 ISSUED: 4-[illegible]

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NUM.) TIME	[illegible]3	21	22	[illegible]	[illegible]
0: 0	69.6	69.6	69.5	69.2	[illegible]
2:30	178.4	74.3	73.1	73.6	72
5: 0	92.0	98.6	88.3	90.0	80
7:30	104.4	110.6	103.6	102.4	86
10: 0	109.3	136.6	125.5	137.4	159
12:30	101.0	139.1	141.8	159.8	136
15: 0	105.0	146.5	161.7	175.2	210
17:30	104.4	150.8	173.9	182.7	214
20: 0	121.3	163.8	175.9	184.5	195
22:30	136.7	178.7	189.3	181.6	175
25: 0	140.8	138.8	176.7	166.1	178
27:30	133.5	153.8	187.6	190.7	199
30: 0	122.3	170.2	197.9	198.5	20[illegible]
32:30	118.0	161.6	199.2	199.3	[illegible]
35: 0	121.0	171.3	205.7	203.7	[illegible]
37:30	118.3	174.0	213.3	209.3	[illegible]
40: 0	123.4	178.8	[illegible]	215.9	[illegible]
42:30	143.9	185.3	221.4	218.[illegible]	[illegible]
45: 0	128.3	183.5	218.2	[illegible]	[illegible]
47:30	130.8	191.1	224.2	223.0	[illegible]
50: 0	137.8	198.6	231.6	226.3	[illegible]
52:30	116.5	199.1	233.5	[illegible]	[illegible]
55: 0	125.8	198.3	240.1	230.5	[illegible]
57:30	123.3	211.4	248.8	238.5	[illegible]
60: 0	116.[illegible]	204.2	251.3	235.2	200

FILE NC505-12 ILL. NO. A-8 ISSUED: 4-17-

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST

84NK29824/NC505

1-3-85

INSULATED STEEL DUCT

CHAN(NLS.. TIME	25	26	27	28	[illegible]
0: 0	70.5	70.3	68.4	67.5	67.
2:30	75.4	73.3	71.0	68.5	68.
5: 0	88.3	87.9	73.8	70.9	69
7:30	100.4	99.1	82.1	75.6	7[illegible]
10: 0	144.5	113.1	100.7	89.1	77
12:30	153.5	124.1	105.4	95.3	85
15: 0	156.6	135.8	113.9	106.9	91
17:30	164.4	159.1	118.8	109.9	95
20: 0	158.6	153.8	121.0	108.9	99
22:30	158.8	163.1	128.6	116.3	103
25: 0	157.6	155.1	103.1	107.8	104
27:30	156.2	145.7	118.5	119.2	108
30: 0	160.5	151.0	127.1	125.3	109
32:30	159.6	137.7	131.1	130.4	117
35: 0	160.7	156.9	137.4	135.1	[illegible]
37:30	159.5	140.9	143.6	146.4	[illegible]
40: 0	166.4	157.4	154.1	155.[illegible]	[illegible]
42:30	169.1	160.9	159.9	15[illegible]	[illegible]
45: 0	167.[illegible]	149.3	163.8	158.[illegible]	[illegible]
47:30	168.6	158.2	168.4	160.[illegible]	[illegible]
50: 0	171.4	162.[illegible]	170.[illegible]	167.[illegible]	[illegible]
52:30	168.0	155.8	179.1	17[illegible]	[illegible]
55: 0	168.1	154.2	184.5	180.[illegible]	[illegible]
57:30	167.7	156.7	181.3	181.1	[illegible]
60: 0	167.2	154.6	185.2	185.3	154.

FILE NC505-12 ILL. NO. A-9 ISSUED: 4

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHANNELS./ TIME	30	31	32
0: 0	70.2	68.1	67.9
2:30	70.2	68.7	68.2
5: 0	71.0	69.4	68.8
7:30	73.1	70.4	69.4
10: 0	75.2	72.7	70.9
12:30	79.7	76.6	73.5
15: 0	88.7	82.8	78.2
17:30	101.2	87.7	82.5
20: 0	87.2	90.6	86.4
22:30	85.9	93.2	89.5
25: 0	88.6	97.5	93.6
27:30	89.2	97.4	91.4
30: 0	91.8	98.7	91.7
32:30	93.3	99.3	92.1
35: 0	90.7	101.0	93.1
37:30	95.6	103.6	95.5
40: 0	95.4	105.5	96.8
42:30	[illegible]	107.3	97.8
45: 0	98.3	108.1	98.6
47:30	98.3	109.5	99.[illegible]
50: 0	102.9	111.[illegible]	101.1
52:30	104.4	112.2	101.5
55: 0	105.8	113.[illegible]	103.[illegible]
57:30	108.9	118.6	104.[illegible]
60: 0	111.1	121.0	105.4

FILE NC505-12

ILL. NO. A-10

ISSUED: 4-17

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN.NOS. TIME	33	34	35	18	1
0: 0	69.2	69.1	69.1	68.5	[illegible]
2:30	1117.9	856.1	673.9	103.1	39[illegible]
5: 0	1157.8	993.1	860.5	137.0	[illegible]
7:30	1252.5	1070.1	922.2	243.0	20[illegible]
10: 0	1374.8	1143.9	1028.3	324.3	27[illegible]
12:30	1242.3	1065.1	961.2	355.8	33[illegible]
15: 0	1210.0	1049.2	950.8	335.6	39[illegible]
17:30	1193.0	1038.8	943.1	378.6	41
20: 0	1187.4	1024.1	921.0	431.3	32
22:30	1194.5	1024.2	907.6	499.4	33
25: 0	1220.9	1051.4	931.9	483.1	33
27:30	1243.3	1071.7	937.4	372.2	40
30: 0	1260.8	1087.7	953.2	448.1	39
32:30	1257.0	1085.3	977.2	462.7	40
35: 0	1269.1	1093.0	974.3	390.[illegible]	[illegible]
37:30	1281.1	1103.6	985.5	390.[illegible]	[illegible]
[illegible]	1292.9	1110.5	[illegible]4.1	[illegible]	[illegible]
[illegible]	1299.2	[illegible]	985.[illegible]	40[illegible]	[illegible]
[illegible]	[illegible]	1108.[illegible]	[illegible]	[illegible]	[illegible]
47:[illegible]	1313.9	1124.2	98[illegible]	[illegible]	[illegible]
50: [illegible]	[illegible]	[illegible]	984.1	[illegible]	[illegible]
52:30	1319.5	1121.8	976.4	375.[illegible]	4[illegible]
[illegible]	1318.3	[illegible]116.5	980.[illegible]	[illegible]	[illegible]
57:30	1329.0	1127.1	988.1	372.[illegible]	[illegible]
60: 0	1336.9	1134.3	991.8	378.7	44[illegible]

FILE NC305-12 ILL. NO. A-11 ISSUED: 4-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC305
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	38	39	40	41	[illegible]
0: 0	68.3	70.1	69.7	69.9	71.[illegible]
2:30	99.3	98.2	86.8	89.8	9[illegible]
5: 0	164.2	142.4	115.2	110.1	115
7:30	163.1	163.2	131.2	122.1	129
10: 0	129.9	218.5	165.5	141.3	164
12:30	128.6	251.8	187.6	146.5	170
15: 0	133.3	241.7	191.5	153.6	158
17:30	144.2	252.4	196.8	154.0	166
20: 0	154.8	248.2	197.6	155.2	167
22:30	149.4	269.0	209.4	162.1	165
25: 0	148.3	248.9	204.1	161.5	157
27:30	157.2	308.0	232.8	172.8	158
30: 0	158.3	295.6	242.1	184.5	163
32:30	150.1	336.3	253.3	193.7	169
35: 0	148.[illegible]	341.0	274.0	201.9	17[illegible]
37:30	162.6	350.4	288.3	206.0	[illegible]
40: 0	[illegible]	375.3	[illegible]	210.[illegible]	[illegible]
42:30	[illegible]	347.5	284.8	209.[illegible]	[illegible]
45: 0	[illegible]	370.[illegible]	307.8	[illegible]	[illegible]
47:30	175.1	363.2	312.5	213.[illegible]	[illegible]
50: 0	151.2	376.[illegible]	317.6	220.3	[illegible]
52:30	156.5	373.2	315.5	219.3	[illegible]
55: 0	164.0	399.1	323.6	224.[illegible]	198
57:30	169.9	407.8	339.8	229.3	[illegible]
60: 0	156.9	393.5	330.6	222.5	195

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	43	44	45	46	47
0: 0	70.3	70.1	69.8	65.2	68.
2:30	83.8	85.0	81.4	75.3	72
5: 0	106.7	107.7	103.4	92.0	79
7:30	119.6	117.2	125.3	107.5	86
10: 0	141.2	139.2	194.0	149.5	103
12:30	146.6	139.5	323.0	256.7	131
15: 0	146.0	139.8	348.8	278.4	138
17:30	148.9	136.4	363.9	287.1	138
20: 0	150.1	136.7	357.7	287.6	140
22:30	149.3	128.3	368.2	295.7	144
25: 0	146.0	123.7	176.1	159.8	112
27:30	144.0	120.4	336.1	238.7	126
30: 0	150.6	127.9	371.2	292.3	139
32:30	155.1	137.5	388.1	307.0	146
35: 0	161.9	143.8	399.3	328.2	146
37:30	160.8	149.2	412.2	335.7	[illegible]
40: 0	175.7	[illegible]	[illegible]	[illegible]	[illegible]
42:30	[illegible]	143.[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	179.3	150.[illegible]	443.[illegible]	[illegible]	[illegible]
[illegible]	184.9	172.2	[illegible]	[illegible]	[illegible]
[illegible]	186.9	[illegible]	[illegible]	383.3	[illegible]
52:30	176.9	151.8	466.9	387.[illegible]	[illegible]
[illegible]	[illegible]	149.8	469.4	[illegible]	[illegible]
57:30	189.1	163.3	479.0	397.[illegible]	173.
60: 0	179.7	154.3	491.6	406.1	182.

FILE NC505-12 ILL. NO. A-13 ISSUED: 4-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	48	49	50
0: 0	69.8	66.4	68.2
2:30	80.1	73.3	71.0
5: 0	94.4	80.3	75.1
7:30	99.4	86.1	78.5
10: 0	127.8	100.8	86.0
12:30	128.6	103.2	88.8
15: 0	139.9	108.5	91.3
17:30	126.4	106.7	91.8
20: 0	132.9	112.5	94.8
22:30	120.5	107.9	93.9
25: 0	109.2	107.6	92.0
27:30	112.9	109.9	93.0
30: 0	113.1	110.7	93.5
32:30	128.7	112.7	95.8
35: 0	122.2	111.5	95.1
37:30	130.4	115.6	96.9
40: 0	121.6	116.7	96.7
42:30	132.5	119.3	99.3
45: 0	131.2	118.0	[illegible]
47:30	130.1	118.2	100.2
50: 0	129.4	119.3	101.2
52:30	128.2	116.6	[illegible]
55: 0	127.4	118.3	101.3
57:30	133.9	[illegible]	101.9
60: 0	134.5	121.5	102.4

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHANNELS./ TIME	51	52	53	54	*
0: 0	66.9	67.1	67.1	[illegible]	-
2:30	1510.1	1144.3	842.7	123.0	
5: 0	1111.7	986.1	812.7	237.5	13
7:30	957.6	790.0	674.1	132.9	3
10: 0	894.6	757.5	635.5	124.3	1
12:30	1052.2	897.3	730.3	122.5	2
15: 0	1297.7	1300.2	1124.3	144.1	
17:30	1394.5	1508.3	1370.2	159.6	5
20: 0	1431.2	176.2	117.6	162.7	24
22:30	1455.4	66.4	73.0	168.7	6
25: 0	1423.4	61.6	72.0	292.9	[illegible]
27:30	1356.7	64.0	70.7	87.1	6
30: 0	[illegible]	64.0	70.1	86.2	[illegible]
32:30	1352.8	63.7	69.4	84.6	[illegible]
35: 0	1384.7	63.3	69.9	82.8	[illegible]
37:30	1407.4	63.6	69.6	82.9	[illegible]
40: 0	1421.2	63.6	69.6	[illegible]	[illegible]
42:30	1419.6	63.4	69.2	82.8	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
47:30	1455.2	63.8	69.2	[illegible]	[illegible]
50: 0	1474.6	64.1	69.4	82.4	[illegible]
52:30	1495.7	63.5	69.7	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	69.5	[illegible]	[illegible]
57:30	[illegible]	63.7	69.8	[illegible]	[illegible]
60: 0	1546.0	63.6	69.7	84.3	[illegible]

*T.C. 55, located on top surface of fiberglass duct, 6 ft from unexposed surface of wall, malfunctioned at the start of test and remained inoperable throughout the test.

