9B Summary of Analysis Supporting Fire Protection Design Requirements

9B.1 Introduction

This appendix is included to discuss in detail some of the analysis associated with the design decisions and requirements stated in Subsection 9.5.1.

9B.2 Fire Containment System

As stated in Subsection 9.5.1.0.3, the Fire Containment System is the structural system and appurtenances that work together to confine the direct effects of a fire to the fire area in which the fire originates. The Fire Containment System is required to contain a fire with a maximum severity as defined by the time-temperature curve defined in ASTM E119 for a fire with a duration of three hours.

9B.2.1 Fire Types

The Fire Containment System is capable of coping with three general types and magnitudes of fires. They are:

(1) Three-Hour Fire

A three-hour fire is a fully involved fire producing a time-temperature profile equal to the standard ASTM E119 time-temperature test curve for a time period of three hours. For this condition, the temperature in the room at the end of three hours would be 1052°C. Complete burn-out of the fire area is assumed and would probably occur for a fire of this magnitude. No survival or recovery of equipment in the fire area is assumed. This capability of the Fire Containment System meets the requirements of Policy Issue SECY-89-013 (Reference 9B-1).

It is not likely that a true three-hour fire would ever occur as the fire would be limited to a lesser magnitude by fire suppression systems, available fuel, or available combustion air.

(2) Limited Growth Fire

A limited growth fire is a fire which produces a thermal column sufficient to create a heated layer of gases in the upper elevation of the room involved in the fire. Room flashover for this type of fire will be prevented as a result of insufficient fuel, heat venting or fire suppression activities. Although some of the equipment in the fire area would probably be unaffected by the fire, it is assumed that the function of all equipment in the fire area is lost. If not limited as assumed, this type of fire could flashover and become a fully involved three-hour fire, if sufficient fuel is available.

(3) Limited Growth, Smoky Fire

A severely limited growth, smoky fire is a fire such as smoldering rags or an electrically initiated cable fire. The heat release from the fire is small so that the smoke is cooled by entrainment of air and the thermal column is thereby limited in size. Since the smoke is cold, its travel is highly influenced by the HVAC air flow patterns in the room. Most equipment in the fire area would not be affected by the fire although no credit is taken for the equipment remaining functional. It is possible, but highly unlikely, that this type of fire could progress to a limited growth or fully involved three-hour fire.

A limited growth or a limited growth smoky fire are the most likely types of fires to occur.

9B.2.2 Fire Barriers

For the ABWR design, the direct effects of a fire are confined to a single fire area by provision of a three-hour-rated fire barrier surrounding each fire area. Fire barriers are formed by:

(1) Concrete fire barrier floors, ceilings, and walls which must be at least six inches thick (Reference 9B-2, Figure 7-8T) if made from carbonate and silicious aggregates. Other aggregates and thicknesses are acceptable if the type of construction has been tested and bears a UL (or equal) label for a three-hour rating.

(2) Partitions or other constructions such as steel stud and gypsum board partition walls which have been tested in accordance to Standard ASTM E119 to have a fire rating of at least three hours.

(3) Rated fire doors with the label of a certified laboratory which indicates that the door and frame have been tested to the requirements of ASTM E119 for a standard time-temperature curve for three hours.

(4) Penetration seals for process pipes and cable trays which have been shown by test to withstand a three-hour fire per the standard ASTM E119 time-temperature curve. Certain penetrations such as the primary containment penetrations may be shown by analysis to have a fire resistance equal to a three-hour rating.

(5) Special assemblies and constructions as listed in subsection 9A.3.6 and 9A.3.7 of the Fire Hazard Analysis.

(6) Fire dampers in HVAC ducts (two per division) within secondary containment. With the exception of secondary containment, separate HVAC systems have been provided for each division so that there are no HVAC ducts routed between divisions except within secondary containment. Within secondary containment there are common supply and a common exhaust ducts for all of secondary containment. The ducts are branched in three places to provide divisional branches which are protected by fire dampers and isolation valves.

Backup protection for failure of fire barrier penetrations is provided in that once a fire has been discovered, the HVAC system for the area experiencing the fire is switched to its smoke removal mode. In the smoke removal mode, the pressure differentials are such that leakage through a penetration would be into the area of the fire. The leakage air velocity would be sufficiently high to confine the combustion products to the fire area with the fire. The smoke control system is capable of providing sufficient air to provide control for an opening between fire areas as large as an open personnel access door. For this reason, mechanical failure of a fire barrier penetration seal would not result in the fire breaching the barrier.

