Tennessee Valley Authority, Post Office Box 2000, Decatur, Alabama 35609-2000

O. J. "Ike" Zeringue
Vice President, Browns Ferry Nuclear Plant

APR 14 1993

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-259
Tennessee Valley Authority	)	50-260
		50-296

BROWNS FERRY NUCLEAR PLANT (BFN) - GENERIC LETTER (GL) 92-08 - THERMO-LAG 330-1 FIRE BARRIERS

References:
1. TVA letter to NRC dated September 30, 1992, "Response to NRC Bulletin 92-01, Supplement 1, Failure of Thermo-Lag Fire Barrier System to Perform Its Specified Fire Endurance Function, Sequoyah Nuclear Plant (SQN) and Browns Ferry Nuclear Plant (BFN)"

2. TVA letter to NRC dated July 31, 1992, "Response to NRC Bulletin 92-01, 'Failure of Thermo-Lag 330 Fire Barrier System to Maintain Cabling in Wide Cable Trays and Small Conduits Free From Fire Damage' - Sequoyah Nuclear Plant (SQN) and Browns Ferry Nuclear Plant (BFN)"

This letter is being issued in response to NRC Generic Letter 92-08. In this letter TVA provides information concerning qualification of the Thermo-Lag 330-1 fire barrier, ampacity derating factors used by BFN, and the qualification of the Thermo-Lag installations at BFN. Enclosure 1 of this letter provides a detailed response to each of the requested reporting requirements.

As a result of the Staff concerns over the qualification of the Thermo-Lag 330-1 fire barrier systems, BFN has initiated modifications that will allow BFN to comply with Section III.G of Appendix R without the use of Thermo-Lag 330-1 fire barrier systems. TVA intends to have these modifications implemented prior to Unit 2 Cycle 7 operation.

9304190319 930414
PDR ADOCK 05000259
P PDR

A029 1/1

Additionally, in Enclosure 2 TVA requests an exemption from 10 CFR 50, Appendix R requirements for Residual Heat Removal Service Water (RHRSW) system power cables installed at the Intake Pump Station at BFN.

Finally, Enclosure 3 provides engineering evaluation as described by Generic Letter 86-10, Fire Protection Requirements, for separation of redundant RHRSW pump power cables in Turbine Building in accordance with 10 CFR 50, Appendix R requirements.

Please direct questions concerning this issue to Pedro Salas at (205) 729-2636.

Sincerely,

O. J. Zeringue

Enclosures
cc (Enclosures):

Mr. Thierry Ross, Senior Project Manager
U.S. Nuclear Regulatory Commission
One White Flint, North
11555 Rockville Pike
Rockville, Maryland 20852

NRC Resident Inspector
Browns Ferry Nuclear Plant
Route 12, P.O. Box 637
Athens, Alabama 35609

U.S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

ENCLOSURE 1

BROWNS FERRY NUCLEAR PLANT (BFN)

RESPONSE TO NRC GENERIC LETTER (GL) 92-08,

THERMO-LAG 330-1 FIRE BARRIERS

GENERIC LETTER (GL) 92-08 (THERMO-LAG 330-1 FIRE BARRIERS)

The following is in response to NRC reporting requirements specified in GL 92-08.

Each required reporting item from GL 92-08 is provided below with corresponding responses.

1. State whether Thermo-Lag 330-1 barriers are relied upon (a) to meet 10 CFR 50.48, to achieve physical independence of electrical systems, (b) to meet a condition of a plant's operating license, or (c) to satisfy a licensing commitment. If applicable, state that Thermo-Lag 330-1 is not used at the facility. This GL applies to all 1-hour and all 3-hour Thermo-Lag 330-1 materials and barrier systems assembled by any assembly method such as by assembling preformed panels and conduit shapes, as well as spray, trowel and brush-on applications.

   Item 1 Response:

   (a) Thermo-Lag 330-1 barriers have been installed at BFN and are relied upon to meet nuclear power plant fire protection requirements for electrical systems as specified in 10 CFR 50.48. The material has been used to achieve compliance with 10 CFR 50 Appendix R, Section III.G requirements for BFN Unit 2. As described in item 3a (below), limited amounts of Thermo-Lag 330-1 barriers are installed on Units 1 and 3, to support Unit 2 Appendix R requirements.

   (b) Thermo-Lag 330-1 barriers are not relied upon to meet a condition of a plant's operating license, nor do they satisfy a licensing commitment.

   (c) Thermo-Lag 330-1 barriers are not installed to satisfy a licensing commitment.

2. If Thermo-Lag 330-1 barriers are used at the facility,

   (a) State whether or not the licensee has qualified the Thermo-Lag 330-1 fire barriers by conducting fire endurance tests in accordance with the NRC's requirements and guidance or licensing commitments.

   Item 2.(a) Response:

   Prior to installation at BFN, TVA did not qualify the Thermo-Lag 330-1 fire barriers by conducting independent fire endurance tests in accordance with the NRC's requirements and guidance or licensing commitments. TVA procured the vendors acceptance test as part of the Thermo-Lag fire barrier system contract. At the time of installation, TVA believed that the barriers had been qualified to existing NRC requirements and guidance. The NRC requirements for test performance, acceptance, and comparison of tested to installed configurations has evolved over time. Recently provided Nuclear Management and Resource Council (NUMARC) information indicates that many early fire endurance test results were based on cable temperature rather than cold side barrier temperature, as discussed in GL 86-10. Depending on the time the test was used to qualify a particular barrier, this may have been acceptable. There was no requirement for the licensees to "conduct" qualification testing of the fire barriers.

2. (b) State (1) whether or not the fire barrier configurations installed in the plant represent the materials, workmanship, methods of assembly, dimensions, and configurations of the qualification test assembly configurations; and (2) whether or not the licensee has evaluated any deviations from the tested configurations.

Item 2.(b) Response:

As stated in response to Item 2.(a), TVA did not conduct fire endurance testing of the Thermo-Lag 330-1 fire barrier configurations, but relied upon furnished Thermal Science Incorporated (TSI) test report data for the qualification of the Thermo-Lag 330-1 fire barrier systems that were installed at BFN. Therefore, the qualification of the fire barrier systems installed at BFN, to achieve 10 CFR 50 Appendix R compliance, is based on TSI performed fire endurance tests. To our knowledge, the pre-shaped Thermo-Lag 330-1 fire barrier systems for individual conduits installed in the plant do represent the materials, workmanship, methods of assembly, dimensions, and configurations of the qualification test assembly. However, Thermo-Lag fire barriers installed on some junction boxes may not represent the dimensional configuration of tested assemblies. Also, Thermo-Lag fire barriers for multiple conduit assemblies (i.e., conduits collectively wrapped or boxed in) may not represent the configuration of tested assemblies. BFN has not evaluated any deviations from tested configurations.

2. (c) State (1) whether or not the as-built Thermo-Lag 330-1 barrier configurations are consistent with the barrier configurations used during the ampacity derating tests relied upon by the licensee for the ampacity derating factors used for all raceways protected by Thermo-Lag 330-1 (for fire protection of safe shutdown capability or to achieve physical independence of electrical systems) and (2) whether or not the ampacity derating test results relied upon by the licensee are correct and applicable to the plant design.

BFN Item 2.(c) Response:

TVA did not conduct ampacity derating testing of the Thermo-Lag 330-1 fire barrier configurations, but relied upon furnished TSI test report data for the qualification of the Thermo-Lag 330-1 fire barrier systems that were installed at BFN. Therefore, the qualification of the fire barrier systems installed at BFN to achieve 10 CFR 50 Appendix R compliance, is based on TSI performed ampacity derating tests. However, the corrective actions identified in response to question 3 below will eliminate the use of Thermo-Lag 330-1 as a fire barrier system for 10 CFR 50 Appendix R compliance and thus eliminate the need for ampacity analysis on these circuits.

3. With respect to any answer to items 2(a), 2(b), or 2(c) above in the negative, (a) describe all corrective actions needed and include a schedule by which such actions shall be completed and (b) describe all compensatory measures taken in accordance with the technical specifications or administrative controls. When corrective actions have been completed, confirm in writing their completion.

BFN Item 3(a) Response:

The following is a list of conduits/junction boxes (JBs) and compartmentation features where Thermo-Lag protection is provided. Corresponding to each item, the proposed corrective action has been listed.

I. CONDUITS

CONDUIT	LOCATION	CONDUIT SIZE	CORRECTIVE ACTION
2ES3033-II	U2 Reactor Building EL565	1 Inch	Circuit modification to replace existing emergency open switch to avoid reliance on the seal-in circuit eliminated the need for Thermo-Lag. (Design Change Notice (DCN) W20653).
2ES3045-II	U2 Reactor Building EL565	1 Inch	Conduits were wrapped to meet the 18" rule in association with 2ES3033-II. Need for fire wrap has been eliminated.
2ES3047-II	U2 Reactor Building EL565	1 Inch	Conduits were wrapped to meet the 18" rule in association with 2ES3033-II. Need for fire wrap has been eliminated.
2ES3034-II	U2 Reactor Building EL565	1 Inch	Conduits were wrapped to meet the 18" rule in association with 2ES3033-II. Need for fire wrap has been eliminated.
2B290-IID	U2 Reactor Building EL593 and EL593 Electrical Board Room	1.5 Inch	Circuit modification to install isolation fuses in the 250V DC control power normal remote indicating light circuit on 480V Shutdown Board 2B to eliminate the need for Thermo-Lag. (DCN W20660)

I. CONDUITS (continued)

CONDUIT	LOCATION	CONDUIT SIZE	CORRECTIVE ACTION
2ES173-I	U2 Reactor Building EL593 and EL593 Board Room	1.5 Inch	Based on analysis contained in associated circuit low impedance calculation ED-Q2999-880675, this conduit is acceptable without the requirement of Thermo-Lag. (DCN S20656)
2PC931-I	U2 Reactor Building EL593	1.5 Inch	Conduit is being rerouted outside the fire zone to meet Appendix R III.G.2b separation requirements. (DCN W20655)
2ES3906-II	U2 Reactor Building EL593	1.5 Inch	Conduit is being rerouted outside the fire zone to meet Appendix R III.G.2b separation requirements. (DCN W20653)
1B284-IIC	U2 Reactor Building EL621	2 Inch	Conduit located in Unit 1 Reactor Building and is not required to be wrapped for Unit 2 Appendix R compliance. Therefore, no corrective measures are warranted.
2PC2450-I	U2 Reactor Building EL593	2 Inch	Conduit is being rerouted outside the fire zone to meet Appendix R III.G.2b separation requirements. (DCN W20661)
2ES3907-II	U2 Reactor Building EL565	2 Inch	Circuit modification eliminates the emergency open function as required by this cable/conduit. New cable/conduit 2ES5691-II now has this function and is routed outside fire zone to meet Appendix R III.G.2b separation requirements. (DCN W20653)
2B284-IB	U2 Reactor Building EL621 and Shutdown Board Room 2A	2 Inch	Conduit is being rerouted outside the fire zone to meet Appendix R III.G.2b separation requirements. (DCN W20654)

I. CONDUITS (continued)

CONDUIT	LOCATION	CONDUIT SIZE	CORRECTIVE ACTION
2PC918-I	U2 Reactor Building EL593	2 Inch	Cable 2PC945-I is routed in conduits 2PC931-I and 2PC918-I. 2PC931-I was rerouted out of fire zone. (DCN W20655). 2PC918-I was inadvertently included only by association. Hence, no further corrective actions are required.
2ES3046-II	U1 & 2 Reactor Building EL565	2.5 Inch	Conduit was wrapped to meet 18" rule in association with 2ES3033. Need for fire wrap has been eliminated.
2PL5250-II	U2 Shutdown Board Room EL593	2.5 Inch	Based on analysis contained in calculation ED-Q2999-920327, this conduit is acceptable without the requirement of Thermo-Lag (DCN S20656). Hence, no further corrective actions are required.
2ES141-I	U2 Shutdown Board Room EL593	3 Inch	Based on analysis contained in calculation ED-Q2999-880675, this conduit is acceptable without the requirements of Thermo-Lag (DCN S20656). Hence, no further corrective actions are required.
2ES215-I	U2 Shutdown Board Room EL593	3 Inch	Based on analysis contained in associated circuit low impedance calculation ED-Q2999-880675, this conduit is acceptable without the requirement of Thermo-Lag. (DCN S20656)
2PL451-II	U2 Shutdown Board Room EL621	3 Inch	Conduit is being rerouted outside the fire zone to meet Appendix R III.G.2b separation requirements. (DCN W20657)

I. CONDUITS (continued)

CONDUIT	LOCATION	CONDUIT SIZE	CORRECTIVE ACTION
2PL453-II	U2 Shutdown Board Room EL621	3 Inch	Conduit is being rerouted outside the fire zone to meet Appendix R III.G.2b separation requirements. (DCN W20657)
2ES3235-II	U2 Reactor Building EL565	3 Inch	Based on analysis contained in associated circuit low impedance calculation ED-Q2999-880675, this conduit is acceptable without the requirement of Thermo-Lag. (DCN S20656)
3ES225-I	U3 Shutdown Board Room EL593	3 Inch	Based on analysis contained in associated circuit low impedance calculation ED-Q2999-880675, this conduit is acceptable without the requirement of Thermo-Lag.
ES75-I ES88-I ES100-I ES113-I 3ES1580-I 3ES1590-I	Intake Pump Station EL550	3 Inch	Exemption Request for lack of 20' separation between redundant trains is being submitted. It was concluded in the engineering evaluation that a fire affecting one division of the shutdown circuits will not cause damage to its redundant division. This conclusion was reached by utilizing a multi-compartment computer fire model (HAZARD I). It was also demonstrated that sprinkler heads in the area will actuate prior to target damage. Therefore, Thermo-Lag fire wrap is not required in this area.
2B76-B2S	U2 Reactor Building EL565	4 Inch	Conduit being rerouted outside the fire zone to meet Appendix R III.G.2b separation requirements. (DCN W20658)
2B80-B3S	U2 Reactor Building EL565	4 Inch	Conduit being rerouted outside the fire zone to meet Appendix R III.G.2b separation requirements. (DCN W20659)

II. JUNCTION BOXES AND COMPARTMENTATION

(a) JB3208/Associated Circuits	Required cables being rerouted outside the fire zone. JBs no longer needed to be wrapped.
JB1177/Associated Circuits	Required cables being rerouted outside the fire zone. JBs no longer needed to be wrapped.
JB6113/Associated Circuits	Required cables being rerouted outside the fire zone. JBs no longer needed to be wrapped.
JB2132/Associated Circuits	Required cables being rerouted outside the fire zone. JBs no longer needed to be wrapped.
(b) Compartmentation (Internal Conduit Seals) Flexible Conduit Protection U1 Reactor Building EL593 and Shutdown Board Room B U1 Reactor Building EL621 and Shutdown Board Room A (No Thermo-Lag in this area) U2 Reactor Building EL593 and Shutdown Board Room D U2 Reactor Building EL621 and Shutdown Board Room C U3 Reactor Building EL593 and Shutdown Board Room F U3 Reactor Building EL621 and Shutdown Board Room E	<u>Background</u>: The above listed conduits and JBs were protected by Thermo-Lag to meet Appendix R III.G.2b separation requirements, i.e., these conduits (cables) are required to remain operable for a fire in the area. In addition to the above described Thermo-Lag installations, in some cases small lengths (2 to 5 feet) of flexible conduits have also been protected with Thermo-Lag; however, these conduits are not required to remain operable for a fire in the area. The fire wrapping was done to maintain the integrity of the flex conduit such that the internal conduit seal will satisfactorily withstand exposure to a fire event. <u>Corrective Action:</u> Calculation MD-N0026-920544 evaluated the necessity of Thermo-Lag fire wrap protection for small lengths of flexible conduits. It was concluded that Thermo-Lag was not required to maintain the integrity of the flexible conduit and that the internal conduit seals were adequate to prevent the passage of fire, smoke, or hot gases. Therefore, Thermo-Lag fire wrap is no longer required.