FILE NC505-12 ILL. NO. A-15 ISSUED:

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	56	57	58	59	[illegible]
0: 0	68.1	68.6	68.6	68.6	[illegible]
2:30	111.7	76.7	75.2	79.6	7[illegible]
5: 0	148.7	103.2	101.4	102.6	87
7:30	179.3	122.4	114.1	113.5	93
10: 0	183.6	113.4	113.9	124.5	108
12:30	173.8	120.6	116.0	116.4	105
15: 0	179.4	134.3	131.0	139.1	123
17:30	294.3	176.4	157.2	123.0	133
20: 0	78.3	157.5	160.5	168.9	328
22:30	75.4	161.7	158.5	167.7	360
25: 0	74.6	696.5	761.4	664.3	142
27:30	72.3	131.2	151.1	94.0	119
30: 0	71.8	118.6	144.4	94.0	11[illegible]
32:30	71.5	108.9	121.1	82.7	9[illegible]
35: 0	71.2	99.9	113.5	81.5	9[illegible]
37:30	71.8	99.3	119.6	85.9	[illegible]
40: 0	[illegible]	94.8	[illegible].5	[illegible]	[illegible]
42:30	[illegible]	92.0	107.3	[illegible]	[illegible]
45: 0	71.[illegible]	92.[illegible]	106.6	[illegible]	[illegible]
47:30	70.3	86.5	102.8	81.3	[illegible]
50: 0	71.5	89.0	105.9	[illegible]	[illegible]
52:30	71.8	91.1	102.8	79.[illegible]	[illegible]
55: 0	71.7	92.0	105.[illegible]	[illegible]	[illegible]
57:30	71.4	91.6	108.0	81.3	[illegible]
60: 0	72.0	91.2	103.7	80.3	80

FILE NC505-12 ILL. NO. A-16 ISSUED: 4-17

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	61	62	63	64
0: 0	68.8	69.1	68.0	67.1
2:30	71.9	73.8	69.2	67.9
5: 0	87.5	82.1	75.5	71.1
7:30	95.5	89.0	91.2	80.3
10: 0	101.5	92.3	109.8	91.8
12:30	99.8	89.4	112.5	96.4
15: 0	113.6	100.4	140.2	111.8
17:30	145.4	127.1	537.2	262.9
20: 0	326.7	314.1	675.1	339.3
22:30	362.2	349.2	721.1	363.2
25: 0	165.6	148.8	634.4	636.1
27:30	140.0	128.1	207.1	184.9
30: 0	125.7	115.9	174.9	158.1
32:30	114.7	106.9	151.3	137.0
35: 0	106.8	101.5	133.4	118.6
37:30	106.3	100.6	128.1	119.9
40: 0	101.1	94.6	123.0	112.1
42:30	98.4	95.4	124.3	123.1
45: 0	96.4	91.6	117.5	111.3
47:30	97.4	94.3	116.1	113.5
50: 0	95.1	92.0	113.6	113.5
52:30	93.1	90.1	115.2	116.1
55: 0	91.6	88.6	114.5	113.4
57:30	91.8	89.4	113.7	118.9
60: 0	90.4	87.0	114.1	111.6

FILE NC505-12 ILL. NO. A-17 ISSUED [illegible]17-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	66	67	[illegible]
0: 0	68.[illegible]	67.0	66.6
2:30	69.5	68.2	67.5
5: 0	71.2	69.2	67.9
7:30	74.2	71.1	68.5
10: 0	75.7	72.2	69.8
12:30	76.3	73.1	70.2
15: 0	80.0	75.3	72.2
17:30	110.8	84.7	75.8
20: 0	290.0	271.3	271.0
22:30	455.4	444.2	502.2
25: 0	166.3	176.4	166.8
27:30	140.0	146.5	135.8
30: 0	125.9	130.4	120.5
32:30	117.6	122.5	110.6
35: 0	109.1	114.2	103.3
37:30	105.2	109.9	99.4
40: 0	101.3	106.[illegible]	97.[illegible]
42:30	99.9	103.[illegible]	95.[illegible]
45: [illegible]	99.3	101.9	9[illegible]
47: [illegible]	97.3	10[illegible]	94.[illegible]
50: [illegible]	97.0	99.6	92.3
52:30	96.8	99.[illegible]	92.[illegible]
[illegible]	96.[illegible]	98.[illegible]	90.[illegible]
57:30	95.3	96.7	91.0
60: 0	94.9	97.7	90.9

FILE NC505-12 | ILL. NO. A-3 | ISSUED: 4-17-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	1	2	3	4	
0: 0	65.0	66.5	65.4	63.6	65
2:30	67.0	67.4	66.5	64.5	66
5: 0	71.4	70.1	69.2	69.0	70
7:30	80.6	78.5	77.4	85.8	84
10: 0	106.0	99.6	97.5	119.5	112
12:30	135.5	124.6	120.1	150.2	138
15: 0	157.3	143.9	137.6	166.1	150
17:30	169.4	155.3	147.7	173.9	156
20: 0	175.5	161.9	153.1	176.7	158
22:30	178.6	164.6	157.9	176.2	159
25: 0	181.2	166.2	167.6	178.3	16[illegible]
27:30	183.9	169.9	176.3	193.2	17[illegible]
30: 0	188.0	174.3	179.2	186.6	17[illegible]
32:30	191.2	178.5	187.8	198.5	17[illegible]
35: 0	205.8	191.2	198.5	209.9	[illegible]
37:30	218.3	202.9	207.7	219.7	[illegible]
40: 0	227.7	213.9	[illegible].0	226.8	[illegible]
42:30	[illegible]	221.7	[illegible].0	231.[illegible]	[illegible]
45: 0	238.6	226.2	223.4	233.[illegible]	[illegible]
47:30	239.9	228.6	225.8	236.1	[illegible]
50: 0	239.8	229.8	228.4	238.2	[illegible]
52:30	239.5	230.8	235.4	240.1	[illegible]
55: 0	239.1	232.0	237.8	242.[illegible]	[illegible]
57:30	239.1	234.4	239.7	245.2	[illegible]
60: 0	239.5	236.0	241.8	250.1	243

FILE NC505-12 ILL. NO. A-4 ISSUED

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN. NOS.) TIME	6	7	8	9	[illegible]
0: 0	65.1	[illegible]	63.9	[illegible]	[illegible]
2:30	66.1	64.4	64.8	65.5	[illegible]
5: 0	70.5	68.0	68.4	69.1	[illegible]
7:30	86.0	81.3	81.8	81.2	[illegible]
10: 0	112.9	106.1	107.6	105.1	11
12:30	136.2	129.5	131.1	127.8	13
15: 0	149.8	145.2	146.0	143.6	14
17:30	156.4	154.0	153.8	152.2	15
20: 0	159.4	158.3	157.2	156.2	15
22:30	162.1	160.4	159.2	158.1	16
25: 0	166.9	162.9	163.9	161.8	16
27:30	173.3	167.6	169.8	167.5	17
30: 0	175.5	175.0	174.0	173.9	17
32:30	184.0	178.3	177.[illegible]	177.0	[illegible]
35: 0	194.5	188.[illegible]	186.6	186.[illegible]	[illegible]
37:30	204.1	198.7	195.[illegible]	195.5	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	204.5	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	224.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
47:30	[illegible]	224.9	221.[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	234.[illegible]	231.7	228.[illegible]	229.9	[illegible]
[illegible]	[illegible]	236.0	[illegible]	[illegible]	[illegible]
57:30	242.4	[illegible]	[illegible]	[illegible]	[illegible]
60: 0	249.2	244.2	242.1	242.1	24.

FILE NC505-12 ILL. NO. A-5 ISSUED: 4-17

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

UNEXPOSED SURFACE

CHAN(NOS.) TIME	11	12	13	
0: 0	55.2	65.8	67.0	[illegible]
2:30	66.1	66.6	68.0	67
5: 0	68.9	69.4	70.3	[illegible]
7:30	78.8	78.7	80.8	7
10: 0	100.9	99.9	103.5	[illegible]
12:30	123.3	122.3	125.7	11
15: 0	140.7	140.4	140.9	13
17:30	151.3	151.7	149.7	14
20: 0	156.3	157.0	154.8	15
22:30	158.9	159.7	158.2	15
25: 0	162.0	162.7	162.0	16
27:30	165.8	167.2	168.1	17
30: 0	174.3	175.7	182.0	18
32:30	177.5	179.3	190.4	18
35: 0	186.0	189.2	198.7	19
37:30	195.4	199.1	206.5	[illegible]
40: 0	[illegible]	208.1	214.0	[illegible]
42:30	[illegible]	215.4	220.5	[illegible]
45: 0	[illegible]	221.1	225.[illegible]	[illegible]
47:30	220.4	225.6	229.[illegible]	[illegible]
50: 0	224.[illegible]	230.0	233.2	[illegible]
52:30	[illegible]29.0	233.9	237.7	[illegible]
55: 0	233.3	237.4	242.[illegible]	[illegible]
57:30	236.3	241.9	249.1	[illegible]
60: 0	245.1	249.2	266.8	27

FILE NC505-12 ILL. NO. A-6 ISSUED: 4 [illegible]

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	15	16	17	36	*
0: 0	67.9	67.8	68.1	69.6	[illegible]
2:30	1084.5	820.1	720.1	71.7	16.
5: 0	1148.1	976.7	892.8	71.3	7[illegible]
7:30	1270.0	1077.0	969.6	79.8	7[illegible]
10: 0	1360.3	1164.4	1055.5	93.9	7[illegible]
12:30	1381.8	1197.8	1076.7	102.6	7[illegible]
15: 0	1385.0	1216.2	1089.8	108.1	7[illegible]
17:30	1364.0	1214.5	1098.4	112.7	7
20: 0	1366.5	1211.5	1098.1	118.1	7
22:30	1369.7	1212.3	1099.6	121.4	7
25: 0	1376.8	1217.2	1104.3	121.8	7
27:30	1400.2	1235.7	1116.1	125.4	7
30: 0	1392.6	1237.4	1120.7	130.0	7
32:30	1401.4	1240.7	1123.5	133.5	7
35: 0	1427.9	1251.7	1127.5	138.3	7
37:30	1440.4	1258.5	11[illegible]8.4	144.4	
40: 0	1430.4	1254.3	11[illegible].0	152.[illegible]	
42:30	1418.5	1243.6	112[illegible].[illegible]	155.[illegible]	[illegible]
45: 0	1421.9	1241.[illegible]	111[illegible].3	16[illegible]	[illegible]
47:30	1427.2	1241.3	1118.0	164.[illegible]	[illegible]
50: 0	1437.[illegible]	1237.8	111[illegible].7	166.[illegible]	[illegible]
52:30	14[illegible]8.5	1238.7	1111.[illegible]	167.[illegible]	[illegible]
55: 0	1466.5	1246.0	1115.[illegible]	169.[illegible]	[illegible]
57:30	1468.7	1249.0	1113.4	170.7	[illegible]
60: 0	1472.7	1251.1	1118.1	176.3	7[illegible]

*T.C. 37, located on top surface of insulated steel duct, 6 ft from unexposed surface of wall, malfunctioned at the start of test and remained inoperable throughout the test.

