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Collection and Analysis of Fire Events (2010-2013) – Extensions in the Database and Applications

Fire Project Report

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NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

NEA/CSNI/R(2015)14
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Fire Project Report

"Collection and Analysis of Fire Events (2010-2013) - Extensions in the Database and Applications"

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English text only

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 31 countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission also takes part in the work of the Agency.

The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;
– to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

THE COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of senior scientists and engineers with broad responsibilities for safety technology and research programmes, as well as representatives from regulatory authorities. It was created in 1973 to develop and co-ordinate the activities of the NEA concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations.

The committee's purpose is to foster international co-operation in nuclear safety among NEA member countries. The main tasks of the CSNI are to exchange technical information and to promote collaboration between research, development, engineering and regulatory organisations; to review operating experience and the state of knowledge on selected topics of nuclear safety technology and safety assessment; to initiate and conduct programmes to overcome discrepancies, develop improvements and reach consensus on technical issues; and to promote the co-ordination of work that serves to maintain competence in nuclear safety matters, including the establishment of joint undertakings.

The priority of the committee is on the safety of nuclear installations and the design and construction of new reactors and installations. For advanced reactor designs, the committee provides a forum for improving safety-related knowledge and a vehicle for joint research.

In implementing its programme, the CSNI establishes co-operative mechanisms with the NEA's Committee on Nuclear Regulatory Activities (CNRA), which is responsible for the Agency's programme concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also co-operates with the other NEA Standing Technical Committees as well as with key international organisations such as the International Atomic Energy Agency (IAEA) on matters of common interest.

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EXECUTIVE SUMMARY

Background

Fire Hazard Analyses (FHA) and Probabilistic Fire Safety Analyses (Fire PSA) have shown that fire may be an important contributor to fault trees leading to core damage and other major plant damage states, particularly for older nuclear power plants (NPP). Yet, realistic modelling of fire scenarios within Fire PSA is difficult due to the scarcity of reliable data for fire analysis.

In an attempt to improve the situation, the Committee on the Safety of Nuclear Installations (CSNI) Working Group on Risk Assessment (WGRISK) (formerly PWG5) established in 1996 a Task Group to review the status and maturity of methods used in fire risk assessment for operating NPP. This group concluded in 2000 that "*The shortage of fire analysis data is one of the major deficiencies in the present fire risk assessment.*" Based on these conclusions, several OECD member countries agreed to establish the International Fire Data Exchange Project (OECD FIRE) under the umbrella of the CSNI to encourage multilateral co-operation in the collection and analysis of data related to fire events in NPP. The project was formally launched in January 2003 for a three-year period with nine countries, which was followed by two four-year terms (phase two and phase three) with the addition of three further countries. Phase four started in 2014, and members anticipate that a further term for the project will start in 2016.

Objective of the work

The objectives of the OECD FIRE Project include the establishment of a framework for multi-national co-operation in sharing event information useful to fire risk assessment. The primary activity was to define the format for collecting fire event experience in a quality assured and consistent database. In the course of the project improvement of fire record event attributes was made to facilitate quantification of fire frequencies and fire risk analysis. The permanent activity is to collect and analyse fire events over the long term so as to better understand such events, their causes, and their prevention. The database thus obtained allows generating qualitative insights into the root causes of fire events which can then be used to derive approaches or mechanisms for their prevention or for mitigating their consequences. Among the applications of the database is the possibility for member countries to establish a mechanism for the efficient feedback of experience gained in connection with fire events, including the development of defences against their occurrence, such as improvements of the existing national as well as international reporting systems and indicators for risk-based inspections.

Description of the work

Applicable to commercial NPPs only, the OECD FIRE Project exchanges fire events data covering all plant lifetimes with the operational modes including post-commercial operational shutdown phases, but also construction and decommissioning phases. Currently, the database contains 438 fire events, most of them quality assured. The events are from the period from the early 1980s to the end of 2013, with the bulk of the events in the period of the mid-1990s to the end of 2013. Although the reporting of events is not exhaustive, the database meanwhile provides a good platform for first use within Fire PSA as well as for deterministic investigations.

Results and their significance

Important observations from the statistical evaluation can be summarised as follows:

With respect to the buildings and rooms or plant areas where fires initiate, the observation from the FIRE Database is that fires are most likely to occur in process rooms and in turbine buildings (about one third each of all events stored in the database), approximately twenty percent of the fires having occurred in process rooms inside a turbine building. This is generally in accordance with observations from international event databases such as IRS and INES. Auxiliary buildings and electrical buildings, as well as rooms for electrical control equipment and switchgear rooms also represent significant locations of fire ignition with contributions of about ten percent or more.

Regarding components of fire initiation, electrical cabinets and transformers provide the highest share with approximately twelve percent each, followed by pumps, turbine generators and cables with more than five percent of all events in the database. Material ignited by hot work and transient materials together make up more than 15 percent of all initial fires; most of these are small incipient fire being quickly extinguished.

With regard to fire detection and suppression, the availability of an adequate amount of suitable fire detectors as well as appropriate and reliable manual fire fighting capabilities is essential. A large majority of the fires in the OECD FIRE Database were confirmed within a very short time period (minutes). Only a small portion (about 2.5 percent) of fires was suppressed by automatically actuated fixed extinguishing systems alone; for more than seventy-five percent of the events, manual fire fighting means were involved in the successful fire suppression. The share of self-extinguished fires and of fires terminated by fire source isolation is also significant. Finally, it has been concluded that events associated with long suppression times are more likely to cause severe fire effects than those with short suppression times, and they are correlated with the need for several attacks by different means of fire suppression.

Conclusions and recommendations

The data are still inhomogeneous to some extent due to the differing reporting thresholds and criteria in the project member states. However, the OECD FIRE Database provides qualitative insights into the apparent causes of incipient fires and time dependent fire development. National applications of the database have shown the importance of detailed fire event descriptions providing broader insights beyond the information in the coded fields.

Meanwhile, first applications with respect to Fire PSA are possible; however it will be highly important to collect as many events as possible in the future to enlarge the database through continuous and consistent reporting of events by the project members and to encourage additional OECD member countries to support the OECD FIRE database project for achieving better corroborated data for PSA use. The human factor in the fire event sequence still needs to be investigated in more detail.

The database is considered large enough for use in roughly estimating fire frequencies or, for specific concerns, determining branch point probabilities for generic event trees.

As an outcome of the database project work, one of the main questions which could be answered by the database is whether fire events experienced in a member country are similar to those in other countries. Another question the database is able to answer is: How do the fire events in an NPP of a specific country compare to other countries? For example, if a given country is experiencing a large number of transient fires, the experts from this country may wish to discuss with other countries how they limit those fires. Likewise, if all countries are experiencing common fires such as high energy arcing faults (HEAF), additional international research would be beneficial.

Another question which might be answered by the database is how fires can propagate from the initial fire compartment to other compartments, even if there are protective means available for prevention of fire spreading.

The coding of events has to reflect as far as feasible the needs of the analysts. Therefore the coding guidelines are continuously improved and enhanced to meet these requirements. Improvements in the database structure and a more consistent and exhaustive reporting to the database ensures meanwhile to provide a high level of information.

Data collection is continuing. An average data flow of approximately 30 events per year is expected, as can be extrapolated from the operating experience.

Project members express the hope that this report will encourage additional participation of organisations from other OECD member countries to support the FIRE Database Project.

1. INTRODUCTION AND PROJECT BACKGROUND

The OECD FIRE Database is one of the four nuclear power plants (NPP) operational events databases currently being developed under the umbrella of the NEA. The need for such a database emerged in the late 1990s when it became evident that the information collected in the IAEA's Incident Reporting System (IRS) could not be used for specific analysis and use in risk assessment. In this respect only dedicated databases can deliver "topic focused" lessons learned as well as quantitative analysis and eventually determination of initiator frequencies.

Fire Hazard Analyses (FHA) and Probabilistic Fire Safety Analyses (Fire PSA) have shown that fire may be an important contributor to fault trees leading to core damage and other major plant damage states, particularly for older NPP. Yet, realistic modelling of fire scenarios for Fire PSA applications is difficult due to the scarcity of reliable data for fire analysis.

In an attempt to improve the situation the CSNI/WGRISK (formerly PWG5) established a Task Group to review the status and maturity of methods used in fire risk assessment for operating nuclear power plants. The Task Group issued a questionnaire in May 1997 to all nuclear power generating OECD countries. The Summary Report [1] of this activity was published in March 2000. One of its concluding remarks was as follows:

"The shortage of fire analysis data is one of the major deficiencies in the present fire risk assessment. In order to facilitate the situation, it would be highly important to establish an international fire analysis data bank, similar to that set up by OECD for the CCF data collection and processing system (ICDE/CCF data bank at OECD). Such a data bank would provide fire event data on real fire cases, incipient fires (e.g. smouldering) detected/extinguished before development, dangerous or threatening situations, reliability data on fire protection measures, and the unavailability of fire fighting systems, for example, due to component failures or operational errors."

Based on the above concluding remarks, several OECD member countries agreed to establish the International Fire Data Exchange Project (OECD FIRE). This was to encourage multilateral co-operation in the collection and analysis of data related to fire events in NPP. During its annual meeting in 2000, CSNI formally approved the carrying out of this project. The project was formally launched in January 2003, initially joined by nine countries. At the end of the first term (December 2005), a second term was agreed on. The project was successfully continued with three additional member countries in Phase Two (2006 - 2009) under an agreed set of Terms and Conditions. During this Project Phase, several project members started activities for testing the comprehensiveness of the chosen database format and its applicability. This resulted in valuable improvements in storing and retrieving existing information for specific purposes from the database.

The member countries of Phase Two of the Project and the Operating Agent (OA) agreed to continue this Project in phase three (2010 - 2013) under new Terms and Conditions aimed at achieving reasonable progress in how to apply the database. This involved using the database to answer questions arising in the licensing and in supervisory activities of NPP in member countries that required feedback from fire related operating experience. Other activities were directed at supporting Fire PSA.

The project is currently in the fourth Project Phase (2014 – 2015) with a change in the Operating Agent. The project is conducted according to an agreed set of Operating Procedures [2]. In particular, the responsibilities of the participants and the OA, as well as the funding and the distribution of the database are addressed.

The project is managed by a Project Review Group composed of National Coordinators (NC) of the currently participating member countries (Canada, Czech Republic, Finland, France, Germany, Japan, Korea, The Netherlands, Spain, Sweden, Switzerland and United States), who have full responsibilities to take decisions for the project. Funding and event data are provided by each country and the OA ensures the quality assurance (QA) and the operation of the database.

Applicable to commercial nuclear power plants only, the OECD FIRE Project exchanges fire events data covering all plant operational modes including construction and decommissioning phases[1].

Currently, the Database [3] contains 438 fire events, the majority of these being quality assured, for the others QA pending. The events at the end of the third phase are from between the early 1980s to 2013, with the bulk of the events in the period between the mid-1990s to the end of 2013. Although the reporting of events is still not exhaustive, the database currently provides a good platform for first use within Fire PSA as well as for deterministic investigations.

Population of the FIRE Database is achieved using a set of coding guidelines [4] developed by the project and inputted by the national coordinators of the member countries. Quality assurance of the data inputted is carried out by the Operating Agent.

1. The OECD FIRE Database currently contains a limited number of construction phase fire events and no decommissioning phase events. However, the Database infrastructure is capable of handling the reporting of fire events during these phases.

2. PURPOSE AND SCOPE OF THE PROJECT

The purpose of the OECD FIRE Project is to provide a platform for multiple countries to collaborate and exchange fire event data and thereby to enhance the knowledge of fire phenomena and in turn improve the quality of risk assessments that require fire related data and knowledge.

Improving the safety of NPP by better accounting for feedback from operating experience and by providing common resources for analytical work in the frame of deterministic and probabilistic assessments is a key objective of the OECD FIRE Project. To meet this objective, the project includes the establishment of a framework for a multi-national co-operation in fire data collection and analysis.

The core objectives of the OECD FIRE Project are:

- To collect fire event experience by international exchange in an appropriate format in a quality assured and consistent database (the "OECD FIRE Database"),
- To collect and analyse fire events over the long term so as to better understand such events and their causes, and to encourage their prevention,
- To generate qualitative insights into the root causes of fire events in order to derive approaches or mechanisms for their prevention and to mitigate their consequences,
- To establish a mechanism for the efficient operational feedback on fire event experience including the development of policies of prevention, such as indicators for risk informed and performance based inspections, and
- To record characteristics of fire events in order to facilitate fire risk analysis, including quantification of fire frequencies.

The database is envisioned to be used to:

- Support model development, validation, etc.,
- Identify all types of events and scenarios for inclusion in PSA models ensuring that all mechanisms are accounted for,
- Support Fire PSA by real data, in particular to evaluate fire occurrence frequencies, and
- Compare fire event data from member states with the accumulated international data collected within the FIRE Database.

The objectives of the OECD FIRE Database have been further extended during Phase Three of the Project to include the following analytical topics:

- Further improving the database by providing additional guidance on the construction of narrative fields including prompting questions and event sequence diagrams,
- Grouping events, e.g. "challenging fires", "potentially challenging fires", etc.,

- Performing trending analysis, e.g. for consolidation of national databases,
- Extending the analysis, e.g. by fire frequency estimation, fire scenario quantification, human performance analysis, fire scenario screening, fire causes and related phenomena, analysis of homogenous event groups, fire brigade response time estimation, HEAF (*h*igh *e*nergy electric *a*rcing *f*aults), fire development, growth rate and spreading.

