EXPERIENCES FROM THE OECD FIRE DATABASE AND INTENDED FUTURE EXTENSIONS

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The international fire incidents database OECD FIRE (Fire Incidents Records Exchange) is one of the four nuclear power plants (NPP) operational events databases currently operated under the umbrella of the OECD Nuclear Energy Agency (NEA). This database collecting detailed information from fire events at nuclear power plants from meanwhile thirteen NEA member countries is already in its fifth phase and mature enough for first applications in fire probabilistic risk assessment.

The most recent version of this database covers already more than 450 well documented fire events during all operational phases of the entire plant life cycle from construction up to the longer term safe shutdown before decommissioning. The number of recorded events increases continuously within each annual update.

A suitable database structure enables the analyst to make search queries for different aspects and investigations of even more complex fire scenarios. Various analyses can be systematically performed in an automated manner, from generating different samples up to a more or less complete statistical analysis.

The paper presents a brief overview of the manifold application possibilities of the OECD FIRE Database for supporting nuclear power plant operators as well as regulators in assessing fire safety issues, in particular in the frame of probabilistic safety assessment (PSA). Each application presented is illustrated by examples.

One important objective of the data collection is to generate generic compartment specific as well as component related fire occurrence frequencies for different reactor types and plant operational states.

Other applications with significance for regulatory assessments are in-depth investigations of transformer fires and event combinations of fires and other events.

From PSA viewpoint, control room habitability as well as risk significant contributions in PSA for fires has to be analyzed. For the latter, available Fire PSA have to be analyzed compartment or component specifically to identify significant elements in PSA and to find out if there is consistency with and within the OECD FIRE Database.

Moreover, the FIRE Database Project shall support providing analytical tools for performing Fire PSA by using different fire simulation codes to establish the differences between the outputs of the codes using the data within the FIRE Database. Last but not least one objective of the next Project Phase is to collect new or sort out from existing fire records of already collected and known fire events, those ones that have some multi-unit/area effects. This activity may provide some support for Site Level PSA (representing an ongoing task of the OECD working group on risk assessment (WGRISK).

In the future, efforts will be started to publish insight reports, which evaluate causes of fires in the Database content. The reports will be available to designers of nuclear plant fire detection and extinguishing systems and layout. It is expected that this could support activities for preventing fires and their combinations with other anticipated events.

I. INTRODUCTION

The sequence of a fire event can generally be characterized as a continuous stochastic process depending on multiple random influences. The international fire incidents database OECD FIRE (Fire Incidents Records Exchange) is one of the nuclear power plants (NPP) operational events databases currently operated under the umbrella of the OECD Nuclear Energy Agency (NEA). Detailed information from fire events at nuclear power plants from now thirteen NEA member countries is recorded in this Database, which is meanwhile mature enough for first applications in fire probabilistic risk assessment.

In January 2016, the already fifth phase of this Database Project has started with duration of four years (2016-2019). The collection of fire events data covers up to the end of 2015 (Ref. 1) approx. 8200 reactor years of nuclear power plant (NPP) operation from about 350 reactor units in meanwhile thirteen member countries (Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Korea, the Netherlands, Spain, Sweden, Switzerland, and United States of America).

As the FIRE Database has been widely improved and extended in its fourth Project phase (2014-2015), it is applicable as a source of generic fire event data in the frame of probabilistic fire risk assessment (so-called Fire PSA). Important goals of the improvements, in particular with respect to the statistical use and application for performing probabilistic risk analysis with respect to the internal fire hazard were and still are to enable the applicant to generate reactor type specific generic fire occurrence frequencies and to develop generic fire event trees from the operating experience collected for nuclear power plants (NPPs) in member countries.

The actual version of the OECD FIRE Database covers already more than 450 well documented fire events during all operational phases of the entire plant life cycle from construction up to the longer term safe shutdown before decommissioning. The number of recorded fire events increases continuously within each annual update.

For joining the Project, the new member needs to contribute by providing fire event data to the Database. Furthermore, an annual member fee of 5.000 € per year and country needs to be paid to OECD. In addition, a new member has to pay an entrance fee of 10.000 €. More details on the OECD FIRE Database Project can be found on https://www.oecd-nea.org/jointproj/fire.html.