FILE NC505-12

ILL. NO. A-7

ISSUED: 4-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS.) TIME	20	21	22	23	[illegible]
0: 0	69.6	69.6	69.5	69.2	[illegible]
2:30	178.4	74.5	73.1	73.6	[illegible]
5: 0	92.0	98.6	88.3	90.0	[illegible]
7:30	104.4	110.6	103.6	102.4	[illegible]
10: 0	109.3	136.6	125.5	137.4	[illegible]
12:30	101.0	139.1	141.8	159.8	[illegible]
15: 0	105.0	146.5	161.7	175.2	[illegible]
17:30	104.4	150.8	173.9	182.7	[illegible]
20: 0	121.3	163.8	175.9	184.5	[illegible]
22:30	136.7	178.7	189.3	181.6	[illegible]
25: 0	140.8	138.8	176.7	166.1	[illegible]
27:30	133.5	153.8	187.6	190.7	[illegible]
30: 0	122.3	170.2	197.9	198.5	[illegible]
32:30	113.0	161.6	199.2	199.5	[illegible]
35: 0	121.0	171.3	205.7	203.7	[illegible]
37:30	118.3	174.0	213.3	209.3	[illegible]
40: 0	123.4	179.3	[illegible]	215.5	[illegible]
42:30	143.9	183.3	[illegible]	219.	[illegible]
45: 0	128.3	183.5	226.2	224.5	[illegible]
47:30	130.8	191.1	224.2	223.0	[illegible]
50: 0	137.8	198.6	231.6	228.5	[illegible]
52:30	118.5	199.1	233.6	224.2	[illegible]
55: 0	124.8	198.[illegible]	240.1	230.5	[illegible]
57:30	123.5	211.4	248.3	238.8	[illegible]
60: 0	116.1	204.2	251.8	235.5	[illegible]

FILE NC505-12 ILL. NO. A-8 ISSUED: 4

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DUCT

CHAN(NOS./ TIME	25	26	27	28	
0: 0	70.5	70.3	69.4	67.5	67
2:30	75.4	73.3	71.0	68.5	68
5: 0	88.3	87.9	73.8	70.9	6
7:30	100.4	99.1	82.1	75.6	7
10: 0	144.5	113.1	100.7	89.1	7
12:30	153.5	124.1	105.4	95.3	8
15: 0	156.6	135.8	113.9	106.9	9
17:30	164.4	159.1	118.8	109.9	9
20: 0	158.6	153.8	121.0	108.9	9
22:30	158.8	163.1	128.3	116.3	10
25: 0	157.6	155.1	103.1	107.8	10
27:30	153.2	145.7	118.5	119.2	10
30: 0	160.5	151.0	127.1	125.3	10
32:30	159.3	137.7	131.1	130.4	11
35: 0	160.7	156.9	137.4	135.1	11
37:30	159.5	140.9	148.6	146.4	[illegible]
40: 0	166.4	157.8	154.1	155.9	[illegible]
42:30	169.1	160.9	159.3	154.9	[illegible]
45: 0	167.1	149.3	163.3	158.2	[illegible]
47:30	168.6	158.2	168.4	160.7	[illegible]
50: 0	171.4	162.3	170.2	167.3	[illegible]
52:30	168.0	155.8	179.1	174.2	[illegible]
55: 0	168.1	154.2	184.3	180.8	[illegible]
57:30	167.7	156.7	181.3	181.1	[illegible]
60: 0	167.2	154.6	185.2	185.3	15

FILE NC505-12 ILL. NO. A-9 ISSUED: 4-1

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

INSULATED STEEL DECK

CHAN. NOS. TIME	30	31	32
0: 0	70.2	68.1	67.9
2:30	70.2	68.7	68.2
5: 0	71.0	69.4	68.8
7:30	73.1	70.4	69.4
10: 0	75.2	72.7	70.9
12:30	79.7	76.6	73.5
15: 0	88.7	82.8	78.2
17:30	101.2	87.7	82.5
20: 0	87.2	90.6	86.4
22:30	85.9	93.2	89.5
25: 0	88.6	97.5	93.6
27:30	89.2	97.4	91.4
30: 0	91.8	98.7	91.7
32:30	93.3	99.3	92.1
35: 0	90.7	101.0	93.1
37:30	95.6	103.6	95.5
40: 0	95.4	105.6	96.6
42:30	[illegible]	107.3	97.8
45: 0	[illegible]	108.1	98.6
47:30	98.3	109.5	[illegible]
50: 0	102.9	[illegible]	101.1
52:30	104.4	112.2	102.3
55: 0	105.6	[illegible]	103.9
57:30	108.9	[illegible]	[illegible]
60: 0	111.1	121.0	105.4

FILE NC505-12

ILL. NO. A-10

ISSUED: 4-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS. TIME	33	34	[illegible]	[illegible]
0: 0	69.2	69.1	69.1	68.3
2:30	1117.9	856.1	673.9	103.1
5: 0	1157.8	993.1	860.5	187.0
7:30	1252.5	1070.1	922.[illegible]	243.0
10: 0	1374.8	1143.9	1028.3	324.3
12:30	1242.3	1065.1	961.2	355.8
15: 0	1210.0	1049.2	950.8	335.6
17:30	1193.0	1038.8	943.1	378.6
20: 0	1187.4	1024.1	921.0	431.3
22:30	1194.5	1024.2	907.6	499.4
25: 0	1220.9	1051.4	931.9	483.1
27:30	1243.3	1071.7	937.4	372.2
30: 0	1260.8	1087.7	953.2	448.1
32:30	1257.0	1085.3	977.2	462.7
35: 0	1269.1	1093.0	974.9	390.9
37:30	1291.1	1103.6	985.5	390.7
40: 0	1292.9	1110.3	[illegible]	[illegible]
42:30	1298.[illegible]	[illegible]	[illegible]	[illegible]
45: 0	[illegible]	[illegible]	[illegible]	[illegible]
47:30	1316.0	[illegible]	[illegible]	[illegible]
50: 0	1323.3	[illegible]	[illegible]	[illegible]
52:30	1319.5	[illegible]	984.1	[illegible]
55: 0	1318.3	1121.8	976.4	375.3
57:30	1329.0	1116.3	980.[illegible]	[illegible]
60: 0	1336.9	1127.1	988.1	372.4
		1134.3	991.3	378.7

FILE NC505-12

ILL. NO. A-11

ISSUED: 4-17-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL BOLT WITHOUT INSULATION

CHAN(NOS.) TIME	20	39	40	41	[illegible]
0: 0	68.8	70.[illegible]	69.7	68.9	[illegible]
2:30	99.3	98.2	86.8	89.8	9[illegible]
5: 0	164.2	142.4	115.2	110.1	115
7:30	163.1	163.2	131.2	122.1	129
10: 0	129.9	218.5	165.5	141.3	164
12:30	128.6	251.3	187.6	146.5	170
15: 0	133.3	241.7	191.5	153.6	158
17:30	144.2	252.4	196.8	154.0	166
20: 0	154.8	248.2	197.6	155.2	15[illegible]
22:30	149.4	269.0	209.4	162.1	16[illegible]
25: 0	148.3	248.9	204.1	161.5	15[illegible]
27:30	157.2	308.0	232.8	172.8	15[illegible]
30: 0	158.3	295.6	242.1	184.5	16[illegible]
32:30	150.1	336.3	253.3	193.7	16[illegible]
35: 0	148.0	341.0	274.0	201.9	17[illegible]
37:30	162.6	350.4	288.3	206.0	17[illegible]
[illegible]	150.3	375.3	[illegible]	210.[illegible]	[illegible]
42:30	153.5	347.3	[illegible]84.4	20[illegible]	[illegible]
[illegible]	[illegible]	370.2	307.8	[illegible]	[illegible]
47:30	175.1	463.2	412.5	218.2	[illegible]
50: [illegible]	151.2	376.2	317.6	220.3	[illegible]
52:30	156.5	373.2	315.5	219.3	[illegible]
[illegible]	163.9	399.[illegible]	328.6	224.[illegible]	[illegible]
57:30	169.9	407.8	338.8	229.[illegible]	[illegible]
60: 0	156.9	393.5	330.6	222.5	19[illegible]

FILE NC505-12

ILL. NO. A-12

ISSUED: 4-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.) TIME	43	44	45	46	[illegible]
0: 0	70.3	70.1	69.8	69.2	69.[illegible]
2:30	83.8	85.0	81.4	75.3	72[illegible]
5: 0	106.7	107.7	103.4	97.0	79[illegible]
7:30	119.6	117.2	125.3	107.5	86[illegible]
10: 0	141.2	139.2	194.0	149.5	103[illegible]
12:30	146.6	139.5	323.0	256.7	131[illegible]
15: 0	146.0	139.8	348.8	278.4	138[illegible]
17:30	148.9	136.4	363.9	287.1	138[illegible]
20: 0	150.1	136.7	357.7	287.6	140[illegible]
22:30	149.2	128.3	368.2	295.7	144[illegible]
25: 0	146.0	123.7	176.1	159.8	112[illegible]
27:30	144.0	120.4	336.1	238.7	126[illegible]
30: 0	150.[illegible]	127.9	371.2	292.3	134[illegible]
32:30	155.[illegible]	137.5	388.1	307.0	146[illegible]
35: 0	161.9	143.8	399.3	328.2	146[illegible]
37:30	160.3	149.2	412.2	335.[illegible]	[illegible]
40: 0	173.[illegible]	155.[illegible]	421.[illegible]	[illegible]	[illegible]
42:30	153.[illegible]	[illegible]	436.[illegible]	[illegible]	[illegible]
[illegible]	179.[illegible]	160.[illegible]	445.7	[illegible]	[illegible]
[illegible]	184.[illegible]	172.2	457.8	[illegible]	[illegible]
50: [illegible]	168.9	145.7	466.8	[illegible]	[illegible]
52:30	176.9	151.8	466.9	[illegible]	[illegible]
55: [illegible]	174.[illegible]	148.8	469.[illegible]	387.0	[illegible]
57:30	189.1	163.6	479.0	[illegible]	[illegible]
60: 0	179.7	154.3	491.6	406.[illegible]	182[illegible]

FILE NC505-12 ILL. NO. A-13 ISSUED: 4-17-

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

STEEL DUCT WITHOUT INSULATION

CHAN(NOS.)/ TIME	48	49	50
0: 0	69.3	63.4	68.2
2:30	80.1	73.3	71.0
5: 0	94.4	80.3	75.1
7:30	99.4	86.1	78.5
10: 0	127.8	100.8	86.0
12:30	128.6	103.2	88.8
15: 0	139.9	108.5	91.3
17:30	126.4	106.7	91.8
20: 0	132.9	112.5	94.8
22:30	120.5	107.9	93.9
25: 0	109.2	107.6	92.0
27:30	112.9	109.8	93.0
30: 0	113.1	110.7	93.5
32:30	128.7	112.7	95.8
35: 0	122.2	111.5	95.1
37:30	130.4	115.6	96.9
40: 0	121.5	118.7	96.7
42:30	132.5	[illegible]	98.3
45: 0	131.[illegible]	115.0	99.[illegible]
47:30	130.1	118.2	100.1
50: 0	129.4	119.3	101.1
52:30	128.2	118.6	100.3
55: 0	127.5	118.3	101.3
57:30	135.9	120.[illegible]	101.8
60: 0	134.5	121.5	102.4

FILE NC505-12 ILL. NO. A-14 ISSUED: [illegible]

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

[illegible] (FIBERGLASS DUCT)

CHAN NOS. / TIME	51	52	53	54	*55
0: 0	66.9	67.1	67.1	87.3	[illegible]
2:30	1510.1	1144.3	842.7	128.0	2
5: 0	1111.7	986.1	812.7	237.5	130
7:30	957.6	790.0	674.1	132.9	36
10: 0	894.6	757.5	635.5	124.3	13
12:30	1052.2	897.3	730.3	122.5	24
15: 0	1297.7	1300.2	1124.3	144.1	5
17:30	1394.5	1508.3	1370.2	159.6	53
20: 0	1431.2	176.2	117.6	162.7	249
22:30	1455.4	66.4	73.0	168.7	66
25: 0	1423.4	61.6	72.0	292.9	5[illegible]
27:30	1356.7	64.0	70.7	87.1	6[illegible]
30: 0	1348.5	64.0	70.1	96.2	6[illegible]
32:30	1352.8	63.7	69.4	84.6	6[illegible]
35: 0	1384.7	63.3	69.9	92.8	6[illegible]
37:30	1407.4	63.6	69.6	82.8	[illegible]
40: 0	1421.2	63.6	69.6	80.3	[illegible]
42:30	1419.6	63.4	69.2	82.8	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
47:30	1455.2	63.3	69.2	84.8	[illegible]
[illegible]	1478.8	64.1	69.4	[illegible]	[illegible]
52:30	1495.[illegible]	63.5	69.[illegible]	[illegible]	[illegible]
[illegible]	1522.9	[illegible]	[illegible]	[illegible]	[illegible]
57:30	1539.0	63.7	69.8	[illegible]	[illegible]
60: 0	1546.0	63.6	69.7	84.3	66

*T.C. 55, located on top surface of fiberglass duct, 6 ft from unexposed surface of wall, malfunctioned at the start of test and remained inoperable throughout the test.

