Application Study of Fire Severity Classification

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1. Introduction

The Fire Events Database (FEDB) is the primary source of fire data which are used for fire frequency in Fire PSA (Probabilistic Safety Assessment)[1]. The purpose of its development is to calculate the quantitative fire frequency at the comprehensive and consolidated source derived from the fire incident information available for Nuclear Power Plants (NPPs).

Recently, the Fire Events Database (FEDB) was updated by Electric Power Research Institute (EPRI) and Nuclear Regulatory Commission (NRC) in US.

The FEDB is intended to update the fire event history up to 2009. A significant enhancement to it is the reorganization and refinement of the database structure and data fields. It has been expanded and improved data fields, coding consistency, incident detail, data review fields, and reference data source traceability. It has been designed to better support several Fire PRA uses as well.

This paper introduces the Fire Incidents Severity Classification Method[2] for Korean NPPs that may be derived directly from the data fields and feasibility study for domestic uses.

2. Methods and Results

The classification method associates each event with the appropriate severity level. The severity level used in the updated FEDB is 5 types of classifications, that is, "challenging, potentially challenging, non-challenging, and 2 kinds of undetermined."[2].

2.1 Fire Severity Classifications

1) Challenging (CH) fires are those events that had observable and substantial effects on the environment outside the initiating source regardless of where the fire occurred or actually damaged by the fire.

2) Potentially C**hallenging** (PC) fires are those events that were not determined to be CH events but that could have reached a CH state.

3) Non-Challenging (NC) Fires are that did not cause or would not have caused adjacent objects or components to become damaged or ignite regardless of location for essentially any amount of time but can be detected automatically by fire detection system.

4) Undetermined (PC-CH) Fires are considered at least potentially challenging ones based on available information, but there is insufficient information to determine for classifying as challenging fires.

5) Undetermined (NC-PC) Fires where there is insufficient information to determine for classifying as potentially challenging or non-challenging fires.

2.2 Fire Severity Determination Algorithm (FSDA)

The FSDA determines the severity of fire event automatically by determination criteria in the FEDB as shown at table 2-1.

The result of the automatic event classification algorithm provides conservatively estimates of the event severity classification for certain types of fire events.

Therefore, the standard override field is used to correct the classification because the fire severity algorithm is imprecise and tends to conservatively interpret the values of FEDB data field with respect to fire severity classification as shown at table 2-2. As a result of override, the category is re-classified from potentially challenging fire to non-challenging one.

The final determination of the fire severity is confirmed generally by analyst of the data and comment fields, and subsequent reviewers.

Table 2-1 Fire Severity Determination Criteria

Challenging Criteria (CH)
Any of the following
High Energy Arcing Fault / Explosion
Fully developed compartment fire / Severe Smoke or High room temp.
Severe room temperature / Fully developed room fire
Fire damage beyond the component of origin
Evidence of collateral damage due to heat / Evidence of secondary ignition
Detection due to heat sensor / Suppression
Specified combinations of the following
Suppression modes / Room state
Fire brigade involvement for fire durations $\geq$ 10 minutes
Potentially Challenging Criteria (PC)
Not Challenging and one of the following
Open flaming(small)
Combination of smoldering combustion and Moderate smoke or Temperature in room / Heavy smoke - SCBAs needed
Combination of Moderate smoke and power supply removed
Suppression by - manual actuation
Fire fighting $\geq$ 30 min. for events where fire brigade provides initial attack
or
Fire fighting $\geq$ 30 min. for events where fist responders provide initial attack
Any two of the following combinations
The four combinations are;
detection(smoke detector, gas ionization, automatic fixed..)
plant condition(SCRAM, TT, LOOP)
Fire fighting(brigade $\geq$ 10) / Fire fighting(first responder $\geq$ 10)
Non-Challenging Criteria (NC)
Not Challenging, Not Potentially Challenging, and no unknowns that would change to PC or CH
Overheating - no smoldering or flaming combustion
self-extinguished without ANY intervention
Undetermined Criteria [U (PC-CH) or U (NC-PC)]
One or more "unknown" fields exist which result in Challenging(CH), Potentially Challenging(PC), or Non-Challenging(NC) classification