II. RECENT IMPROVEMENTS IN THE DATABASE STRUCTURE

According to insights from recent applications and use of the OECD FIRE Database the Database structure has been recently enhanced significantly based on experience with different applications facilitating statistical analysis needed for probabilistic fire risk assessment. The search possibilities have been further extended in order to enable the analyst making queries with respect to fires originating from inside and outside the plant boundaries, re-ignition of fires, event combinations of fires and other anticipated events, multi-unit aspects, etc. Numerous subsets of fire events have been or can be created, based e.g. on reactor type, plant operational state (POS), event combinations, groups of failure causes, reporting criteria and thresholds, etc. for providing meaningful results for different analyses. Figure 1 shows a screenshot of the improved FIRE Database entry page (main menu).

In particular, the following new coded fields have been added in the most recent version of the Database (Ref. 1):

- There is a code distinguishing between plant external fires originating outside the site boundary and plant internal fires.
- For each reactor unit from the participating member countries, for which fire events are being reported, it has been coded in the Database if the plant site is a multi-unit site (with more than one reactor unit on-site, either power or research reactor) and if it is a multi-source site (in addition to any reactor unit, there are other non-negligible sources of radioactivity, such as dry storage facilities, spent fuel pool, nuclear waste treatment facilities present on-site). This is highly important for the recently ongoing activities with regard to Site Level (multi-unit, multi-source) PSA.
- For identifying event *combinations* of fires and other events the following coded fields have been added to distinguish different types of combinations:
  - Correlated events:
    - Fires and consequential events;
    - Anticipated initial vent and consequential fires;
  - Independently, but simultaneously occurring fires and other events.

Meanwhile, there are numerous pre-defined subsets of data available to the Database user for further analysis, covering, e.g. event combinations of fires and other events, fires having re-ignited, self-extinguished fires (or better: fires which went out without any fire suppression means), fires extinguished by fire source isolation, fires grouped by apparent cause categories, etc. These subsets are made available to the Database user by a subset library from which subsets can be imported, or to which a user can export subsets he/she has created.

Since the search form had become too crowded through the addition of many new features it has been re-structured into four separate tables corresponding to "*General data*", "*Ignition phase*", "*Extinguishing phase*" and "*Functional consequences and corrective actions*".

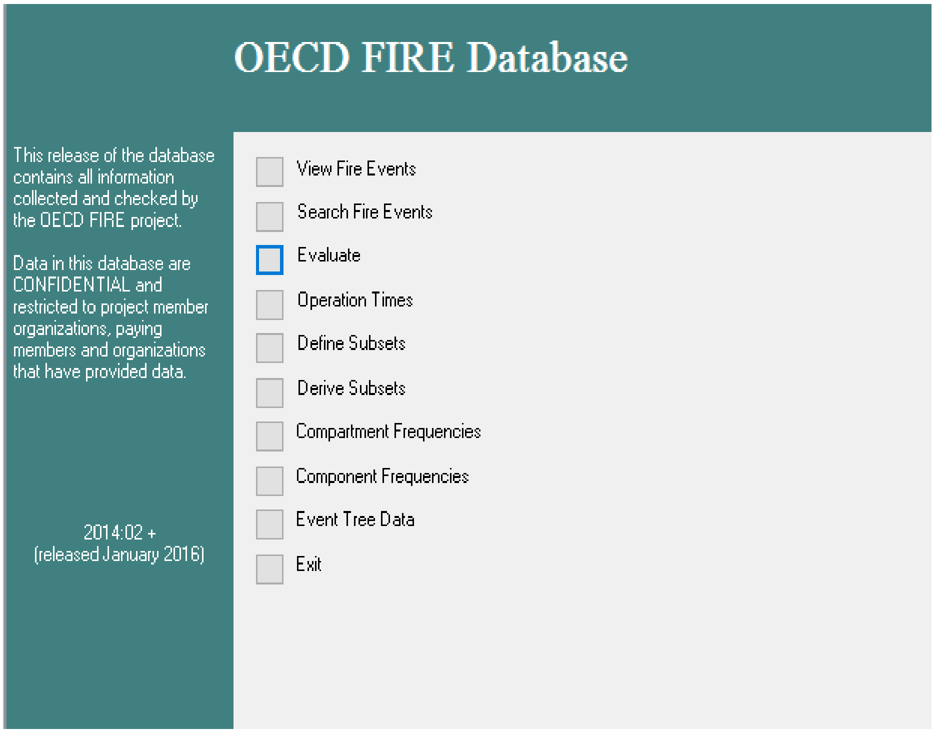

Figure 1. Screenshot of OECD FIRE Database entry page from (Ref. 2)

Another new feature is the import/export capability of event tree data. Each fire event is mapped, according to defined mapping criteria, to three different types of event trees, representing event development over time, fire detection and fire suppression, respectively. Figure 2 provides an example of such an event tree of the evolution in time, created from data stored in the database. Details are provided in Section III.B.