With emphasis on data validity and data quality, OECD FIRE Coding Guidelines [4] have been significantly enhanced (see also Appendix A) for collecting and classifying fire event data to ensure consistent interpretations and applications. The Operating Procedures [2] and the Quality Assurance Manual [5] complete the project documentation. The task of document adaption to the recent needs of the applicants has been part of Phase Three of the Project (2010 - 2013).

Fire data have been continuously delivered to the OECD FIRE Project within phase three resulting in more than 100 new events being stored and quality assured in the database. The first data collection concerned the observation period from January 1, 2001 to December 31, 2002. The first data collection had the following limited objectives:

- To confirm and, if necessary, improve the design and attributes of the OECD FIRE Database,
- To confirm and, if necessary, improve the coding guidelines against data,
- To test routines for further data collection.

Already since 2004, and based on the feedback from the first years, stable routines for reporting and QA [5] are in place.

At the end of Phase One (2003 to 2005), the project was successfully continued with three additional member countries from 2006 to 2009 (Phase Two) under a given set of Terms and Conditions. During Phase Two of the project, several members started activities for testing the comprehensiveness of the chosen format and its applicability resulting in valuable improvements and retrieving existing information for specific purposes from the database. For example, ignition mechanisms have been analysed in Japan in order to understand the ignition mechanisms and to identify potential fire sources for Fire PSA. Another activity in Sweden resulted from a switchgear room fire in a Swedish NPP to resolve the task of making the existing pre-incident planning more effective with respect to emergencies. This planning has to a large extent been created on the basis of the identified and most common types of fires and their relevance checked against “real fire events” from the FIRE Database. German applications were triggered by the more recent nuclear power plant operating experience in the late 2000s resulting in a comprehensive investigation of events such as “fire and explosion” and “filter fires”. Results of the first two Project Phases can be found in [6].

One challenge in setting up an international database is to ensure a consistent reporting level between countries in order to capture all events fulfilling the objectives of the project. Regulatory and utilities' reporting levels are different between member countries (e.g., did the fire or did it not affect safety equipment, different duration thresholds, etc.), and, in addition, the reporting criteria may have changed with time. For events from the past, the database includes for reference the evolution with time of reporting levels. For future events, one objective of the first three years phase was to define a project reporting level, which will account for the countries' policies while correctly addressing the technical objectives of the project.

Fire events considered in the OECD FIRE Database are defined as follows [4]:

- Any process of combustion characterised by the emission of heat accompanied by (open) flame or smoke or both, or

- Rapid combustion spreading in an uncontrolled manner in time and space.

Note: This includes incipient fires as well as fully developed fires. Fires shall be included in the database if they are relevant to safety and also if the same type of fire has the potential to be relevant/significant for safety under different boundary conditions (such as different ventilation conditions, other plant operating states (POS), same components affected in other locations, etc.). Explosions not resulting in an open flame shall be excluded.

3. STRUCTURE OF THE OECD FIRE DATABASE

3.1 Reported events

The reporting of fires is limited to nuclear power plants. Fires at other nuclear facilities, such as research reactors, nuclear waste storage facilities, etc., are currently out of the scope. The reporting includes all plant internal fires on-site (inside and outside buildings) as well as plant external fires if these have the potential to impact nuclear safety. The reporting covers fires during all modes of plant operation, including post-commercial shutdown phases and fires during construction and decommissioning.

3.2 Description of OECD FIRE events

An OECD FIRE event is described by the narrative event description and a number of coded descriptive fields with attributes selectable from predefined menus (see Appendix A and [4]). The source of information normally is the narrative event description; the entries in the coded fields are derived from that description. The classification of the fire event through coded attributes provides the possibility to search for and identify specific fire events or groups of such events of interest in the OECD FIRE Database for a wide range of applications.

3.3 Fire event analysis support data

Fire event analysis requires supporting data that are stored in two database support modules. These are:

- The *Reporting Threshold Module* which defines thresholds for reporting fire events to authorities by the utilities. If collected fire data are to be used for statistical purposes it is essential to know the reporting routines applied in the various countries. Essentially, there are two different reporting threshold levels:

  - **LER level fires:**
    The Licensee Event Report (LER) level is normally defined in the technical specifications. Several different definitions exist, depending on member country and date of the fire event. In some member countries a fire event will be reported as a LER if it had affected a safety component. Other LER definitions are based on the duration of the fire.

  - **All fires:**
    Some OECD FIRE member countries have access to all fire reports. This fact also has to be documented in the reporting threshold module.

- The *fire brigade organisation module* which contains the general description of on-site and off-site fire brigade organisation. Distance between plant and off-site fire brigade stations as well as off-site fire brigade response time are provided. Changes over time in the organisation can be addressed in the database.

3.4 Actual enhancements of the database structure

In the third Project Phase, the structure of the FIRE Database as provided to the users has been significantly enhanced to enable quick and efficient searches by the analysts. The updated database structure particularly facilitates statistical analysis needed for providing generic fire frequencies for nuclear power plants.

Using in-built query routines a variety of queries can be made based on reactor type, plant operational state (power operation, low power and shutdown, decommissioning), selection of countries, from which events are reported depending on reporting criteria and thresholds, etc. to make the query as meaningful as possible for the task to be performed.

For example, the function '*Search Fire Events*' has been substantially improved and the functions '*Evaluate*' and '*Operation times*' have been added to the Database [3] (see Figure 1).

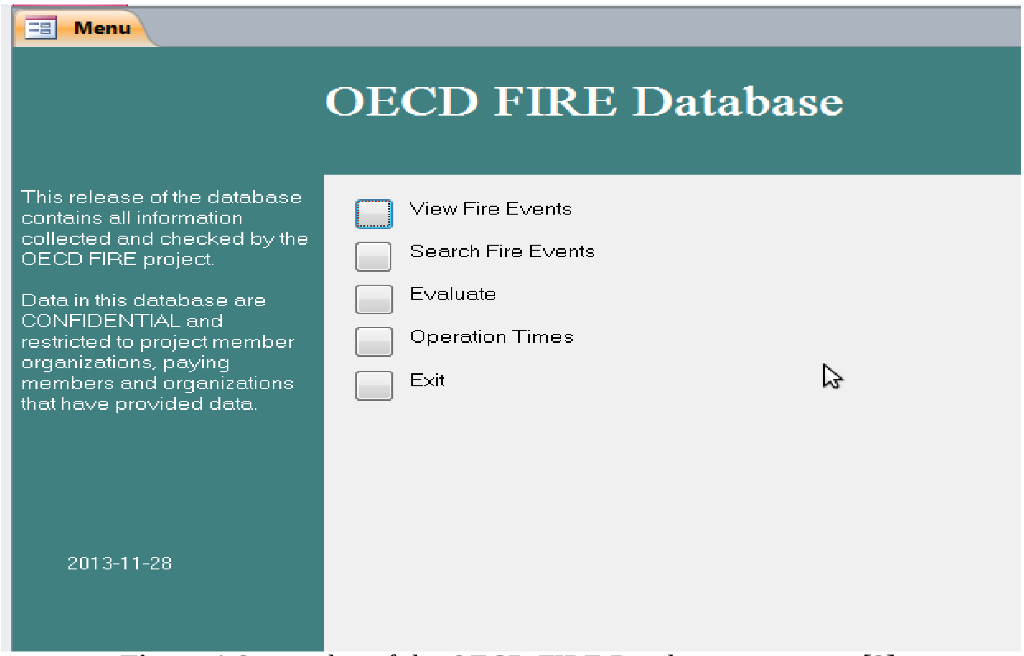


Figure 1. Screenshot of the OECD FIRE Database entry page [3]

A screenshot of the most recent database version [3] for event search is shown in Figure 2. To allow differentiation between fires occurring during power operation, low power and shutdown states including post-commercial shutdown phases, construction and decommissioning activities, associated nuclear phases of the plant lifetime have also been included summarised by reactor type and country.

By means of the '*Search fire events*' function, either the whole database (default) can be used as a basis for the query or already existing subsets generated by earlier queries can be applied as a basis for new queries. Four different types of fields exist:

- Fields permitting the selection of one attribute from a pull down menu;
- Fields permitting the selection of multiple attributes connected by logical '*OR*' within the field; these are '*Operation mode*', '*Country*', and '*Reactor type*';
- Fields permitting the selection of multiple attributes connected by logical '*AND*' or '*OR*' or '*EX-CLUDE*' within the field;
- Fields permitting text string searches in comments fields.

All fields are connected by logical '*AND*'. The result of any search is displayed on the page '*Search Fire Events*'. The newly added feature '*Create Subset*' allows storing the result in the format used in '*View*

Fire Events' by assigning a unique name to the subset. The created subset can then be viewed and further analysed in the '*View Fire Events*' mode. It can be used as a basis for further queries.

With respect to the '*Evaluate'* function, three different analysis modes can be examined:

- Single selection fields and mutually exclusive multiple selections fields (reactor type, country, operation mode),
- Pairs of single selection fields (cross tables),
- Fields in which multiple attributes can be selected.

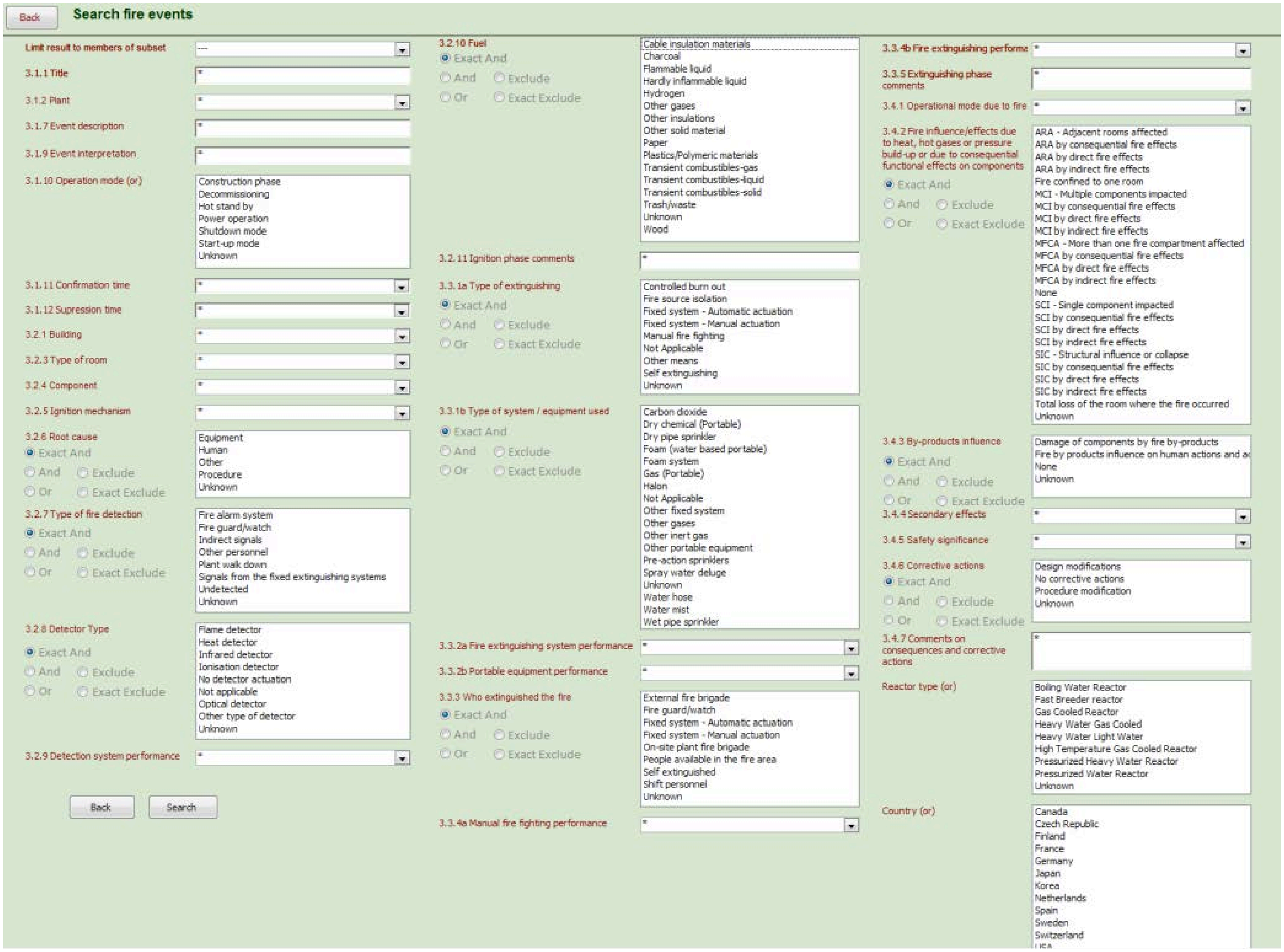


Figure 2.OECD FIRE Database screenshot for event search, from [3]

The same input form is used for all three options. For each of the three options the evaluation can either be based on the whole data set or on subsets. This is illustrated by two examples. The first example shows the input format for single selection fields or mutually exclusive multiple selections fields. The search for “all ignition mechanisms” provides the following result (see Figure 3):

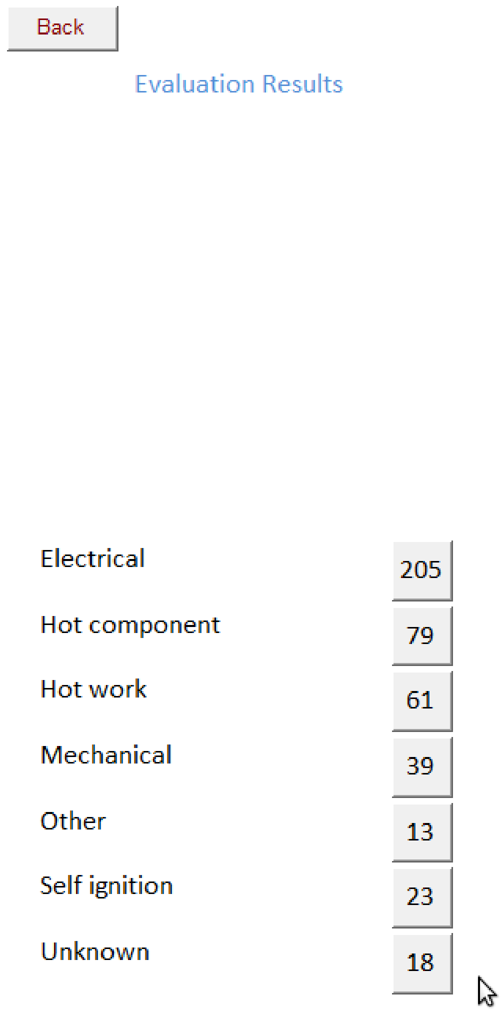


Figure 3. Result of the query “evaluation of all ignition mechanisms” in the actual OECD FIRE Database version 2013:01 [3]

As another example, the database screenshot provided in Figure 4 shows the input format for pairs of single selection fields (cross tables) providing the result presented in Figure 5.