FILE NC505-12

ILL. NO. A-15

ISSUED: 4-17-

AMERICAN IRON & STEEL INSTITUTE
FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	56	57	58	59	6
0: 0	68.1	68.6	68.6	68.6	68
2:30	111.7	76.7	75.2	79.6	71
5: 0	148.7	103.2	101.4	102.6	87
7:30	179.3	122.4	114.1	113.5	93
10: 0	193.6	113.4	113.9	124.5	108
12:30	173.8	120.6	116.0	116.4	105
15: 0	179.4	134.3	131.0	139.1	123
17:30	294.3	176.4	157.2	123.0	133
20: 0	78.3	157.5	160.5	168.9	326
22:30	75.4	161.7	158.5	167.7	360
25: 0	74.6	696.5	761.4	664.3	142
27:30	72.3	131.2	151.1	94.0	119
30: 0	71.6	118.6	144.4	94.0	110
32:30	71.5	108.9	121.1	82.7	94
35: 0	71.2	99.9	113.5	81.5	[illegible]
37:30	71.8	99.3	119.6	85.9	[illegible]
40: 0	71.7	94.9	111.5	81.3	[illegible]
42:30	71.2	92.[illegible]	107.3	[illegible]	[illegible]
[illegible]	71.3	92.[illegible]	106.6	[illegible]	[illegible]
47:30	70.3	86.5	102.6	81.3	8[illegible]
50: 0	71.5	89.0	105.9	80.4	8[illegible]
52:30	71.8	91.1	102.6	79.9	8[illegible]
55: 0	71.7	92.9	106.[illegible]	87.1	[illegible]
57:30	71.4	91.6	108.0	81.6	8[illegible]
60: 0	72.0	91.2	103.7	80.3	80

FILE NC505-12 ILL. NO. A-16 ISSUED 17-

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST
84NK29824/NC505
1-3-85

FIBERGLASS DUCT

CHAN(NOS.) TIME	61	62	63	64	65
0: 0	68.3	69.1	68.0	67.1	[illegible]
2:30	71.9	73.8	69.2	67.9	67
5: 0	87.5	82.1	75.5	71.1	69
7:30	95.5	89.0	91.2	80.3	73
10: 0	101.5	92.3	109.8	91.8	77
12:30	99.8	89.4	112.5	96.4	81
15: 0	113.6	100.4	140.2	111.8	86
17:30	145.4	127.1	532.2	262.9	127
20: 0	326.7	314.1	675.1	339.3	152
22:30	362.2	349.2	721.1	363.2	163
25: 0	165.6	148.8	634.4	636.1	442
27:30	140.0	128.1	207.1	184.9	142
30: 0	125.7	115.9	174.9	158.1	12
32:30	114.7	106.9	151.3	137.0	11
35: 0	106.8	101.5	133.4	118.6	10
37:30	106.3	100.6	128.1	119.9	10
40: 0	101.1	94.6	[illegible]	112.1	[illegible]
42:30	98.[illegible]	95.4	[illegible]	123.2	[illegible]
45: 0	96.[illegible]	[illegible]	117.3	[illegible]	[illegible]
47:30	97.4	94.3	116.1	113.3	[illegible]
50: 0	95.1	92.0	113.6	113.[illegible]	[illegible]
52:30	93.1	90.1	115.2	116.1	[illegible]
55: 0	91.5	88.6	[illegible]	113.4	[illegible]
57:30	91.8	89.4	115.7	113.9	[illegible]
60: 0	90.4	87.0	114.1	111.6	110

FILE NC505-12

ILL. NO. A-17

ISSUED: 4-1

AMERICAN IRON & STEEL INSTITUTE

FULL-SCALE TEST

84NK29824/NC505

1-3-85

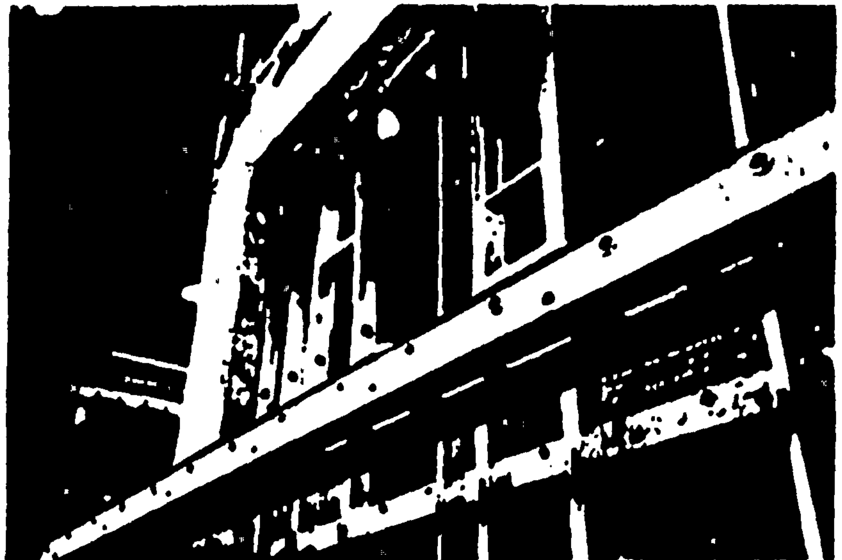
FIBERGLASS DUCT

CHAN(NOS.) TIME	66	67	68
0: 0	68.[illegible]	67.0	66.6
2:30	69.5	68.2	67.5
5: 0	71.2	69.2	67.9
7:30	74.2	71.1	68.5
10: 0	75.7	72.2	69.8
12:30	76.3	73.1	70.2
15: 0	80.0	75.3	72.2
17:30	110.8	84.7	75.8
20: 0	290.0	271.3	271.0
22:30	455.4	444.2	502.2
25: 0	166.3	176.4	166.3
27:30	140.0	146.5	135.8
30: 0	125.9	130.4	120.5
32:30	117.6	122.5	110.6
35: 0	109.1	114.2	103.8
37:30	105.2	109.9	99.4
40: 0	101.8	106.[illegible]	97.[illegible]
42:30	94.9	103.5	95.[illegible]
[illegible]	[illegible]	101.[illegible]	[illegible]
47:30	97.8	100.[illegible]	94.[illegible]
50: 0	97.0	99.6	92.[illegible]
52:30	96.3	99.[illegible]	92.1
[illegible]	96.0	98.7	[illegible]
57:30	95.5	96.7	91.0
60: 0	94.9	97.7	90.9