The completeness of the barriers for the Fire Containment System is examined and documented on a room by room basis in the Fire Hazard Analysis, Appendix 9A.

9B.2.3 Allowable Combustible Loading

Subsection 9B.2.2 documents that the ABWR plant design provides capability by fire barriers to cope with a standard three-hour fire. It is the purpose of this subsection to explore what this means in terms of the expected and allowable combustible loading in the plant.

9B.2.3.1 Permanent Loading

The problem associated with predicting the allowable combustible loading compatible with a given fire rating is well stated in the NFPA handbook (Reference 9B-2, p7-111).

> “Technically accurate methods for relating fire severity, fire load, and fire resistance requirements are complex but can be advantageously used in important specific applications. Such methods require consideration of parameters other than the fuel load, such as ventilation, type of enclosure walls, and ceiling. These methods are complex and currently too difficult for general use in design or selection of barrier fire resistance.”

With this quote in mind allowable fire loading for the ABWR was worked out on the basis of information available from industry experience and testing which classifies the types of occupancies, their fire loads and the expected fire severity which might occur in the occupancies. This information can be used to approximately relate the fire loading and expected severity for the various types of occupancies. Three examples of how this was done for the ABWR design follow.

Example 1

One example is taken from Table 7-9B of the NFPA handbook (Reference 9B-2) and reproduced here as Table 9B-1. From the table, a fire as a result of ignition of ordinary combustibles (wood, paper and similar materials) with a heat of combustion of 7,000 (16.30 MJ/kg) to 8,000 (18.63 MJ/kg) Btu per pound and a loading of 146.5 kg/m^2 (30 lbs/ft^2) of floor area in a fire resistive building is estimated to produce a fire of severity equivalent to the standard time-temperature curve for three hours. This equates to an average fire loading of 2.73 GJ/m^2 (146.5x18.63). This is an

indication of the capacity limit for the three-hour fire containment system for the ABWR.

In making the comparisons on the table, recognition was made that for two fires with different temperature histories, the fires may be considered to have equivalent severity when the areas under their time-temperature curves are equal.

Burning rate is an indication of fire severity and therefore of interest. For this example, the average burning rate is 15.14 MJ per min per square foot of floor area (2.73 GJ/m^2 divided by 180 minutes).

Example 2

Another method by which the allowable combustible loading may be determined is by reference to the information summarized in Figure 7-9B of Reference 9B-2. Figure 9B-1 is a reproduction of that figure for the period of time of zero to two hours. The figure has fire endurance and time-temperature curves plotted on it. Each curve is tagged with an alpha character from A through E which indicates the type of occupancy assumed for the curve per Table 7-9E of Reference 9B-2 and reproduced as Table 9B-2. The straight lines indicate the length of fire endurance (how long the fire burns) based upon amounts of combustibles involved in the fire. The curved lines indicate the severity expected for the various occupancies. There is no direct relationship between the straight and curved lines, but, for example, from the straight line curves, 48.82 kg/m^2 of ordinary combustibles is capable of producing a 90-minute fire in a “C” occupancy. The 90-minute fire might be expected to have a severity equal to that of the curved line “C”. As additional examples, 48.82 kg/m^2 of combustibles would produce 75 and 60 minute fires in “D” and “E” occupancies, respectively. The fire severity would be expected to follow their respective “D” and “E” time-temperature curves.

Time-temperature curve “E” also represents the standard ASTM E119 time-temperature curve. It is the design capability curve for the ABWR. Note that given enough fuel and time a fire in any of the types of occupancies will eventually equal the standard time-temperature curve. While fast developing fires may peak above the standard curve in the early stages of fire development, they will tend to come back to or below the standard curve with time. This early peaking has little immediate effect on the life of fire barriers as they tend to respond to the area under the time-temperature curve more than to instantaneous values of temperature.

Figure 7-9B of the NFPA handbook covered a time frame of two hours. Figure 9B-1 has been extended to three hours by extrapolation. Note that the extrapolated fire endurance curve for an “E” type occupancy indicates that a fire loading of 151.4 kg/m^2 will produce a three-hour fire. This corresponds quite well with the 146.5 kg/m^2 mentioned in Example 1.