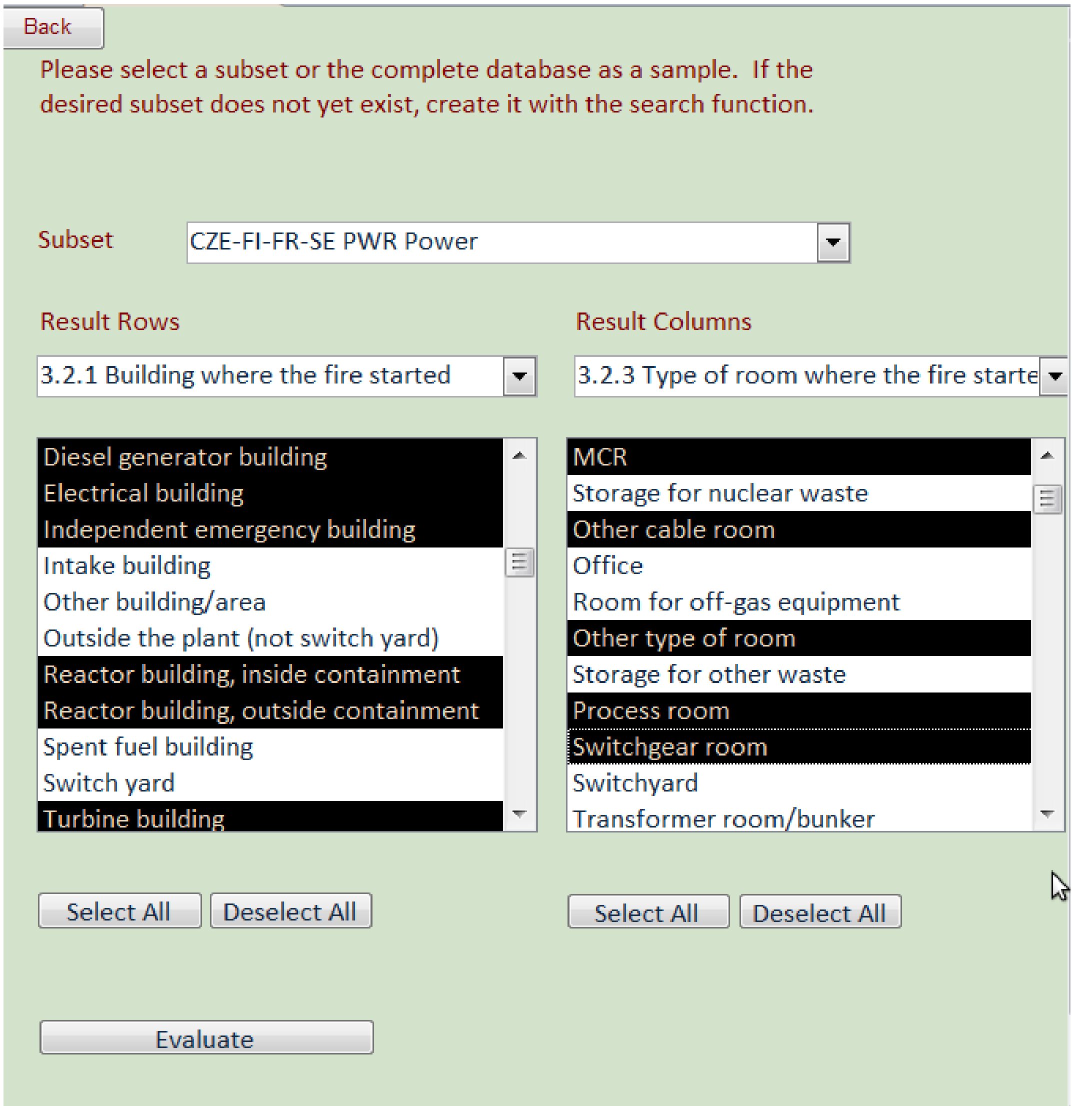
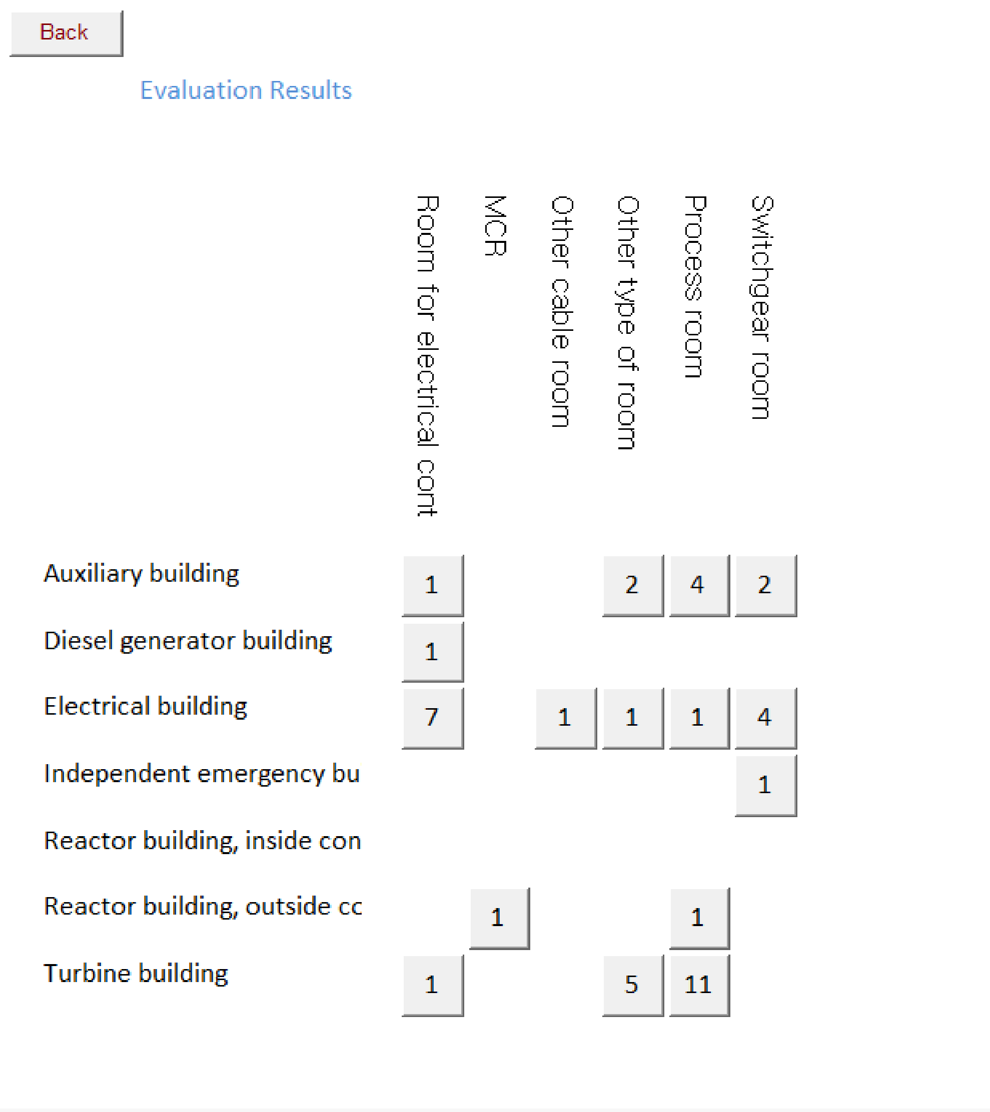


Figure 4. Screenshot of the query on rooms per buildings in the actual OECD FIRE Database version 2013:01 [3]



Back

Evaluation Results

	Room for electrical cont	MCR	Other cable room	Other type of room	Process room	Switchgear room
Auxiliary building	1			2	4	2
Diesel generator building	1					
Electrical building	7		1	1	1	4
Independent emergency bu						1
Reactor building, inside con						
Reactor building, outside cc		1			1	
Turbine building	1			5	11	

Figure 5. Result of the query on number of selected types of rooms for selected buildings in the actual OECD FIRE Database version 2013:01 [3]

The ‘*Observation times*’ function provides (see screenshot in Figure 6) anonymised plant operational times for the different OECD member countries, reactor types and the different plant modes, as power operation, low power and shutdown, and decommissioning phase.

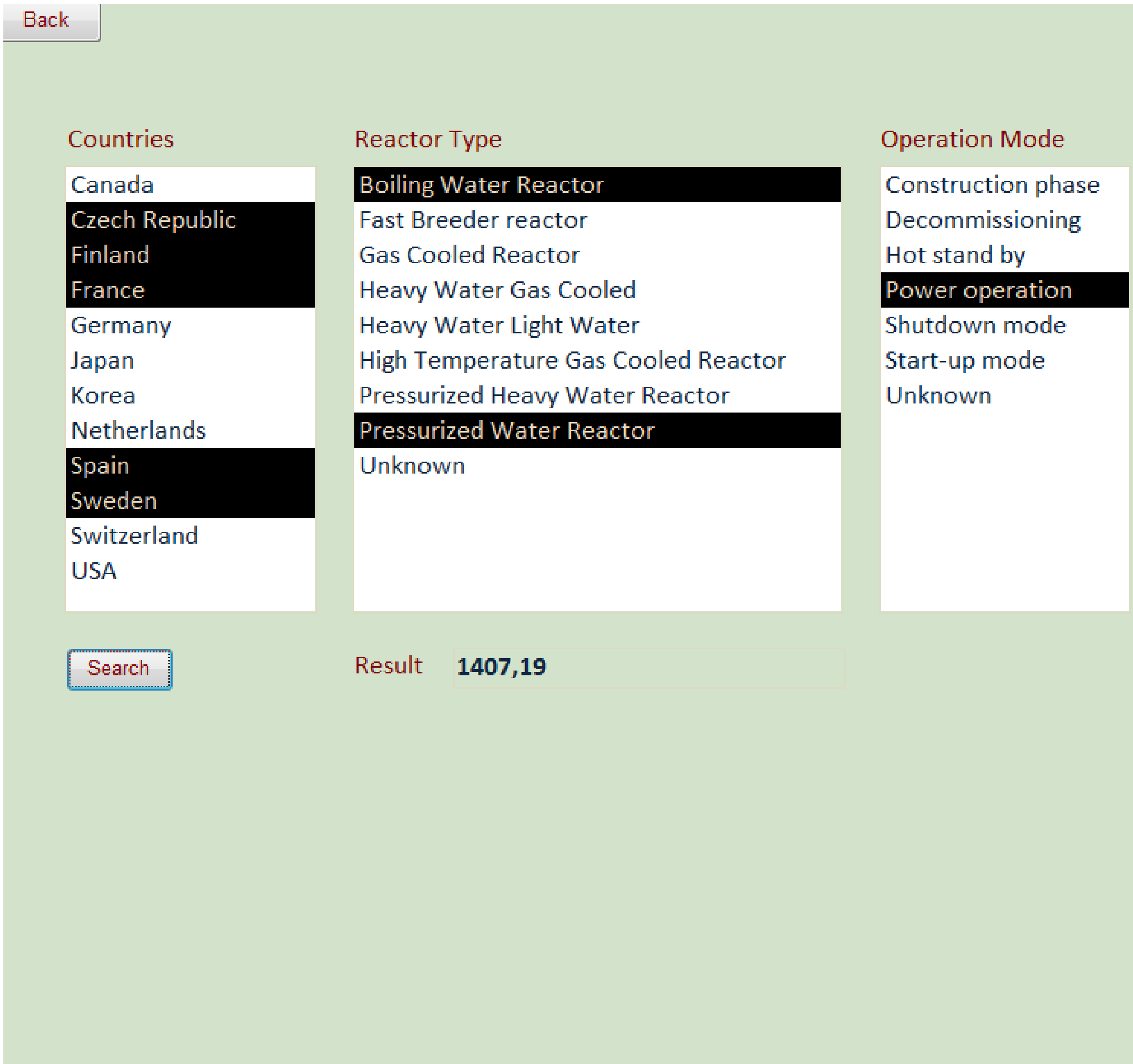


Figure 6. Screenshot of search by '*Observation times*' function, from [3]

4. RECENT DATABASE APPLICATIONS OF THE PROJECT

4.1 Topical reports

A number of Topical Reports were initiated in the Third Phase of the Project. One of these has been completed and the others have moved forward into the Fourth Phase defined later.