APPENDIX B

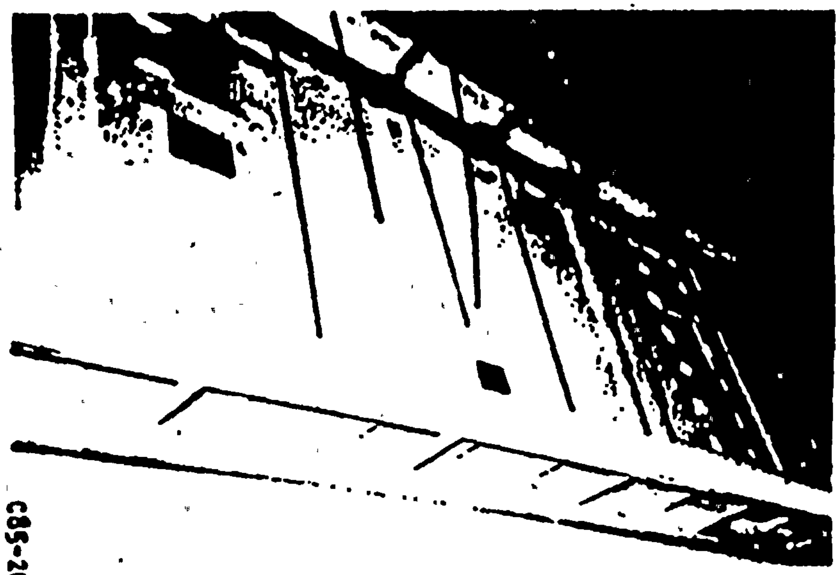
TEST RECORD - GENERAL

PICTORIAL HISTORY



STEEL STUDS AND FRAMING ANGLES
FOR AIR DUCT PENETRATIONS

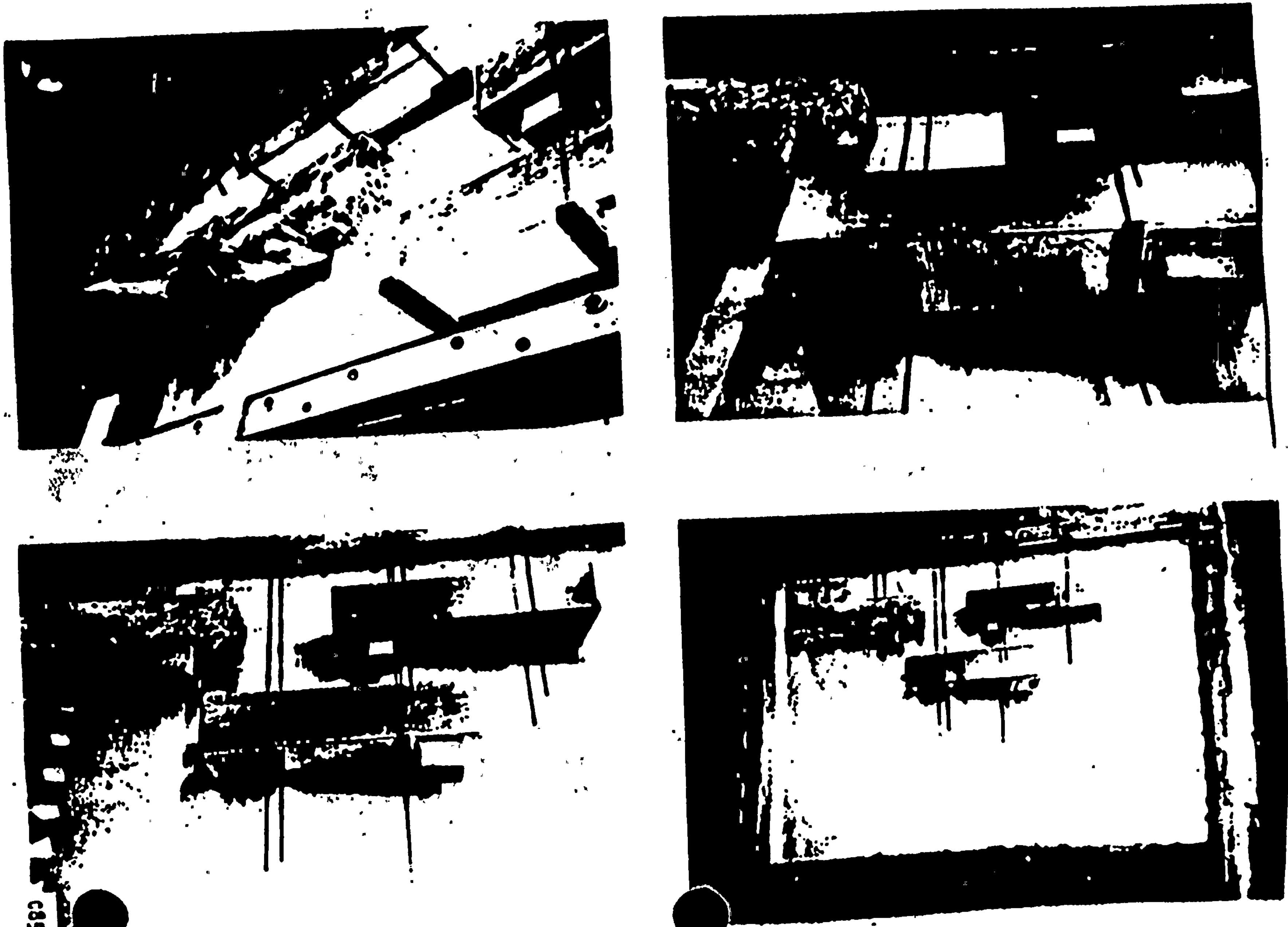
STEEL STUDS AND FRAMING ANGLES
FOR AIR DUCT PENETRATIONS



UNEXPOSED GYPSUM WALLBOARD SURFACE WITH
OPENINGS FOR AIR DUCT PENETRATIONS

STEEL STUDS AND INNER FACE OF EXPOSED
GYPSUM WALLBOARD

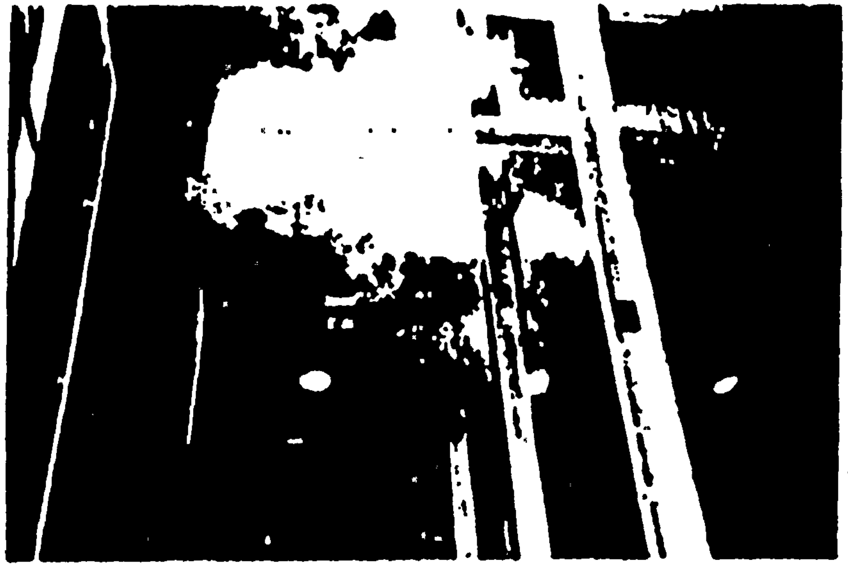
C85-2086



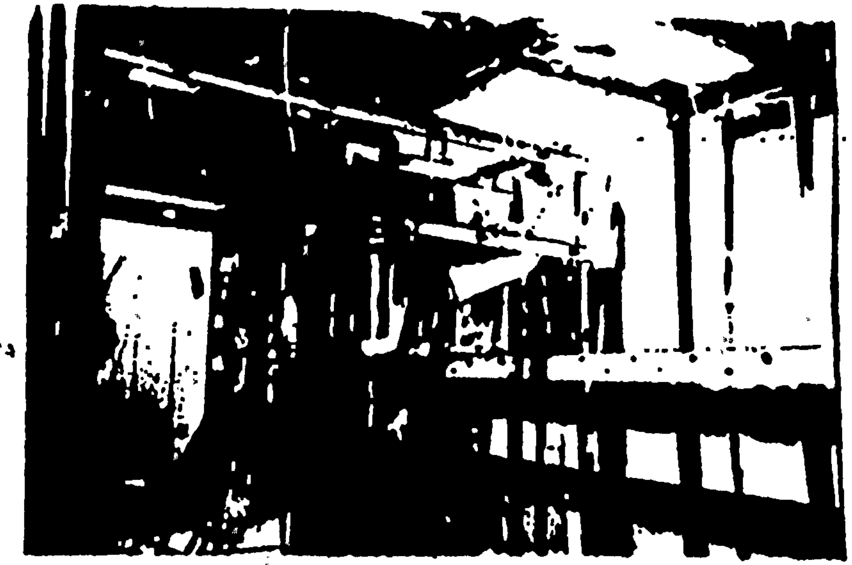
C85-201

EXPOSED SURFACE OF TEST ASSEMBLY

[illegible] TEST

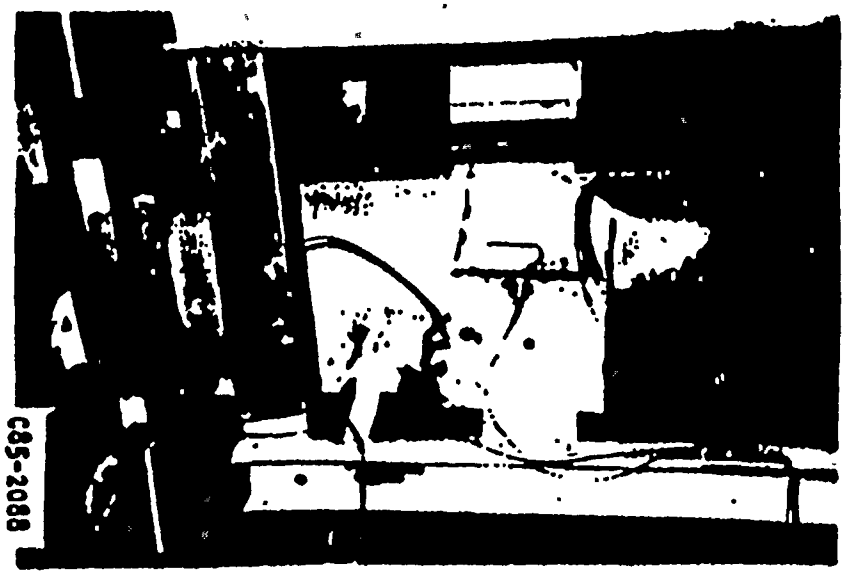


SMOKE ISSUING FROM RIGID FIBERGLASS AIR DUCT DROP OUTLET ON UNEXPOSED SIDE OF ASSEMBLY. TEST TIME - 2 MIN.



COLLAPSE OF RIGID FIBERGLASS AIR DUCT ON UNEXPOSED SIDE OF ASSEMBLY. TEST TIME - 19 MIN.

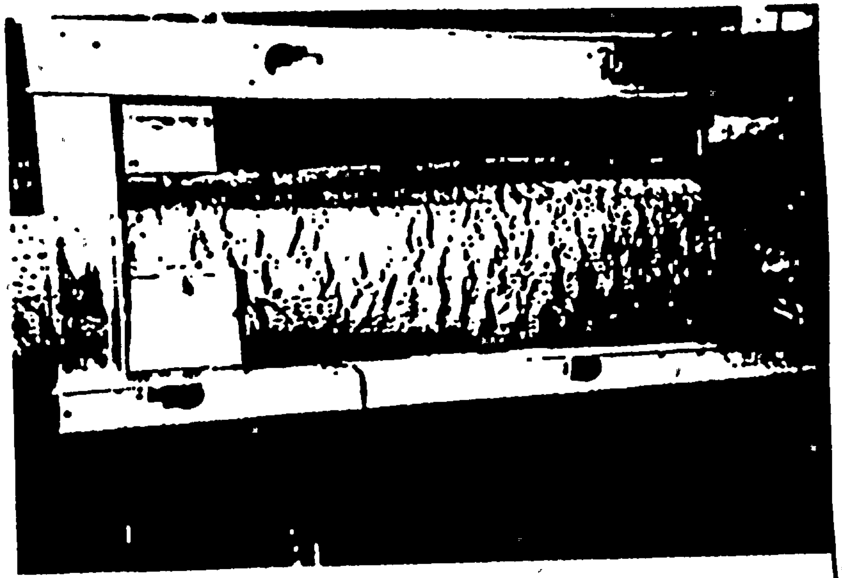
C85-2088



DISCOLORATION OF GALVANIZED STEEL AIR DUCT ON [illegible] [illegible] ASSEMBLY. TEST TIME - 34 MIN.

DISCOLORATION OF WALL SURFACE AND DETERIORATION OF INSULATED GALV. STEEL AIR DUCT ON UNEXPOSED [illegible] TEST TIME - 50 MIN.

UNEXPOSED SURFACE AFTER TEST



INSULATED GALVANIZED STEEL AIR DUCT AFTER TEST

GALVANIZED STEEL AIR DUCT AFTER TEST

INSULATED GALVANIZED STEEL AIR DUCT AFTER TEST

C85-2089

FPRR F0007

APPENDIX R DEVIATION REQUEST NO. 14

REACTOR BUILDING FIRE ZONES WITHOUT FIRE DETECTION

DEVIATION REQUEST:

Fire detection need not be provided in fire zones which do not contain safe shutdown raceway or do not represent an exposure hazard to safe shutdown equipment even if a fire zone within the same area contains redundant safe shutdown raceway. The provision of automatic sprinkler protection in lieu of fire detection is acceptable in Fire Zones 1-2C and 2-2C.

FIRE AREA/ZONES AFFECTED:

This deviation applies to Unit 1 and Unit 2 Reactor Buildings, Fire Area: R-1A, R-1B, R-2A and R-2B.

REASON FOR DEVIATION REQUEST:

The requirement of 10 CFR 50, Appendix R, Section III.G.2 require fire detection. The NRC guidance indicates fire detection should be provided throughout a fire area. Fire detection has not been provided in the Reactor Building fire zones listed below under Existing Arrangement.

EXISTING ARRANGEMENT:

The following fire zones do not have fire detection:

Fire Area	Fire Zones	Reason
R-1A	1-2C	Railroad Airlock / Access Shaft - No detection - Automatic sprinklers provided
	1-4E	CRD Room - No safe shutdown cables-very low combustible loadings
	0-6H	Cask Storage Pit - Filled with water
	1-7B	Recirculation Fan Room - No safe shutdown cables-very low combustible loadings
	1-6F	Spent Fuel Pool - Filled with water

FPRR F0007

Fire Area	Fire Zones	Reason
R-1B	1-1J	Stairwell-no safe shutdown raceway or combustibles
	1-6F	Spent fuel pool- Filled With Water
	0-6H	Cask Storage Pit - Filled with water
R-2A	2-2C	Same as 1-2C
	2-4E	Same as 1-4E
	~~2-1I~~	~~Same as 1-1I~~
	2-6F	Same as 1-6F
R-2B	2-1J	Same as 1-1J
	2-6F	Same as 1-6F

JUSTIFICATION:

Fire Zones 1-2C and 2-2C have been provided with automatic sprinkler protection. Detection of a fire is provided via the sprinkler flow alarm when heat activates a sprinkler head. The remainder of the fire zones listed above do not contain safe shutdown raceway or equipment. None of the zones listed above represent a fire hazard which impacts on adjacent fire zones.

The NRC requested additional detection for Fire Zones 1-7B and 1-6F in FSAR Question 281.17. There was no additional detection requested for Fire Zones 1-2C, 1-4E or 0-6H. Our response to the staff and our Fire Protection Review Report both indicated that additional smoke detection would be provided in zones which contain or present a fire exposure hazard to safe shutdown equipment. The fire zones delineated in this request do not present an exposure fire hazard to safe shutdown equipment.

FPRR F0010

Appendix R DEVIATION REQUEST

AUTOMATIC FIRE SUPPRESSION IN Fire Zone 2-5D

DEVIATION REQUEST:

We request approval of the following:

The installation of an automatic fire suppression system in Fire Zone 2-5D in order to comply with Appendix R, Section III.G.2.b would not significantly enhance the fire protection for that zone nor overall plant safety, and therefore is not required.

Fire Zone AFFECTED:

This deviation request applies only to Fire Zone 2-5D, which is in Fire Area R-2A.

REASON FOR DEVIATION REQUEST:

10 CFR 50, Appendix R, Section III.G.2.b requires the existence of an automatic fire suppression system, in addition to fire detectors, in those fire areas where separation of redundant safe shutdown cables and equipment is greater than 20 feet with no intervening combustibles. Fire Zone 2-5D contains cables for HV-E21-2F005A (Div. I) and power cables from 2D613 and 2D653A (Div. I) as well as Valve HV-G33-2F004 (Div. II).

Redundant safe shutdown equipment/cables in Fire Zone 2-5D are separated by a horizontal spatial distance of approximately 50 feet with negligible intervening combustibles. No automatic fire suppression system exists in the fire zone. Fire Zone 2-5D is a fire zone in which relief from the automatic fire suppression system requirement of Appendix R, Section III.G.2.b is sought.

EXISTING ARRANGEMENT:

RWCU Outboard Isolation Valve HV-G33-2F004 is normally open during power operation and is required closed to isolate Reactor Coolant letdown to the RWCU System when performing plant shutdown. In the event Valve HV-G33-2F004 is unavailable, the RWCU Inboard Isolation Valve HV-G33-2F001 may be called upon to close to isolate Reactor Coolant letdown. Valve 2F001 is located inside containment (Fire Zone 2-4F) and 2F004 is located in Fire Zone 2-5D.

For a fire in Fire Zone 2-5D (physical location of Valve HV-G33-2F004), HV-G33-2F004 (Division II) and its cables may be disabled. The valve and its cables are located in the northwest corner of the fire zone (refer to drawing C-1824). The cables travel West to Fire Zone 2-5C. No cables for Inboard Isolation Valve HV-G33-2F001 (Division I) are located in Fire Zone 2-5D. Cables for Valve HV-G33-2F001 and its power supply are wrapped in adjacent (i.e., communicating) Fire Zones (2-4A-W and 2-5A-W) (except for 2-4A-S for

C-1732, sh 1, R1

which 3 hour barrier upgrades are provided between zones). Refer to Figures X and X for applicable fire zone layouts.
C-1731, sh1, R1

The total combustible loading in Fire Zone 2-5D is 5910 BTU/sq. ft. , which translates into an equivalent fire duration of approximately 4.4 minutes assuming all combustibles are fully consumed. The combustibles consist of a total of five (5) gallons of lube oil (five separate one-gallon locations) and cable in cable trays.

Division I cable trays E2PK, E2KK, 2PKB and 2KKB are located, at the East end of Fire Zone 2-5D and are separated from Valve HV-G33-2F004 (Division II) by a horizontal distance of about 49 feet at the closest point. The effect of combustible oil in the zone was evaluated with respect to Division I cable trays. The five gallons total of lube oil in the fire zone is composed from 1 gallon in each of the Cleanup System Recirculation Pumps (2P221A and B) and 1 gallon in each of three valves (HV-G33-2F042, HV-G33-2F044, and HV-G33-2F104--each are non-safe shutdown valves). The pumps are located in individual cubicles each equipped with a floor drain which contains any spilled lube oil within the pump cubicles. The spatial separation between HV-G33-2F004 and the closest pump lube oil is approximately 17 feet and is separated by a pump cubicle wall. The pump cubicles are totally enclosed by concrete and/or masonry walls and communicate only with the Valve HV-G33-2F004 area via a few penetrations in the labyrinth wall arrangement. The three valves and hence the three gallons of lube oil, are separated from Valve HV-G33-2F004 by approximately 35 feet of horizontal spatial separation. Within the 35 feet between the valves exists two floor drains which would preclude a lube oil fire from affecting Valve HV-G33-2F004. The lube oil is the only intervening combustible between HV-G33-2F004 and the redundant safe shutdown equipment cables (refer to C-1824).