Another point of reference is that, as indicated in Table 9B-2, non-combustible power houses fall in the occupancy group defined as “Slight” and have an expected fire severity curve of “A”. The “A” group has the least fire severity of the five groups. It represents a minimum challenge to the “E” capability of the ABWR. There are four groupings with greater fire severities. This is another indication of the margin provided by the three-hour barriers in the ABWR design. Such activities as paper working, printing, furniture-manufacturing and finishing would be within the fire containment capabilities of the ABWR three-hour fire barriers.

The extrapolated fire endurance curve for an “A” type occupancy, which includes non-combustible power houses, is approximately 39.1 kg/m^2 for a three-hour fire. This suggests that to be consistent with normal power house design, combustible loading in any given area of the ABWR should be limited to the equivalent of 39.1 kg/m^2 of ordinary combustibles having a heat of combustion of 18.63 MJ/kg and in a configuration that would not exceed an average burning rate of 242.3 MJ/m^2·h (39.1x18.6/3) or 4.04 MJ/min. There is margin for higher loadings but they should be considered on a case by case basis and eliminated if possible or protected by automatic suppression systems. For the ABWR design, areas with permanent loadings higher than this magnitude are protected by automatic suppression systems, except for cable tray runs as discussed below.

Choosing the defined design limit in the above fashion gives a design margin for the combustible loading of 34/8 or 425% as compared to the ABWR design capability. While this is a rather large design margin, the uncertainties are also rather large. It does not appear that an undue hardship for the detail designers and plant operators will be created by utilizing this large margin.

Example 3

The British have graded building occupancies according to hazard by three classifications as determined by the fire load per sq ft. The classifications are occupancies of low, moderate and high fire load. The occupancy is defined as low if it does not exceed an average of 1.14 GJ/m^2 of net floor area of any compartment, nor an average of 2.28 GJ/m^2 in limited isolated areas, provided that storage of combustible material necessary to the occupancy may be allowed to a limited extent if separated from the remainder and enclosed by appropriate grade fire-resistive construction. Examples of occupancies of normal low fire load are offices, restaurants, hotels, hospitals, schools, museums, public libraries, and institutional and administrative buildings.

At 39 kg/m^2 of combustibles with a heat of combustion of 18.63 MJ/kg , the combustible loading would be 727 MJ/m^2. This is a low fire load occupancy per the British classification system.

The normal combustible loading limit of 727 MJ/m^2 average and the electrical room combustible loading limit of 1454 MJ/m^2 for limited areas as stated in Subsection 9.5.1.0.4 was chosen on the basis of the above three examples.

9B.2.3.2 Transient Combustibles

The design limit as stated in Subsection 9.5.1.1.4 should also be reasonable and acceptable for transient combustible loadings. Although there are many possible types of transient loads, one of the transient combustibles most likely to occur would be plastic garbage bags of protective clothing which might accumulate at a temporary change area during the cleanup of a radioactive spill. The justification of the acceptability of the stated design limit for this situation follows.

From the results of fire tests run at Southwest Research Laboratory and reported in Reference 9B-4, a 21.2 liter garbage sack of protective clothing weighs approximately 6.34 kg and burns at an average peak rate of 5.28 MJ/minwith a total heat release of 147.7 MJ. The minimum required number of square meters of floor per garbage bag in the change area would therefore be the total combustibles per bag divided by the normal combustible loading limit or 140,000/64,000 or 0.2 m^2. In actuality, if the bags were stacked this tightly together their burning rate would be greatly reduced as compared to the test because the available burning surface per bag would be greatly reduced. The value of the calculation is that it points out that a reasonable number of bags of protective clothing (3 or 4) located in a temporary change area would not materially threaten the limits of the fire tolerance of the plant.

Combustible liquid spills such as gasoline, lubricating oils, or diesel oil are another type of transient combustible which might be introduced into the plant during normal operation and maintenance. Although combustible liquids are required to be kept in approved containers, the possibility of a spill exists. The acceptable size for a spill may be estimated on the basis that these types of liquids burn in a pool with a heat release rate of approximately "542 kcal/second per m^2", per Table 4-1 of the NFPA handbook, (Reference 9B-2). This is equal to 8.16 GJ/m2·h. The percent of room area which could be covered by a spill and still be within the defined design limit is 8.9% ((64,000/720,000) times 100). In other words a 10 by 10 foot room could have a spill covering 0.83 m^2 and still be within the design limit.