4.1.1 Topical report on HEAF fire events

The operating experience from nuclear installations has shown a non-negligible number of reportable events with non-chemical explosions and rapid fires resulting from high energy arcing faults (HEAF) in high voltage equipment such as circuit breakers and switchgears. Such electric arcs have led in some events to partly significant consequences to the environment of these components exceeding typical fire effects. Investigations of this type of events have indicated failures of fire barriers and their elements as well as of fire protection features due to pressure build-up in electric cabinets, transformers and/or compartments.

Due to the high safety significance and importance to nuclear regulators, a Topical Report on "Analysis of High Energy Arcing Fault (HEAF) Fire Events" [7] was prepared by an international group of fire specialists from the OECD FIRE Database Project to pool international knowledge and research for examining the phenomena in nuclear power plants.

Items important to safety can be severely damaged by HEAF events so that their intended function may be degraded or lost. Such events can produce an arc blast, lead to significant pressure waves and/or cause high speed metal projectiles all of which may impair or damage systems, structures or components (SSC).

Therefore, the main objectives of the study (resulting in the above mentioned Topical Report [7]) were to investigate HEAF fire events in the OECD FIRE Database that resulted in failures of fire barriers and their elements as well as of fire protection features due to pressure build-up in electric cabinets, transformers and/or compartments. In addition, it was examined if HEAF is a common phenomenon at NPP and how HEAF develops, in order to extend the existing knowledge of this particular fire phenomenon. Last but not least it was to be determined if these events provide sufficient insights on HEAF related events to prevent them and to provide a better understanding of their causes.

Although meaningful statistical conclusions could not be obtained due to the small sise of the HEAF event sample, the Topical Report provided the following overall conclusions:

- The 48 HEAF fire events constituted a significant share of more than 10 % of the entire events stored in the OECD FIRE Database.
- The conditional probability of a HEAF event with fire to occur was roughly estimated to be approximately 8 E-03 per reactor year for power operation and 2 E-02 for low power and shut-down states.

- In general, there was nothing conspicuous about the occurrence dates of HEAF induced fire events except events at high voltage transformers, for which the occurrence dates seem to suggest a trend of increasing frequencies of HEAF in the more recent years. This might be attributed to ageing problems of electric insulation materials.

- The dominating contribution to HEAF events with consequential fires comes from transformers, with nearly 30 % from high voltage transformers and approximately 8 % from medium and low voltage transformers. HEAF in high voltage transformers typically lead to the destruction of the transformer and consequentially to massive economic losses. Safety significant consequences have not been observed in the events collected for high voltage transformers. The reason for this seems to be the fact that most of these transformers are located outside of buildings or plant areas relevant to safety. On the other hand, HEAF events in high or medium voltage electrical cabinet have a high potential for impairing nuclear safety.

- With respect to the root causes of the HEAF fire events, technical causes (equipment failures) dominated the root causes.

The results of the Topical Report [7] created within the FIRE Project resulted in an experimental research project named "Joint Analysis of Arc (JOAN of Arc) Faults - OECD International Testing Programme for High Energy Arc Faults (HEAF)" under the auspices of NEA, which is still ongoing.

More details can be found in [7].

4.1.2 Topical report on fire specific regulations in FIRE member countries

Another benefit for the International FIRE Database Project is to provide the member countries a venue to discuss the NPP fire experience from their countries. The corresponding Topical Report is aiming to assemble and consolidate the fire protection and post fire safe shutdown regulations of each member country. Member countries will then be better able to determine how their fire protection regulations compare with other member countries.

Details can be found in [8].

4.1.3 Topical report on combinations of fires and other events

A Topical Report on results from the OECD FIRE Database on event combinations of fires with other anticipated events or hazards was initiated with the intent of basing the outcome on the most recently updated version of the Database [3].

Background for this Topical Report was the operating experience from nuclear power plants and other nuclear facilities having indicated that combinations of fires and other anticipated events do occur during the entire lifetime of these facilities. The required function of structures, systems and components (SSC) important to safety may be impaired in case of the occurrence of such event combinations resulting in degradation or even loss of their required functions.

Combinations of hazards, with either a causal relationship or occurring independently but simultaneously, have been investigated in more detail as a lesson learned from the Fukushima Dai-ichi reactor accidents. This was the main reason for systematically investigating combinations of fires and other anticipated events and/or hazards in the FIRE Database. For that purpose, three types of combinations have to be distinguished:

- Fire and consequential event,
- Event and consequential fire, and
- Fire and independent event occurring (nearly) simultaneously.

For each of these event combinations, it has to be systematically checked, which types of internal or external hazards can be correlated to fire events. The general answer to this question is that only internal hazards may occur as a consequence of a plant internal fire, while fires may be induced by several internal or external hazards. As a result, a list of possible combinations has been provided. Only some of these combinations have been observed in the operating experience reported to the OECD FIRE Database up to the time being.

47 out of the in total 438 fire events in the most recent database version [3] have been identified as event combinations of fires and other events representing a contribution of approximately 10 %, which is still rather small but non-negligible. Figure 7 shows the share of the different types of event combinations of fire and other events.

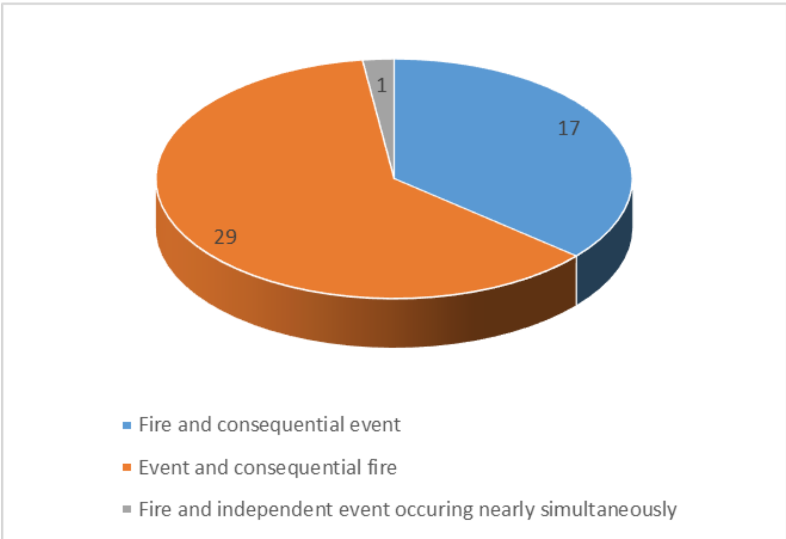


Figure 7.Share of the different types of combinations of fires and other events as observed from the OECD FIRE Database [3]

Details on the 47 event sequences are provided in the Topical Report No. 3 [9] are being prepared for final discussion and approval by the FIRE Project. Lists of the event combinations identified with details regarding plant operational state, equipment/component where the fire started, fuel, plant area, root causes, fire duration and extinguishing means used are being presented in tables. Moreover, it is intended to address consequences of the events with respect to plant operational state and, as far as possible, good practices to efficiently prevent such types of event combinations in the future will be addressed. Some exemplary event combinations will be outlined in more detail. In addition, already existing national regulations considering event combinations will be provided.

The investigations have provided the result that the number of event combinations of the same type is typically very low, most of the combined event sequences have occurred so far only one, two or four time. There are only two types of causally related event combinations, for which the OECD FIRE Database contains significantly more events: Fires consequential to an explosion constituted the vast majority of event combinations in the 2013 version of the Database [3] with 25 events. Ten fire events resulted in internal flooding, mostly due to the necessary fire extinguishing activities. Three event combinations show a domino effect (earthquake resulting in a high energy arcing fault (HEAF) and a consequential fire as well as fire resulting in an explosion and a consequential fire). Combinations of fires and independently occurring hazards were expected to be practically excluded. Nevertheless, such an event combination of a fire and an independently occurring event (flooding) was found in the database underlining that such combinations do occur in reality.

Moreover, the investigation has shown that in the case of several event combinations the plant operational state changed from full power to low power and/or shutdown and in some cases, safety trains were lost during the event sequence.

Regarding the use of the OECD FIRE Database for analysing event combinations in PSA there are still limitations resulting from inconsistencies due to different reporting criteria in the participating member countries. However, the available data provides valuable insights and allow at least probabilistic considerations. More details can be found in [9].

4.2 PSA Related applications

4.2.1 Fire frequency estimations

Fire frequency estimation has been recognised by members of NEA/CSNI WGRISK as well as FIRE Project members (see [10]) as an important topic to be addressed by the database project.

Fire frequency estimation was begun in Phase Three of the Project and continues to be ongoing to improve the determination of frequencies from fire event data. In this context, the OECD FIRE Database has been re-structured to provide easier to use and more extensive search capabilities to facilitate the generation of statistical data that are typically needed for Fire PSA as well as for other applications.

To allow differentiation between fires occurring during power operation, low power and shutdown states including post-commercial shutdown phases, construction and decommissioning activities, associated nuclear phases of the plant lifetime have also been included summarised by reactor type and country. Based on the time periods for the different phase of the plant lifetime (called “operating times”) from the beginning of the reporting to the FIRE Database up to the end of the reporting period (actually December 2013), which differs by country and individual plant, it is possible to calculate compartment specific as well as component specific fire occurrence frequencies.

Compartment specific fire frequencies

As an example for the estimation of compartment specific fire occurrence frequencies, the screenshots from the database as given in Figure 8 to Figure 11 show those buildings and compartments currently included in the OECD FIRE Database and the respective numbers of fire occurrences for all PWR (pressurised water reactor) and BWR (boiling water reactor) units respectively for power operation and low power and shutdown states respectively. The corresponding fire occurrence frequencies can be easily determined using the country and reactor type specific operation times for the different phases of the plant life included in the database.

In order to estimate generic compartment specific fire frequencies average numbers of compartments per building have to be known. The average numbers of compartments considered in the examples presented in this report and the correspondingly estimated fire frequencies are shown in Table 1 to Table 4. They are calculated from the data provided by the project participants and are shown together with the calculated estimates of fire frequencies. The collection of this data is highly reliant on member country resources being available and thus at the end of Phase Three of the Project, not all member countries had provided this information.

The country and reactor type specific operation times for full power (FP) and low power and shutdown (LP/SD) states applied so far are shown in the headings of the tables.

In the following, results obtained by queries that strongly utilised the new "*Evaluation'* function of the OECD FIRE Database are presented. The term "*countries reporting all events*" used in this context refers to Czech Republic, Finland, France, and Sweden for pressurised water reactors (PWR) and Finland and Sweden for BWR. Figure 8 and Figure 9 show search results on compartment specific occurrences of fire events for selected buildings during power operation (FP, referring to more than 5 % of full power level) and, in comparison, also for low power and shutdown (LPSD) states.

Table 1 provides, as an example, the average numbers of selected compartments of selected buildings typically relevant for PSA for PWR plants from countries reporting all events, and the correspondingly estimated fire occurrence frequencies for FP. Table 2 provides the analogous information for LPSD. Figure 10 and Figure 11 provide the same type of information on fire occurrences per selected compartments and buildings for BWR plants in countries reporting all events. The corresponding average compartment numbers for BWRs and the respective fire frequencies are given in Table 3 and Table 4.

These types of figure and tables have already been presented (cf. [11]) or published (see [12]), but with preliminary information and have updated accordingly after the actual database version [3] had been distributed.