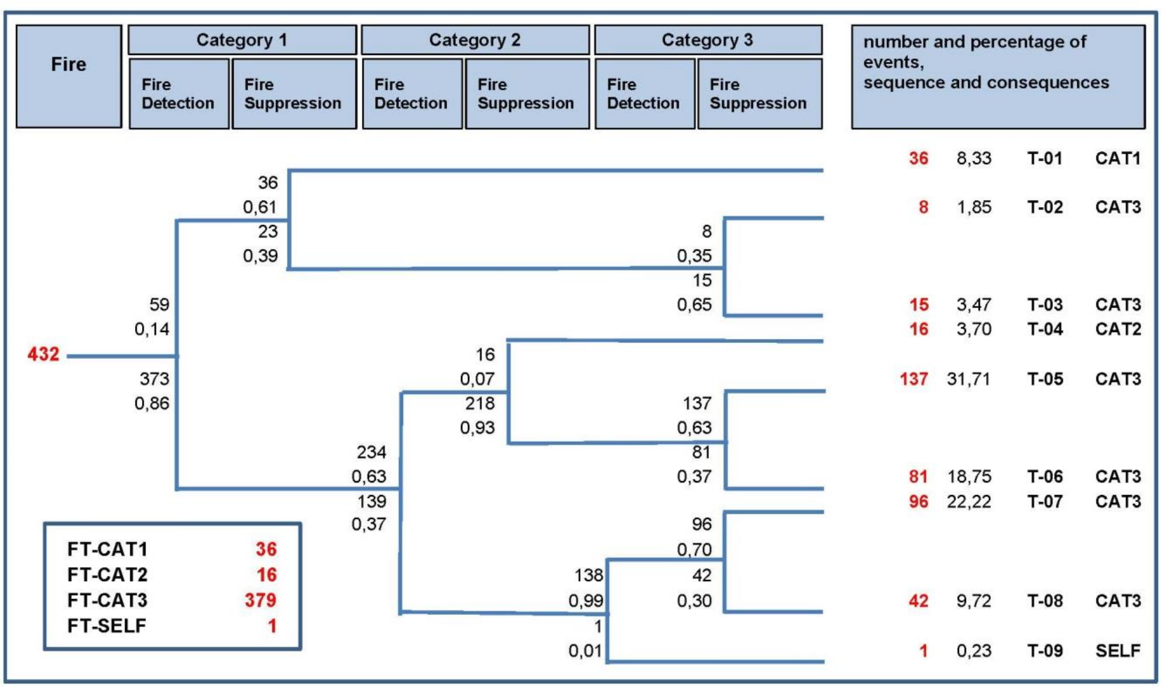

Figure 2. Results of the FET-T mapping for all events in the Database with sufficient information for mapping, from (Ref. 3)

III. RECENT APPLICATIONS OF THE OECD FIRE DATABASE

III.A. Compartment Specific Fire Initiator Frequency Estimation

Initiator frequencies for the events to be studied are indispensable in any probabilistic risk assessment (PRA, synonymously used for PSA). Fire PSA for nuclear power plants typically use room or component based fire initiator frequencies. Both can be readily obtained via tools implemented in the OECD FIRE Database. The available options permit to calculate the relative frequencies, e.g., for selected countries, different reactor types, plant areas (typically rooms/compartments inside different buildings and areas outside of buildings on-site), and component specifically for a variety of components where the fire started.

Meanwhile it is possible to derive compartment type specific generic fire occurrence frequencies from a majority of plants in FIRE member countries. In the following, results from queries strongly utilizing the '*Evaluation'* function of the Database are presented. In this context, it has to be mentioned that reporting criteria and thresholds for fire events in member countries vary widely, in some countries the reporting criteria were even changed over time. Therefore, statistically applicable consistent fire occurrence data can be mainly derived from "*countries reporting all events*". This term actually refers to Czech Republic, Finland, France, and Sweden for pressurized water reactors (PWR) and Finland and Sweden for boiling water reactors (BWR).

Figure 3 shows search results on exemplary compartment specific occurrences of fire events for different buildings during power operation (FP, referring to more than 5 % of full power level) as well as during low power and shutdown (LPSD) plant operational modes for PWR units. The respective results for BWR units are provided in Figure 4.