It is not intended that the defined design limit be rigidly applied to spills as they would occur very infrequently and be cleaned up quickly. The example is included here to give an indication of the size of a spill which would be consistent with the restrictions of the defined design limit. It validates the requirement that combustible liquids must be stored in limited quantities in approved containers (Subsection 9.5.1.1).

The example also points out the necessity to provide automatic fire suppression for areas, as has been done, where oil spills which could cover the entire floor area of a room are possible.

9B.2.3.3 Cable Trays

Insulation for electrical cables in cable trays is the major permanent combustible loading through-out the plant. For this reason cable trays are worthy of specific attention.

Twenty-four inch wide cable trays in stacks two trays wide and three trays high (six 0.61m wide trays or equal) are permitted without fixed automatic fire suppression in general plant areas. The acceptability of this configuration may be analyzed in at least two ways. One method (Total Combustibles Per Square Meter) is to calculate the total combustible loading per meter of stack and limit the width of the room through which the tray stack passes or the distance between the two by three stack and any additional stacks in the room to maintain the combustible loading per square meter of floor per meter of tray to no more than the design limit value. The second method (Burning Rate Limit) is to calculate a burning rate for the plastic insulation on the cables and restrict the quantities of cables per meter of cable tray stack to a value that will provide a heat release rate equal to or less than the design limit of 4.04 MJ per min per m^2 of floor. These two calculations and their results follow.

Total Combustible Cable Insulation Per Square Foot

From previous plant design experience the average weight of insulation per 0.3048m of cable tray is 4.53 kg for cross-linked polyethylene (XLPE-FR). With a heat of combustion of 6.69 MJ/kg, the stack would represent a heat load of 4.53 kg times 6.69 MJ/kg times 6 trays per double stack or 2.91 GJ per m of double tray stack. The normal combustible loading limit is 727 MJ/m^2. For the tray stack to be routed through a room such as a corridor, the room would be required to have a minimum width of 4m (2.91 GJ per m of cable tray stack divided by 727 MJ/m^2).

Since the above is based on averages a specific calculation is warranted. Cross-linked polyethylene, flame retardant (XLPE-FR) and Tefzel (Registered trade mark, E.I. Du Pont De Nemours & Co. (Inc.)) are two types of cable insulations which are commercially available and for which standard constructions are compared in Table 9B-3.

In the above tabulation, 94 and 37 cables represent a design maximum fill of 40% for the two sizes of XLPE-FR insulated cables. 202 and 58 cables represent 40% fill for Tefzel. To stay within the allowable average combustible loading of 727 MJ per m^2 of floor, each square meter of cable tray loaded to 40% fill with XLPE-FR requires approximately two square meters of floor area (35,280/16,128). Each 0.093 m^2 of cable tray loaded to 40% fill with Tefzel would require from approximately one half to three quarters of a 0.093 m^2 (7,056/16,128 to 12,096/16,128). A 40% fill would provide almost twice as many Tefzel cables as XLPE-FR.

There is a reduced diameter cross-linked polyethylene cable (XLR) available. Its combustible loading and quantity of cables per a given tray width approaches that of Tefzel and either type would be quite viable for use in the ABWR.

Burning Rate of Cable Insulation

Although, as stated above, the effect on the fire barriers is dependent on the integral of the time-temperature curve more than the peak burning rate, a feel for the maximum burning rate which is possible with the allowable combustible load is still of interest.

Burning rate in kcal per kg is dependent on the amount of surface area available to burn, the amount of oxygen available for the combustion process and the properties of the combustible. For a solidly filled ladder cable tray with one full layer of cables, the surface available for the instantaneous combustion process is the total of the circumferences of the individual cables times the length of the cables. This equates to being pi times the width of the tray times the length of the tray. For a tray one meter wide and one meter long the cable surface area available for burning is 3.14 sq m (Pi x 1m x 1m). This is the maximum available burning surface as the top and bottom surface area is unchanged for additional layers of cables. The 10.2 cm deep side rails protect the sides of the cable stack in the trays so that they do not receive combustion air.