	Storage for combustible	Staircases and corridors	Diesel generator room	Room for electrical cont	MCR	Other cable room	Office	Other type of room	Storage for other waste	Process room	Switchgear room	Switchyard	Transformer room/bunk	Room for ventilations	Workshop
Auxiliary building		2		1				2	1	4	2			3	1
Diesel generator building				1											
Electrical building				7		1		1		1	4			2	
Independent emergency bu											1				
Intake building										2					
Other building/area						1	1	2							
Outside the plant (not switc	1							1	1						
Reactor building, inside con															
Reactor building, outside cc					1					1					
Spent fuel building	1							1						3	
Switch yard								1				1	1		
Turbine building				1				5		11					

Figure 8. Number of fire occurrences in buildings/compartments for PWR at power operation with known average compartment numbers from countries reporting all events (screenshot from the OECD FIRE Database [3])

	Storage for combustible	Staircases and corridors	Diesel generator room	Room for electrical cont	MCR	Other cable room	Office	Other type of room	Storage for other waste	Process room	Switchgear room	Switchyard	Transformer room/bunk	Room for ventilations	Workshop
Auxiliary building				1				4		2				1	
Diesel generator building								2							
Electrical building											3				
Independent emergency bu															
Intake building															
Other building/area	1									1					
Outside the plant (not switc								2							
Reactor building, inside con								3		1				1	
Reactor building, outside cc										1				1	
Spent fuel building								1						3	
Switch yard													1		
Turbine building										10					

Figure 9. Number of fire occurrences in buildings/compartments for PWR at low power and shutdown with known average compartment numbers from countries reporting all events (screenshot from the OECD FIRE Database [3])

	Storage for combustible	Staircases and corridors	Diesel generator room	Room for electrical cont	MCR	Other cable room	Office	Other type of room	Storage for other waste	Process room	Switchgear room	Switchyard	Transformer room/bunk	Room for ventilations	Workshop
Auxiliary building			1	1				1		5				1	
Diesel generator building			1					1							
Electrical building				2			1			1	1				
Independent emergency bu															
Intake building															
Other building/area								1		1				2	
Outside the plant (not switc															
Reactor building, inside con										1					
Reactor building, outside cc				2		1				3					
Spent fuel building															
Switch yard										1	2				
Turbine building				1				1		16					

Figure 10. Number of fire occurrences in buildings/compartments for BWR at power operation with known average compartment numbers from countries reporting all events (screenshot from the OECD FIRE Database [3])

	Storage for combustible	Staircases and corridors	Diesel generator room	Room for electrical cont	MCR	Other cable room	Office	Other type of room	Storage for other waste	Process room	Switchgear room	Switchyard	Transformer room/bunk	Room for ventilations	Workshop
Auxiliary building			1					1		2					
Diesel generator building										1					
Electrical building				2											
Independent emergency bu															
Intake building															
Other building/area		1						1							
Outside the plant (not switc															
Reactor building, inside con								1		1					
Reactor building, outside cc								1							
Spent fuel building															
Switch yard															
Turbine building				1				1		17					

Figure 11. Number of fire occurrences in buildings/compartments for BWRs at low power and shutdown with known average compartment numbers from countries reporting all events (screenshot from the OECD FIRE Database [3])

Table 1. Average number of compartments in selected buildings and corresponding fire frequencies for PWR (power operation, countries reporting all events)

Compartment type / Building	Process rooms	Rooms for electrical control equipment (including main control room)	Rooms for ventilation	Other types of rooms (including staircases and corridors)	Switchgear rooms
Turbine Building	45 2.6 E-04 /a	8 1.3 E-04 /a	7 - *	51 1.0 E-04 /a	4 - *
Auxiliary Building	34 1.2 E-04 /a	4 2.7 E-04 /a	40 8.1 E-05 /a	45 4.9 E-05 /a	9 2.4 E-04 /a
Reactor Building	32 3.4 E-05 /a	16 - *	6 - *	11 - *	12 - *
Electrical Building	18 6.0 E-05 /a	22 3.4 E-04 /a	9 2.4 E-04 /a	14 7.7 E-05 /a	5 8.6 E-04 /a
* no event occurred, therefore no frequency estimate given					

Remark: This table covers an operating experience of in total 932 reactor years.

Table 2. Average number of compartments in selected buildings and corresponding fire frequencies for PWR (low power and shutdown operation, countries reporting all events)

Compartment type / Building	Process rooms	Rooms for electrical control equipment (including main control room)	Rooms for ventilation	Other types of rooms (including staircases and corridors)	Switchgear rooms
Turbine Building	45 2.2 E-03 /a	8 - *	7 - *	51 - *	4 - *
Auxiliary Building	34 5.9 E-04 /a	4 2.5 E-03 /a	40 2.5 E-04 /a	45 8.9 E-04 /a	9 - *
Reactor Building	32 6.2 E-04 /a	16 - *	6 3.3 E-03/a	11 2.7 E-3/a	12 - *
Electrical Building	18 - *	22 - *	9 - *	14 - *	5 6.0 E-03 /a
* no event occurred, therefore no frequency estimate given					

Remark: This table covers an operating experience of in total 100 reactor years.

Table 3. Average number of compartments in selected buildings and corresponding fire frequencies for BWR units (power operation, countries reporting all events)

Compartment type / Building	Process rooms	Rooms for electrical control equipment (including MCR)	Switchgear rooms
Turbine Building	70 8.3 E-04 /a	8 4.5 E-04 /a	16 - *
Diesel Generator Building	11 - *	12 - *	4 - *
Auxiliary Building	30 6.1 E-04 /a	16 2.3 E-04 /a	4 - *
Reactor Building	81 1.8 E-04 /a	18 4.0 E-04 /a	21 - *
Electrical Building	10 3.6 E-04 /a	18 4.1 E-04 /a	11 3.3 E-04 /a

* no event occurred, therefore no frequency estimate given

Remark: This table covers an operating experience of in total 274 reactor years.

Table 4. Average number of compartments in selected buildings and corresponding fire frequencies for BWR units (low power and shutdown operation, countries reporting all events)

Compartment type / Building	Process rooms	Rooms for electrical control equipment (including MCR)	Switchgear rooms
Turbine Building	70 4.0 E-03 /a	8 2.1 E-03 /a	16 - *
Diesel Generator Building	11 1.5 E-03 /a	12 - *	4 - *
Auxiliary Building	30 1.1 E-03 /a	16 - *	4 - *
Reactor Building	81 2.0 E-04 /a	18 - *	21 - *
Electrical Building	10 - *	18 1.8 E-03 /a	11 - *

* no event occurred, therefore no frequency estimate given

Remark: This table covers an operating experience of in total 60 reactor years.

The following observations from Figure 8 to Figure 11 and Table 1 to Table 4 have been made:

Process rooms have been found to have the highest fire occurrence frequency, with nearly one half or even more of the events having started in these rooms. Among them, process rooms in the turbine building are dominant. Except for switchgear rooms the estimated fire frequencies per room and reactor year are significantly lower for PWR type plants than for BWR type ones during full power operation as well as for low power and shutdown phases. For PWR type plants the fire frequencies of switchgear rooms are significantly higher than for other rooms, for BWR type ones switchgear rooms have the lowest fire frequencies, fire occurrence frequencies are the highest in process rooms.

Component specific fire frequencies

For some selected important components, data on their quantities are available, enabling the analysts to derive generic component specific fire frequencies. An example is given in Table 5 for Finland, France, Germany and Sweden as those countries have already provided sufficient information on selected component numbers. The average numbers of the selected components where fires are to be considered according to the Coding Guideline [4], as well as the numbers of fires that have occurred at these components and the associated estimated component specific fire frequencies are shown.

Table 5. Average numbers of components, corresponding numbers of fire events and component specific fire occurrence frequencies during all plant operational states for selected components for PWR and BWR type plants in those countries having already provided component numbers

Component type	Average number of components per NPP unit	Number of fires		Estimated fire frequency [1/a] per component	
		FP	LPSD	FP	LPSD
High voltage transformer	6.90	4	2**	3.3 E-04	- *
Turbine generator	1.06	8	1**	5.8 E-03	- *
Diesel generator	3.73	2	3	4.2 E-04	3.1 E-03
Medium or low voltage transformer	41.20	3	3	5.6 E-05	1.9 E-04
High or medium voltage electrical cabinet (> 1 kV) Low voltage electrical cabinet (< kV)	1436	15	2	7.0 E-06	5.0 E-06
Electrically driven pump	266	3	4	8.7 E-06	4.3 E-05
Rectifiers and inverters	46.26	2	0	3.3 E-05	- *
Heater	473	4	6	6.5 E-06	4.9 E-05
Fan	196	7	3	2.7 E-05	5.9 E-05
Battery	28	0	0	- *	- *

Remark:
* no fire event observed, therefore no frequency estimate
** events at high voltage transformers and turbine generator in the LPSD column occurred during hot stand-by or start-up

In this context, it has to be mentioned that cable specific fire occurrence frequencies are still difficult to estimate due to differences in the approaches used to account for cables across the FIRE member countries.

Using the fire event data reported to the database and described exemplarily above, it is possible to efficiently search event data, if needed differentiated by plant operational state, reactor type, and member country, and generate fire occurrence frequencies for compartments and components. In this way, the OECD FIRE Database is capable of supporting the application of the fire event data within the frame of Fire PSA.

4.2.2 Generic fire event trees

A key element of performing Fire PSA is the determination of fire induced failure probabilities of components and cables for those fire sources identified as relevant, typically by means of fire event trees. The Fire PSA analyst derives specific fire event trees for all possible fire sequences taking into account plant characteristics (e.g. on-site plant internal or only external fire brigade), the compartment specific situation and boundary conditions (e.g. compartment volume and ventilation conditions), potential fire sources (e.g. location, fuel) and safety targets (e.g. components, cables). Generic event trees are a valuable tool for the analysis, however have to be adapted within a plant specific Fire PSA, e.g. branch points to reflect the plant characteristics, and branch point probabilities needed to be determined by applying plant specific data.

Generic event trees can also be applied for another purpose. A set of standardised generic event trees can be used to describe the main fire specific characteristics of fire events observed from the operating experience (see also [2]). In the frame of an ongoing research and development project the following set of generic fire event trees has been developed:

- A time dependent event tree which sub-divides a fire event into different phases (called FET-T),
- An event tree specifically addressing fire detection (called FET-D), and
- An event tree specifically addressing fire suppression (called FET-S).

The set of generic fire event trees characterises all the possibilities of the phases of fire initiation, fire development and propagation as a stochastic process. Each fire event having occurred represents a realisation of this process and can be described by a corresponding sequence number.

The above mentioned set of generic fire event trees can be used to analyse fire events reported to the OECD FIRE Database. For the entity of fire events observed from the operating experience collected from nuclear power plants in FIRE member countries the corresponding sequence numbers of the generic fire event trees can be determined. The triplet of sequence numbers represents an additional attribute of each reported fire event, which can be stored in the database as additional information in the future.

Thereby, real fire incidents are assigned to individual sequences of predetermined generic fire event sequences. This analytical approach is currently being tested and will be implemented in the database during Phase Four of the Project. One result of the ongoing tests of the approach was that a clear picture of both similarities and differences of fire events could be demonstrated. Through the mapped differences additional information could be derived from the fire events. The outcome of the mapping of events also generated a corresponding sequence number for each generic event tree which can also be stored in the OECD FIRE Database. Details can be found in [14].

4.2.3 Correlations between suppression time, fire suppression success and severity of consequences

One characteristic, although not the only one, of fire events with severe consequences is their potential of damaging rooms or plant areas outside compartment where the fire started. Such events are called "severe consequence events" in this section.

Suppression time distribution

Figure 12 shows the distribution of suppression times for the database subset not containing events with severe consequences and Figure 13 the corresponding distribution for the subset with severe consequence events.

In Figure 12, the maximum of the share of events corresponds to the shortest duration and the minimum for the longest duration, with a continuous decline from the maximum to the minimum. The mean value for fire suppression of events with no severe consequences is 37 minutes.

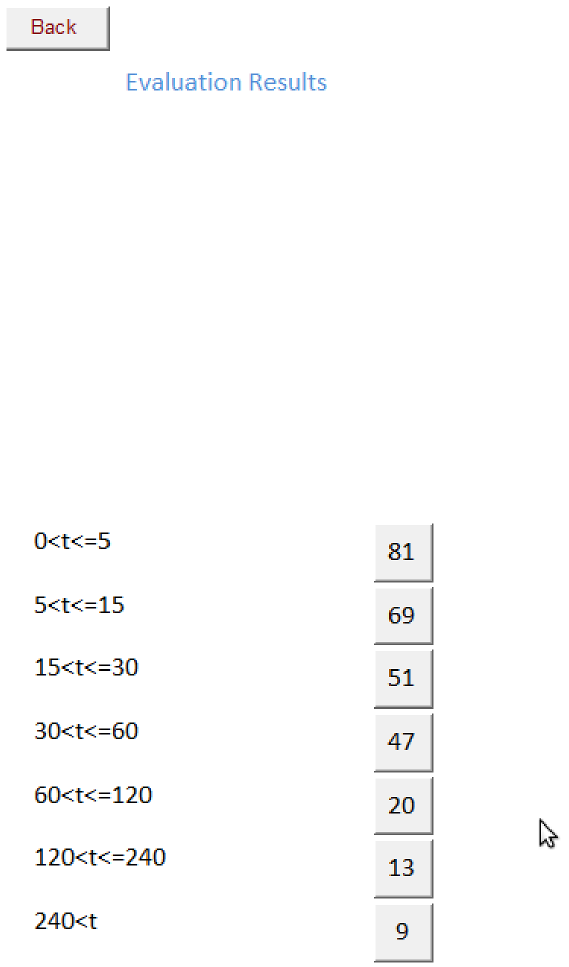


Figure 12. Distribution of fire suppression times for events with no severe consequences, from [3]

In Figure 13, the minimum is at the shortest suppression time; from there on the distribution is quasi flat with some non-informative undulation. The mean value for suppression of fire events with more severe consequences is 86 minutes.

Remark: The numbers do not add up to 438 events, because events with the attribute '*Unknown*' are not included.