The above-mentioned cable trays constitute the only other combustibles in Fire Zone 2-5D. However, the large horizontal spatial separation of the cable trays from HV-G33-2F004 and the intervening labyrinth wall arrangement make these combustibles inconsequential.

Fire Zone 2-5D is equipped with fire detection capability.

JUSTIFICATION:

A study performed, which included analyzing the combustible loading configuration of Fire Zone 2-5D, determined that a fire occurring in Fire Zone 2-5D is highly improbable based on the negligible level of in situ combustible loading. However, assuming a fire did start in Fire Zone 2-5D, approximately 50 feet horizontal spatial separation exists between redundant safe shutdown equipment/cables. Currently, the only intervening combustibles are five gallons of lube oil which are protected for spillage by pump cubicles and floor drains such that any spilled lube oil will not contribute to the propagation of a fire. Additionally, the closest lube oil to Valve HV-G33-2F004 is approximately 17 feet separated by an intervening concrete/masonry wall, which provides substantial assurance that a fire will not disable redundant shutdown equipment/cables that are approximately 50 feet apart.

FPRR F0010

Based on the low probability of a fire in Fire Zone 2-5D, and the insignificant consequences of a fire (due to the configuration of the room) if one were to start, the only possible concerns, therefore, are: 1) a fire may start due to the presence of transient combustibles, and 2) a fire may spread from an adjacent fire zone to Fire Zone 2-5D with the existence of transient combustibles as the fire propagation medium. Both of these concerns are alleviated by controlling the level of transient combustibles in Fire Zone 2-5D and by zone barrier upgrades to prevent such communication between zones where different shutdown paths are specified.

The introduction of transient combustibles into Fire Zone 2-5D would be limited due to infrequent access to the room as a result of the presence of high radioactivity in the fire zone. Additionally, Generic Letter 86-10, Section 3.6.2 stipulates that transient combustibles need not be considered intervening combustibles. The second concern is further addressed in the communicating fire zone discussions below.

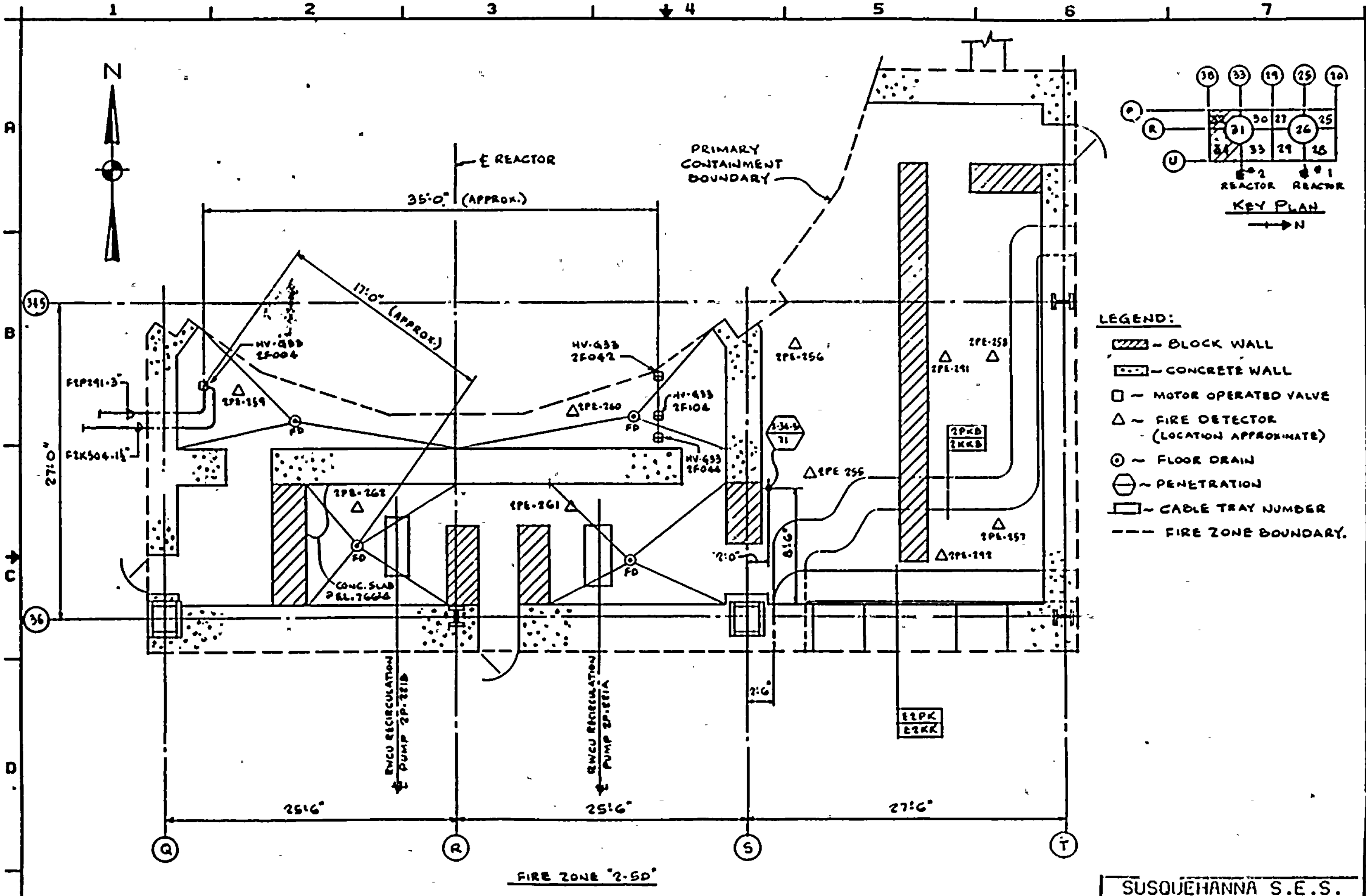
Fire Zone 2-5D has five communicating fire zones as follows: 2-4A-S, 2-4A-W, 2-5A-S, 2-5A-W and 2-5C. Only Fire Zones 2-4A-S, 2-4A-W and 2-5A-S contain cables for redundant isolation Valve HV-G33-2F001 or its power supply (2A203) A study conducted concluded that a fire involving the worst case spatial separation would have to start in Fire Zone 2-4A-S (a fire zone with low in situ combustibles) damaging cables for Valve 2F001 or Power Source 2A203, traverse into Fire Zone 2-5D through the small penetration (3-inch diameter, X-34-5-71), propagate 50 feet horizontally via negligible in situ combustibles in Fire Zone 2-5D, and damage cables for Valve 2F004 or the valve itself. This scenario is highly improbable based on the large spatial separation and low amounts of combustible loading in both fire zones. Hence, operability of RWCU Inboard Isolation Valve HV-G33-2F001 is assured for a fire in Fire Zone 2-5D. For a fire in Fire Zone 2-4A-S, HV-G33-2F004 is assured operable.

Therefore, based on the existence of: 1) large spatial separation between redundant safe shutdown equipment, 2) fire detection, 3) minimal in situ combustibles and 4) negligible intervening combustible loading in Fire Zone 2-5D, the current configuration provides an equivalent degree of safety as that required by Section III.G.2 of Appendix R.

The installation of an automatic fire suppression system in Fire Zone 2-5D to meet the requirements of 10 CFR 50 Appendix R, Section III.G.2 would not significantly augment the level of fire protection for that fire zone.

Future Appendix R compliance will be assured by: 1) Wrapping safe shutdown raceways that are needed for a fire in Fire Zone 2-5D, 2) installing three-hour fire rated penetration seals for any future penetrations in the barrier separating Fire Zones 2-5D and 2-4A-S and 3) by controlling the level of transient combustibles in Fire Zone 2-5D.

wc/msj179i(16)



PARTIAL FLOOR PLAN ELEV. 749'-1"

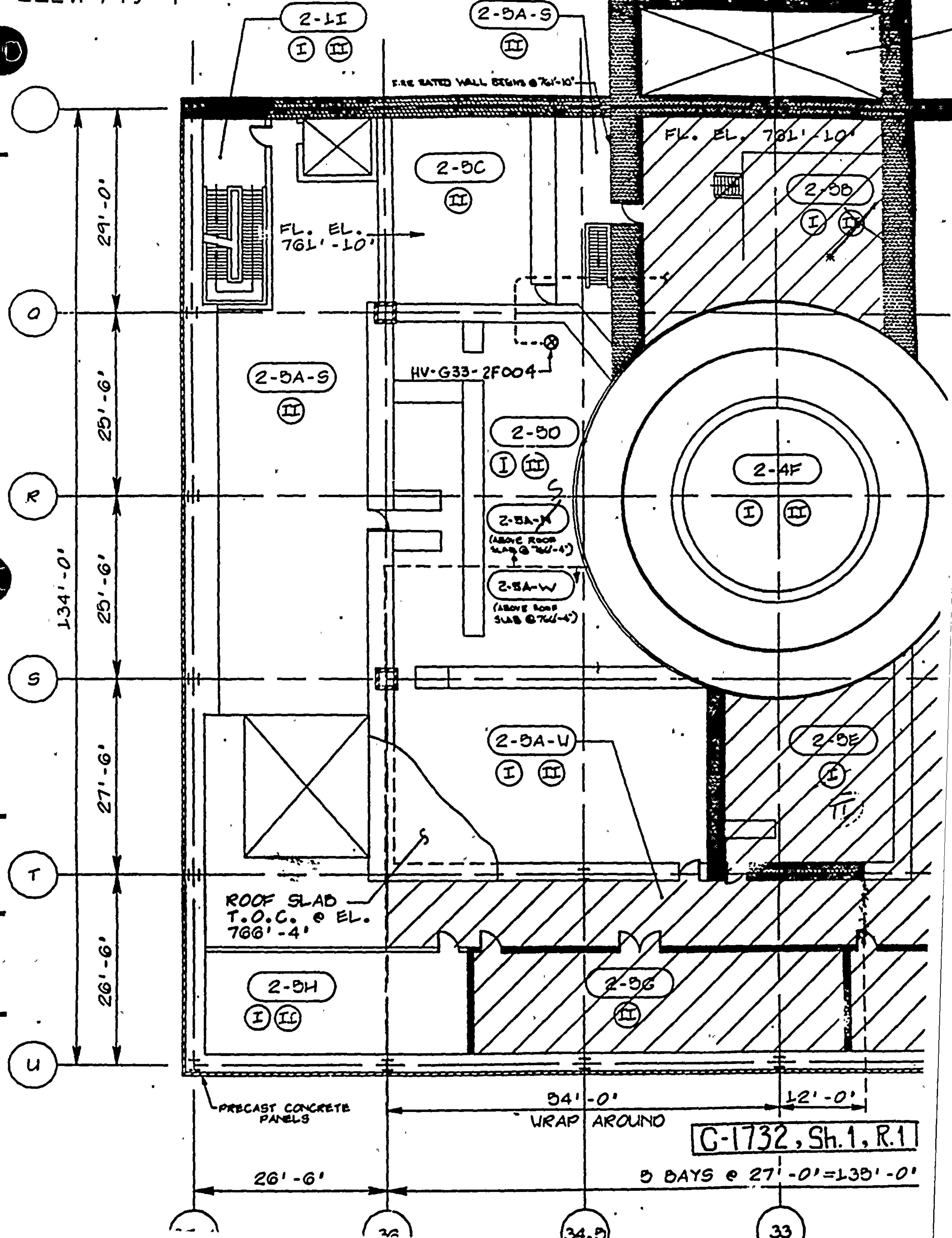
SUSQUEHANNA S.E.S. UNIT # 2 REACTOR BUILDING APPENDIX R-DEVIA. REQ.# 24 FIRE ZONE 2-5D EL. 749'-1"	
AREA 32&34 / ELEV. 749'-1 / SCALE: NONE	
PENNSYLVANIA POWER & LIGHT COMPANY ALLENTOWN PA.	
C213408	SHEET NO. 1
C 1824	0