A summary of burning rate calculations is presented in Table 9B-4 by source and material type.

The burning rate for cross-linked polyethylene was calculated by use of equation 2 from section 5.3 of attachment 10.4 of the draft of the Fire Vulnerability Evaluation (FIVE) (Reference 9B-4). For this calculation the peak heat release rate is taken to be:

$$Q_{fs} = 0.45 q_{bs} A \qquad (9B\text{-}1)$$

where q_{bs} is the bench scale burning rate taken from Table A-7M of the FIVE document (Reference 9B-4). "A" is the burning surface area.

The data estimated from tests at UL was taken from a series of modified IEEE 383 tests conducted in 1976 (Reference 9B-5). Although it was not the purpose of the tests to determine burning rate, it is possible to estimate the burning rate from the reported insulation consumed and cable burning time as determined by time tagged photographs of the tests in progress. Cross-linked polyethylene and Tefzel insulated cables of the constructions discussed earlier in this section (Table 9B-3) were tested with the range of burning rates indicated in Table 9B-4 as the results.

The ventilation limited burning rate was calculated using the FIVE methodology using the Draft FIVE Plant Screening Guide (Reference 9B-4). The equation is:

$$Q_{max}/V = 3600 \text{ kW/m}^3\text{/s} \qquad (9B\text{-}2)$$

where Q_{max} is the maximum heat release rate, V is the volume flow, and m^3/s is the volume flow rate in cubic meters per second.

(9B-3)

For one m^2 of a room with a ceiling height of 4.57m and a ventilation rate of 3 air changes per hour the ventilation rate is 13.71 m^3/h (1 m^2 x 4.57m x 3 changes per h). Q_{max} is equal to:

$$Q_{max} = 3600 \times 13.71 \quad (9B-4)$$

= 49.37 MJ/h per m^2

The burning rate for the design normal combustible load limit is the combustible load limit of 727 MJ/m^2 as defined in Subsection 9B.3.2.1, divided by 180 minutes (3 hours) is 4.04 MJ/min per m^2.

Similarly the burning rate of 15.13 MJ/min per m^2 for the fire barrier capability is the capability of 2.72 GJ/m^2 divided by 180 minutes.

The normal combustible load limit of 964 kcal/min per m^2 divided into the burning rate of 6.99 MJ/m^2 to 37.84 MJ/m^2 of open ladder cable tray gives a ratio of 1,581 to 8,742 cm^2 of floor area per 0.093 m^2 of cable tray in a room, depending on the type of insulation used.

The value of the burning rate calculations is that they give an idea of what the localized burning rate might be for a cable fire that is not burning in the ventilation controlled mode. Multiple trays of cables should not be run in rooms such as oil storage tank rooms where there would be an ignition source sufficiently large to ignite the entire amount of cable in the room. Also, areas containing potential ignition sources sufficiently large to ignite large amounts of cables in the areas are sprinkled. For these reasons, the normal combustible loading limit based on the total combustibles per square foot should be used in preference to using the localized burning rate as the basis for setting the limit.

One additional comment is that the low ventilation controlled burning rate of 49.36 MJ/hr per m^2 of floor area as compared to the barrier system capacity of 15.13 MJ/min per m^2 is another indication of the design margin that is provided by the three-hour fire barrier system. The capacity of the barrier system should not be approached by the fire intensity except possibly during the time when the ventilation rate to the area experiencing the fire has been increased to facilitate fire suppression activities.

It is possible that during the detailed design phase certain areas of concentration of cable trays may exceed the normal or electrical combustible loading limit. The use of data communication and the overall plant layout will tend to minimize the number of these areas of concentration of cable trays. There are options available to the detail designer to limit specific concentrations above the general stated combustible loading limits. For example, the designer could use one or more of the following options.

Option 1

Use a cable insulation with a lower required thickness, a low heat of combustion or a low burning rate, such as Tefzel. The number of cable trays could be held constant or the same number of cables could be routed through fewer cable trays.

Option 2

A second option would be to utilize cable trays with solid bottoms and solid covers for the congested areas.