	Room for electrical control equipment	Other cable room	Other type of room	Process room	Switchgear room	Room for ventilations
Auxiliary building	1		3	5	3	4
Electrical building	7	1	1	1	5	2
Other building/area		1	3			
Reactor building, inside containment				1		
Reactor building, outside containment				1		
Spent fuel building			2			3
Turbine building	1		6	13		

	Room for electrical control equipment	Other cable room	Other type of room	Process room	Switchgear room	Room for ventilations
Auxiliary building	1		4	2		1
Electrical building					4	
Other building/area				1		
Reactor building, inside containment			3	1		1
Reactor building, outside containment			1	1		1
Spent fuel building			1			3
Turbine building				10		

Figure 3. Compartment specific number of fire events for different buildings from PWR units in those FIRE member countries reporting all events (left: FP, right: LPSD)

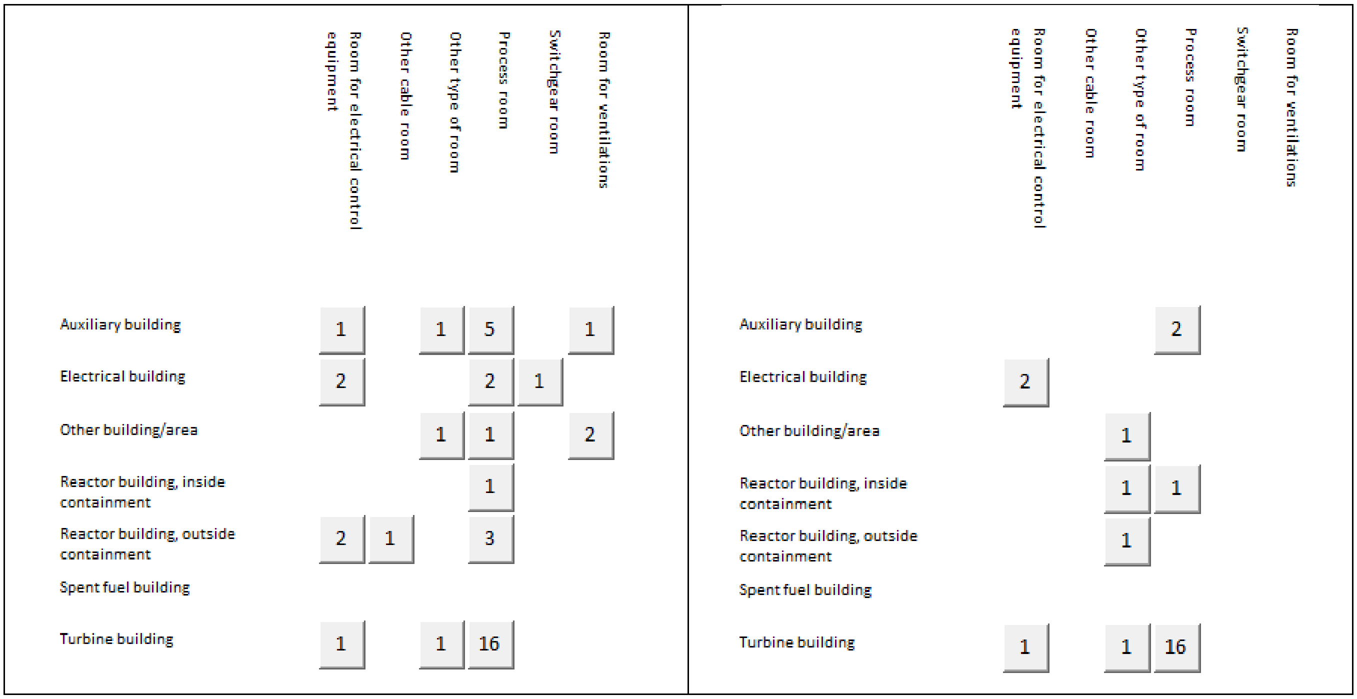

Figure 4. Compartment specific number of fire events for different buildings from BWR units in those FIRE member countries reporting all events (left: FP, right: LPSD)

As an example, Table 1 provides for PWR from those countries reporting all events the compartment specific fire occurrence frequencies for different compartments in various buildings relevant for PSA use for FP as well as for LPSD. The corresponding frequencies for BWR type units are given in Table 2.