II. JUNCTION BOXES AND COMPARTMENTATION (continued)

(c) Conduit Pull Box Cover (Radwaste Pipe Tunnel)

Background:
Conduit pull box covers were fire wrapped with 3-hour Thermo-Lag to provide separation between redundant trains in accordance with Appendix R III.G.2(a) requirements. However, the fire would have to travel approximately 400 feet to damage redundant safe shutdown circuit.

Corrective Action:
An engineering evaluation per GL 86-10 has been performed. It concluded that lack of complete 3-hour fire barrier between redundant circuits is adequately compensated by the substantial separation (400 feet) and numerous fire travel path obstacles. Therefore, fire wrap for conduit pull box covers is not required.

Schedule of Corrective Action

(1) Corrective actions: identified in response to question no. 3.	All corrective actions will be completed prior to restart of Unit 2 from its current outage (Unit 2 Cycle 6).
(2) Exemption Request: for Intake Pump Station.	See Enclosure 2
(3) Engineering Evaluation: for Pipe Tunnel Conduit Pull Box Covers	Enclosure 3

BFN Item 3.(b) Response:

Fire watches were posted in all areas where Thermo-Lag fire barrier systems were installed. See our response to NRC Bulletin 92-01, Supplement 1.

4. List all Thermo-Lag 330-1 barriers for which answers to item 2 cannot be provided in the response due within 120 days from the date of this generic letter, and include a schedule by which such answers shall be provided.

4. Response:

None.

ENCLOSURE 2

BROWNS FERRY NUCLEAR PLANT (BFN)

RESPONSE TO NRC GENERIC LETTER (GL) 92-08,

THERMO-LAG 330-1 FIRE BARRIERS

(EXEMPTION REQUEST)

ENGINEERING EVALUATION

IMPACT OF FIRE IN THE INTAKE PUMP STATION
ON
REDUNDANT SAFE SHUTDOWN CAPABILITY OF RHRSW SYSTEM

PROBLEM:

10CFR50 Appendix R, Section III.G.2.b requires that cables and equipment of redundant safe shutdown trains be separated from each other by 20 or more feet of space with no intervening combustibles. It also requires that automatic suppression and detection be provided in the area. Contrary to this requirement RHRSW safe shutdown circuits located in the Intake Pump Station are not separated by 20 or more feet. Automatic suppression and detection is however provided in the area.

OBJECTIVE:

The purpose of this analysis is to show the impact of a fire in the Intake Pump Station (IPS) on RHRSW pumps safe shutdown circuits. The analysis will show that a fire affecting one division of the RHRSW pump circuits will not cause damage to its redundant division.

REFERENCES:

1. EPRI TR-100370, Fire Induced Vulnerability Evaluation (FIVE) Methodology, April 1992.

2. EPRI NP-7332, Design Guide for Fire Protection of Grouped Cables, May 1991.

3. EPRI TR-100443, Methods for Quantitative Fire Hazards Analysis, May 1992.

4. NUREG/CR-3192, SAND83-0306- Investigation of 20 foot Separation Distance as a Fire Protection method as Specified in 10CFR50, Appendix R, October 1983.

5. NUREG/CR-5384, SAND89-1359, A Summary Of Nuclear Power Plant Fire Research at Sandia National Laboratories, 1975-1987

6. SFPE Handbook of Fire Protection Engineering. First Ed.

7. "HAZARD I" Fire Assessment Method, Version 1.1 National Institute of Standards and Technology.

8. Generic Letter 86-10, Implementation of Fire Protection Requirements, April 1986.

9. Calculation MD-N0026-910163, BFN Combustible Load tables.

10. "FPETOOL", Computerized package of fire hazard evaluation, National Institute of Standards and Technology.

11. Tewarson and Khan, Electrical cables- Evaluation of Fire Propagation Behavior, FM Research Corp, 1989.

ASSUMPTIONS:

1. Cable trays are the only significant combustibles in the area where redundant RHRSW circuits are located. Another combustible source is the lube oil associated with the CCW pump discharge valves which is fully sealed and will not be considered as an exposed combustible. Administrative controls are in place to remove the risk of transient combustibles fire. Therefore cable tray fire is the only fire that needs to be considered.

2. No credit is being taken for the current THERMOLAG fire wrap protection of division I RHRSW conduits. THERMOLAG will be left in place or removed pending completion of ongoing tests regarding its combustibility and cable derating factors.

ANALYSIS:

The analysis for a fire in the Intake Pump Station is organized as follows:

1. Description of the area

2. Cable damage criteria

3. Type of fire

4. Consequences of a fire

   (A) Fire screening methodology (FIVE-Conservative, neglects fire growth).

   (B) HAZARD I, Multi compartment fire growth model.

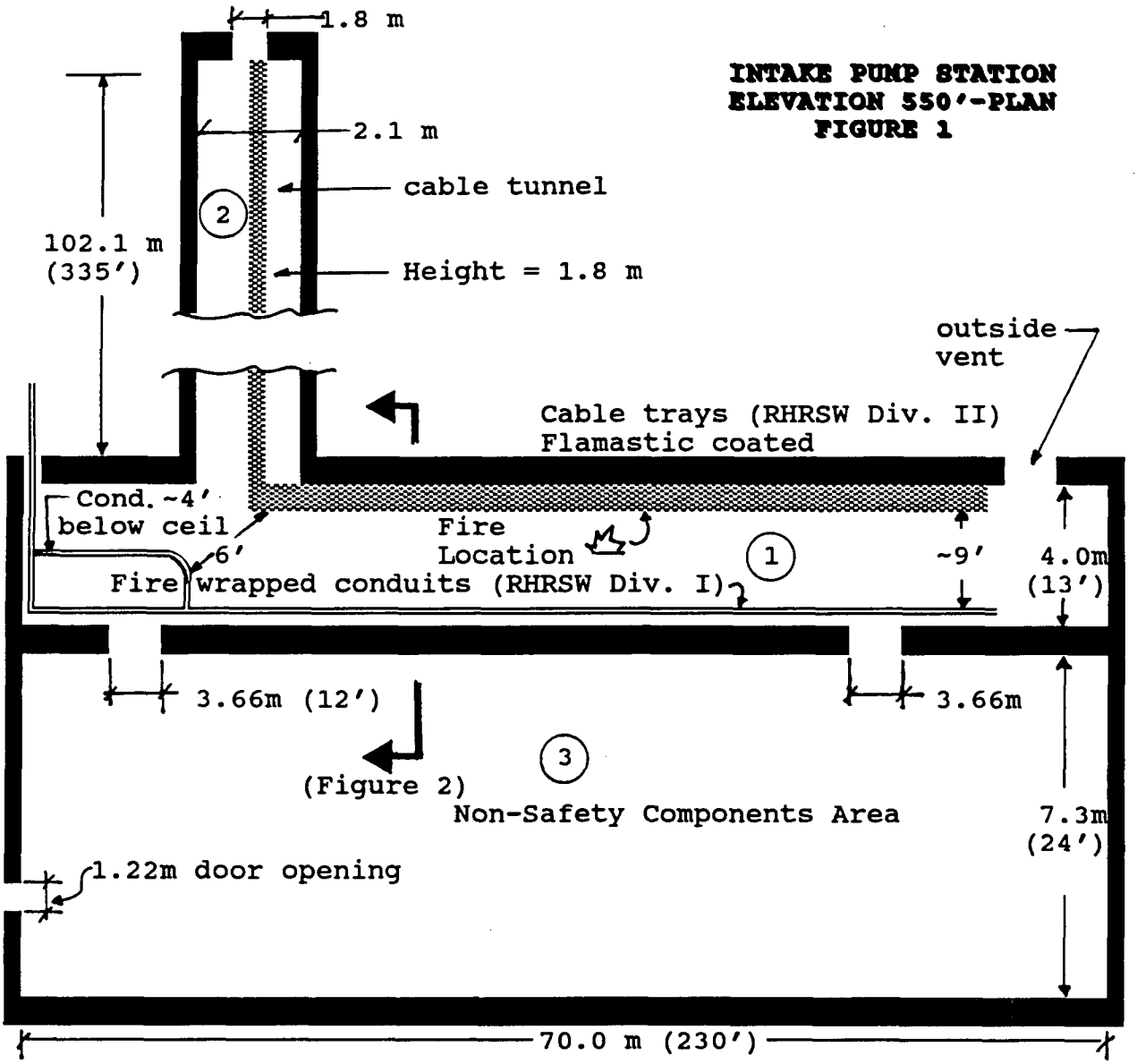
   (C) Response of smoke detector and sprinkler head activation.
   Appendix - Sprinkler head and smoke detector response using FPETOOL.

5. Conclusion.

   Attachment 1 - HAZARD I Fire Model Output
   Attachment 2 - FPETOOL, Sprinkler Head Actuation Output
   Attachment 3 - FPETOOL, Smoke Detector Actuation Output

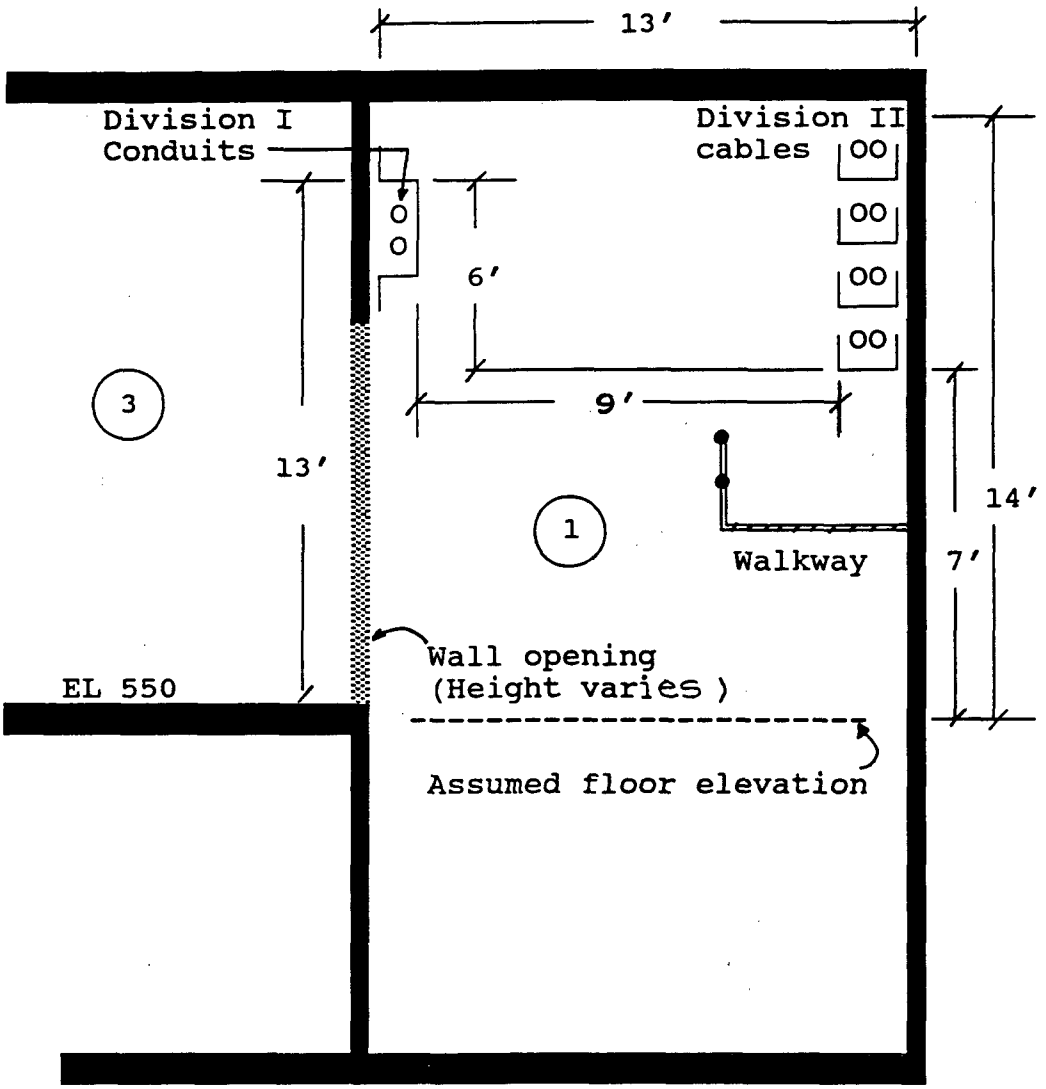
Description of the Area:

The following sketch shows the layout of elevation 550 of the IPS. RHRSW Division II circuits are located in cable trays, running along the north wall. Division I circuits are in conduits and are located approximately 10 feet from the cable trays. Cables in cable trays are coated with "Flamastic" and conduits are fire wrapped with "Thermolag". Air supervised preaction sprinkler system is provided in this area (Shown as Area 1). Photoelectric smoke detectors are provided on EL 550 (Areas 1 & 3) and linear beam detectors are provided in the cable tunnel (Area 2). The detection system is a microprocessor based addressable Class A system with local and main control room annunciation.