Table 2-2 Fire Severity Override Categories

Hot Work Fires Extinguished by a Posted Fire Watch
Equipment Failures during Monitored Test and Maintenance Activities
Materials Overheating on a Diesel Generator Exhaust Manifold
Smoking Materials on a Hot Pipe or Bearing Housing
Individual Sub-Component Failures Not Resulting in Flaming Combustion
Lighting Ballast, Wall Outlet and Switch Failure Events (110/220 VAC)
Self Extinguished Events (clarification)
Outside Protected Area (not fire PRA applicable)
Other basis (specified for each event application)

2.3 Process for the Severity Determination

1) An algorithm based classification is automatically generated and displayed.

2) The analyst reviews documentation, algorithm output, and classification criteria.

3) After reviewing all the event descriptions and fire severity algorithm output, the analyst can "accept" or "override" the algorithm based classification.

4) The results of the fire severity classifications are reviewed by a senior analyst and/or by an auditor.

5) The differences of opinion are resolved and documented appropriately in the comment field.

2.4 Application of FSC(Fire Severity Criteria) for Korean NPPs

The Fire Severity can be classified based on Criteria and re-classified from potentially challenging to non-challenging by the fire severity override for domestic NPPs.

2.4.1 Challenging (CH) Fires

1) Challenging Fires in General
It is classified to Challenging Fire (CF) 1 to 3 as Challenging Fires by the characteristics of fires to the environmental effects.
- CF 1: Fire is observed with the substantial and self sustained flaming combustion.
- CF 2: Fire results in observable damage to nearby components or combustible material.
- CF 3: Fire results in substantial damage to the ignition source or propagate to nearby components.

2) Subjective Challenging Fires
It is categorized to Subjective Challenging Fires (SCF) by characteristics of fires in the aspect of fire intensity and its duration.
- SCF 1: Active intervention is needed to prevent spread.
- SCF 2: The heat is generated of sufficient intensity and duration to affect components outside the boundaries.
- SCF 3: The flames, heat fluxes, hot gases are generated that can cause the ignition of secondary combustibles outside the boundaries.

2.4.2 Potentially Challenging(PC) Fires

- PC 1: Substantial smoke is generated.
- PC 2: Fire fighting time after initial attack.
- PC 3: If two or more of the following features are satisfied.
  1) Actuation of an automatic detection or suppression system.
  2) A plant trip is experienced due to fire effects on the ignition component.
  3) A burning duration or suppression time of 10 minutes or longer that does not meet the challenging classification criteria.
  4) A single portable fire extinguisher is used.

2.4.3 Non-Challenging(NC) Fires
Those are not Challenging, nor Potential Challenging Fires, and no unknowns that would change event to potential Challenging or Challenging.

2.4.4 Undetermined [U (PC-CH), U (NC-PC)] Fires
These are one or more "unknown" fields in the FEDB, and they could be resulted as Challenging, Potential Challenging, or Non-Challenging Fires by the detail analysis for their classifications.

2.4.5 Fire Severity Override
A fire event generally will be changed to Non-Challenging or other Fire Groups based on the following detail review results;
1) Smoking materials on a hot pipe or bearing housing.
2) Individual Sub-Component failures not resulting in Flaming Combustion
3) Equipment failures during Monitored Test and Maintenance Activities
4) Electrical auxiliary facility failure
5) Hot Work Fires Extinguished by a Posted Fire Watch

3. Conclusions

FEDB was characterized in more detail and assessed based on the significance of fire incidents in the updated database and five fire severity categories were defined.

The logical approach to determine the fire severity starts from the most severe characteristics, namely challenging fires, and continues to define the less challenging and undetermined categories in progress.

If the FEDB is utilized for Korean NPPs, the ways of Fire Severity Classification suggested in 2.4 above can be utilized for the quantitative fire risk analysis in future.

REFERENCES

[1] R.PKassawara, EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities, EPRI 1011989, 2005
[2] R.Wachowiak, A.Lindeman, The Updated Fire Events Database:Description of Content and Fire Event Classification Guidance, EPRI 1025284, 2013.