Determination of Fire Resistance Ratings of Fire Barriers for Operating Nuclear Power Plants

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1. Introduction

To improve fire safety of operating nuclear power plants, fire hazard analysis should be performed periodically after initial analysis at design stage. Therefore, according to plant-specific fire hazard analysis, it requires appropriate action to improve fire protection features and programs correspond with safety codes and standards. Fire hazard analysis is to analyze whether nuclear power plant is capable of safe shut down and radiation protection ultimately. It fulfilled to minimize occurrence and scale of a fire by appropriate design of fire prevention, detection and suppression systems and to avoid loss of safe shutdown function from fire hazard. It is possible to estimate design basis fire by calculation of fire loadings from fixed and transient combustibles to evaluate potential fire vulnerabilities and fire barrier structures during fire hazard analysis. Method to estimate fire loadings and severity can be used by engineering estimation, experimental result, and computational analysis, also which should be enough to assume combustibles conservatively. In this paper, we describe method to determine fire barrier ratings in fire risk assessment for operating nuclear power plants.

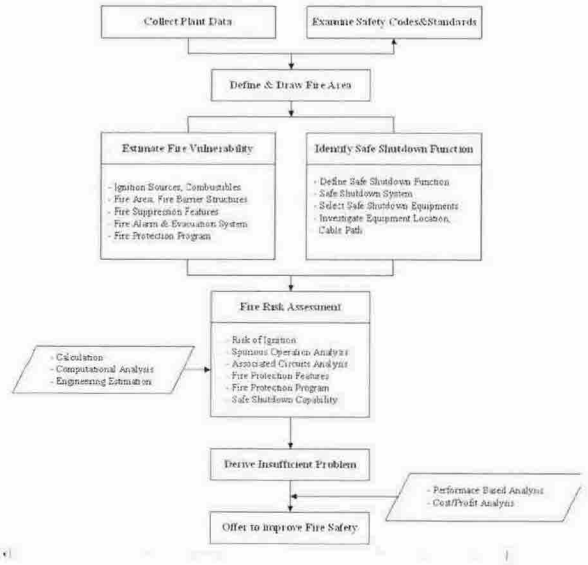

Figure 1. Process of Fire Hazard Analysis

2. Process of Fire Risk Assessment

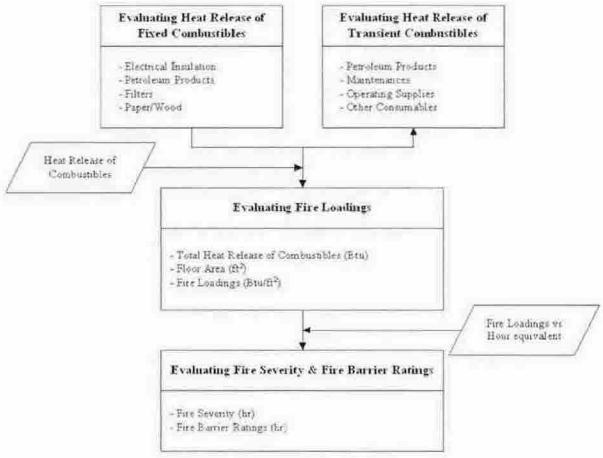

Figure 2. Process of Fire Risk Assessment

2.1 Definition of Fire Area

Fire area is defined as an area physically separated from other areas by space, barrier, walls or other means in order to contain fire within that area. In case of yard, it can be defined as a single fire area consists of several buildings, tanks, transformers, and so on.

2.2 Evaluation of heat release of combustibles

Whole amount of heat release in a fire area are evaluated by investigating type and quantity of fixed combustibles such as electrical insulation, petroleum products, charcoal filters, wood, etc. and transient combustibles such as lubricant in equipment, electrical maintenance, various consumable materials.

2.3 Evaluation of fire loadings

Fire loadings in a fire area are evaluated by calculating specific heat release divided by floor area. Considering whole effect of potential heat release against floor area, influence of a fire can be represented actually and estimated conservatively.