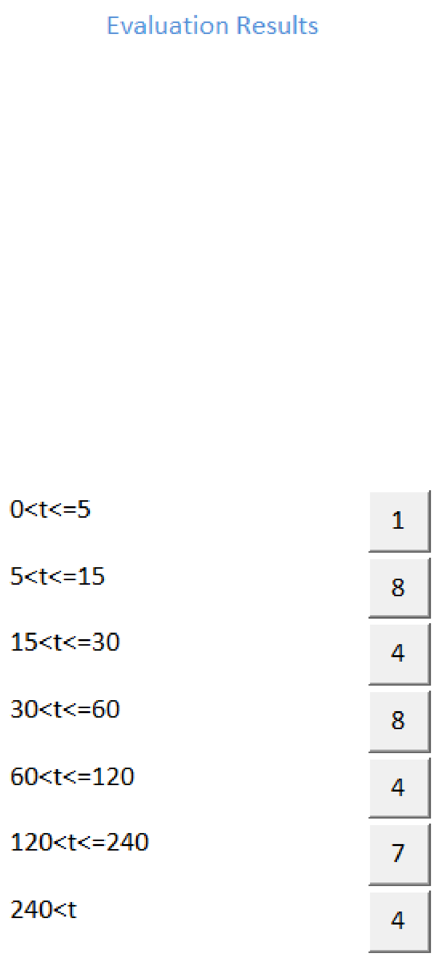


Figure 13. Distribution of fire suppression times for events with severe consequences, from [3]

Suppression time versus extinguishing systems performance

Figure 14 presents suppression time versus fire extinguishing performance for the database subset not containing events with severe consequences. The column '*Initial attack successful*' is dominant with 173 events. Their distribution is strongly biased towards short suppression times. In contrary, the column '*Several attacks needed'* contains only approximately one fourth of the events with the maximum in the center of the distribution.

Figure 15 shows suppression time versus fire extinguishing performance for the subset containing events with severe consequences. Only one fifth of the events are correlated to the attribute '*Initial attack successful*', whereas nearly 80 % can be found in the column '*Several attacks needed*' with the distribution biased towards the longer suppression times.

Remark: The numbers do again not add up to 438 events, because events with the attribute '*Unknown*' are not included.

Back

Evaluation Results

	Initial attack succesful	Not applicable	Several attacks needed
0<t<=5	61	13	4
5<t<=15	48	10	10
15<t<=30	32	5	12
30<t<=60	16	9	22
60<t<=120	8	2	10
120<t<=240	5		8
240<t	3		5

Figure 14. Suppression times versus fire extinguishing performance (for events with no severe consequences, from [3])

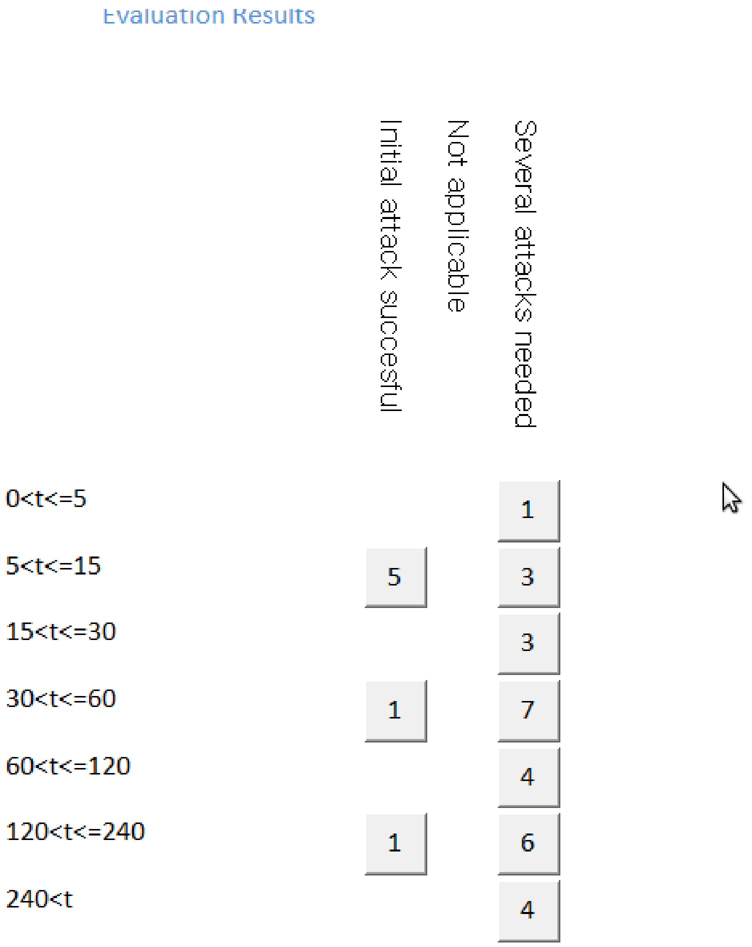


Figure 15. Suppression times versus fire extinguishing performance for events with severe consequences, from [3]

Fire extinguishing performance

In Table 6, the performance of fire extinguishing for fire events with no severe consequences is compared to those ones with more severe consequences. For nearly three thirds of the non-severe consequences fires the initial attack was successful, whereas approximately 80 % of those with severe consequences needed several attacks to be successfully suppressed.

Table 6. Fire extinguishing performance for fire events without severe consequences versus severe consequence fire events, from [3]

Fire extinguishing performance	Events without severe consequences	Events with severe consequences

Initial attack successful	237	8
Several attacks needed	80	30

Remark: The numbers do again not add up to 438 events, because events with the attribute '*Unknown*' are not included.

All examples presented confirm the existence of significant correlations between severe consequences and long fire suppression times as well as the need for several attacks to extinguish the fire successfully.

Another worthwhile observation is that for events without severe consequences 77 % of the fire were extinguished by manual actions, whereas for the more complex events with severe consequences 88 % of the fires were extinguished by manual actions. This indicates that the flexibility and diversity of the various manual fire fighting means is highly important for a successful control of the more complex and difficult fire scenarios.

5. FURTHER NATIONAL APPLICATIONS OF THE DATABASE

The US NRC is using the OECD FIRE Database to evaluate how U.S. NPP fire events compare with international fire event operating experience. The US NRC Office of Nuclear Regulatory Research (RES) working with the Electric Power and Research Institute (EPRI) under a Memorandum of Understanding (MOU) on fire risk has assembled an updated Fire Events Database for operating U.S. nuclear power plants [15]. Figure 16 shows the percentage of NPP fire events between the updated Fire Events Database (FEDB with operating experience from the U.S.) and the OECD FIRE Database (international operating experience from12 OECD member countries).

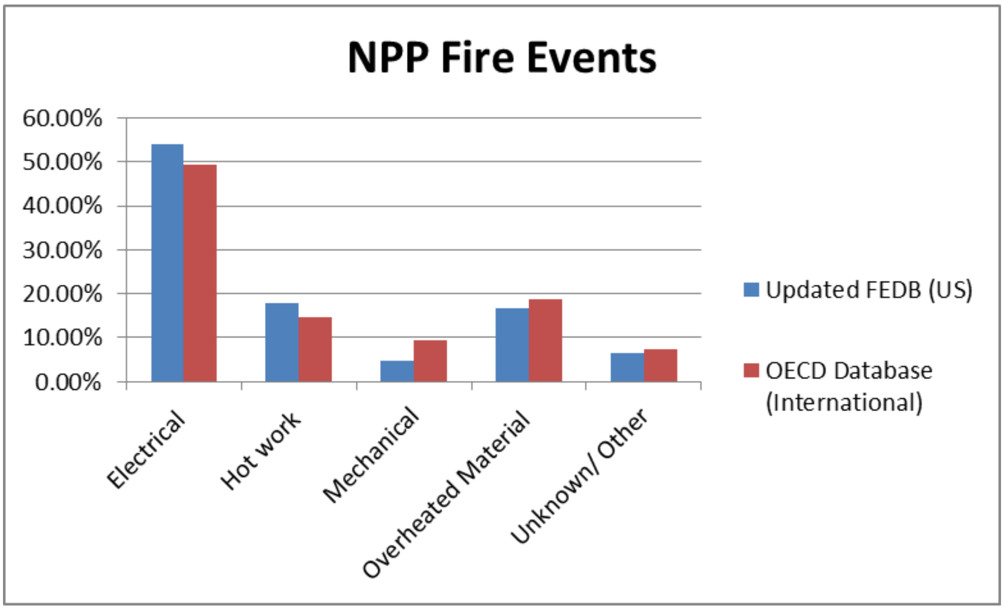


Figure 16. Comparison of NPP fire events in the OECD FIRE Database and the updated FEDB from the U.S.

The US NRC RES also compared U.S. NPP fire initiators with those reported in the international OECD FIRE Database as provided in Figure 17.

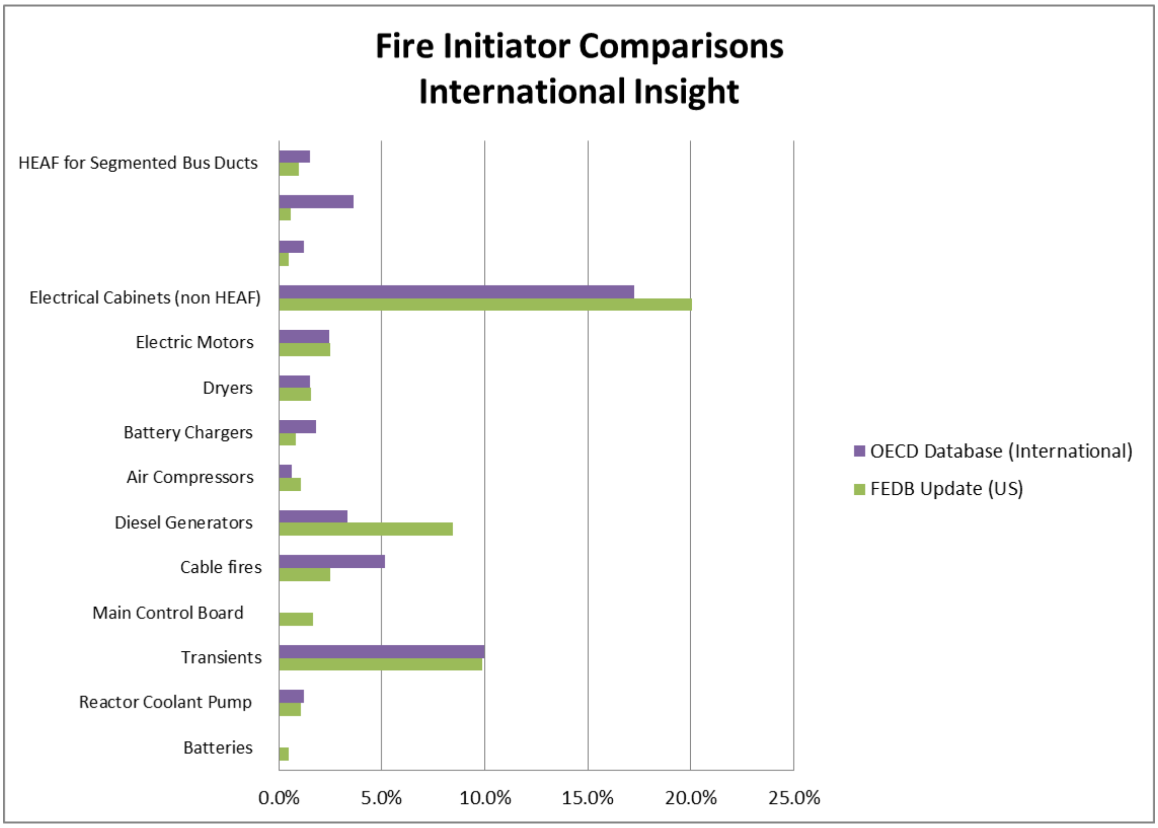


Figure 17. Fire initiator comparisons international insight

A coarse review of these two figures indicate that the U.S. NPP operating experience for fire events and fire initiators are consistent with international operating experience.

Radiation and Nuclear Safety Authority of Finland (STUK) has summarised some experiences of transformer fires having occurred in Finland [16] and provided a rough comparison of transformer fire frequencies based on the U.S. FEDB data [15] and OECD FIRE Database in 2010. The transformer yard fire frequencies provided in the report [15] were comparable to the survey of transformer fires in the OECD FIRE Database. The number of transformer yard fires being reported in the OECD FIRE Database in 2010 seemed to be adequate for qualitative purposes (23 events were studied), however quantitative analysis would have needed information about number of transformers under consideration in each NPP, which was not available at that time. Information on the amount of burned transformer oil was not provided in the event descriptions and without that information some uncertainty remains in realising the performance of fire fighting measures.

In 2013, STUK carried out a survey of pump fires being reported in the OECD FIRE Database. In total, 26 reported pump fires were studied and only in case of four events other components in addition to the ignited pump were damaged. In some cases the fire affected one safety train, but most of the events can be understood as single failures [17]. No harmful fire effects were reported outside the fire compartment. Pump fire frequency was not estimated in that survey, because the estimation of average numbers of pumps and numbers of reactor years was still ongoing.

6. FUTURE DATABASE APPLICATIONS AND CHALLENGES

The OECD FIRE Database has become a quality assured tool for evaluating the operating experience from member countries with fire events in nuclear power plants during different plant operational states. It provides qualitative insights into the causes of incipient and fully developed fires as well as valuable information on time dependent fire sequences and development.

The applications of the database so far have shown the significance of a clear and meaningful fire event description which provides broader insights beyond the information in the coded fields when needed.

Although the data are inhomogeneous due to the differing reporting thresholds and criteria in the project member countries, the existing data from the event sequences can be used e.g. as input information for fire modelling to support the model improvement.

It is well known that the quality of a Fire PSA strongly depends on the one hand on careful modelling and, on the other hand, on reliable data; the latter one can and will be achieved by further expanding the OECD FIRE Database supported by a continuous and consistent reporting of events by the project members. Enhancements in this direction are expected from the collection of more event data with additional information suitable for probabilistic analyses.

The positive and negative role of human factor in fire ignition, detection and extinguishing still needs investigations in more detail to generate Fire PSA results with a higher level of confidence. Positive effects of human behaviour for fire extinguishing have already been identified in the existing database, however, with low statistical significance according to the limited number of events, some of them lacking from this type of information. However, quantification with regard to PSA would be useful in the future.