Note: All dimensions are approximate. Figure is not to scale

INTAKE PUMP STATION
ELEVATION 550' - SECTION
FIGURE 2



Note: All dimensions are approximate
Figure not to scale

2. CABLE DAMAGE CRITERIA:

The power cables for the RHRSW pumps in the IPS are cross-linked polyethylene insulation (XLPE), polyvinyl-chloride jacket (PVC). The conductor size is 2/0 awg (3-1/c). These cables are qualified for vertical flame test in accordance with IPCEA S-19-81, section 6.19.6.

Appendix R states that the redundant safety system shall be "free of fire damage". Therefore the temperatures and heat fluxes at which cable damage occurs need to be identified. The exposure fire can then be analysed and resulting heat flux and temperatures can be compared to the cable damage criteria.

Several small scale cable burn tests were done by Factory Mutual (Reference 11) which determined the critical heat flux for cables. The results have also been summarized in Reference 2, Table 3.2. The critical heat flux for various cables ranges from 10 to 30 kW/sq. m. However, the predominant values are between 15 to 25 kW/sq. m. UL tests performed in a radiant heat facility (Reference 4) indicates the critical heat flux to be ~8kW/sq. m for non-qualified cable (piloted ignition) and ~22 kW/sq. m for non-qualified cable (non-piloted ignition). Reference 11 also concluded that for most insulation and jacketing materials, the fire propagation index decreases with increase in overall cable diameters. The cables being analysed are classified as large cables. Based on the above review a conservative critical heat flux value can be selected as 10 kW/sq. m or 0.9 BTU/sec/sq ft.

Research conducted by FMRC and sponsored by EPRI addressed quantifying cable ignitability in terms of auto ignition temperatures. This is summarized in Table 3.1 of Reference 2. The worst auto ignition temperature for the non-qualified PE/PVC cable was 789 ^{0}K or 960 ^{0}F. A conservative critical temperature of 700 ^{0}F will be selected to account for circuit failures prior to auto ignition.

Critical flux = 0.9 BTU/sec/sq ft (10 kW/sq m)
Critical Temperature = 700 deg ^{0}F (371 ^{0}C)

3. TYPE OF FIRE:

For purposes of this analysis the fire is assumed to occur in the RHRSW division II cable trays (area 1, figure 1). Since the cable trays are coated with Flamastic, the most likely type of fire will be small and self extinguishing. However, a much worse fire will be considered which would be most likely initiated by an external source.

The type of fire was determined using an equation developed by B.T. Lee in a study conducted in 1985. This research indicates that the peak full scale heat release rate ($\dot{q}fs$) can be predicted according to bench scale measurements

$$\dot{q}fs = 0.45 \cdot \dot{q}bs'' \cdot A \quad \text{(Reference 6 Section 2-1)}$$

where the bench scale heat release value ($\dot{q}bs''$) is the peak measured under irradiance conditions of 60 kW/sq m, and A is the exposed tray area actively pyrolyzing. The active pyrolysis area is estimated based on the type of cable and its bench scale heat release rate which can be obtained from Figure 2-1.18 (Reference 6), which gives dA/dt as a function of $\dot{q}bs''$. Thus at any given time t,

$$A(t) = A + dA/dt \cdot t$$

Using a conservative number 350 kW/sq m for the bench scale heat release rate and 0.75 sq m/min rate of flame coverage (Obtained from Ref. 6 Figure 2-1.18), the following fire growth was generated:

TIME (sec)	AREA (sq m)	HEAT RELEASE (kW)
0	0.00	0
60	0.75	118
120	1.50	236
180	2.25	354
240	3.00	472
300	3.75	590
360	4.50	708
420	5.25	827
480	6.00	945
540	6.75	1063
600	7.50	1181
660	8.25	1299
720	9.00	1417
780	9.75	1535
840	10.50	1653
900	11.25	1772
960	12.00	1890
1020	12.75	2008
1800	22.50	3540

The above fire growth information will be used as input data in the "HAZARD I" fire model. For a constant heat release rate evaluation, select 1181 kW or 1125 Btu/sec as the representative heat release rate. This heat release rate corresponds to approximately 7.5 sq m (81 sq ft) or approximately 54′ length of a 18" wide cable tray burning.

4. CONSEQUENCES OF A FIRE:

A) Fire Screening Methodology

This screening methodology will permit the preliminary evaluation of the IPS with respect to its fire potential. It is intended to permit conservative estimates to be made of the environmental conditions that could develop at the target as a result of a specified fire scenario. These estimated environmental conditions are then compared with target damage threshold criteria. For screening purposes temperature and heat flux criteria are used. If the estimated maximum environmental condition does not exceed the damage threshold criteria, then it can be concluded that the redundant RHRSW circuits will remain free of fire damage. The methodology is extracted from "Fire Induced Vulnerability Evaluation" (Reference 1).

See Figures 1 and 2 for location of the potential fire source (division II cable trays) and the target (division I conduits). This fire scenario corresponds to the target being outside plume and subjected to the effects of a ceiling jet sublayer.

Following is an evaluation of target outside plume scenario:

Area Geometry: (See Figure 1 and 2)

Height of target above fire source $Z = 6'$
(value selected represents target being closer to ceiling, thus is conservative)

Height from fire source to ceiling $H = 7'$
Longitudinal distance from the source to target $L = 9'$
Ratio of Z & H, $Z/H = 6/7 = 0.85$
(Ratio is > 0.85. Hence target would be subjected to ceiling jet sublayer effects which will yield higher ceiling temperatures.)

Note that Figure 1 shows a small section of a conduit is approximately 6′ from the redundant cables. However it is located well below the ceiling and will not be affected by the ceiling jet temperature affects.

Enclosure width $W_{ENCL} = 13'$
Enclosure length $L_{ENCL} = 230'$

Calculation:

Heat Release Rate $\dot{q}$ = 1125 Btu/sec (From type of fire)

Fire Location Factor = 2 (Since the fire is against wall)

Effective Heat release Rate ($\dot{q}_{eff}$) = 1125 x 2 = 2250 Btu/sec

a) Temperature rise determination at target:

Plume temperature rise at ceiling: (Equation 9, Ref. 1)

$$\Delta T(^{o}F) = 340 Q_{eff}^{2/3}(Btu/sec) / H_{ceil}^{5/3}(ft)$$

$$= 340 \frac{(2250)^{2/3}}{7^{5/3}}$$

$$= 2324\ ^{0}F \quad \text{or } 1600\ ^{0}F \text{ maximum}$$

Max. temp rise is set at 1600 °F (Table 5E, Ref. 1)
(Also see Reference 3, Section 7.1.1)

Ceiling jet temperature rise factor:
(unconfined ceiling) (Equation 10, Ref. 1)

$$\Delta T_{cj}/\Delta T_{pl} ceil = 0.3/(L/H)^{2/3}$$

$$= 0.3/(9/7)^{2/3}$$

$$= 0.25$$

(Confined ceiling jet factors are approximately the same as unconfined ceiling jet factors. Table 6B Reference 1)

Ceiling jet temperature rise at target:

$$T_{cj,Target} = 1600 \times 0.25 = 400\ ^{0}F$$

Therefore ceiling jet temperature at the target
= 400 + 90 = 490 ^{0}F

Hence the temperature at the target (conduits) will be below its damage threshold.

b) <u>Critical radial distance determination:</u>

Critical flux for cable $\dot{q}''_{crit}$ = 0.9 Btu/sec/sq. ft
Heat release rate $\dot{q}$ = 1125 Btu/sec
Radiant fraction = 0.4 (Reference - 1)
(Typically 20 to 40% of total heat release rate in fires is radiative, with the remainder being convective. 40% will be selected as a conservative value.)
Radiant heat release rate $\dot{q}_R$ = Peak heat release rate x Radiant fraction
= 1125 x 0.4
= 450 Btu/sec

Critical radial distance $R_{crit} = \sqrt{\dot{q}_R / 4\pi \dot{q}''_{crit}}$
(Equation 16, Reference 1)
$= \sqrt{\frac{450}{4\pi \times 0.9}} = 6.3'$

Actual distance between source and target is 9'
(Note that one conduit located 6' from the cable trays will not be subjected to the full impact of the radiant heat. For approximately 1/4th heat release rate, the critical distance is 3').

c) <u>Total heat flux at target:</u>

Radiant heat release rate $\dot{q}_R$ = 450 Btu/sec
Radiant heat flux $\dot{q}''_R = \dot{q}_R / 4\pi R^2$
(Eq. 17, Ref. 1)

Where R is radial distance from exposure fire to target
$\dot{q}_R''$ = $450/4\pi(9)^2$
= 0.44 Btu/sec/ft^2

Convective heat flux $\dot{q}_c''$ = $0.3 \frac{\dot{q}_{eff}}{Z^2} x 0.13/(R/Z)^{1/3}$

Where Z is target height above fire source (Equation 18 & 19 Reference 1)
$\dot{q}_c''$ = 0.3 x $2250/6^2$ x $0.13/(9/6)^{1/3}$
= 9 (Max value) x 0.11
(per Table A-4E, Ref 1)
= 0.99 Btu/sec/ft^2
Total heat flux at the target = $\dot{q}_R'' + \dot{q}_c''$ = 0.44 + 0.99
= 1.4 Btu/sec/sq ft
Critical heat flux at cable = 0.9 Btu/sec/sq ft

The calculated heat flux values based on conservative approach are higher than the critical heat flux. Detailed analysis using "HAZARD 1" fire model will however show that the resulting heat fluxes at the target are substantially lower.

B) **HAZARD I, multi compartment fire growth model:**

The Intake Pump Station (IPS) has been modeled as a three compartment configuration. See Figure 1 for details. Compartment # 1 is where redundant circuits are located. Compartment # 2 is the cable tunnel having single train of safe shutdown circuits. Compartment # 3 houses the fire pumps and other non-safety equipment. Vertical vents in compartment # 1 have been modeled as horizontal slits near the ceiling. Openings between compartment 1 & 3 have been combined into two openings. Outside vents from compartment 2 & 3 have been modeled as closed doors with undercuts. Sills and soffits have been taken into account.

The fire source is the cable trays. Fire growth (heat release rate) has been calculated as described in "Type of Fire". This information will be used as input to the program. Heat of combustion is 12000 Btu/lb (Reference 9). Oxygen limiting index has been chosen as 12% (HAZARD I guide).

Three separate computer runs have been made by varying the length of the fire compartment and/or fuel height. Since the fire compartment is long and narrow (230' long and 13' wide), the possibility of non-uniform conditions may exist in an actual fire situation (note that the program considers uniform flux and temperatures throughout the upper hot gas layer and lower colder layer). A reduced length (using 100' instead of 230') will yield more conservative results. The fuel height was also varied to account for various level of cable trays.

The results are tabulated on the following sheet. For Case 1 and Case 2 the heat flux and temperature conditions in the upper hot gas layer remain well below the damage threshold of the cables. For Case 3, the temperature and heat flux conditions momentarily reach damage threshold but quickly decline due to lack of oxygen to sustain combustion. Therefore, a fire in the IPS is not likely to cause damage to redundant RHRSW circuits.

Attachment 1 include the computer runs for the 3 analysed cases.

SUMMARY OF RESULTS
(Fire Compartment # 1)

TIME (SEC)	CASE 1 LENGTH = 230′ FUEL HT. = 7′		CASE 2 LENGTH = 100′ FUEL HT. = 7′		CASE 3 LENGTH = 100′ FUEL HT. = 10′	
	TEMP	HEAT FLUX	TEMP	HEAT FLUX	TEMP	HEAT FLUX
	°K	kW/m²	°K	kW/m²	°K	kW/m²
0	305	0	305	0	305	0
240	376	0.6	426	1.4	439	1.6
480	421	1.3	502	3.1	519	3.6
720	461	2.1	540	4.3	581	5.9
960	494	2.9	535	4.1	631	8.5
1200	509	3.3	551	4.7	661	11.0
1440	507	3.2	475	2.4	606	7.1
1680	509	3.3	477	2.4	517	3.6
1800	511	3.4	-	-	482	2.6

$^0F = (^0K-273)9/5 + 32$

Btu/sec/sq. ft = kW/m^2 x 0.088055

Critical Temperature = 700 ^0F (644 ^0K)
Critical Heat Flux = 0.9 Btu/sec/ft^2 (10 kW/m^2)

C) **Potential for critical damage of cables(target) and response time of smoke detector and sprinkler head**

The IPS EL 550 is protected with an area wide photo-electric smoke detection system. The detection system is a Class A (Style 6 and Z per NFPA 72), microprocessor based addressable system. Upon detection of smoke in the vicinity of RHRSW power cables, the preaction system is automatically activated.

The following transient response method permits conservative estimates of the time to critical damage of targets exposed to supercritical environmental conditions. It also permits estimation of actuation of thermally responsive fire detection devices, such as automatic sprinklers. The estimated target damage time can then be compared with the expected response time of suppression systems to evaluate the potential for critical damage of target.

Time for target damage:
Evaluation of the targets thermal response requires data regarding the thermal properties exposed to the imposed heat flux conditions. For semi-infinite solids, a parameter for the thermal response of the surface is needed. This is called the thermal response parameter (TRP) and is expressed as:

$$TRP=\sqrt{k\rho c_p}(T_d-T_0)$$

Thermal Response Parameter (TRP) for the cables being evaluated is chosen from Table A-7E (Reference 1) to be 30 $(Btu/sec/ft^2)s^{1/2}$ which is the value for the largest PVC/PVC cable (.51"). (Note that the TRP for RHRSW cables will be much higher since its cable diameter is 1.2").
Time to target damage (td): (Reference 3, Eq. 9, Appendix A)

$$(t_d)=\frac{\pi}{4}(TRP/q_{total})^2$$

$$= \pi/4(30/.9)^2 = 872 \text{ seconds}$$

Response time for sprinkler head:
Sprinkler head temperature rating $(T_{spr}) = 212\ ^0F$
$(T_{amb}) = 90\ ^0F$
Detection device rated temp. rise $= T_{spr} - T_{amb}$
$dT_{det} = 212 - 90 = 122\ ^0F$
Gas temperature rise at ceiling $= 1600\ ^0F$ (see page 9)
Gas temperature rise factor at sprinkler head
$(dT_{gas})_{factor} = 0.3/(r/H)^{2/3}$
$= 0.3/(6/7)^{2/3}$
$= 0.33$

Where r =Radial distance from fire source to sprinkler head. Sprinkler heads are spaced ~6′ apart and are located ~3′ from the cable trays. Select 6 ft as a conservative radial distance.