Table 1. Compartment specific fire frequencies [1/ry] derived from (Ref. 1) for selected buildings in PWR units from those FIRE member countries reporting all events (FP and LPSD)

Compartment Type / **Building**	POS	Other cable room	Room for electrical control equipment	Switchgear room	Room for ventilation	Process room	Workshop	Diesel generator room
Auxiliary Building	FP	-	5.7 E-05	4.5 E-04	1.2 E-04	7.1 E-05	2.0 E-04	
	LP/SD	-	5.8 E-04	-	3.1 E-04	2.9 E-04		
Diesel Generator Building	FP	-	3.8 E-04	-	-	1.2 E-04		
	LP/SD	-	-	-	-			4.1 E-03
Electrical Building	FP	3.7 E-05	3.0 E-04	9.7 E-04	2.0 E-04	4.7 E-05		
	LP/SD	-	-	7.9 E-03	-			
Independent Emergency Building	FP	-	-	9.4E-04	-			
	LP/SD	-	-	-	-			
Intake Building	FP	-	-	-		2.3 E-04		
	LP/SD	-	-	-				
Reactor Building Inside Containment	FP	-	-	-	-	4.8 E-05		
	LP/SD	-	-	-	8.7 E-04	4.9 E-04		
Reactor Building Outside Containment	FP	-	-	-	-	2.8 E-05		
	LP/SD	-	-	-	1,5E-03	2.8E-04		

Building \ Compartment Type	POS	Other cable room	Room for electrical control equipment	Switchgear room	Room for ventilation	Process room	Workshop	Diesel generator room
Spent Fuel Building	FP	--	-	-	4.7 E-04			
	LP/SD	-	-	-	4.8 E-03			
Turbine Building	FP	-	1.0 E-04	-	-	2.6 E-04		
	LP/SD	-	-	-	-	2.0 E-03		

Remarks:
FP: power operational states – 1059 reactor years in total
LP/SD: low power and shutdown states – 104 reactor years in total
-: no fire event observed, therefore no frequency estimate

In this context, it has to be mentioned that for cable spreading rooms and the main control room in the corresponding PWR units so far no room numbers per building have been provided, while for battery rooms, offices and storages such data are available, but no fire events occurred in the plants considered in Table 1.

Table 2. Compartment specific fire frequencies [1/ry] derived from (Ref. 1) for selected buildings in BWR units from those FIRE member countries reporting all events (FP and LPSD)

Building \ Compartment Type	POS	Other cable room	Room for electrical control equipment	Switchgear room	Battery room	Room for ventilation	Process room	Office	Diesel generator room
Auxiliary Building	FP	-	9.1 E-04	-		1.0 E-04	3.3 E-04	-	7.8 E-04
	LP/SD	-	-	-	-	-	1.5 E-03	-	1.7 E-02
Diesel Generator Building	FP	-	-	-	-	-	-	-	-
	LP/SD	-	-	-	-	-	6.7 E-04	-	-
Electrical Building	FP	-	3.7 E-04	1.3 E-04	2.7 E-04	-	2.4 E-04	8.1 E-05	-
	LP/SD	-	4,1E-03	-	-	-	-	-	-
Reactor Building Inside Containment	FP	-	-	-	-	-	1.6 E-04	-	-
	LP/SD	-	-	-	-	-	1.8 E-03	-	-
Reactor Building Outside Containment	FP	6.6 E-05	1.3 E-04	-	-	-	5.3 E-05	-	-
	LP/SD	-	-	-	-	-	-	-	-
Turbine Building	FP	-	1.4 E-04	-	3.1 E-03	-	3.6 E-04	-	-
	LP/SD	-	1.6 E-03	-	-	-	4.0 E-03	-	-

Remarks:
FP: power operational states – 321 reactor years in total
LP/SD: low power and shutdown states – 29 reactor years in total
-: no fire event observed, therefore no frequency estimate

In the context of Table 2, it has to be mentioned that for cable spreading rooms and the main control room of the BWR units investigated so far no room numbers per building have been provided, while for storages and workshops in the controlled area such data are available, but no fire events occurred in the plants considered in this table.

Information similar to the one shown in Table 1and Table 2 has already been presented in earlier publications. A comparison with these former results clearly demonstrates the robustness of the generic relative fire frequency values. For compartment/building combinations with the highest number of events, see Figure 3 and Figure 4, the former fire occurrence frequencies are nearly identical to the most recent ones. Towards the lower end of the number of events, the relative frequencies may differ by up to a factor 2.