6.1 Database consolidation challenges

In July 2013, the Electric Power Research Institute (EPRI), in co-ordination with the US Nuclear Regulatory Commission´s (NRC) Office of Nuclear Regulatory Research (RES) under a Memorandum of Understanding issued EPRI 1025284 entitled, “The Updated Fire Events Database: Description of Content and Fire Event Classification guidance”. This report [15] provides a description of the updated and enhanced Fire Events Database (FEDB) and will become the principal source of fire incident data for use in U.S. fire probabilistic risk assessments (FPRAs, equivalent to the term Fire PSA used in Europe) as described in EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities (EPRI report 1011989 and NUREG/CR-6850 [18]). It provides a comprehensive and consolidated source of fire incident information for nuclear power plants operating in the United States covering experience from 1990 to 2009. The database classification scheme identifies important attributes of fire incidents to characterise their nature, causal factors, and severity consistent with available data. The database is sufficiently detailed to delineate important plant specific attributes of the incidents to the extent that these details were obtainable.

The updated Fire Events Database (FEDB) includes a total of roughly 2000 fire events at varying severity levels and is intended to capture fire event history up to 2009. These events have been pre-screened and severity classifications have been thoroughly reviewed through several NRC audits. In addition to providing more recent data, the updated FEDB has expanded and improved data fields, coding consistency, incident details, data review fields, and reference data source traceability. The improvement is designed to better support several FPRA uses. The project has an additional objective of updating fire ignition frequency trends and bin frequencies. That task is currently under development and should be completed in 2014. Once that task is completed OECD will evaluate the merit of merging the two databases.

There are several challenges associated with potentially merging the OECD FIRE Database and the FEDB. The first of which will be aligning the information into a usable format. The OECD FIRE Database shares similar input fields as the FEDB; however significant work is needed in order to ensure consistency between the two databases. The OECD FIRE Database e.g. generally aligns with the ignition bins found in Chapter 6 of NUREG/CR-6850 [18] but it is not a one to one match. Each event in the FEDB database will have to be reviewed in order to assure consistency with the OECD binning methodology and considering the number of events this will not be a trivial task.

Moreover, a large portion of the supplementary information contained within the FEDB database remains proprietary plant information. A brief description of the event will be able to be presented but the supporting documentation will be lost. While the brief description will be satisfactory for the generation of frequencies and suppression data, the supporting documentation is invaluable while attempting to gain insight into the fire event for fields which require interpretation and an understanding of the fire event timeline is a necessity.

In addition to the logistical challenges with merging the OECD FIRE Database and the FEDB, there should be an investigation into the applicability of merging the databases. That is, if the same trends do exist in the FEDB as in the OECD FIRE Database. The FEDB database with approximately 2000 events contains a much larger pool of events than the OECD FIRE Database with actually 438 events. By merging the two databases without performing a sensitivity study, country specific variations may be overwhelmed by the large number of FEDB contributions.

The FEDB events would significantly increase the total number of events which currently make up the OECD FIRE Database and add further evidence to support realistic frequency calculations. The FIRE Project will evaluate the additional data and make recommendations for use during the Phase Four of the Project.

6.2 Challenges regarding component specific fire frequency estimation

First attempts have been made in the third Project Phase to collect component numbers for components at which fires have occurred. The list of components is given in the OECD FIRE Database Coding Guideline [4].

First estimates of component fire frequencies are presented in Table 5. Many of these components are significant contributors to Fire PSA results. Cables, although being important contributors to fire risk, are not included in Table 5 because of the differing ways of their recording in the various nuclear power plants (by segments or by length, using a cable management system or not, etc.) and the resulting, still unresolved data collection issues.

The list of components in the database still contains approximately 30 items, such as batteries, electrical cabinets, diesel generators or pumps, for which the average component numbers have to be collected and assessed. This activity is ongoing.

6.3 Further challenges to reduce uncertainties

In many cases the event descriptions provided in the OECD FIRE Database have no words for conditions inside the compartment, where the fire occurred. For example, information on compartment dimensions, components installed, and amount of combustibles inside the compartment is needed to apply the fire event coding of the database for statistical purposes and to avoid possibly misleading conclusions.

An effort is ongoing to estimate fire frequencies for selected types of compartments based on the average number of such compartments, plant operational years and number of fire events involved. In this case, the average fire frequency is representative for an average compartment; however the average compartment is not specified by any measures. Knowledge on components installed in the compartment as well as floor area and/or volume of the compartment, where the fire occurred, would be useful to better realise what the average conditions represent for given types of compartments. Additional information might be traced from member countries for an important pilot case, e.g. considering fires in switchgear rooms, I&C cabinet rooms, or cable rooms.

The OECD FIRE Database includes coding of fire impact and consequences. The lack of knowledge on components installed in the fire compartment as well as on the amount of combustibles present causes several uncertainties in conclusions. For example, the impact of a pump fire can be coded as loss of single component despite of fire propagation, if the pump is the only component vulnerable to fire in that fire compartment. Similarly, fire impact and consequences should be applied carefully while assessing “other ignition sources” in process rooms, because the conditions in such compartments strongly differ. Additional information may be gained from member countries considering the number of components present inside the process room where the fire occurred, in particular considering events where fire affected only a single component or no damage resulted. Moreover, clarification of the overall amount of oil inside the system or component would be useful, considering fires in the process rooms where oil has been coded as combustible, to better realise the potential of fire propagation and fire impact in such events.

7. CONCLUSIONS

The OECD FIRE Database currently provides a valuable tool for facilitating the use of fire experience of nuclear power plants in the member countries for Fire PSA containing 438 fire events up to the end of 2013, the wide majority of them quality assured. Although the reporting of events is not yet exhaustive according to limitations by different reporting criteria and thresholds in the project member countries, the database provides a good platform for starting the analytical phase.

It is possible to quickly estimate, according to the analytical task to be performed, fire frequencies for different samples of fire events for all plant operational states, different types of reactors, selected sets of countries under consideration of reporting criteria and thresholds in member countries. A variety of applications has already been started making increased use of the newly added enhanced capabilities for interactive queries and evaluation tasks and of the enhanced statistical possibilities.

Data collection is continuing with an average of approximately thirty events to be expected per year. There may be additional data available for the database if a substantial amount of fire events data from the U.S. could be submitted in the future or if additional members with fire events data join the project.

Further extension of the project scope and objectives is possible and is already being discussed in the Phase Four of the OECD FIRE Database Project. An extension of the data collection to data needed in the frame of Fire PSA on fire detection and fire fighting systems and equipment is already envisioned. Collecting data on events inducing a leak of explosive gas (notably hydrogen) may be possible. The potential widened scope also covers extending the database to larger research reactors and other facilities of the nuclear fuel cycle.

8. RECOMMENDATIONS

As an outcome of the phase three of the OECD FIRE Database Project, some recommendations have been revealed affecting the project itself as well as its use for CSNI and CNRA working groups.

One already identified example of future analysis to be carried out by the project itself is the application of generic event trees within Fire PSA. Generic fire event trees provide a tool for determining fire induced failure probabilities of components including cables for probabilistic analyses. In addition, such event trees can be used for deterministically analysing the main fire specific characteristics of fire events observed from the operating experience. Fire events stored in the OECD FIRE Database shall thereby be assigned to individual sequences of predetermined generic fire event sequences. This analytical approach which has already being tested is intended to be implemented in the database during Phase Four of the FIRE Project.

The project members also recommend re-starting the analyses of apparent causes of fire events in the database for observation of trends and potential issues to be addressed in more detail in the future.

8.1 Feedback to CSNI (WGRISK)

The recent activities with respect to fire risk analysis and, in particular, PSA performed in OECD member countries in the frame of safety assessment have shown the need for a sound data base from the operating experience with fires. To meet the expectations of the WGRISK, the OECD FIRE Database is intended to serve as a basic instrument for enhancing the existing Fire PSA results and increasing the level of confidence making them more robust.

In its succession plan WGRISK therefore requests that as far as is feasible, meaningful output from the Database Projects to support risk analysis be developed. Although the existing database covers fire events from NPP in 12 member states generally within a period of more than 15 years, it is currently not yet exhaustive and sufficiently consistent for full statistical use. The main reason for this deficiency is the difference in reporting with reporting thresholds of fire events in member countries being different and varying over time. However, a reliable and statistically meaningful database for PSA applications is expected in the future meeting the needs of the analysts in OECD member countries.

8.2 Feedback to CNRA (WGIP, WGOE)

One observation from the operating experience in OECD FIRE member countries is that fires occurring independently or in causal relation with other hazards still may contribute significantly to the overall risk of core damage or radioactive releases. In this context, the importance of carefully analysing fire events in detail was recognised. Moreover, some countries are in the process of introducing significant changes to the inspection process of fire protection programmes specifically related to the use of risk informed inspections in order to assess the impact of fire on safety significant safety systems and components (SSC).

The OECD FIRE Database Project was created with the main objective to examine the operating experience with fire events data on an international basis and to determine, through analysis and trending, potential safety issues related to fires and to systems and facilities designed to cope with fires (e.g., prevention, mitigation, suppression, etc.). Insights can be deduced from fire operating experience feedback to focus the inspection activities on those areas where the fire is considered to be safety significant and the facilities´ fire protection programmes need improvements.

In particular, the contents of the OECD FIRE Database provide more suitable information to the analysts than standard databases such as the INES and IRS databases which are not well adapted to the analysis of fire events. The lessons learned from the data collection and analysis in project member countries may be generically used for feedback to other OECD member countries.

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APPENDIX A – OECD FIRE CODING GUIDELINE, VERSION OECD FIRE-CG-2013:1

Document No.: OECD FIRE CG	Revision: 2013:1 VERSION 1	FIRE OECD Fire Incident Records Exchange	
Prepared for: OECD FIRE PRG			
Date: August 2014	Classification: Level 1		
Prepared by: W. Werner (SAC, Operating Agent)		Total number of pages: 52	Number of Attachments/Appendices: 3
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OECD FIRE CODING GUIDELINE
(OECD FIRE-CG-2013:1)

June 2014

OECD FIRE Coding Guideline Revision Summary

Rev.	Date	Status	Author	Saved As	Changes
01	2002-07-08	Draft	A. Angner		
Version 1	8 Nov 2005	Approved	E. Mathet	2005:1 VERSION 1	
Version 2	28 Feb 2007	Approved	J. Gauvain	2007:1 VERSION 1	
Version 3	18 Dec 2007	Approved	M. Roewekamp	2008:1 VERSION 1	
Version 4	18 Jan 2008	Approved	M. Roewekamp	2008:1 VERSION 2	§ 3.3.1.b – 3.3.2.a
Version 5	24 Dec 2008	Approved	A Angner	2008:2 VERSION 1	§ 3.3.2a and § 3.4.5 Appendix B
Version 6	14 July 2011	Approved	H. Bigun, M. Roewekamp	2011:1 VERSION 1	§ 3.1.17, 3.2.4, 3.3.2a, 3.4.2
Version 7	08 Sep 2012	Approved	M. Roewekamp	2012:1 VERSION 1	3.4.2
Version 8	04 Aug2014	Approved	W. Werner, M. Lehto, M. Roewekamp	2013:1 VERSION 1	3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.10, 3.3.1.a, 3.3.1.b, 3.3.2,a, 3.3.2.b 3.3.3, 3.3.4, 3.4.1, 3.4.3, 3.4.5, Appendix A

1. INTRODUCTION

Fire Hazard Analysis (FHA) and Probabilistic Fire Safety Analysis (PSA) have shown that fire may be an important risk contributor, especially for older nuclear power plants.

Uncertainties in fire data have resulted in numerous research projects. However, the lack of reliable data, especially for larger fires, makes it difficult to realistically model fire scenarios.

CSNI/PWG5 established a Task Group to review the present status and maturity of methods used in Fire PSA for operating nuclear power plants. The Task Group issued a questionnaire in May 1997 to all nuclear power generating OECD countries. One of the concluding remarks presented in the summary report [NEA/CSNI/R (99)27] was as following:

"The shortage of fire analysis data is one of the major deficiencies in the present Fire PSA. In order to facilitate the situation, it would be highly important to establish an international fire analysis data bank, similar to that set up by OECD for the CCF data collection and processing system (ICDE/CCF data base at OECD). Such a data base would provide fire event data on real fire cases, incipient fires (smouldering etc.) detected/extinguished before development, dangerous or threatening situations, reliability data on fire protection measures, and the unavailability's of fire fighting systems, for example, due to component failures or operational errors."

Based on the above concluding remarks several OECD member countries have agreed to establish the International Fire Data Exchange Project (OECD FIRE) to encourage multilateral co-operation in the collection and analysis of data relating to fire events in nuclear power plants. The objectives of the project are to:

9. Record fire event attributes to facilitate quantification of fire frequencies and fire scenarios frequencies;

10. Collect and analyse fire events in the long term in order to better understand such events, their causes, and their prevention;

11. Generate qualitative insights into the causes of fire events, which can then be used to derive approaches or mechanisms for their prevention or for mitigating their consequences; and

12. Establish a mechanism for the efficient feedback of experience gained in connection with fires, including the development of defences against their occurrence, such as indicators for risk-based inspections.

The guide provides instruction how to describe a fire event by use of a narrative description. The guide also defines codes to be used for classifying the event. The narratives and the coding are based on documented references.