H = Distance from source to ceiling (ft)

dT_{GAS} (at sprinkler head) = $dT_{GAS,CEILING}$ x $(dT_{GAS})_{FACTOR}$

= 1600 X 0.33
= 528 ^0F

dT_{DET} / dT_{GAS} = 122/528
= 0.23

Dimensionless actuation time of sprinkler (t/τ)
(Eq. 21, Reference 1)

$$\frac{t}{\tau} = -\ln(1 - dT_{det}/dT_{gas})$$

$$= -\ln(1-0.23)$$
$$= 0.26$$

Time constant for solder type of sprinkler head
τ = ~100 sec (Table A-6E, Reference 1)

Estimated time for sprinkler actuation (T_{ACT})
T_{ACT} = t/τ x Time constant
= .26 x 100 = 26 seconds

Therefore, target damage will occur in 872 sec. however, sprinkler head will activate prior to target damage.

APPENDIX

Calculation of sprinkler head response time using FPETOOL (Reference 10) and comparison with calculated values

Using the DETACT portion of FPETOOL, which calculates sprinkler head response time based on defining the sprinkler location with respect to the fire source, its thermal parameters and fire growth. Response Time Index (RTI) for the sprinkler was chosen to be a conservative 700 (English Units). The RTI of a standard sprinkler head varies from 200 to 700.

The response time of the sprinkler (Detector) was calculated to be 394 seconds (Attachment 2). The increased duration over earlier calculation (26 seconds) can be attributed to the slow fire growth considerations as opposed to a larger constant heat release rate fire.

Smoke detector response time using FPETOOL:

Smoke detector actuation can also be predicted based on postulated temperature rise due to a fire. For PVC cables fire source, a temperature rise of 13 ^{0}F (7 ^{0}C) is considered to cause detector activation (Reference NBS-GCR-77-95). Per reference 3, section A.2.1.1, a temperature rise of 20 ^{0}F will cause smoke detector actuation. Using a temperature rise of 20 ^{0}F and defining additional parameters i.e. room dimensions, vents etc. the smoke detector response time is calculated to be 42 seconds by the Fire Simulator portion of FPETOOL (Reference 10), Attachment 3. Note that the sprinkler head actuated at 350 seconds which is not significantly different from that calculated by DETACT program (394 seconds).

5.0 Conclusion:

For a postulated fire in the IPS, analysis has been performed to show that the environmental conditions (temperature and heat flux) in the area will not be significant enough to cause damage to the redundant safe shutdown circuits.

The initial screening using a conservative methodology demonstrated that area temperatures remain well below cable damage threshold, whereas the heat flux was slightly above critical conditions. Subsequently, a detailed multi-compartment analysis (HAZARD 1 fire model) was performed taking into account the fire growth rate of the cable trays. No credit was taken for the Thermo-Lag fire wrap or automatic sprinklers. Temperature and heat flux conditions were demonstrated to be below the damage threshold.

Additional analysis was performed to take credit for the automatic sprinklers. It was demonstrated that the sprinklers will activate well before the redundant cables reach their damage threshold.

ATTACHMENT - 1 CASE - 1

FAST version 18.5.2 - created May 1, 1990 INTAKE PUMP STATION
(SEE FIGURE 1 FOR AREA DESIGNATIONS)

Total compartments = 3

FLOOR PLAN

	AREA 1	AREA 2	AREA 3
Width	70.1	2.1	70.1
Depth	4.0	102.1	7.3
Height	4.3	1.8	4.3
Area	280.4	217.5	512.4
Volume	1205.7	398.0	2203.5
Ceiling	4.3	1.8	4.3
Floor	0.0	0.0	0.0

FUEL HT - 7'

NORMAL CONNECTIONS (OPENINGS, DOORS & VENTS)

					OUTSIDE
1 (1)	Width	0.00	2.13	0.00	0.00
	Soffit	0.00	1.83	0.00	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	1.83	0.00	0.00
	a.Sill	0.00	0.00	0.00	0.00
1 (2)	Width	0.00	0.00	3.66	0.00
	Soffit	0.00	0.00	3.70	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	0.00	3.70	0.00
	a.Sill	0.00	0.00	0.00	0.00
1 (3)	Width	0.00	0.00	3.66	0.00
	Soffit	0.00	0.00	3.70	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	0.00	3.70	0.00
	a.Sill	0.00	0.00	0.00	0.00
1 (4)	Width	0.00	0.00	0.00	0.91
	Soffit	0.00	0.00	0.00	4.26
	Sill	0.00	0.00	0.00	3.66
	a.Soffit	0.00	0.00	0.00	4.26
	a.Sill	0.00	0.00	0.00	3.66
2 (1)	Width	2.13	0.00	0.00	1.83
	Soffit	1.83	0.00	0.00	1.52
	Sill	0.00	0.00	0.00	1.37
	a.Soffit	1.83	0.00	0.00	1.52
	a.Sill	0.00	0.00	0.00	1.37
3 (1)	Width	0.00	0.00	0.00	1.22
	Soffit	0.00	0.00	0.00	0.15
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	0.00	0.00	0.15
	a.Sill	0.00	0.00	0.00	0.00
3 (2)	Width	3.66	0.00	0.00	0.00
	Soffit	3.70	0.00	0.00	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	3.70	0.00	0.00	0.00
	a.Sill	0.00	0.00	0.00	0.00
3 (3)	Width	3.66	0.00	0.00	0.00
	Soffit	3.70	0.00	0.00	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	3.70	0.00	0.00	0.00
	a.Sill	0.00	0.00	0.00	0.00

THERE ARE NO FAN CONNECTIONC

Material names

Ceiling:	CONCRETE	CONCRETE	CONCRETE
Walls:	CONCRETE	CONCRETE	CONCRETE
Floor:	CONCRETE	CONCRETE	CONCRETE

Thermal data base used: THERMAL.TPF

Name	Conductivity	Specific heat	Density	Thickness	Emissivity
CONCRETE	1.75 (.0003 Btu/sec-ft-°F)	1.000E+03 (0.24 Btu/lb°F)	2.200E+03 (137 lb/ft³)	0.150 6"	0.940

Compartment of origin is	1
Print interval (seconds)	120
Number of fire specification intervals is	10
Total time (seconds)	1800
Fire position	2
Limiting oxygen index (%) =	12.0
Initial relative humidity (%) =	0.0

Fire type is a SPECIFIED (CONSTRAINED)

Pyrolysis temperature (K) =	300.
Ambient air temperature (K) =	305.
Ambient reference pressure (Pa) =	101300.
Reference elevation (m) =	0.
External ambient temperature (K) =	300.
External reference pressure (Pa) =	101300.
Reference elevation (m) =	0.

See Note

1 *Fmass=	0.00	8.40E-03	1.69E-02	2.54E-02	3.39E-02	4.23E-02	5.08E-0
2 *Hcomb=	2.79E+07	2.81E+07	2.79E+07	2.79E+07	2.79E+07	2.79E+07	2.80E+0
3 *Fqdot=	0.00	2.36E+05	4.72E+05	7.08E+05	9.45E+05	1.18E+06	1.42E+0
Fhigh=	2.1	2.1	2.1	2.1	2.1	2.1	2.1
C/CO2=	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO/CO2=	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H/C=	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Ftime=	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+0

Dump file = IPS.DMP

*1. PYROLYSIS - Kg/sec - CALCULATED
2. HEAT OF COMBUSTION - Joules/kg (12000 Btu/lb..) User input.
3. HEAT RELEASE - Joul/sec. User input.

Time = 0.0 seconds.

Upper temp(K)	305.0	305.0	305.0	
Lower temp(K)	305.0	305.0	305.0	300.0
Upper vol(m**3)	1.2	0.4	2.2	
Layer depth(m)	0.0	0.0	0.0	
Ceiling temp(K)	305.0	305.0	305.0	
Up wall temp(K)	305.0	305.0	305.0	
Low wall temp(K)	305.0	305.0	305.0	
Floor temp(K)	305.0	305.0	305.0	

Plume flow(kg/s)	0.000E+00	0.000E+00	0.000E+00
Pyrol rate(kg/s)	0.000E+00	0.000E+00	0.000E+00

Note: Data for additional time frames did not print, but is included in the output sheets

Fire size(W)	0.000E+00	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
On target(W/m^2)	0.000E+00	0.000E+00	0.000E+00	
Pressure(Pa)	0.000E+00	0.000E+00	0.000E+00	

Time = 120.0 seconds.

Upper temp(K)	347.9	305.0	305.0	
Lower temp(K)	305.0	305.0	305.0	300.0
Upper vol(m**3)	53.8	0.4	2.2	
Layer depth(m)	0.2	0.0	0.0	
Ceiling temp(K)	306.5	305.0	305.0	
Up wall temp(K)	306.2	305.0	305.0	
Low wall temp(K)	305.2	305.0	305.0	
Floor temp(K)	305.2	305.0	305.0	
Plume flow(kg/s)	6.051E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	8.400E-03	0.000E+00	0.000E+00	
Fire size(W)	2.360E+05	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	2.360E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
On target(W/m^2)	3.381E+02	0.000E+00	0.000E+00	
Pressure(Pa)	-2.510E-01	-2.582E-01	-2.468E-01	

Time = 240.0 seconds.

Upper temp(K)	376.2	305.0	305.0	
Lower temp(K)	305.0	305.0	305.0	300.0
Upper vol(m**3)	130.9	1.0	2.3	
Layer depth(m)	0.5	0.0	0.0	
Ceiling temp(K)	309.5	305.0	305.0	
Up wall temp(K)	308.3	305.0	305.0	
Low wall temp(K)	305.5	305.0	305.0	
Floor temp(K)	305.5	305.0	305.0	
Plume flow(kg/s)	8.161E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.690E-02	0.000E+00	0.000E+00	
Fire size(W)	4.720E+05	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	4.720E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
On target(W/m^2)	6.411E+02	0.000E+00	0.000E+00	
Pressure(Pa)	-2.013E-01	-2.087E-01	-1.914E-01	

Time = 360.0 seconds.

Upper temp(K)	399.9	305.0	306.1	
Lower temp(K)	305.1	305.0	305.0	300.0
Upper vol(m**3)	199.8	1.1	11.1	
Layer depth(m)	0.7	0.0	0.0	
Ceiling temp(K)	313.0	305.0	305.0	
Up wall temp(K)	311.1	305.0	305.0	
Low wall temp(K)	306.0	305.0	305.0	
Floor temp(K)	306.0	305.0	305.0	

Plume flow(kg/s)	9.068E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	2.540E-02	0.000E+00	0.000E+00	
Fire size(W)	7.080E+05	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	7.080E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
On target(W/m^2)	9.544E+02	0.000E+00	7.085E+00	
Pressure(Pa)	-4.376E-01	-4.015E-01	-4.005E-01	

Time = 480.0 seconds.

Upper temp(K)	421.4	305.0	311.8	
Lower temp(K)	305.6	304.9	305.0	300.0
Upper vol(m**3)	235.7	1.1	104.9	
Layer depth(m)	0.8	0.0	0.2	
Ceiling temp(K)	317.1	305.0	305.2	
Up wall temp(K)	314.2	305.0	305.1	
Low wall temp(K)	306.7	305.0	305.0	
Floor temp(K)	306.7	305.0	305.0	
Plume flow(kg/s)	1.071E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	3.390E-02	0.000E+00	0.000E+00	
Fire size(W)	9.450E+05	0.000E+00	1.766E-02	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	9.450E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	1.766E-02	2.210E-02
On target(W/m^2)	1.291E+03	0.000E+00	4.467E+01	
Pressure(Pa)	-8.120E-01	-7.273E-01	-7.105E-01	

Time = 600.0 seconds.

Upper temp(K)	441.9	305.0	316.3	
Lower temp(K)	305.8	304.8	305.0	300.0
Upper vol(m**3)	246.7	1.1	247.0	
Layer depth(m)	0.9	0.0	0.5	
Ceiling temp(K)	321.6	305.0	305.5	
Up wall temp(K)	317.7	305.0	305.4	
Low wall temp(K)	307.4	305.0	305.1	
Floor temp(K)	307.4	305.0	305.1	
Plume flow(kg/s)	1.239E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	4.230E-02	0.000E+00	0.000E+00	
Fire size(W)	1.180E+06	0.000E+00	3.102E-02	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.180E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	3.102E-02	2.542E-02
On target(W/m^2)	1.663E+03	0.000E+00	7.643E+01	
Pressure(Pa)	-1.058E+00	-9.438E-01	-9.218E-01	

Time = 720.0 seconds.

Upper temp(K)	461.2	305.0	319.7	
Lower temp(K)	306.1	304.7	304.9	300.0
Upper vol(m**3)	254.3	1.0	373.5	
Layer depth(m)	0.9	0.0	0.7	
Ceiling temp(K)	326.5	305.0	305.8	

Up wall temp(K)	32[illegible].6	305.0	305.6	
Low wall temp(K)	308.4	305.0	305.2	
Floor temp(K)	308.3	305.0	305.2	
Plume flow(kg/s)	1.399E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	5.080E-02	0.000E+00	0.000E+00	
Fire size(W)	1.420E+06	0.000E+00	3.169E-02	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.420E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	3.169E-02	2.392E-02
On target(W/m^2)	2.064E+03	0.000E+00	1.008E+02	
Pressure(Pa)	-1.172E+00	-1.041E+00	-1.017E+00	

Time = 840.0 seconds.

Upper temp(K)	478.6	305.0	323.4	
Lower temp(K)	306.5	304.6	304.9	300.0
Upper vol(m**3)	259.1	1.0	480.6	
Layer depth(m)	0.9	0.0	0.9	
Ceiling temp(K)	331.6	305.0	306.2	
Up wall temp(K)	325.8	305.0	305.9	
Low wall temp(K)	309.4	305.0	305.2	
Floor temp(K)	309.4	305.0	305.2	
Plume flow(kg/s)	1.545E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	5.930E-02	0.000E+00	0.000E+00	
Fire size(W)	1.650E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.650E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.213E-02
On target(W/m^2)	2.471E+03	0.000E+00	1.288E+02	
Pressure(Pa)	-1.263E+00	-1.116E+00	-1.079E+00	

Time = 960.0 seconds.