9B.3 References

9B-1 Stello, Victor, Jr., "Design Requirements Related To The Evolutionary Advanced Light Water Reactors (ALWRS)", Policy Issue, SECY-89-013, The Commissioners, United States Nuclear Regulatory Commission, January 19, 1989

9B-2 Cote, Arthur E., "NFPA Fire Protection Handbook", National Fire Protection Association, Sixteenth Edition

9B-3 Not Used

9B-4 Professional Loss Control, "Fire Vulnerability Evaluation Methodology (FIVE) Plant Screening Guide", Draft, EPRI7.REV, Contract No. RP 3000-41, Electric Power Research Institute, Palo Alto, CA, 1990

9B-5 "Flame Tests". A report on tests conducted by Underwriters Laboratories, Inc., at Northbrook, Illinois, September 27, 28, and 29, 1976, E. I. Du Pont De Nemours & Co. (Inc.) E-12952

Table 9B-1 Estimated Fire Severity for Offices and Light Commercial Occupancies*

Data Applying to Fire-Resistive Buildings with Combustible Furniture and Shelving		
Combustible Content Total, Including Finish, Floor, and Trim, psf	**Heat Potential Assumed † Btu Per Sq Ft**	**Equivalent Fire Severity Approximately Equivalent to That of Test under Standard Curve for the Following Periods:**
5	40,000	30 min
10	80,000	1 hr
15	120,000	1 1/2 hrs
20	160,000	2 hrs
30	240,000	3 hrs
40	320,000	4 1/2 hrs
50	380,000	7 hrs
60	432,000	8 hrs
70	500,000	9 hrs

* Reproduced from Table 7-9B, NFPA Fire Protection Handbook, Reference 9B-2.

† Heat of combustion of contents taken at 8,000 Btu per lb up to 40 psf; 7,600 Btu per lb for 50 lb, and 7,200 Btu for 60 lb and more to allow for relatively greater proportion of paper. The weights contemplated by the tables are those of ordinary combustible materials, such as wood, paper, or textiles.

Table 9B-2 Fire Severity Expected by Occupancy*

Temperature Curve A (Slight)
Well-arranged office, metal furniture, noncombustible building.
Welding areas containing slight combustibles.
Noncombustible power house.
Noncombustible buildings, slight amount of combustible occupancy.
Temperature Curve B (Moderate)
Cotton and waste paper storage (baled) and well-arranged, noncombustible building.
Paper-making processes, noncombustible building.
Noncombustible institutional buildings with combustible occupancy.
Temperature Curve C (Moderately Severe)
Well-arranged combustible storage, e.g., wooden patterns, noncombustible buildings.
Machine shop having noncombustible floors.
Temperature Curve D (Severe)
Manufacturing areas, combustible products, noncombustible building.
Congested combustible storage areas, noncombustible building.
Temperature Curve E (Standard Fire Exposure—(Severe)
Flammable liquids.
Woodworking areas.
Office, combustible furniture and buildings.
Paper working, printing, etc.
Furniture manufacturing and finishing.
Machine shop having combustible floors.

* 1.Reproduction of Table 7-9E, NFPA Fire Protection Handbook (Reference 9B-2).
2.See Figure 9B-1 for the temperature curves identified in this table.