III.B. Generic Fire Event Trees

Determining fire induced component failure probabilities for fire sources identified as being relevant is a key element of Fire PSA. This is typically done via fire event tree analyses. The analyst derives specific fire event trees for the entire potential fire sequences, considering the plant characteristics with respect to fires, the compartment specific parameters such as compartment volume and ventilation conditions, information on potential fire sources and safety related targets (including type, amount and location). Generic event trees are a valuable tool for the analysis, however need to be adapted to the plant specific Fire PSA. This was the reason that a set of three types of generic fire event trees has been developed using data from the OECD FIRE Database characterizing all the possibilities of the phases of fire initiation, fire development and propagation as a stochastic process:

– a time dependent event tree sub-dividing a given fire event sequence into different phases,
– an event tree specifically addressing fire detection, and
– an event tree specifically addressing fire suppression.

Each fire event having been recorded represents a realization of this process and can be characterized by a corresponding sequence number. Details on this approach can be found in (Ref. 3). The set of generic fire event trees can be used in order to analyze fire events reported to the OECD FIRE Database. For the entire fire events observed from the NPP operating experience collected from FIRE member countries the corresponding sequence numbers of the generic fire event trees have been determined. The triplet of sequence numbers represents an additional attribute of each reported fire event, which is stored in the OECD FIRE Database as additional information.

III.C. Combinations of Fires and Other Anticipated Events

The operating experience from nuclear installations has demonstrated that combinations of fires and other anticipated events do occur during the entire lifetime of these installations. This became even more evident as a lesson learned from the post-Fukushima reactor accident investigations clearly demonstrating that the required function of structures, systems and components (SSCs) important to safety may be impaired in case of the occurrence of such event combinations resulting in degradation or even loss of their intended functions.

Combinations of hazards, with either a causal relationship (so-called correlated events) or an independently occurrence, have been discussed in detail, in particular the need for covering these in PSA. This was the reason for the decision to systematically investigate combinations of fires and other anticipated events including internal and external hazards. For that purpose, the following types of combinations have to be distinguished:

- Correlated events:
  – Fires and consequential events;
  – Anticipated initial vents and consequential fires;
- Independently, but simultaneously occurring fires and other events.

The corresponding investigation carried out as an OECD FIRE Task has provided the result that the overall number of such event combinations in the Database is non-negligible (approx. 11 % of the entire events recorded). However, the number of event combinations of the same type is typically low. Nevertheless, there are correlations of fires and other events for which the FIRE Database contains significantly more event records, such as high energy arcing faults (HEAF).

One example of a fire and a simultaneously occurring event independently of the fire has been observed from the FIRE Database records, underlining that such combinations are not only academic assumptions even if the probability of such an event combination is low.

A few event sequences have shown a domino effect: fire with consequential HEAF causing another fire, missiles causing a fire resulting in subsequent flooding, event sequences with seismically induced HEAF and subsequent fires, and weather induced hydrological impact causing HEAF and subsequent fire.

In this context, it is notable that none of event combinations observed so far in the FIRE Database resulted in a loss of all safety trains. Moreover, the events were limited to one plant unit in case of multi-unit sites. However, this may result from the fact that a majority of the event records in the Database represent scenarios with low safety significance. Moreover, passive fire protection means ensure in the utmost cases that fires occurring inside buildings are at least limited to the building where they occurred. Detailed results and recommendations resulting from the in-depth investigation can be found in the corresponding Topical Report (Ref. 4) and a paper presentation at PSAM13 specifically devoted to this important issue (Ref. 5).

III.D. Ongoing and Intended Activities

Already in the third Project phase there was a strong interest of the Project to investigate fire causes in more detail. It turned out that, particularly for events from the past, the root causes have not been recorded systematically. Root causes are more completely addressed for the recently recorded events. This was the main reason that the members of the FIRE Database Project will focus in a first step on the apparent causes of the fires in order to improve fire prevention.

Several investigations carried out so far have clearly demonstrated that human actions are highly important for the success of fire suppression. The statistical analyses performed recently provided the following insights:

- Disregarding those events that did not require active fire fighting actions (self-extinguished fires, fires terminated by fire source isolation or controlled burnout) results in 337 from in total 448 event records in (Ref. 2) (75 %) needing active fire suppression.
- 314 of these 337 fire events, representing 93 %, were successfully suppressed by manual actions demonstrating the significance of well trained, high skills fire fighters familiarized with the plant. While 310 of these events were extinguished successfully by manual fire fighting, in case of four events the fire could be suppressed by manual actuation of the stationary fire extinguishing systems being installed at the fire location,
- The contribution of those fires extinguished by plant personnel is remarkable (approx. 94 % representing 294 of 314 fires); in case of 188 of the 314 fires (approx. 60 %) the on-site fire brigade participated. This indicates that professional on-site fire fighters may significantly reduce the damage resulting from plant internal fires.
- Sensitive fire detectors can also be seen very important to be able to confirm fire alarms as early as possible in order to start manual fire fighting during an early phase of fire propagation.