FPRR F0C10

FPRR 0010

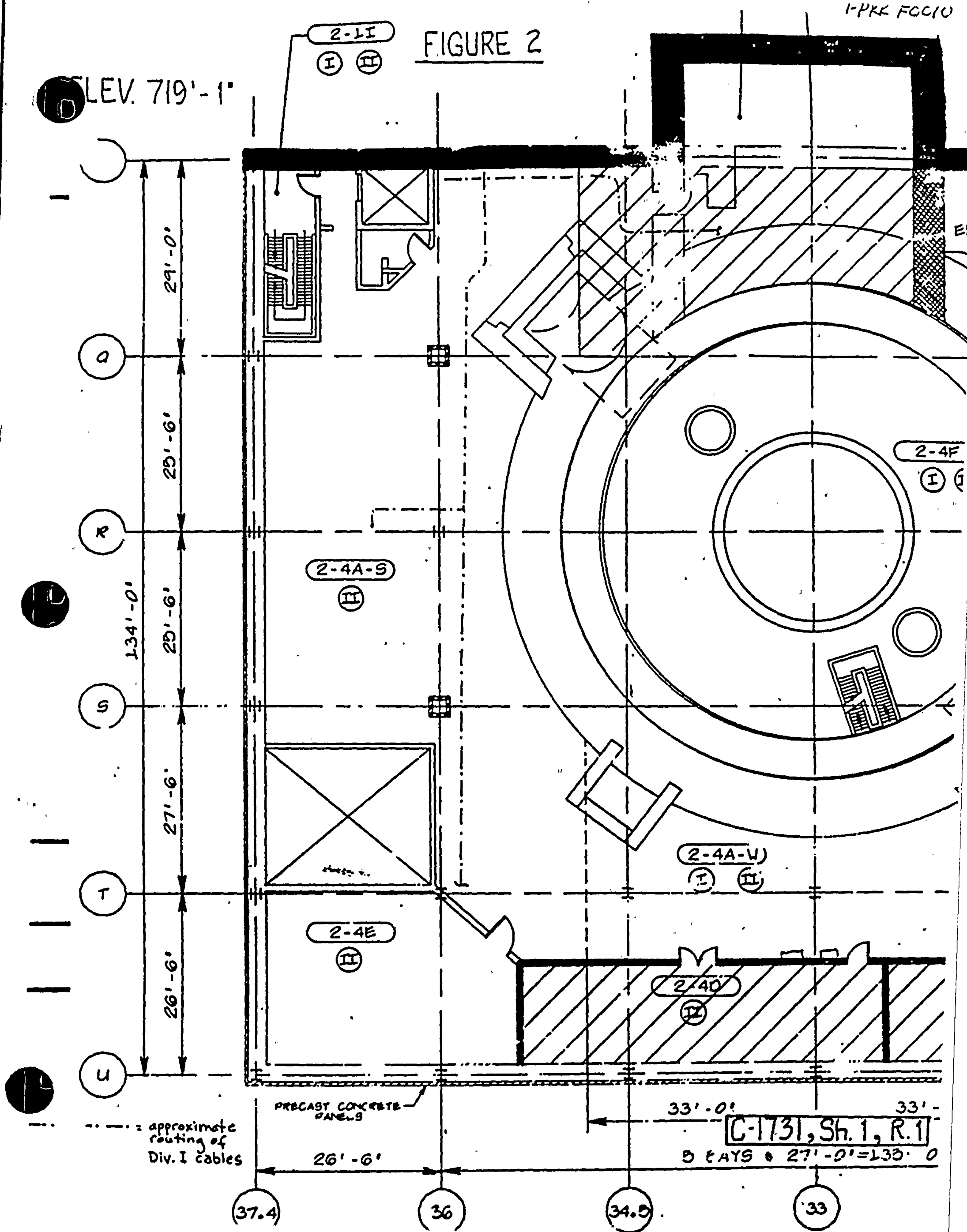
FIGURE 1

ELEV. 749'-1"



C-1732, Sh.1, R.1

FIGURE 2



I-PKK FOCIO
2-LI
I II
ELEV. 719'-1"
Q
R
S
T
U
29'-0'
25'-6'
25'-6'
27'-6'
26'-6'
134'-0'
2-4F
2-4A-S
II
2-4A-W
I II
2-4E
II
2/40
II
PRECAST CONCRETE PANELS
— · — · = approximate routing of Div. I cables
26'-6'
33'-0'
33'-
C-1731, Sh. 1, R.1
5 BAYS @ 27'-0'=135'-0
37.4
36
34.5
33

APPENDIX R DEVIATION REQUEST NO. 27

NUCLEAR BOILER INSTRUMENTATION IN FIRE ZONE 1-5A-S

DEVIATION REQUEST:

The current arrangement of Nuclear Boiler Instrumentation in Fire Zone 1-5A-S provides an equivalent degree of safety as that required by 10 CFR 50, Appendix R, Section III.G.2.b based on the present in-situ combustible loading configuration, horizontal separation of redundant safe shutdown ECCS interlock components of 14 feet, horizontal separation of redundant safe shutdown vessel indication components of 6 feet, plant procedure to control transient combustibles, transient combustible fire hazards analysis, and protection of raceways within 10 feet of required safe shutdown components.

FIRE AREAS/ZONES AFFECTED:

This deviation request applies only to Fire Zone 1-5A-S, which is in Fire Area R-1A.

REASON FOR DEVIATION REQUEST:

10 CFR 50, Appendix R, Section III.G.2.b requires the existence of an automatic fire suppression system, in addition to fire detectors, in those fire areas where separation of redundant safe shutdown cables and equipment is greater than 20 feet with no intervening combustibles.

The redundant Nuclear Boiler Instrumentation in Fire Zone 1-5A-S as identified in Table DR27-1 does not meet the separation criteria as required by Appendix R, Section III.G.2.b. The horizontal separation of individual redundant ECCS interlock components is 14 feet and horizontal separation of the redundant vessel indication components is 6 feet. Automatic fire suppression and detection is provided throughout Fire Zone 1-5A-S. An analysis has demonstrated the following conclusions:

1. The in-situ combustible loading arrangement will not support a design basis fire that will disable both divisions of nuclear boiler instrumentation.

2. A transient combustible fire will not be of sufficient magnitude to disable both divisions of safe shutdown ECCS interlock components.

3. The necessary safe shutdown cables will be protected to insure that a fire will not disable one division's components and the opposite division's cables.

4. Initiation of the fire suppression system will not disable any required nuclear boiler system.

Therefore, the existing arrangement, along with protecting Division I cables in the vicinity of Division II components, provides an equivalent degree of safety as that required by Appendix R, Section III.G.2.b.

EXISTING ARRANGEMENT

In Fire Zone 1-5A-S, Division II of safe shutdown equipment is assured available for plant shutdown. Both divisions of required nuclear boiler instruments, are located in Fire Zone 1-5A-S. The instruments and terminal boxes on instrument rack 1C004 required for Unit 1 safe shutdown are identified in Table DR27-1. The instruments and terminal boxes on instrument rack 1C005 required for Unit 1 safe shutdown are also identified on Table DR27-1. The arrangement of the instruments was designed to insure proper RPS input of the "1-out-of-2-taken-twice" logic for a single instrument line failure. The existing arrangement of the nuclear boiler instrument racks and other relative equipment is shown on Drawing C-213437. 1

The combustible loading in the entire Fire Zone 1-5A-S was conservatively calculated to be relatively low. Automatic fire suppression is installed using the guidance of NFPA 13 and fire detection is provided throughout Fire Zone 1-5A-S.

Several cable trays traverse East-West in front of and above the nuclear boiler instrument racks in Fire Zone 1-5A-S. Three cable trays are enclosed by sheet metal, while one other is a ladder type tray enclosed on the top. The lowest cable tray is 13-feet above the floor and 7-feet above the instrument racks. All cable is metallically shielded and the insulation meets all requirements of IEEE-383 Flame Test.

JUSTIFICATION:

To meet the requirements of 10CFR50, Appendix R, Section III.G.2.b, the following features must exist to ensure that a fire is limited so that one division of redundant components important to safe shutdown is available:

F0012

a. fire detection,
b. automatic fire suppression,
c. no intervening combustibles, and
d. greater than 20 feet horizontal separation between redundant safe shutdown equipment/cables.

Requirements a and b are met and a fire hazard analyses has demonstrated that the existing configuration is acceptable even though requirements c and d are not met.

Justification is as follows:

1. <u>Fire Detection & Suppression</u>

   Fire Zone 1-5A-S is fully covered by an automatic fire detection system.

   The automatic fire suppression system in Fire Zone 1-5A-S provides suppression capability to immediately suppress a fire in incipient stages. This fire zone has full ceiling and lower level coverage in the area of the reactor building chillers and rack 1C004 and 1C005 using the guidance of NFPA 13.

2. <u>In-Situ Combustible Fire Hazard Analyses</u>

   The only combustibles located in the immediate vicinity of the nuclear boiler instrumentation are the cable trays, terminal blocks and the instruments themselves. 1 The instruments contain negligible combustibles and are completely encased in metal enclosures which will contain any internal fire within the housing. Terminal blocks for external cable connections are also completely enclosed in metallic boxes. 1 Therefore, even with very little horizontal spatial separation, any fire on an instrument rack will not be propagated to other racks, equipment, or cable trays. There are four cable trays in the area; three are completely enclosed by sheet metal and one is a ladder type enclosed on top but open on the bottom. The trays completely enclosed are not considered to constitute intervening combustibles, while the open tray does constitute an intervening combustible. The cable tray that is not enclosed is equipped with fire resistant cables that have passed the IEEE-383 flame test. Due to type of materials used, the cables have a low probability for spreading fire. Any fire in the cable trays will not radiate downward to impact the nuclear boiler instruments. All Division II safe shutdown cables in this fire zone have been addressed in the hit resolution process and have been protected if necessary.

Other combustibles within the fire zone are various control panels and lube oil from the reactor building chillers and fuel pool cooling pumps. The control panels contain very little combustible materials within enclosed metallic housing, have spatial separation greater than 8 feet, and therefore, have no impact on the required nuclear boiler instrumentation. The lube oil equipment is located in areas where the floor is sloped to local drains. The drainage areas are of sufficient size to contain any oil spill. The areas are equipped with full suppression over the chillers and pumps to mitigate the spread of a resultant fire. Horizontal spatial separation between pumps/chiller and the instruments rack is greater than 20 feet. In addition, the fuel pool cooling pumps are located within the fuel pool cooling room which is surrounded by concrete walls.

3. <u>Transient Combustible Fire Hazard Analysis</u>

Based on limited quantities of transient combustibles and fire suppression systems, any fire caused by transients will be limited in size. The resultant fire is defined to be a cylindrical area of influence with a radius of 5 feet and a height of 10 feet. Therefore, a transient combustible fire can only disable 3 of the 4 nuclear boiler instrument racks, 1C004, 1C224, and 1C225 or 1C005, 1C225, and 1C224. This will insure that either Rack 1C004 or 1C005 will always be operable and one division of nuclear boiler ECCS interlock components will be available to insure safe shutdown. However, both divisions of nuclear boiler vessel wide range pressure and level transmitters are located within the cylinder of influence and may be lost. Although availability of this instrumentation is highly desirable, its loss is acceptable because safe shutdown can be achieved and maintained without it.

The main concern is a fire that disables one division's components and the opposite division's cables. Since all required Division II safe shutdown raceways will be protected in Fire Zone 1-5A-S, loss of Division I components and Division II cables is not probable. However, it is possible for a fire to disable Division II components and Division I cables. Therefore, all Division I safe shutdown raceways in the area around Rack 1C005, which contains the Division II components, defined by:

- Height of 10 feet

- On the South by the fuel pool cooling room wall,
- On the East by a line 14 feet from the East end of Rack 1C005,
- On the North by the containment wall, and
- On the West by a line 10 feet from the West end of Rack 1C005,

have been protected by a 1 hour fire rated wrap.

4) <u>Effects of Sprinklers</u>.

The actuation of the sprinkler system will not disable any safe shutdown nuclear boiler instrumentation.