Upper temp(K)	494.9	305.0	325.9	
Lower temp(K)	306.9	304.5	304.9	300.0
Upper vol(m**3)	269.5	1.0	592.1	
Layer depth(m)	1.0	0.0	1.2	
Ceiling temp(K)	337.0	305.0	306.7	
Up wall temp(K)	330.2	305.0	306.3	
Low wall temp(K)	310.5	305.0	305.3	
Floor temp(K)	310.5	305.0	305.3	
Plume flow(kg/s)	1.679E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	6.800E-02	0.000E+00	0.000E+00	
Fire size(W)	1.900E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.900E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.270E-02
On target(W/m^2)	2.895E+03	0.000E+00	1.486E+02	
Pressure(Pa)	-1.284E+00	-1.124E+00	-1.073E+00	

Time = 1080.0 seconds.

Upper temp(K)	502.4	305.0	328.8	
Lower temp(K)	307.5	304.4	304.9	300.0

Upper vol(m**3)	287.2	1.1	710.0	
Layer depth(m)	1.0	0.0	1.4	
Ceiling temp(K)	342.0	305.0	307.1	
Up wall temp(K)	334.4	305.0	306.6	
Low wall temp(K)	311.7	305.0	305.4	
Floor temp(K)	311.7	305.0	305.4	
Plume flow(kg/s)	1.714E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	7.330E-02	0.000E+00	0.000E+00	
Fire size(W)	2.050E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	2.050E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	4.051E-02
On target(W/m^2)	3.106E+03	0.000E+00	1.712E+02	
Pressure(Pa)	-1.312E+00	-1.133E+00	-1.071E+00	

Time = 1200.0 seconds.

Upper temp(K)	508.8	305.0	333.9	
Lower temp(K)	308.2	304.4	305.0	300.0
Upper vol(m**3)	321.6	1.9	841.8	
Layer depth(m)	1.1	0.0	1.6	
Ceiling temp(K)	346.5	305.0	307.7	
Up wall temp(K)	338.2	305.0	307.0	
Low wall temp(K)	312.9	305.0	305.6	
Floor temp(K)	312.8	305.0	305.6	
Plume flow(kg/s)	1.746E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	8.233E-02	0.000E+00	0.000E+00	
Fire size(W)	2.302E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	2.083E-01	0.000E+00	0.000E+00	
Plume in ll(W)	2.302E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	3.519E-02
On target(W/m^2)	3.291E+03	0.000E+00	2.133E+02	
Pressure(Pa)	-1.095E+00	-9.209E-01	-8.215E-01	

Time = 1320.0 seconds.

Upper temp(K)	509.3	305.1	342.2	
Lower temp(K)	308.8	304.4	305.1	300.0
Upper vol(m**3)	379.1	5.5	995.5	
Layer depth(m)	1.4	0.0	1.9	
Ceiling temp(K)	350.4	305.0	308.5	
Up wall temp(K)	341.4	305.0	307.7	
Low wall temp(K)	314.0	305.0	305.8	
Floor temp(K)	313.9	305.0	305.8	
Plume flow(kg/s)	1.654E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	9.137E-02	0.000E+00	0.000E+00	
Fire size(W)	2.554E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	2.554E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.704E-02
On target(W/m^2)	3.307E+03	0.000E+00	2.854E+02	
Pressure(Pa)	-7.438E-01	-5.821E-01	-4.372E-01	

Time = 1440.0 seconds.

Upper temp(K)	506.9	305.2	352.4	
Lower temp(K)	309.5	304.5	305.2	300.0
Upper vol(m**3)	457.6	13.0	1168.4	
Layer depth(m)	1.6	0.1	2.3	
Ceiling temp(K)	353.4	305.0	309.7	
Up wall temp(K)	344.0	305.0	308.6	
Low wall temp(K)	315.1	305.0	306.1	
Floor temp(K)	315.0	305.0	306.0	
Plume flow(kg/s)	1.390E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.004E-01	0.000E+00	0.000E+00	
Fire size(W)	2.806E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	2.806E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	1.620E-02
On target(W/m^2)	3.235E+03	1.346E+00	3.813E+02	
Pressure(Pa)	-3.939E-01	-2.363E-01	-5.716E-02	

Time = 1560.0 seconds.

Upper temp(K)	506.0	305.3	362.2	
Lower temp(K)	310.1	304.6	305.4	300.0
Upper vol(m**3)	542.5	23.0	1342.4	
Layer depth(m)	1.9	0.1	2.6	
Ceiling temp(K)	356.0	305.0	311.2	
Up wall temp(K)	346.2	305.0	309.7	
Low wall temp(K)	316.1	305.0	306.5	
Floor temp(K)	316.0	305.0	306.4	
Plume flow(kg/s)	9.187E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.094E-01	0.000E+00	0.000E+00	
Fire size(W)	3.057E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	6.152E+05	0.000E+00	0.000E+00	
Plume in ll(W)	2.442E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	1.065E-02
On target(W/m^2)	3.208E+03	1.738E+00	4.829E+02	
Pressure(Pa)	-2.463E-01	-7.623E-02	1.152E-01	

Time = 1680.0 seconds.

Upper temp(K)	509.5	305.3	370.7	
Lower temp(K)	310.8	304.7	305.7	300.0
Upper vol(m**3)	614.2	33.5	1493.7	
Layer depth(m)	2.2	0.2	2.9	
Ceiling temp(K)	358.6	305.0	312.8	
Up wall temp(K)	348.5	305.0	310.9	
Low wall temp(K)	317.4	305.0	306.9	
Floor temp(K)	317.2	305.0	306.9	
Plume flow(kg/s)	1.185E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.185E-01	0.000E+00	0.000E+00	
Fire size(W)	3.309E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	3.309E+06	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	1.130E-02
On target(W/m^2)	3.313E+03	1.853E+00	5.765E+02	
Pressure(Pa)	-5.075E-01	-3.001E-01	-1.470E-01	

Time = 1800.0 seconds.

Upper temp(K)	511.0	305.3	377.9	
Lower temp(K)	311.7	304.7	306.0	300.0
Upper vol(m**3)	686.7	43.5	1624.7	
Layer depth(m)	2.4	0.2	3.2	
Ceiling temp(K)	361.2	305.0	314.5	
Up wall temp(K)	350.8	305.0	312.2	
Low wall temp(K)	318.7	305.0	307.5	
Floor temp(K)	318.6	305.0	307.5	
Plume flow(kg/s)	1.275E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.275E-01	0.000E+00	0.000E+00	
Fire size(W)	3.560E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	3.560E+06	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	1.107E-02
On target(W/m^2)	3.356E+03	2.044E+00	6.619E+02	
Pressure(Pa)	-8.849E-01	-6.359E-01	-4.756E-01	

CASE- 2

FAST version 18.5.2 - created May 1, 1990 INTAKE PUMP STATION

Total compartments = 3

FLOOR PLAN

Width	30.0	2.1	30.0
Depth	4.0	102.1	7.3
Height	4.3	1.8	4.3
Area	120.0	217.5	219.3
Volume	516.0	398.0	943.0
Ceiling	4.3	1.8	4.3
Floor	0.0	0.0	0.0

NORMAL CONNECTIONS

1 (1)	Width	0.00	2.13	0.00	0.00
	Soffit	0.00	1.83	0.00	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	1.83	0.00	0.00
	a.Sill	0.00	0.00	0.00	0.00
1 (2)	Width	0.00	0.00	3.66	0.00
	Soffit	0.00	0.00	3.70	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	0.00	3.70	0.00
	a.Sill	0.00	0.00	0.00	0.00
1 (3)	Width	0.00	0.00	3.66	0.00
	Soffit	0.00	0.00	3.70	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	0.00	3.70	0.00
	a.Sill	0.00	0.00	0.00	0.00
1 (4)	Width	0.00	0.00	0.00	0.91
	Soffit	0.00	0.00	0.00	4.26
	Sill	0.00	0.00	0.00	3.66
	a.Soffit	0.00	0.00	0.00	4.26
	a.Sill	0.00	0.00	0.00	3.66
2 (1)	Width	2.13	0.00	0.00	1.83
	Soffit	1.83	0.00	0.00	1.52
	Sill	0.00	0.00	0.00	1.37
	a.Soffit	1.83	0.00	0.00	1.52
	a.Sill	0.00	0.00	0.00	1.37
3 (1)	Width	0.00	0.00	0.00	1.22
	Soffit	0.00	0.00	0.00	0.15
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	0.00	0.00	0.15
	a.Sill	0.00	0.00	0.00	0.00
3 (2)	Width	3.66	0.00	0.00	0.00
	Soffit	3.70	0.00	0.00	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	3.70	0.00	0.00	0.00
	a.Sill	0.00	0.00	0.00	0.00
3 (3)	Width	3.66	0.00	0.00	0.00
	Soffit	3.70	0.00	0.00	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	3.70	0.00	0.00	0.00
	a.Sill	0.00	0.00	0.00	0.00

THERE ARE NO FAN CONNECTIONC

Material names

Ceiling:	CONCRETE	CONCRETE	CONCRETE
Walls:	CONCRETE	CONCRETE	CONCRETE
Floor:	CONCRETE	CONCRETE	CONCRETE

Thermal data base used: THERMAL.TPF

Name	Conductivity	Specific heat	Density	Thickness	Emissivity
CONCRETE	1.75	1.000E+03	2.200E+03	0.150	0.940

Compartment of origin is	1
Print interval (seconds)	120
Number of fire specification intervals is	10
Total time (seconds)	1800
Fire position	2
Limiting oxygen index (%) =	12.0
Initial relative humidity (%) =	0.0

Fire type is a SPECIFIED (CONSTRAINED)

Pyrolysis temperature (K) =	300.
Ambient air temperature (K) =	305.
Ambient reference pressure (Pa) =	101300.
Reference elevation (m) =	0.
External ambient temperature (K) =	300.
External reference pressure (Pa) =	101300.
Reference elevation (m) =	0.

Fmass=	0.00	8.40E-03	1.69E-02	2.54E-02	3.39E-02	4.23E-02	5.08E-0
Hcomb=	2.79E+07	2.81E+07	2.79E+07	2.79E+07	2.79E+07	2.79E+07	2.80E+0
Fqdot=	0.00	2.36E+05	4.72E+05	7.08E+05	9.45E+05	1.18E+06	1.42E+0
Fhigh=	2.1	2.1	2.1	2.1	2.1	2.1	2.1
C/CO2=	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO/CO2=	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H/C=	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Ftime=	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+0

Dump file = IPS.DMP

Time = 0.0 seconds.

Upper temp(K)	305.0	305.0	305.0	
Lower temp(K)	305.0	305.0	305.0	300.0
Upper vol(m**3)	0.5	0.4	0.9	
Layer depth(m)	0.0	0.0	0.0	
Ceiling temp(K)	305.0	305.0	305.0	
Up wall temp(K)	305.0	305.0	305.0	
Low wall temp(K)	305.0	305.0	305.0	
Floor temp(K)	305.0	305.0	305.0	

Plume flow(kg/s)	0.000E+00	0.000E+00	0.000E+00
Pyrol rate(kg/s)	0.000E+00	0.000E+00	0.000E+00

Fire size(W)	0.000E+00	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
On target(W/m^2)	0.000E+00	0.000E+00	0.000E+00	
Pressure(Pa)	0.000E+00	0.000E+00	0.000E+00	

Time = 120.0 seconds.

Upper temp(K)	378.9	305.0	305.0	
Lower temp(K)	305.0	305.0	305.0	300.0
Upper vol(m**3)	47.2	0.4	0.9	
Layer depth(m)	0.4	0.0	0.0	
Ceiling temp(K)	308.1	305.0	305.0	
Up wall temp(K)	307.3	305.0	305.0	
Low wall temp(K)	305.3	305.0	305.0	
Floor temp(K)	305.3	305.0	305.0	
Plume flow(kg/s)	5.457E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	8.400E-03	0.000E+00	0.000E+00	
Fire size(W)	2.360E+05	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	2.360E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
On target(W/m^2)	6.749E+02	0.000E+00	0.000E+00	
Pressure(Pa)	-2.910E-01	-2.820E-01	-2.790E-01	

Time = 240.0 seconds.

Upper temp(K)	426.4	305.0	309.2	
Lower temp(K)	305.1	305.0	305.0	300.0
Upper vol(m**3)	87.9	0.4	13.6	
Layer depth(m)	0.7	0.0	0.1	
Ceiling temp(K)	313.8	305.0	305.0	
Up wall temp(K)	311.6	305.0	305.0	
Low wall temp(K)	306.1	305.0	305.0	
Floor temp(K)	306.1	305.0	305.0	
Plume flow(kg/s)	6.863E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.690E-02	0.000E+00	0.000E+00	
Fire size(W)	4.720E+05	0.000E+00	3.105E-03	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	4.720E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	3.105E-03	1.300E-02
On target(W/m^2)	1.377E+03	0.000E+00	2.769E+01	
Pressure(Pa)	-7.840E-01	-7.023E-01	-7.339E-01	

Time = 360.0 seconds.

Upper temp(K)	467.7	305.0	320.0	
Lower temp(K)	305.4	304.8	304.9	300.0
Upper vol(m**3)	96.4	0.4	97.8	
Layer depth(m)	0.8	0.0	0.4	
Ceiling temp(K)	321.0	305.0	305.5	
Up wall temp(K)	317.3	305.0	305.4	
Low wall temp(K)	307.2	305.0	305.1	
Floor temp(K)	307.2	305.0	305.1	

Plume flow(kg/s)	8.609E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	2.540E-02	0.000E+00	0.000E+00	
Fire size(W)	7.080E+05	0.000E+00	1.253E-02	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	7.080E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	1.253E-02	1.630E-02
On target(W/m^2)	2.210E+03	0.000E+00	1.031E+02	
Pressure(Pa)	-1.178E+00	-1.058E+00	-1.081E+00	

Time = 480.0 seconds.