2.4 Determination of fire severity and fire barrier ratings

Fire severity according to fire loadings is estimated by using conversion table offered from NFPA. Fire area should be separated by fire rated barriers and the fire

resistance rating of barrier should be commensurate with the potential fire severity in each area.
Penetration seals existed on a fire barrier for piping and cabling require the fire retardant performance equal to that of a fire barrier structure.

3. Method to Determine Fire Barrier Ratings

The major types of combustibles inventoried are electrical insulation, petroleum products, charcoal filters, operating supplies, and maintenance. Combustibles in the nuclear power plants are classified as fixed and transient.

Operating supplies and maintenance consist of wood, cloth, plastic and other material items required for normal plant operations. In contrast to petroleum products, electrical insulation, and charcoal, which are fixed and part of the design, these combustibles are transient, may vary with time and can be moved about. For the fire risk assessment, it is assumed that plant housekeeping procedures would limit quantities of transient combustibles in general plant areas. Total heat release from combustibles can be evaluated by using conversion table 1 offered from KEPIC mostly based on experimental result.

Fire loadings in a fire area can be evaluated by calculating specific heat release divided by floor area.

Fire barrier is defined as components of construction (walls, floors, and their supports), including beams, joists, columns, penetration seals or closures, fire doors, and fire dampers that are rated by approving laboratories in hours of resistance to fire, that are used to prevent the spread of fire.

And also fire barrier resistance is defined as the ability of an element of building construction, component, or structure to fulfill, for a stated period of time, the required load-bearing functions, integrity, thermal insulation, or other expected duty specified in a standard fire resistant test. Therefore, required fire barrier ratings are determined as the time that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251.

Table 1. Heat release of various combustibles

Combustibles	Heat Release	
Industrial Cleaner	10,320 kcal/L	155,000 Btu/gal
Lubricant or Grease	10,320 kcal/L	155,000 Btu/gal
Transformer Oil	9,520 kcal/L	143,000 Btu/gal
Diesel Oil	9,720 kcal/L	146,000 Btu/gal
Fuel Oil	10,320 kcal/L	155,000 Btu/gal

(Continued)

Cable Insulation		
- Instrument	749 kcal/m	907 Btu/ft
- Power & Control	1,332 kcal/m	1,612 Btu/ft
Paper/Wood	4,435 kcal/kg	8,000 Btu/lb
Battery	10,035 kcal/kg	18,100 Btu/lb
Cellulose Filter	4,331 kcal/cart.	17,185 Btu/cart.
Flexible Connector	5,544 kcal/kg	10,000 Btu/lb
HEPA Filter	4,032 kcal/mod.	16,000 Btu/mod.
Pre-Filter	4,032 kcal/mod.	16,000 Btu/mod.
Charcoal Filter	7,762 kcal/kg	14,000 Btu/lb
Duct Insulation	3,021 kcal/kg	5,450 Btu/lb
Duct Lining	4,435 kcal/kg	8,000 Btu/lb
Blanket	5,544 kcal/kg	10,000 Btu/lb
Acetone	5,877 kcal/L	88,275 Btu/gal
Methanol	4,265 kcal/L	64,064 Btu/gal
Ethane	4,416 kcal/L	66,329 Btu/gal
Cloth	3,992 kcal/kg	7,200 Btu/lb
Rubber	4,435 kcal/kg	8,000 Btu/lb
Hydrogen	2,838 kcal/m3	319 Btu/ft3
Acetylene	13,350 kcal/m3	1,500 Btu/ft3
LNG Gas	10,600 kcal/m3	1,190 Btu/ft3

4. Conclusion

· Methodology of determining fire barrier ratings in fire risk assessment for operating nuclear power plants was developed by using engineering estimation, experimental result, and safety codes and standards.

· To improve fire safety for operating nuclear power plants, plant-specific fire hazard analysis should be performed periodically after initial analysis at design stage.

· Transient combustibles in fire area should be controlled under reasonable quantity, and design changes during operation reviewed to fire hazard analysis.

REFERENCES

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