Further improvements are needed and intended for the fifth Project phase in the analyses regarding self-extinguished fires, fire suppression sequences and dependency of the suppression success on the time when the activities start, as well as other issues relevant for Fire PSA.

IV. DATABASE CHALLENGES

In order to enable the PSA analyst to derive component specific fire occurrence frequencies from the OECD FIRE Database, first attempts have been made in the recent past to collect component numbers for the main components at which fires have occurred, separately for PWR and BWR units. The list of "*components, where the fire started*" is given in the FIRE Database Coding Guideline as part of (Ref. 1). First estimates of component specific fire occurrence frequencies are provided in Table 3 for PWR and **Table 4** for BWR units.

Table 3. Fire frequencies for selected components in PWR plant units from those OECD FIRE member countries having provided component numbers so far (FP and LPSD)

Component type	Number of plant units analyzed	Average number of components per NPP unit	Number of fire events		Estimated fire frequency [1/ry] per component	
			FP	LPSD	FP	LPSD
Battery	72	30.3	0	0	-	-
Diesel generator	82	3.5	1	2	1.7 E-04	2.2 E-03
High or medium voltage electrical cabinet (> 1 kV)	72	91.0	9	2	5.9 E-05	8.4 E-05
Low voltage electrical cabinet (< 1 kV)	72	1447.4	12	2	5.0 E-06	5.3 E-06
Fan	66	307.3	7	3	1.4 E-05	3.7 E-05
Fixed heater	58	505.0	4	5	4.7 E-06	3.8 E-05

Component type	Number of plant units analyzed	Average number of components per NPP unit	Number of fire events		Estimated fire frequency [1/ry] per component	
			FP	LPSD	FP	LPSD
Electrically driven pump	76	327.8	4	4	7.3 E-06	4.7 E-05
Reactor coolant pump (RCP, for PWR)	69	3.5	3	2	6.5 E-04	4.4 E-04
Main feedwater pump	70	4.2	0	0	-	-
Rectifiers, inverter, or battery charger	70	83.5	2	0	1.4 E-05	-
High voltage transformer (≥ 50 kV)	82	4.1	7	3	1.1 E-03	2.9 E-03
Medium or low voltage transformer (< 50 kV)	76	41.0	4	6	5.8 E-05	5.6 E-04
Turbine generator	86	1.1	7	1	3.6 E-03	3.3 E-03

Remarks:
FP: power operational states – 1674 reactor years in total
LP/SD: low power and shutdown states – 261 reactor years in total
-: no fire event observed, therefore no frequency estimate

Many of these components are significant contributors to Fire PSA results. One significant challenge for the Database is the difficulty to collect data on cables. Cables do represent significant contributors to the fire risk, however cable numbers are not yet included in the FIRE Database because of the differing ways of their recording in the various NPPs (by segments or by length, using a cable management system or not, etc.) and the resulting - still unresolved - cable data collection issues.

The list of components in the FIRE Database does contain several components for which the average component numbers still need to be collected and assessed. This activity is ongoing.

Table 4. Fire frequencies for selected components in BWR plant units from those OECD FIRE member countries having provided component numbers so far (FP and LPSD)

Component type	Number of plant units analyzed	Average number of components per NPP unit	Number of fire events		Estimated fire frequency [1/ry] per component	
			FP	LPSD	FP	LPSD
Battery	8	18.6	0	0	-	-
Diesel generator	17	4.5	3	2	1.1 E-03	3.5 E-03
High or medium voltage electrical cabinet (> 1 kV)	6	85.5	4	1	7.8 E-05	9.2 E-05
Low voltage electrical cabinet (< 1 kV)	7	1424.6	9	1	1.0 E-05	5.5 E-06
Fan	4	141.0	2	0	2.4 E-05	-
Electrically driven pump	6	179.0	6	2	5.6 E-05	8.8 E-05
Main feedwater pump	8	3.8	0	0	-	-
Rectifiers, inverter, or battery charger	2	21.0	3	0	2.4 E-04	-
High voltage transformer (≥ 50 kV)	17	3.6	2	0	9.3 E-04	-
Medium or low voltage transformer (< 50 kV)	10	32.0	2	1	1.0 E-04	2.5 E-04
Turbine generator	17	1.3	10	1	1.2 E-02	5.9 E-03