Upper temp(K)	502.1	305.0	328.2	
Lower temp(K)	305.8	304.7	304.8	300.0
Upper vol(m**3)	100.6	0.4	168.3	
Layer depth(m)	0.8	0.0	0.8	
Ceiling temp(K)	329.2	305.0	306.2	
Up wall temp(K)	323.9	305.0	305.9	
Low wall temp(K)	308.7	305.0	305.2	
Floor temp(K)	308.7	305.0	305.2	
Plume flow(kg/s)	1.047E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	3.390E-02	0.000E+00	0.000E+00	
Fire size(W)	9.450E+05	0.000E+00	1.501E-02	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	9.450E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	1.501E-02	1.623E-02
On target(W/m^2)	3.097E+03	0.000E+00	1.661E+02	
Pressure(Pa)	-1.303E+00	-1.164E+00	-1.177E+00	

Time = 600.0 seconds.

Upper temp(K)	529.8	305.0	334.8	
Lower temp(K)	306.3	304.6	304.8	300.0
Upper vol(m**3)	107.3	0.4	234.6	
Layer depth(m)	0.9	0.0	1.1	
Ceiling temp(K)	337.9	305.0	307.0	
Up wall temp(K)	331.1	305.0	306.5	
Low wall temp(K)	310.5	305.0	305.4	
Floor temp(K)	310.5	305.0	305.4	
Plume flow(kg/s)	1.198E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	4.230E-02	0.000E+00	0.000E+00	
Fire size(W)	1.180E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.180E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.638E-02
On target(W/m^2)	3.954E+03	0.000E+00	2.207E+02	
Pressure(Pa)	-1.371E+00	-1.217E+00	-1.210E+00	

Time = 720.0 seconds.

Upper temp(K)	540.0	305.0	346.1	
Lower temp(K)	307.1	304.5	304.8	300.0
Upper vol(m**3)	127.6	0.4	311.2	
Layer depth(m)	1.1	0.0	1.4	
Ceiling temp(K)	345.8	305.0	308.1	

Up wall temp(K)	337.7	305.0	307.3	
Low wall temp(K)	312.3	305.0	305.6	
Floor temp(K)	312.3	305.0	305.6	
Plume flow(kg/s)	1.260E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	5.080E-02	0.000E+00	0.000E+00	
Fire size(W)	1.420E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.420E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.519E-02
On target(W/m^2)	4.309E+03	0.000E+00	3.209E+02	
Pressure(Pa)	-1.230E+00	-1.072E+00	-1.028E+00	

Time = 840.0 seconds.

Upper temp(K)	535.2	305.0	365.9	
Lower temp(K)	307.9	304.4	305.1	300.0
Upper vol(m**3)	166.8	1.1	401.9	
Layer depth(m)	1.4	0.0	1.8	
Ceiling temp(K)	351.4	305.0	310.0	
Up wall temp(K)	342.5	305.0	308.7	
Low wall temp(K)	313.9	305.0	306.0	
Floor temp(K)	313.8	305.0	305.9	
Plume flow(kg/s)	1.141E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	5.930E-02	0.000E+00	0.000E+00	
Fire size(W)	1.650E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.650E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.731E-02
On target(W/m^2)	4.138E+03	0.000E+00	5.233E+02	
Pressure(Pa)	-1.023E+00	-8.595E-01	-7.907E-01	

Time = 960.0 seconds.

Upper temp(K)	535.0	305.0	385.9	
Lower temp(K)	308.7	304.4	305.2	300.0
Upper vol(m**3)	213.0	2.8	495.5	
Layer depth(m)	1.8	0.0	2.3	
Ceiling temp(K)	355.7	305.0	312.6	
Up wall temp(K)	346.2	305.0	310.8	
Low wall temp(K)	315.4	305.0	306.6	
Floor temp(K)	315.3	305.0	306.6	
Plume flow(kg/s)	8.445E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	6.800E-02	0.000E+00	0.000E+00	
Fire size(W)	1.900E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.900E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.712E-02
On target(W/m^2)	4.132E+03	0.000E+00	7.625E+02	
Pressure(Pa)	-1.187E+00	-9.849E-01	-9.363E-01	

Time = 1080.0 seconds.

Upper temp(K)	537.8	305.0	399.8	
Lower temp(K)	309.5	304.4	305.4	300.0

Upper vol(m**3)	245.1	4.0	567.4	
Layer depth(m)	2.1	0.0	2.6	
Ceiling temp(K)	359.8	305.0	315.6	
Up wall temp(K)	349.7	305.0	313.0	
Low wall temp(K)	317.1	305.0	307.4	
Floor temp(K)	316.9	305.0	307.4	
Plume flow(kg/s)	3.927E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	7.330E-02	0.000E+00	0.000E+00	
Fire size(W)	2.050E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	1.086E+06	0.000E+00	0.000E+00	
Plume in ll(W)	9.638E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	5.881E-02
On target(W/m^2)	4.231E+03	0.000E+00	9.528E+02	
Pressure(Pa)	-1.914E+00	-1.632E+00	-1.667E+00	

Time = 1200.0 seconds.

Upper temp(K)	551.5	305.0	411.2	
Lower temp(K)	310.6	304.2	305.7	300.0
Upper vol(m**3)	270.7	4.9	610.7	
Layer depth(m)	2.3	0.0	2.8	
Ceiling temp(K)	364.8	305.0	318.5	
Up wall temp(K)	354.1	305.0	315.3	
Low wall temp(K)	319.1	305.0	308.3	
Floor temp(K)	318.9	305.0	308.3	
Plume flow(kg/s)	8.233E-02	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	8.233E-02	0.000E+00	0.000E+00	
Fire size(W)	2.302E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	2.302E+06	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	1.238E-02	0.000E+00	0.000E+00	3.062E-02
On target(W/m^2)	4.730E+03	0.000E+00	1.124E+03	
Pressure(Pa)	-2.512E+00	-2.171E+00	-2.269E+00	

Time = 1320.0 seconds.

Upper temp(K)	546.3	305.0	419.6	
Lower temp(K)	311.6	304.0	306.2	300.0
Upper vol(m**3)	289.6	6.4	643.0	
Layer depth(m)	2.4	0.0	2.9	
Ceiling temp(K)	369.9	305.0	321.5	
Up wall temp(K)	358.5	305.0	317.7	
Low wall temp(K)	321.3	305.0	309.3	
Floor temp(K)	321.1	305.0	309.2	
Plume flow(kg/s)	9.137E-02	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	9.137E-02	0.000E+00	0.000E+00	
Fire size(W)	2.048E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	2.048E+06	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.973E+04
On target(W/m^2)	4.537E+03	0.000E+00	1.261E+03	
Pressure(Pa)	-3.537E+00	-3.061E+00	-3.314E+00	

Time = 1440.0 seconds.

Upper temp(K)	475.1	305.0	396.5	
Lower temp(K)	312.0	303.7	307.4	300.0
Upper vol(m**3)	280.6	6.5	623.7	
Layer depth(m)	2.3	0.0	2.8	
Ceiling temp(K)	367.4	305.0	322.4	
Up wall temp(K)	356.5	305.0	318.4	
Low wall temp(K)	321.0	305.0	309.7	
Floor temp(K)	320.8	305.0	309.6	
Plume flow(kg/s)	1.004E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.004E-01	0.000E+00	0.000E+00	
Fire size(W)	7.589E+05	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	7.589E+05	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.104E+05
On target(W/m^2)	2.385E+03	0.000E+00	9.055E+02	
Pressure(Pa)	-6.867E+00	-6.264E+00	-6.727E+00	

Time = 1560.0 seconds.

Upper temp(K)	473.7	306.1	380.7	
Lower temp(K)	317.3	303.5	310.5	300.0
Upper vol(m**3)	280.2	23.0	656.1	
Layer depth(m)	2.3	0.1	3.0	
Ceiling temp(K)	363.1	305.0	321.6	
Up wall temp(K)	352.9	305.0	317.8	
Low wall temp(K)	320.1	305.0	309.6	
Floor temp(K)	320.0	305.0	309.6	
Plume flow(kg/s)	1.094E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.094E-01	0.000E+00	0.000E+00	
Fire size(W)	1.422E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	1.422E+06	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	5.773E+05
On target(W/m^2)	2.352E+03	7.103E+00	6.970E+02	
Pressure(Pa)	-3.904E+00	-3.369E+00	-3.590E+00	

Time = 1680.0 seconds.

Upper temp(K)	477.1	312.9	392.8	
Lower temp(K)	313.8	303.6	309.2	300.0
Upper vol(m**3)	320.8	38.1	711.6	
Layer depth(m)	2.7	0.2	3.2	
Ceiling temp(K)	363.6	305.2	322.6	
Up wall temp(K)	353.3	305.1	318.7	
Low wall temp(K)	320.7	305.0	310.1	
Floor temp(K)	320.5	305.0	310.0	
Plume flow(kg/s)	1.185E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.185E-01	0.000E+00	0.000E+00	
Fire size(W)	1.430E+06	2.554E+03	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	1.430E+06	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	2.554E+03	0.000E+00	7.331E+05
On target(W/m^2)	2.435E+03	5.239E+01	8.541E+02	
Pressure(Pa)	-3.332E+00	-2.803E+00	-3.087E+00	

CASE - 3

FAST version 18.5.2 - created May 1, 1990 INTAKE PUMP STATION

Total compartments = 3

FLOOR PLAN

Width	30.0	2.1	30.0
Depth	4.0	102.1	7.3
Height	4.3	1.8	4.3
Area	120.0	217.5	219.3
Volume	516.0	398.0	943.0
Ceiling	4.3	1.8	4.3
Floor	0.0	0.0	0.0

NORMAL CONNECTIONS

1 (1)	Width	0.00	2.13	0.00	0.00
	Soffit	0.00	1.83	0.00	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	1.83	0.00	0.00
	a.Sill	0.00	0.00	0.00	0.00
1 (2)	Width	0.00	0.00	3.66	0.00
	Soffit	0.00	0.00	3.70	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	0.00	3.70	0.00
	a.Sill	0.00	0.00	0.00	0.00
1 (3)	Width	0.00	0.00	3.66	0.00
	Soffit	0.00	0.00	3.70	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	0.00	3.70	0.00
	a.Sill	0.00	0.00	0.00	0.00
1 (4)	Width	0.00	0.00	0.00	0.91
	Soffit	0.00	0.00	0.00	4.26
	Sill	0.00	0.00	0.00	3.66
	a.Soffit	0.00	0.00	0.00	4.26
	a.Sill	0.00	0.00	0.00	3.66
2 (1)	Width	2.13	0.00	0.00	1.83
	Soffit	1.83	0.00	0.00	1.52
	Sill	0.00	0.00	0.00	1.37
	a.Soffit	1.83	0.00	0.00	1.52
	a.Sill	0.00	0.00	0.00	1.37
3 (1)	Width	0.00	0.00	0.00	1.22
	Soffit	0.00	0.00	0.00	0.15
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	0.00	0.00	0.00	0.15
	a.Sill	0.00	0.00	0.00	0.00
3 (2)	Width	3.66	0.00	0.00	0.00
	Soffit	3.70	0.00	0.00	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	3.70	0.00	0.00	0.00
	a.Sill	0.00	0.00	0.00	0.00
3 (3)	Width	3.66	0.00	0.00	0.00
	Soffit	3.70	0.00	0.00	0.00
	Sill	0.00	0.00	0.00	0.00
	a.Soffit	3.70	0.00	0.00	0.00
	a.Sill	0.00	0.00	0.00	0.00

THERE ARE NO FAN CONNECTIONC

Material names

Ceiling:	CONCRETE	CONCRETE	CONCRETE
Walls:	CONCRETE	CONCRETE	CONCRETE
Floor:	CONCRETE	CONCRETE	CONCRETE

Thermal data base used: THERMAL.TPF

Name	Conductivity	Specific heat	Density	Thickness	Emissivity
CONCRETE	1.75	1.000E+03	2.200E+03	0.150	0.940

Compartment of origin is	1
Print interval (seconds)	120
Number of fire specification intervals is	10
Total time (seconds)	1800
Fire position	2
Limiting oxygen index (%) =	12.0
Initial relative humidity (%) =	0.0

Fire type is a SPECIFIED (CONSTRAINED)

Pyrolysis temperature (K) =	300.
Ambient air temperature (K) =	305.
Ambient reference pressure (Pa) =	101300.
Reference elevation (m) =	0.
External ambient temperature (K) =	300.
External reference pressure (Pa) =	101300.
Reference elevation (m) =	0.

Fmass=	0.00	8.40E-03	1.69E-02	2.54E-02	3.39E-02	4.23E-02	5.08E-0
Hcomb=	2.79E+07	2.81E+07	2.79E+07	2.79E+07	2.79E+07	2.79E+07	2.80E+0
Fqdot=	0.00	2.36E+05	4.72E+05	7.08E+05	9.45E+05	1.18E+06	1.42E+0
Fhigh=	3.0	3.0	3.0	3.0	3.0	3.0	3.0
C/CO2=	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO/CO2=	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H/C=	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Ftime=	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+0

Dump file = IPS.DMP

Time = 0.0 seconds.

Upper temp(K)	305.0	305.0	305.0	
Lower temp(K)	305.0	305.0	305.0	300.0
Upper vol(m**3)	0.5	0.4	0.9	
Layer depth(m)	0.0	0.0	0.0	
Ceiling temp(K)	305.0	305.0	305.0	
Up wall temp(K)	305.0	305.0	305.0	
Low wall temp(K)	305.0	305.0	305.0	
Floor temp(K)	305.0	305.0	305.0	

Plume flow(kg/s)	0.000E+00	0.000E+00	0.000E+00
Pyrol rate(kg/s)	0.000E+00	0.000E+00	0.000E+00

Fire size(W)	0.000E+00	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	0.000E+00	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
On target(W/m^2)	0.000E+00	0.000E+00	0.000E+00	
Pressure(Pa)	0.000E+00	0.000E+00	0.000E+00	

Time = 120.0 seconds.

Upper temp(K)	388.4	305.0	305.0	
Lower temp(K)	305.0	305.0	305.0	300.0
Upper vol(m**3)	27.9	0.4	0.9	
Layer depth(m)	0.2	0.0	0.0	
Ceiling temp(K)	308.6	305.0	305.0	
Up wall temp(K)	307.7	305.0	305.0	
Low wall temp(K)	305.4	305.0	305.0	
Floor temp(K)	305.4	305.0	305.0	
Plume flow(kg/s)	3.298E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	8.400E-03	0.000E+00	0.000E+00	
Fire size(W)	2.360E+05	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	2.360E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
On target(W/m^2)	7.948E+02	0.000E+00	0.000E+00	
Pressure(Pa)	-3.063E-01	-3.054E-01	-2.975E-01	

Time = 240.0 seconds.