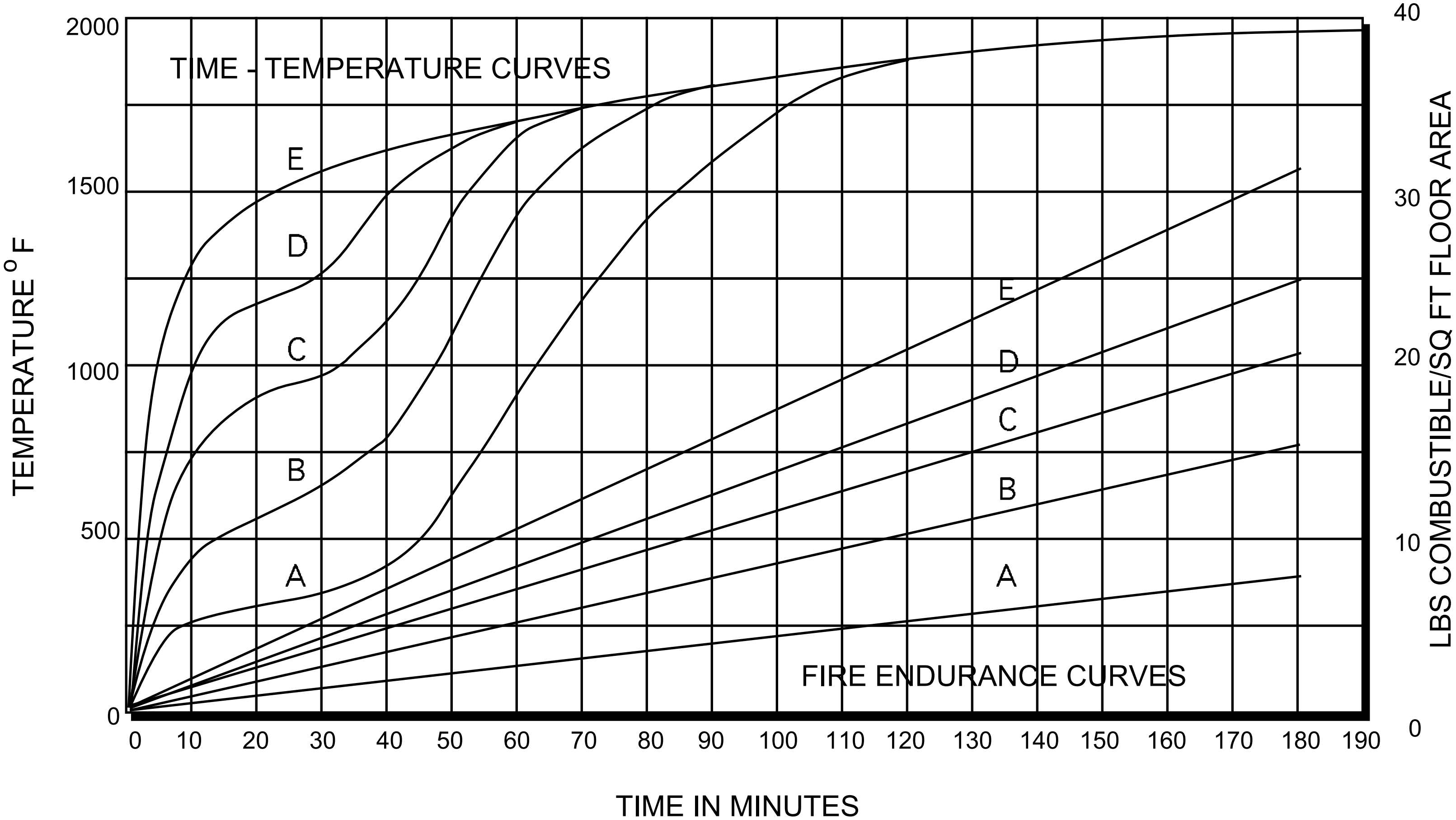
Table 9B-3 Cable Type and Configuration for UI Tests*

Cable Type	Cables Per Tray 1 Ft Wide	Combustible Loading Btus Per Sq Ft of Tray
7/C #14AWG XLPE-FR	94	142,000
7/C #14AWG Tefzel	94	22,500
7/C #14AWG Tefzel	202	48,400
19/C #14AWG XLPE-FR	37	136,000
19/C #14AWG Tefzel	37	17,600
19/C #14AWG Tefzel	58	27,600

* (This table is reproduced from Reference 9B-2)

Table 9B-4 Summary of Burning Rate Calculations

Material	Source of Data	Burning Rate (MJ/min per m^2 of Surface Area)	Burning Rate MJ/min per m^2 of Cable Tray or Floor)
Cross-linked polyethylene	FIVE bench scale burning data (Ref. 9B-4)	10.417	32.724
Cross-linked polyethylene	Estimated from tests at UL (Ref. 9B-5)	6.67 to 12.05	20.955 to 37.853
Tefzel	Estimated from tests at UL (Ref. 9B-5)	2.22 to 4.367	6.988 to 13.716
Ventilation limited (Three air changes per hour)	FIVE Plant Screening Guide, (Ref. 9B-4)		0.820
Design normal maximum limit	Typical for power houses (Ref. 9B-2)		4.040
Fire barrier capability	ASTM E-119 curve for three hours		15.123



NOTE: THIS FIGURE REPRODUCED FROM REFERENCE 9B-2 FOR FIRST 120 MINUTES.

Figure 9B-1 Possible Classification of Building Contents for Fire Severity and Duration