From the justification above, it can be concluded that there is no fire (in-situ or transient) in Fire Zone 1-5A-S that will prevent achieving and maintaining cold shutdown. Therefore, it is concluded that the current configuration provides an equivalent degree of safety as that required by Section III.G.2.b of Appendix R. 1

F0012

SSES-FPRR

TABLE DR27-1

UNIT 1 SAFE SHUTDOWN NUCLEAR BOILER INSTRUMENTS

Instrument Number	Description	Area	Elev	Safe Shutdown Path	Fire Zone	Required Path	Rack
LIS-B21-1N024A	Level Indicating	29	749	1	1-5A-S	3	1C004
*LIS-B21-1N024C	Switch for RPS & RCIC	27	749	3	1-5A-S	3	1C005
LIS-B21-1N024B	Level Indicating	29	749	1	1-5A-S	3	1C004
*LIS-B21-1N024D	Switch for RPS & HPCI	27	749	3	1-5A-S	3	1C005
LIS-B21-1N031A	Level Indicating	29	749	1	1-5A-S	3	1C004
*LIS-B21-1N031B	CS, HPCI & RHR	27	749	3	1-5A-S	3	1C005
LIS-B21-1N031C		29	749	1	1-5A-S	3	1C004
*LIS-B21-1N031D		27	749	3	1-5A-S	3	1C005
LIS-B21-1N042A	Level Indicating	29	749	1,2	1-5A-S	3	1C004
*LIS-B21-1N042B	Switch for ADS	27	749	2,3	1-SA-S	3	1C005
LT-14201A	Wide Range Reactor	27	749	1	1-5A-S	3	1C225
*LT-14201B	Level	27	749	3	1-5A-S	3	1C224
PS-B21-1N021A	Pressure Indicating	29	749	1	1-5A-S	3	1C004
*PIS-B21-1N021B	Switch for CS & RHR	27	749	3	1-5A-S	3	1C005
PS-B21-1N023A	Pressure Switch	29	749	1	1-5A-S	3	1C004
PS-B21-1N023B	for RPS	29	749	1	1-5A-S	3	1C004
*PS-B21-1N023C		27	749	3	1-5A-S	3	1C005
*PS-B21-1N023D		27	749	3	1-5A-S	3	1C005
PT-14201A	Wide Range Reactor	27	749	1	1-5A-S	3	1C225
*PT-14201B	Pressure	27	749	3	1-5A-S	3	1C224
TB1C004-A1	Terminal Box	29	749'	1	1-5A-S	3	1C004
-A2	Terminal Box	29	749'	1	1-5A-S	3	1C004
-B1	Terminal Box	29	749'	1	1-5A-S	3	1C004
-B2	Terminal Box	29	749'	1	1-5A-S	3	1C004

FOO12

TABLE DR27-1

UNIT 1 SAFE SHUTDOWN
NUCLEAR BOILER INSTRUMENTS

Instrument Number	Description	Area	Elev	Safe Shutdown Path	Fire Zone	Required Path	Rack
TB1C005-A1	Terminal Box	27	749'	3	1-5A-S	3	1C005
-A3	Terminal Box	27	749'	3	1-5A-S	3	1C005
-B1	Terminal Box	27	749'	3	1-5A-S	3	1C005
-B2	Terminal Box	27	749'	3	1-5A-S	3	1C005

*Denotes the Required Safe Shutdown Components for this Fire Zone

APPENDIX R DEVIATION REQUEST NO. 28

NUCLEAR BOILER INSTRUMENTATION IN FIRE ZONE 2-5A-N

DEVIATION REQUEST

The current arrangement of nuclear boiler instrumentation in Fire Zone 2-5A-N provides an equivalent degree of safety as that required by 10 CFR 50, Appendix R, Section III.G.2.b, based on the present in-situ combustible loading configuration, horizontal separation of redundant safe shutdown ECCS interlock components of 14 feet, plant procedure to control transient combustibles, transient combustible fire hazards analysis, and protection of raceways within 10 feet of required safe shutdown components.

FIRE AREAS/ZONES AFFECTED:

This deviation request applies only to Fire Zone 2-5A-N, which is in Fire Area R-2A.

REASON FOR DEVIATION REQUEST:

10 CFR 50, Appendix R, Section III.G.2.b requires the existence of an automatic fire suppression system, in addition to fire detectors, in those fire areas where separation of redundant safe shutdown cables and equipment is greater than 20 feet with no intervening combustibles.

The redundant nuclear boiler instrumentation in Fire Zone 2-5A-N as identified in Table 28-1 does not meet the separation criteria as required by Appendix R, Section III.G.2.b. The horizontal separation of individual redundant ECCS interlock components is 14 feet. Automatic fire suppression and detection is provided throughout Fire Zone 2-5A-N. An analysis has demonstrated the following conclusions:

1. The in-situ combustible loading arrangement will not support a fire that will disable both divisions of nuclear boiler instrumentation.

2. A transient combustible fire will not be of sufficient magnitude to disable both divisions of safe shutdown ECCS interlock components.

3. The necessary safe shutdown cables will be protected to insure that a fire will not disable one division's components and the opposite division's cables.

4. Initiation of the fire suppression system will not disable any required nuclear boiler system.

Therefore, the existing arrangement, along with protecting Division II cables in the vicinity of Division I components, provides an equivalent degree of safety as that required by Appendix R, Section III.G.2.b.

EXISTING ARRANGEMENT:

In Fire Zone 2-5A-N, Division I of safe shutdown equipment is assured available for plant shutdown. Both divisions of required nuclear boiler instruments are located in Fire Zone 2-5A-N. The instruments and terminal boxes on instrument rack 2C004 required for Unit 2 safe shutdown are identified on Table DR28-1. The instruments and terminal boxes on instrument rack 2C005 required for Unit 2 safe shutdown are also identified on Table DR28-1. 1 The arrangement of the instruments was designed to insure proper RPS input of the "1-out-of-2-taken-twice" logic for a single instrument line failure. The existing arrangement of the nuclear boiler instrument racks and other relative equipment is shown on Drawing C-213438.

The combustible loading in the entire Fire Zone 2-5A-N was conservatively calculated to be relatively low. Automatic fire suppression is installed using the guidelines of NFPA 13 and fire detection is provided throughout Fire Zone 2-5A-N.

Three cable trays traverse east-west in front of and above the nuclear boiler instrument racks in Fire Zone 2-5A-N. Two cable trays are enclosed by sheet metal, while the other is enclosed with fireproof insulation. The lowest cable tray is 14 feet above the floor and 8 feet above the instrument racks. All cable is metallically shielded and the insulation meets all requirements of IEEE-383 Flame Test.

JUSTIFICATION:

To meet the requirements of 10 CFR 50, Appendix R, Section III.G.2.b, the following features must exist to ensure

that a fire is limited so that one division of redundant components important to safe shutdown is available:

a. Fire detection.

b. Automatic fire suppression.

c. No intervening combustibles.

d. Greater than 20 feet horizontal separation between redundant safe shutdown equipment/cables.

Requirements a and b are met and a fire hazard analyses has demonstrated that the existing configuration is acceptable even though requirements c and d are not met. Justification is as follows:

1. Fire Detection and Suppression

Fire Zone 2-5A-N is fully covered by an automatic fire detection system.

The automatic fire suppression system in Fire Zone 2-5A-N provides suppression capability to immediately suppress a fire in incipient stages. This fire zone has full ceiling and lower level coverage in the area of the Reactor Building chillers using the guidelines of NFPA 13.

2. In-Situ Combustible Fire Hazard Analyses

The only combustibles located in the immediate vicinity of the nuclear boiler instrumentation are the cable trays, terminal blocks and the instruments themselves. 1
The instruments contain negligible combustibles and are completely encased in metal enclosures which will contain any internal fire within the housing. Terminal blocks for external cable connections are also 1
completely enclosed in metallic boxes. Therefore, even with very little horizontal spatial separation, any fire on an instrument rack will not be propagated to other racks, equipment, or cable trays.

There are three cable trays in the area; two are completely enclosed by sheet metal while the third is wrapped with fireproof insulation. The trays completely enclosed are not considered to constitute

intervening combustibles. All Division I safe shutdown cables in this fire zone have been addressed in the hit resolution process and have been protected if required.

Other combustibles within the fire zone are various control panels and lube oil from the Reactor Building chillers and fuel pool cooling pumps. The control panels contain very little combustible materials within enclosed metallic housing, have spatial separation greater than 8 feet, and therefore, have no impact on the required nuclear boiler instrumentation. The lube oil equipment is located in areas where the floor is sloped to local drains. The drainage areas are of sufficient size to contain any oil spill. The areas are equipped with full suppression over the chillers and pumps to mitigate the spread of a resultant fire. Horizontal spatial separation between pumps/chiller and the instruments rack is greater than 20 feet. In addition, the fuel pool cooling pumps are located within the fuel pool cooling room which is surrounded by concrete walls.

3. <u>Transient Combustible Fire Hazard Analysis</u>

Based on limited quantities of transient combustibles and fire suppression systems, any fire caused by transients will be limited in size. The resultant fire is defined to be a cylindrical area of influence with a radius of 5 feet and a height of 10 feet. Therefore, a transient combustible fire will only disable two of the four nuclear boiler instrument racks, 2C004 and 2C224, or 2C225 and 2C005, or 2C225 and 2C004. This will insure that either Rack 2C004 or 2C005 will always be operable and one division of nuclear boiler ECCS interlock components will be available to insure safe shutdown. Also, one division of nuclear boiler vessel wide range pressure and level instrumentation will be available.

The main concern is a fire that disables one division's components and the opposite division's cables. Since required Division I safe shutdown raceways will be protected in Fire Zone 2-5A-N, loss of Division II components and Division I cables is not probable. However, it is possible for a fire to disable Division I components and Division II cables. Therefore, all Division II safe shutdown raceways in the area around Rack 2C004, which contains the Division I components, defined by:

- Height of 10 feet,
- On the north by the fuel pool cooling room wall,
- On the east by a line 10 feet from the east end of Rack 2C004,
- On the south by the containment wall, and
- On the west by a line 14 feet from the west end of Rack 2C004,

have been protected by a one-hour fire-rated wrap.

4. Effects of Sprinklers

The actuation of the sprinkler system will not disable any safe shutdown nuclear boiler instrumentation.

From the justification above, it can be concluded that there is no fire (in-situ or transient) in Fire Zone 2-5A-N that will prevent achieving and maintaining cold shutdown. Therefore, it is concluded that the current configuration provides an equivalent degree of safety as that required by Section III.G.2.b of Appendix R.

SSES-FPRR

TABLE DR28-1

UNIT 2 SAFE SHUTDOWN NUCLEAR BOILER INSTRUMENTS

Instrument Number	Description	Area	Elev.	Safe Shutdown Path	Fire Zone	Required Path	Rack	
*LIS-B21-2N024A	Level Indicating	33	749'	1	2-5A-N	1	2C004	
LIS-B21-2N024C	RPS and RCIC	30	749'	3	2-5A-N	1	2C005	1
*LIS-B21-2N024B	Level Indicating	33	749'	1	2-5A-N	1	2C004	1
LIS-B21-2N024D	Switch for RPS	30	749'	3	2-5A-N	1	2C005	
	and HPCI							
*LIS-B21-2N031A	Level Indicating	33	749'	1	2-5A-N	1	2C004	
LIS-B21-2N031B	CS, HPCI and RHR	30	749'	3	2-5A-N	1	2C005	1
*LIS-B21-2N031C		33	749'	1	2-5A-N	1	2C004	
LIS-B21-2N031D		30	749'	3	2-5A-N	1	2C005	
LIS-B21-2N042A	Level Indicating	33	749'	1, 2	2-5A-N	1	2C004	
LIS-B21-2N042B	Switch for ADS	30	749'	2, 3	2-5A-N	1	2C005	1
*LT-24201A	Wide Range Reactor	30	749'	1	2-5A-N	1	2C225	
LT-24201B	Level	33	749'	3	2-5A-N		2C224	
*PIS-B21-2N021A	Pressure Indicating	33	749'	1	2-5A-N	1	2C004	
PIS-B21-2N021B	Switch for CS and	30	749'	3	2-5A-N	1	2C005	1
	RHC							
*PS-B21-2N023A	Pressure Switch	33	749'	1	2-5A-N	1	2C004	
*PS-B21-2N023B	for RPS	33	749'	1	2-5A-N	1	2C004	
PS-B21-2N023C		30	749'	3	2-5A-N	1	2C005	1
PS-B21-2N023D		30	749'	3	2-5A-N	1	2C005	
*PT-24201A	Wide Range Reactor	30	749'	1	2-5A-N	1	2C225	
PT-24201B	and Pressure	33	749'	3	2-5A-N	1	2C224	

*Denotes the Required Safe Shutdown Components for this Fire Zone.

F0012

SSES-FPRR

TABLE DR28-1

UNIT 2 SAFE SHUTDOWN
NUCLEAR BOILER INSTRUMENTS

Instrument Number	Description	Area	Elev.	Safe Shutdown Path	Fire Zone	Required Path	Rack
TB2C004-A1	Terminal box	33	749'	1	2-5A-N	1	2C004
TB2C004-A2	Terminal box	33	749'	1	2-5A-N	1	2C004
TB2C004-B1	Terminal box	33	749'	1	2-5A-N	1	2C004
TB2C004-B2	Terminal box	33	749'	1	2-5A-N	1	2C004
TB2C005-A1	Terminal box	30	749'	3	2-5A-N	1	2C005
TB2C005-A3	Terminal box	30	749'	3	2-5A-N	1	2C005
TB2C005-B1	Terminal box	30	749'	3	2-5A-N	1	2C005
TB2C005-B2	Terminal box	30	749'	3	2-5A-N	1	2C005

1

F0012