Upper temp(K)	439.6	305.0	305.0	
Lower temp(K)	305.1	305.0	305.0	300.0
Upper vol(m**3)	60.6	0.4	0.9	
Layer depth(m)	0.5	0.0	0.0	
Ceiling temp(K)	315.1	305.0	305.0	
Up wall temp(K)	312.7	305.0	305.0	
Low wall temp(K)	306.2	305.0	305.0	
Floor temp(K)	306.2	305.0	305.0	
Plume flow(kg/s)	4.566E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.690E-02	0.000E+00	0.000E+00	
Fire size(W)	4.720E+05	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	4.720E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	1.480E-02
On target(W/m^2)	1.618E+03	0.000E+00	0.000E+00	
Pressure(Pa)	-5.091E-01	-4.641E-01	-4.840E-01	

Time = 360.0 seconds.

Upper temp(K)	481.8	305.0	308.2	
Lower temp(K)	305.8	304.9	304.9	300.0
Upper vol(m**3)	80.4	0.4	10.9	
Layer depth(m)	0.7	0.0	0.0	
Ceiling temp(K)	323.1	305.0	305.0	
Up wall temp(K)	319.0	305.0	305.0	
Low wall temp(K)	307.5	305.0	305.0	
Floor temp(K)	307.5	305.0	305.0	

Plume flow(kg/s)	5.350E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	2.540E-02	0.000E+00	0.000E+00	
Fire size(W)	7.080E+05	0.000E+00	2.826E-03	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	7.080E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	2.826E-03	2.506E-02
On target(W/m^2)	2.551E+03	0.000E+00	2.057E+01	
Pressure(Pa)	-9.683E-01	-8.618E-01	-8.936E-01	

Time = 480.0 seconds.

Upper temp(K)	519.2	305.0	316.5	
Lower temp(K)	306.2	304.8	304.9	300.0
Upper vol(m**3)	86.5	0.4	59.6	
Layer depth(m)	0.7	0.0	0.3	
Ceiling temp(K)	332.2	305.0	305.4	
Up wall temp(K)	326.4	305.0	305.3	
Low wall temp(K)	309.2	305.0	305.1	
Floor temp(K)	309.2	305.0	305.1	
Plume flow(kg/s)	6.300E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	3.390E-02	0.000E+00	0.000E+00	
Fire size(W)	9.450E+05	0.000E+00	1.036E-02	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	9.450E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	1.036E-02	2.589E-02
On target(W/m^2)	3.609E+03	0.000E+00	7.763E+01	
Pressure(Pa)	-1.261E+00	-1.122E+00	-1.147E+00	

Time = 600.0 seconds.

Upper temp(K)	551.8	305.0	322.8	
Lower temp(K)	306.8	304.6	304.8	300.0
Upper vol(m**3)	88.0	0.4	106.0	
Layer depth(m)	0.7	0.0	0.5	
Ceiling temp(K)	342.2	305.0	305.9	
Up wall temp(K)	334.7	305.0	305.7	
Low wall temp(K)	311.3	305.0	305.1	
Floor temp(K)	311.2	305.0	305.1	
Plume flow(kg/s)	7.335E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	4.230E-02	0.000E+00	0.000E+00	
Fire size(W)	1.180E+06	0.000E+00	2.194E-02	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.180E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	2.194E-02	4.089E-02
On target(W/m^2)	4.741E+03	0.000E+00	1.239E+02	
Pressure(Pa)	-1.373E+00	-1.211E+00	-1.213E+00	

Time = 720.0 seconds.

Upper temp(K)	581.2	305.0	327.7	
Lower temp(K)	307.7	304.5	304.9	300.0
Upper vol(m**3)	89.7	0.4	148.3	
Layer depth(m)	0.7	0.0	0.7	
Ceiling temp(K)	352.8	305.0	306.5	

Up wall temp(K)	343.8	305.0	306.1	
Low wall temp(K)	313.7	305.0	305.3	
Floor temp(K)	313.6	305.0	305.2	
Plume flow(kg/s)	8.258E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	5.080E-02	0.000E+00	0.000E+00	
Fire size(W)	1.420E+06	0.000E+00	2.642E-02	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.420E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	2.642E-02	4.521E-02
On target(W/m^2)	5.948E+03	0.000E+00	1.621E+02	
Pressure(Pa)	-1.444E+00	-1.252E+00	-1.231E+00	

Time = 840.0 seconds.

Upper temp(K)	606.9	305.0	332.3	
Lower temp(K)	308.7	304.4	305.0	300.0
Upper vol(m**3)	91.4	0.8	188.6	
Layer depth(m)	0.8	0.0	0.9	
Ceiling temp(K)	364.1	305.0	307.1	
Up wall temp(K)	353.5	305.0	306.6	
Low wall temp(K)	316.5	305.0	305.4	
Floor temp(K)	316.4	305.0	305.4	
Plume flow(kg/s)	9.059E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	5.930E-02	0.000E+00	0.000E+00	
Fire size(W)	1.650E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.650E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	5.122E-02
On target(W/m^2)	7.162E+03	0.000E+00	1.997E+02	
Pressure(Pa)	-1.516E+00	-1.291E+00	-1.251E+00	

Time = 960.0 seconds.

Upper temp(K)	631.9	305.1	335.6	
Lower temp(K)	310.0	304.3	305.6	300.0
Upper vol(m**3)	94.3	2.7	225.9	
Layer depth(m)	0.8	0.0	1.0	
Ceiling temp(K)	375.8	305.0	307.8	
Up wall temp(K)	363.9	305.0	307.1	
Low wall temp(K)	319.6	305.0	305.5	
Floor temp(K)	319.5	305.0	305.5	
Plume flow(kg/s)	9.759E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	6.800E-02	0.000E+00	0.000E+00	
Fire size(W)	1.900E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.900E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	5.659E-02
On target(W/m^2)	8.502E+03	0.000E+00	2.275E+02	
Pressure(Pa)	-1.579E+00	-1.315E+00	-1.278E+00	

Time = 1080.0 seconds.

Upper temp(K)	645.9	305.2	338.3	
Lower temp(K)	311.6	304.3	306.6	300.0

Upper vol(m**3)	97.3	7.1	256.9	
Layer depth(m)	0.8	0.0	1.2	
Ceiling temp(K)	387.2	305.0	308.4	
Up wall temp(K)	374.0	305.0	307.6	
Low wall temp(K)	322.9	305.0	305.6	
Floor temp(K)	322.7	305.0	305.6	
Plume flow(kg/s)	9.987E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	7.330E-02	0.000E+00	0.000E+00	
Fire size(W)	2.050E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	2.050E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	6.486E-02
On target(W/m^2)	9.329E+03	1.367E+00	2.510E+02	
Pressure(Pa)	-1.681E+00	-1.366E+00	-1.356E+00	

Time = 1200.0 seconds.

Upper temp(K)	661.6	305.5	344.7	
Lower temp(K)	313.4	304.2	308.0	300.0
Upper vol(m**3)	104.4	15.9	288.8	
Layer depth(m)	0.9	0.1	1.3	
Ceiling temp(K)	398.2	305.0	309.2	
Up wall temp(K)	384.0	305.0	308.2	
Low wall temp(K)	326.3	305.0	305.8	
Floor temp(K)	326.0	305.0	305.8	
Plume flow(kg/s)	1.009E+00	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	8.233E-02	0.000E+00	0.000E+00	
Fire size(W)	2.302E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	2.302E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	6.175E-02
On target(W/m^2)	1.032E+04	2.960E+00	3.078E+02	
Pressure(Pa)	-1.618E+00	-1.258E+00	-1.277E+00	

Time = 1320.0 seconds.

Upper temp(K)	658.5	305.8	357.4	
Lower temp(K)	315.6	304.2	309.8	300.0
Upper vol(m**3)	118.1	30.6	326.0	
Layer depth(m)	1.0	0.1	1.5	
Ceiling temp(K)	407.8	305.0	310.4	
Up wall temp(K)	392.8	305.0	309.1	
Low wall temp(K)	329.6	305.0	306.1	
Floor temp(K)	329.3	305.0	306.1	
Plume flow(kg/s)	8.956E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	9.137E-02	0.000E+00	0.000E+00	
Fire size(W)	2.385E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	2.385E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	2.265E+04
On target(W/m^2)	1.012E+04	5.012E+00	4.321E+02	
Pressure(Pa)	-1.579E+00	-1.158E+00	-1.233E+00	

Time = 1440.0 seconds.

Upper temp(K)	606.4	305.9	364.3	
Lower temp(K)	317.4	304.2	311.6	300.0
Upper vol(m**3)	130.7	47.7	354.2	
Layer depth(m)	1.1	0.2	1.6	
Ceiling temp(K)	408.2	305.0	311.9	
Up wall temp(K)	393.2	305.0	310.2	
Low wall temp(K)	330.4	305.0	306.5	
Floor temp(K)	330.1	305.0	306.4	
Plume flow(kg/s)	7.257E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.004E-01	0.000E+00	0.000E+00	
Fire size(W)	1.834E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.834E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	3.185E+05
On target(W/m^2)	7.138E+03	5.766E+00	5.049E+02	
Pressure(Pa)	-2.204E+00	-1.698E+00	-1.877E+00	

Time = 1560.0 seconds.

Upper temp(K)	559.3	305.9	363.2	
Lower temp(K)	318.2	304.1	312.9	300.0
Upper vol(m**3)	138.5	64.5	374.0	
Layer depth(m)	1.2	0.3	1.7	
Ceiling temp(K)	403.8	305.0	313.0	
Up wall temp(K)	389.4	305.0	311.1	
Low wall temp(K)	329.9	305.0	306.8	
Floor temp(K)	329.5	305.0	306.7	
Plume flow(kg/s)	5.822E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.094E-01	0.000E+00	0.000E+00	
Fire size(W)	1.373E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.373E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	6.130E+05
On target(W/m^2)	5.032E+03	5.932E+00	4.939E+02	
Pressure(Pa)	-2.773E+00	-2.215E+00	-2.477E+00	

Time = 1680.0 seconds.

Upper temp(K)	517.8	305.9	358.4	
Lower temp(K)	318.5	303.9	313.5	300.0
Upper vol(m**3)	143.1	80.3	389.2	
Layer depth(m)	1.2	0.4	1.8	
Ceiling temp(K)	398.0	305.0	313.6	
Up wall temp(K)	384.3	305.0	311.6	
Low wall temp(K)	328.8	305.0	307.0	
Floor temp(K)	328.4	305.0	306.8	
Plume flow(kg/s)	4.682E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.185E-01	0.000E+00	0.000E+00	
Fire size(W)	1.008E+06	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	1.008E+06	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	8.768E+05
On target(W/m^2)	3.568E+03	5.803E+00	4.423E+02	
Pressure(Pa)	-3.112E+00	-2.533E+00	-2.844E+00	

Time = 1800.0 seconds.

Upper temp(K)	482.2	305.9	352.0	
Lower temp(K)	318.3	303.8	313.7	300.0
Upper vol(m**3)	145.7	92.8	402.3	
Layer depth(m)	1.2	0.4	1.8	
Ceiling temp(K)	391.8	305.0	313.8	
Up wall temp(K)	379.0	305.0	311.7	
Low wall temp(K)	327.6	305.0	307.1	
Floor temp(K)	327.2	305.0	306.9	
Plume flow(kg/s)	3.825E-01	0.000E+00	0.000E+00	
Pyrol rate(kg/s)	1.275E-01	0.000E+00	0.000E+00	
Fire size(W)	7.305E+05	0.000E+00	0.000E+00	
	0.000E+00	0.000E+00	0.000E+00	
Plume in ul(W)	0.000E+00	0.000E+00	0.000E+00	
Plume in ll(W)	7.305E+05	0.000E+00	0.000E+00	
Vent fire(W)	0.000E+00	0.000E+00	0.000E+00	1.117E+06
On target(W/m^2)	2.561E+03	5.550E+00	3.783E+02	
Pressure(Pa)	-3.218E+00	-2.639E+00	-2.971E+00	

ATTACHMENT- 2

INTAKE PUMP STATION 03-17-1993

Fire to ceiling ft	Detector axial dist. ft	Room temp. F	Device rating F	RTI (english)
7	6	90	212	700

Minimum heat release rate necessary to activate the detector at the location described is 242 BTU/s

~~Time(Sec)~~	~~RHR(BTU/s)~~	~~Jet (F)~~	~~Head/det (F)~~
Time(Sec)	RHR(BTU/s)	Jet (F)	Head/det. (F)
0	0	90	90
10	19	111	90
20	37	124	91
30	56	135	91
40	75	145	93
50	93	154	94
60	112	162	95
70	131	170	97
80	149	178	99
90	168	185	101
100	187	192	103
110	205	199	106
120	224	205	108
130	243	212	111
140	261	218	114
150	280	224	117
160	299	230	120
170	317	236	123
180	336	241	126
190	355	247	130
200	373	252	133
210	392	258	137
220	411	263	140
230	429	268	144
240	448	274	148
250	467	279	152
260	485	284	155
270	504	289	159
280	523	293	163
290	541	298	168
300	560	303	172
310	579	308	176
320	597	313	180
330	616	317	184
340	635	322	189
350	653	326	193
360	672	331	197
370	691	335	201
380	709	340	206
390	728	344	210

---- Detector activation at 394.0 seconds ----

FIRE SIMULATOR
[VER 2.03]

Input data used for run of: 03-17-1993 11:06:03

Data file used: IPS.IN as of 03/17/93 11:04:56

Run title: Intake Pump Station Smoke and Sprinkler Head Actuation

ASCII file name: TOOL.PRN

Heat of combustion: 12000.00 BTU/lb 27883.20 KJ/Kg
Specific extinction coefficient: .10
Flashover temperature: 1112.00 F 600.00 C
Oxygen starvation threshold: 12.00 % by volume
Radiant energy fraction (from flame): .35
Maximum pre flashover energy loss: .80

Sprinkler/Heat detector description:
Radial distance 6.00 ft 1.83 m
RTI: 700.00 (Ft-Sec)^.5 386.46 (m-Sec)^.5
Sprinkler rating: 212.00 F 100.00 C
Sprinkler is not sidewall mounted

Smoke detector description:
Radial distance 15.00 ft 4.57 m
Smoke temperature at detection: 110 F 43.33334 C
Smoke detector is not sidewall mounted