Remarks:
FP: power operational states – 602 reactor years in total
LP/SD: low power and shutdown states – 127 reactor years in total
-: no fire event observed, therefore no frequency estimate

Some compartment specific fire frequencies in different buildings have been estimated based on the data from those member countries reporting all fires (see Table 1 and Table 2). Similarly, fire frequencies could be estimated based on the data from the remaining member countries. The challenge in this effort is to get necessary input, which means average numbers of different compartment types in each building separately for different reactor types in each member country. Some of the compartment types are easy to cover, while other types require even detailed knowledge of the individual plant layout. Therefore, the aim is to get additional input for the most important compartment types based on Fire PSA results.

Electrical cabinet fires are an important contributor in Fire PSA. Cabinet specific fire frequencies are nowadays estimated only for high or medium voltage electrical cabinets (> 1 kV) and low voltage electrical cabinets (< 1 kV). Thus, the low voltage cabinet fire frequency is the same for a low voltage switchgear cabinet and an instrumentation and control (I&C) system cabinet, while the overall number of low voltage cabinets is quite high (cf. Table 3 and Table 4).

One challenge is to get further information of the number of different low voltage cabinets according to the reactor types and to split up the associated fire events in the OECD FIRE Database.

V. CONCLUSIONS AND OUTLOOK

As one of the ongoing OECD NEA Database Projects the *F*ire *I*ncidents *R*ecords *E*xchange (FIRE) Database Project is now in its fifth phase up to the end of 2019. Containing meanwhile more than 450 fire events from about 350 reactor units in thirteen OECD member countries this Database represents a valuable tool for facilitating the use of nuclear power plants fire experience being applicable in the frame of Fire PSA as one potential source of generic event data.

According to the differing reporting criteria and thresholds in the member countries of the OECD FIRE Database Project, the existing data from the operating experience with the corresponding event sequences can meanwhile be applied, e.g., as a input information for fire modeling in order to support model improvements as well as to provide some generic data for Fire PSA.

The numerical results obtained from the Database, in particular fire occurrence frequencies for various types of compartments and buildings as well as for selected components, have turned out to be quite robust. Most of the observations from older versions of the Database have remained valid, demonstrating the stability of the data. The generation of numerical results has been significantly facilitated and expedited by the recently available tools in the Database, allowing for a variety of simplified search queries and automated calculations of fire frequencies, particularly in case of addressing different aspects in parallel. Database subsets generated from search queries are provided for various aspects, such as type of reactor, plant operational state, event combinations of fires and other events, type and duration of detection and/or extinguishing, etc,. enabling the user to apply results from Database analyses not only in the frame of deterministic investigations but also for probabilistic fire risk assessment.

The recent fifth phase of the OECDD FIRE Database Project mainly aims on consolidating the data collection and reducing uncertainties in the analyses. Project members are well aware that several challenges remain:

For statistical and PRA use, further extensions of the Database are necessary:

- In general, more event records with well-defined and more homogeneous information are needed.
  - Compartment specific fire frequencies can in principle be derived, the amount of sufficiently homogeneous data needs to be further increased
  - Deriving component specific fire frequencies is also possible in principle, however challenging for some components such as cables.
- Further investigation of apparent causes of fires is seen possible, but root causes may not be defined for many events. The objective is to realize the causes of fires in order to improve fire prevention in the future.
- Learning from those fire events when fire suppression was not successful is important in order to improve fire fighting capabilities.

Data collection is continuously ongoing with about 15 to 30 events being recorded per year. At the time being, the recording of events from member countries is not yet complete. In this context, it has to be mentioned again that, e.g. in the U.S., there are some hundreds of fire events which have been nationally collected and recorded in the FEDB (*F*ire *E*vents *D*ata*b*ase) by EPRI (Ref. 6) and (Ref. 7). The integration of these events in OECD FIRE would be highly valuable and would remarkably increase the robustness of the Database results.

In the future, efforts will be started to publish insight reports, which evaluate causes of fires in the Database content. The reports are available to nuclear plant fire detection and extinguishing system and layout designers for preventing fires and their combinations with other anticipated events.

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