Description of initial outside opening:
Height of opening: 12.00 ft 3.66 m
Width of opening: 12.00 ft 3.66 m
Height of sill above floor: 0.00 ft 0.00 m

Spacial dimensions of room:
Room height: 14.00 ft 4.27 m
Room floor area: 1300.00 ft^2 120.77 m^2
Room wall perimeter: 226.00 ft 68.88 m
Room is rectangular: 100.00 ft by 13.00 ft 30.48 m by 3.96 m

Description of ceiling materials:
100% CONCRETE 18.000 in 457.200 mm

Description of wall materials:
100% CONCRETE 18.000 in 457.200 mm

There is no HVAC defined

Fire height: 7.00 ft 2.13 m

cable tray fire
Fire description was manually entered as follows:

TIME (Sec)	FIRE (kW)
0.1	0.010
60.0	118.000
120.0	236.000
180.0	354.000
1020.0	2008.000
1800.0	3540.000

Data file is TOOL.PRN 03-17-1993 11:06:06

TIME	-----TEMP-----		------LAYER----		-----FIRE-----	
sec	F	C	ft	m	kW	BTU/sec
0.0	70.0	21.1	14.0	4.3	0.1	0.1

Smoke at Smoke detector = 0 % of detectable concentration.

```
Link temperature          =     70.0 F      21.1  C
Ceiling Jet Temperature (at link) =     70.8 F      21.5  C
Ceiling Jet Velocity (at link)  =     0.25 ft/sec      0.08  m/sec
Vision distance (smoke layer)  =  3000.00  m   9842.52 ft
Smoke gases : Oxygen =  21.0 % : CO =   0.0000 : CO2 =   0.0000 %
Smoke vent rate is       0 cfm    0.00 cms
Enthalpy (Heat content)          0 btu/sec          0 kW
Inside flow of unburned fuel potential            0 BTU/SEC              0 kW

Smoke detector activated at  42  seconds.

    42.0      94.2      34.6      13.3       4.1      82.5      78.3
Link temperature          =     73.2 F      22.9  C
Ceiling Jet Temperature (at link) =    136.2 F      57.9  C
Ceiling Jet Velocity (at link)  =     2.43 ft/sec      0.74  m/sec
Vision distance (smoke layer)  =    12.30  m     40.36 ft
Smoke gases : Oxygen =  20.6 % : CO =   0.0000 : CO2 =   0.2522 %
Smoke vent rate is       0 cfm    0.00 cms
Enthalpy (Heat content)          0 btu/sec          0 kW
Inside flow of unburned fuel potential            0 BTU/SEC              0 kW

Sprinkler/Heat detector
activated at  350  seconds.

   350.0     270.6     132.6      10.8       3.3     688.7     653.3
Vision distance (smoke layer)  =     3.59  m     11.78 ft
Smoke gases : Oxygen =  17.1 % : CO =   0.0004 : CO2 =   2.3806 %
Smoke vent rate is    2121 cfm    1.00 cms
Enthalpy (Heat content)         91 btu/sec         96 kW
Inside flow of unburned fuel potential            0 BTU/SEC              0 kW

   601.0     431.4     221.9      10.7       3.3    1181.0    1120.2
Vision distance (smoke layer)  =     3.51  m     11.50 ft
Smoke gases : Oxygen =  13.6 % : CO =   0.0029 : CO2 =   4.4920 %
Smoke vent rate is    2934 cfm    1.38 cms
Enthalpy (Heat content)        185 btu/sec        195 kW
Inside flow of unburned fuel potential            0 BTU/SEC              0 kW

==============RUN COMPLETED==============
```

ENCLOSURE 3

BROWNS FERRY NUCLEAR PLANT (BFN)

RESPONSE TO NRC GENERIC LETTER (GL) 92-08,

THERMO-LAG 330-1 FIRE BARRIERS

(ENGINEERING EVALUATION)

ENGINEERING EVALUATION

SEPARATION OF REDUNDANT RHRSW PUMP POWER CABLES IN TURBINE BUILDING IN ACCORDANCE WITH 10CFR50 APPENDIX R REQUIREMENTS

PROBLEM:

10CFR50 Appendix R, Section III.G.2(a) requires that cables and equipment of redundant safe shutdown trains be separated by 3-hour fire rated barriers. Contrary to this requirement RHRSW safe shutdown circuits located in the Turbine Building cable tunnel are not completely separated by 3-hour barriers from the redundant circuits located in the pipe tunnel and are not in literal compliance with section III.G.2(a).

EVALUATION:

Division I of the safe shutdown circuits for the RHRSW system (pumps A1, A2, C1 and C2) are routed in embedded conduits in the ceiling of the pipe tunnel under Elevation 565 of the Turbine Building. There are two recessed cable pull boxes located in the ceiling of the pipe tunnel. The redundant division II circuits of the RHRSW system (pumps B2 and D2) are routed in the adjacent cable tray tunnel (see Figures 1 and 2).

The cable and pipe tunnels are separated by a 15" reinforced concrete wall that exceeds 3-hour fire rated construction. These tunnels are provided with entrances which can be accessed from elevation 565 of the Turbine Building. However, access for cable and pipe tunnel may also be a potential path of fire spread to these areas. A fire spread from the cable tunnel access to the pipe tunnel entrance and through the pipe tunnel into the non-fire rated cable pull box has the potential of damaging redundant safe shutdown circuits.

There are two paths between the access to the cable tunnel and the recessed pull boxes. Figure 1 shows the layout of the pipe and cable tunnel. The shortest path is from the cable tunnel access (point 1) to stair #12; down the stairs to backwash receiving room 533.0-T-1; through door 211 and then up the ladder to the entrance to the pipe tunnel (point 2); through the pipe tunnel to the pull box at column T8 (point 4). The total cumulative horizontal separation between the cable trays and the pull boxes is approximately 380 feet. The other path is from the cable tunnel access (point 1) to stair #19; down the stairs to backwash receiving room 533.0-T-3; up a ladder and into the pipe tunnel access (point 3); through the pipe tunnel to the pull box at column 8 (point 4). The total cumulative horizontal separation between the cable trays and the pull boxes is approximately 500 feet. Both paths involve passing through the 565 floor elevation.

There are negligible combustibles in the pipe tunnel. Smoke detectors are provided in the cable tunnel. A fire originating in the cable tunnel will have to be of such a magnitude to engulf the Turbine Building, travel down the stairs and door to the pipe tunnel entrance and travel another 200 feet through the pipe tunnel which is void of any combustibles and reach the cable pull box. This is considered incredible. A fire in the reverse direction is even more incredible.

Based on the above evaluation, the lack of complete 3-hour fire barrier between cable and pipe tunnels is adequately compensated by the substantial separation (at least 380 feet) between the nearest openings in the pipe and cable tunnels and numerous fire travel path obstacles.

Therefore, the power circuits for RHRSW pumps A1, A2, C1 and C2 are adequately separated from the power circuits of RHRSW pumps B2 and D2 and meets the intent of the Appendix R separation requirements.

PHYSICAL SEPARATION BETWEEN REDUNDANT RHRSW CIRCUITS IN TURBINE BUILDING

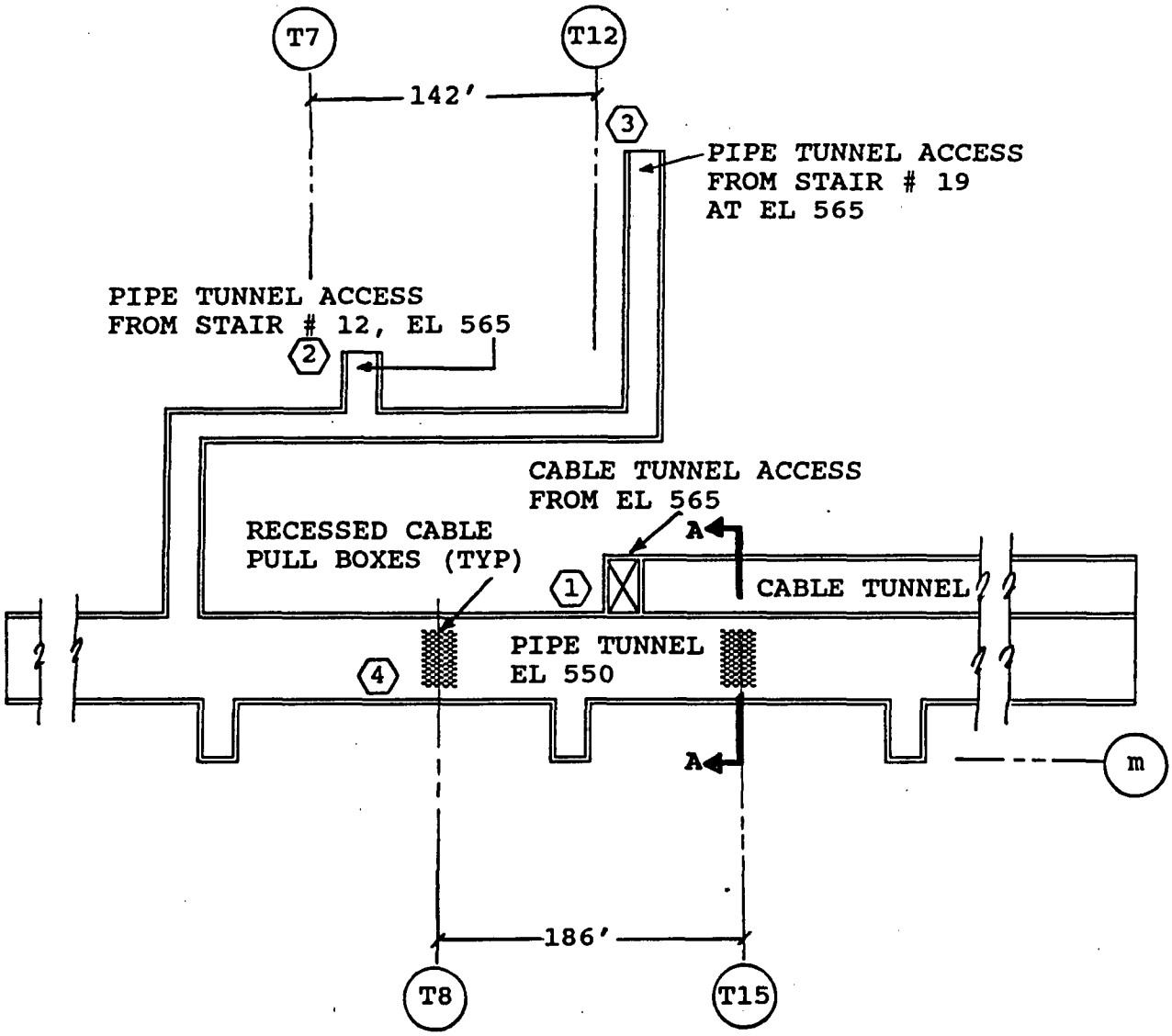
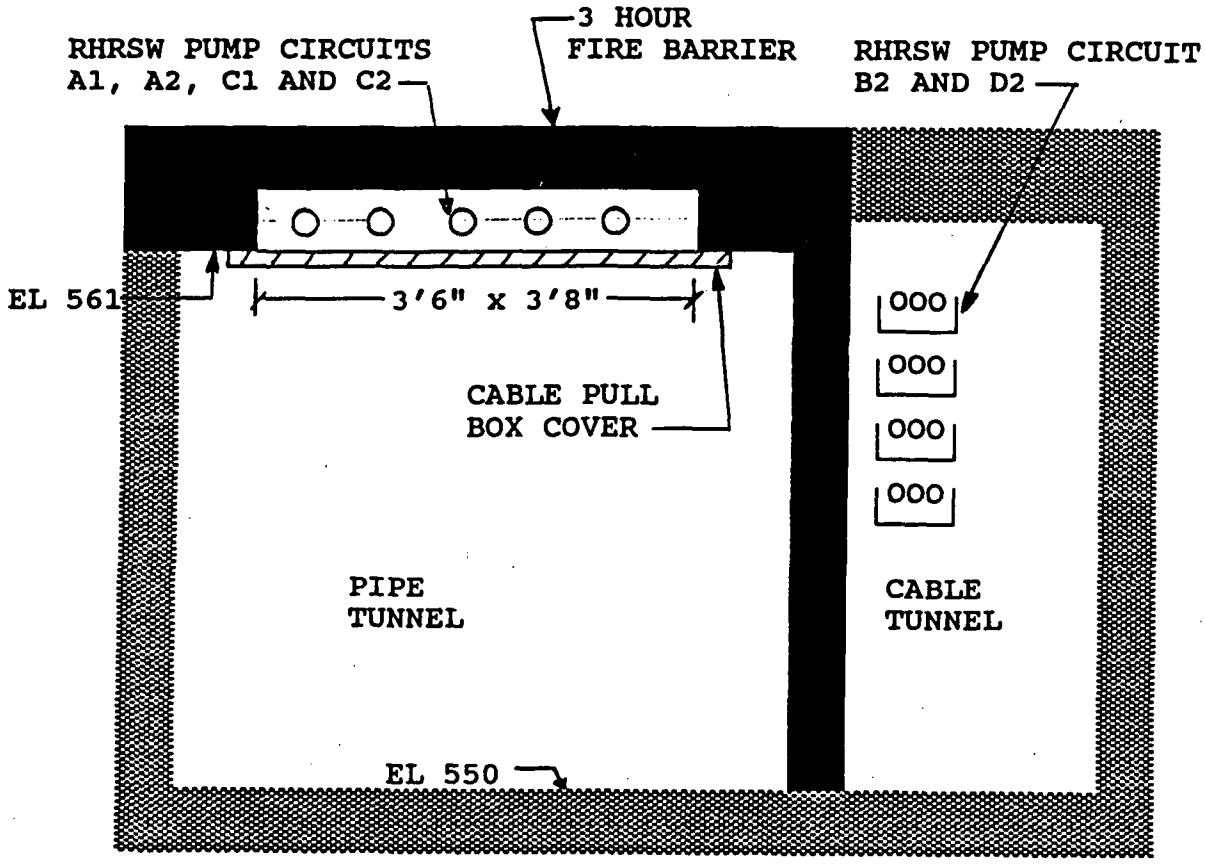


FIGURE 1

REFERENCE DRAWINGS:	41N222	(CIVIL)
	45N820-20	(ELECT)
	45N820-21	(ELECT)
	46W401-6	(ARCH)

Figure not to scale
Dimensions are approximate



SECTION A - A
FIGURE 2