The classifications of the fire event by use of codes provide the possibility to search for and identify specific fire events of interest in the OECD FIRE Database. The coding will also form a basis for statistical calculations.

2. FIRE EVENT ANALYSIS SUPPORT DATA

The support data is supposed to be used in the fire data analysis phase. Support data is stored in two database support modules and one separate table “Plant data and table of correspondence”. The support modules “Reporting thresholds” and “Fire brigade organisation” are accessible from the general data page in the OECD FIRE DB. The separate table includes following information:

1. General data such as, plant code, operator, type of reactor, commercial operation start, etc. The general data is mainly based on the IRS Database.

2. Dates for plant specific start of OECD FIRE data collection.

3. A table of correspondence for the anonymous OECD Plant code ID

2.1 Reporting thresholds

The reporting threshold module defines reporting thresholds for reporting fire events from the utilities to authorities. The reporting threshold module is a part of the OECD FIRE DB.

The reporting thresholds for fire events vary among member countries. If collected fire data are to be used for statistical purposes it is essential to know the reporting routines applied in the various countries. There are two different reporting threshold levels:

- LER level fires - If the reporting to OA only consists of Licensee event reports (LERs), LER definition history has to be known. The LER is normally defined in the technical specifications. Today there exist several different definitions depending on member country and date of the fire event. In some member countries a fire event will be reported as a LER if it had affected a safety component. Other LER definitions are based on the duration of the fire.

- All fires - Some OECD FIRE member countries have access to all fire reports. This fact also has to be documented in the OECD FIRE Database threshold history module.

To enter and edit reporting thresholds in the database you have to click the button “Reporting thresholds EDIT” under the “fire event general data” page. The criteria for reporting fires in OECD FIRE participating countries are listed in Appendix A.

2.2 Fire brigade organisation

The fire brigade organisation module contains the general description of on-site and off-site fire brigade organisation. Distance in kilometres between plant and off-site fire brigade as well as off-site fire brigade response time are also given. Changes over time in the organisation can be addressed in the database.

3. DESCRIPTION OF AN OECD FIRE EVENT

The scope for reporting fires to the OA is limited to nuclear power plants. Fires at research reactors, nuclear waste storage facilities, etc. are excluded. The reporting includes all plant internal fires on-site (inside and outside buildings) as well as plant external fires if these have the potential to impact nuclear safety.

The reporting shall include fires in all operation modes. Also fires during construction and decommissioning shall be reported. The OECD FIRE PRG determines the observation period for which fires are to be reported.

A fire is defined as follows:

- A process of combustion characterised by the emission of heat accompanied by (open) flame or smoke or both,
- Rapid combustion spreading in an uncontrolled manner in time and space.

Note: This includes incipient fires as well as fully developed fires. Fires shall be included in the database if they are relevant to safety and also if the same type of fire has the potential to be relevant/significant for safety under different boundary conditions (such as different ventilation conditions, other plant operating states (POS), same components affected in other locations, etc.). Explosions not resulting in an open flame shall be excluded.

The OECD FIRE event is described in documented references. The database into which it is included is divided into the following major parts:

1. Fire event general data
2. Description of the fire's initiating course of events
3. Description of the fire's continuing course of events such as extinguishing measures etc.
4. Description of the fire's consequences on the plant
5. References
6. Relevance index

Narrative event descriptions as well coded fields are used for the description of the event

The **narrative event description** consists of

Event description: it begins with a short description or title of the event, followed by a detailed factual description of the fire event, including all relevant circumstances.

Sequence of events: it is a structured record of the evolution of the event in form of a bullet list with time and description of the event. The reader should be able to understand how the event developed in time.

Event interpretation: it provides further explanations and interpretation, if required.

Ignition phase comments: may provide further details and comments on the fire ignition phase.

Extinguishing phase comments: may provide further details and comments on the fire extinguishing phase.

Comments on consequences and corrective actions

The entries of the **coded fields** are normally derived from the narrative event description. Coding can also be based on documented references. They are grouped into:

Ignition phase: Describes (by use of codes) the initial course of the fire including items such as location of the fire, type of detection, fire loads, ignition mechanism and root cause.

Extinguishing phase: This section describes (by use of codes) the course of the event after the fire alarm trigged, type of extinguishing equipment used, who extinguished the fire.

Consequences: Heat and smoke influence on plant operation and systems are described (by use of codes). Secondary effects and corrective actions are included.

References: References used, and where to find more information on the specific fire event.

The major part of the information asked for in the narratives and coded fields is compulsory information. However, there is information, such as amount of fire load that is time consuming to collect. This type of information is marked as "if available". This information can be collected in a later stage, if necessary, for a limited number of events.

Terms used are listed in the glossary in Appendix B. They are consistent with terms used elsewhere in the literature. If any abbreviations will be used to describe the event, their contents or unabbreviated expressions should be described for avoiding misunderstandings.

3.1 General data

3.1.1 Event title

Text 3.1.2 Plant	The title should indicate the nuclear safety impact of the event (if any) as well as the apparent lack, failure or deficiency.
Code	The nuclear power plant where the fire event occurred. The table of correspondence is needed to identify the plant.

3.1.2 Registrar

Text	Name of the initial creator of the OECD FIRE event record. *Note:* This description field is to be found on page "References".

3.1.3 Date and time of detection (YYYY-MM-DD HH:MM)

Alpha-numeric	Time of detection of the fire, manually, automatic, etc. Year/month/day_hour/minute

3.1.4 Date of OECD FIRE event description (YYYY-MM-DD)

Alpha-numeric	Date when the OECD FIRE event record was first created. Year/month/day. *Note:* This description field is to be found on page "References".

3.1.5 Date of OECD FIRE event revision (YYYY-MM-DD)

Alpha-numeric	Date and cause (text) of OECD FIRE event revision. Note: This description field is to be found on page "References".

3.1.6 OECD FIRE event description

Text:

The text begins with a short description or title of the event, followed by a detailed factual description of the fire event, including relevant circumstances. As the factual event description forms the basis for the event interpretation and the coding it has to be as clear and complete as possible. Below are important items to be described:

7 Operational mode (physical parameters; power level (% of full power) RCR coolant pressure and temperature prior to the fire

8 Operation mode prior to the fire and after the fire

9 Building and type of room where the fire started

10 Type of component where the fire started and, if possible, age of component

11 Ignition mechanism (Mechanical, electrical, etc.)

12 Root cause (the most basic reason for the fire ignition)

13 How was the fire detected? What type of detector?

14 Fuel properties (quantities and materials)

15 Permanently and temporarily available fire loads (information if available)

16 Type of fire extinguishing

17 Causes for fire protection equipment not activating/failing/not working as intended

18 Multiple fires and dependencies

19 If the fire spreads to adjacent rooms, specifying the pathway of hot gas propagation

20 Influence (impact and/or functionality as well as damage) on equipment due to heat, hot gases and/or smoke; actuated safety functions and occurred radioactive releases; description of spurious actuation, control circuit response to cable damage from fire, instrumentation response and readout on the control panels. Influence on fire barriers (dampers, floor, ceiling, doors)

21 Smoke influence on people's movement; smoke influence on main control room habitability

22 At what elevation above the base of the fire was heat damage observed? At what radius around the centerline of the fire was damage observed at the base? At what radius around the centerline of the fire was damage observed at the ceiling (information if

	available)? Distance between fire source and damaged component (information if available)
23	Damage due to secondary effects and cause of secondary effects
24	Actions taken by the licensee to prevent the fire event from re-occurring
25	HEAF event (if applicable) corresponding to the following definition of HEAF: High Energy Arc Faults (HEAF) are energetic or explosive electrical equipment faults characterised by a rapid release of energy in the form of heat, light, vaporised metal and pressure increase due to high current arcs between energised electrical conductors or between energised electrical components and neutral or ground. HEAF events may also result in projectiles being ejected from the electrical component or cabinet of origin and result in fire.

3.1.7 Sequence of events

Text

This narrative is a structured record of the event in form of a bullet list with time and description of the event. The reader should be able to understand how the event unfolded in time and logic. Short sentences or statements increase clarity. It should be easy to identify the individual occurrences. Below are examples of important occurrences:

- Time of the event
- Time of the alarm
- Time of the physical localisation of the fire
- Time when extinguishing started
- Time when fire was under control
- Time when fire was extinguished

3.1.8 Event interpretation

Text

Event interpretation or added text by the analyst(s) or (registrar) to clarify parts of the event which are neither clearly described elsewhere in the text fields nor in potentially available references. It is also possible to add reflections made such as:

- Applicability to other operational modes (information if available);
- Safety implications to other plants (information if available).

The interpretation of the event from the safety viewpoint should at least include information such as:

- Initiating event due to the fire events, e.g., SCRAM automatically, Manual Reactor Shutdown, or Transient Initiation etc.;
- Safety significant structures, systems and components (SSCs) affected by the fire event;
- Degradation of safety functions (e.g. degradation of (fire) resistance due to fire but safety function was not impaired. Such degradation can be identified by tests after the fire events.);
- SSCs utilised to bring the plant to a safe operational mode;
- Applicability to other operational modes, if available;
- Safety implication to other plants, if available.

3.1.9 Operation mode prior to the event

Code/Text	Plant operational mode prior to the fire
Codes	***Definitions***
Construction phase	
Power operation	Power level > than 5 % of full power level
Hot stand by	Power level 0 (Residual heat system not connected)
Shutdown mode	The shutdown modes normally include several sub-modes such as hot shutdown (RHR connected), cold shutdown, refuelling shutdown and service/ maintenance shutdown (outage) (refuelling included), if possible add sub-mode in the narrative text field. The water level in the primary circuit is also important for events during shutdown operation of PWR (e.g. Mid-Loop Operation).
Start-up mode	
Decommissioning	
Unknown	

3.1.10 Confirmation time (HH:MM)

Alpha-numeric/ Text	Confirmation time in hours and minutes; time interval between time of detection (field 3.1.4) and time of confirmation of the fire. The event specific definition of "Confirmation time" can be explained in the corresponding text field "Confirmation time clarification".

3.1.11 Suppression time (HH:MM)

Alpha-numeric/ Text	Suppression time in hours and minutes; time interval between time of detection (field 3.1.4) and time of suppression of the fire. The event specific definition of "Suppression time" can be explained in the corresponding text field "Suppression time clarification".

3.2 Ignition phase

3.2.1 Building where the fire started

Code/Text		The exact location of the fire can be documented under item 3.2.2 and/or by use of 3.2.3. If a code is not available, select one of the following alternatives: - "Other building" and describe type of building by use of narratives - Unknown
Codes		***Definitions***
Reactor building		The reactor building includes rooms inside the containment (including usually the reactor vessel, primary circuit and the areas of the primary circulation pumps), the space between the containment and the secondary containment and other rooms included in the reactor building according to the room coding.
	Inside containment	Rooms inside the containment usually contain the reactor vessel, the primary circuit and the areas of the primary circulation pumps.
	Outside containment	Rooms outside the containment are usually the space between the containment and the secondary containment, the so-called reactor annulus, and other rooms included in the reactor building according to the room coding
Electrical building		The electrical building normally includes switchgear rooms, battery rooms, relay rooms and the unit control room.
Auxiliary building		The auxiliary building includes safety systems (pumps, valves, etc.). The building may also include local switchgear rooms and the unit control room.
Turbine building		The turbine building includes turbines, feed water systems, condenser, etc.
Diesel generator building		Diesel generator building including rooms for diesel generator and diesel generator support systems

Intake building	Cooling water intake building including mechanical filters (sometimes also service water pumps)
Switchyard	Including external transformers such as start-up transformers (for the transformers which are really located at the switchyard), even if surrounded by protective walls. Compare to "Outside the plant"
Spent fuel building	Building where spent fuel and further nuclear waste is stored
Workshop (controlled area)	Plant area inside the controlled area of the NPP, where maintenance activities can be performed and materials/and equipment for these activities can be temporarily stored
Independent emergency building	Building including diverse auxiliary safety systems and normally also a backup CR
Outside the plant (not switchyard)	Fire started on-site area outside NPP buildings, e.g. main transformers and other outside areas. Fire in switchyard is specified by code Switchyard.
Other building or area	This code shall be used if the predefined codes are not applicable. The code shall be combined with a descriptive text that describes the type of building.
Unknown	There is no information on the type of building or area where the fire started.

3.2.2 Room/Plant area where the fire started

Numeric/If available	Identify the room/plant area where the fire started. Use normal (local) plant coding system (room ID numbers). If the room code is known the following information can be obtained from general plant documentation (database or other types of register): 5 Fire loads and their distribution in the room (limited to a specific location, spread homogeneously over the room, distributed inhomogeneously over the room) 6 Room volumes (floor area, room height, if available) 7 Type of ventilation 8 Type, no. and location of fire detection equipment 9 Type, no. and location of fire extinguishing equipment This information is mainly intended for verification of the distribution factors. Distribution factors are used to generate room specific fire frequencies from the overall fire frequency of the building

3.2.3 Type of room where the fire started

Code/Text	If a code is not available, select one of the following alternatives: - "Other type of room" and describe type of room by use of narratives - Unknown
Codes	***Definitions***
Cable spreading room	Rooms typically including cables and electrical cabinets
Other cable room	Rooms including mainly cables, such as cable corridors, cable cellars, cable shafts, cable vaults
Room for electrical control equipment	Local electrical rooms in auxiliary buildings, relay room in electrical building, rooms for system control, etc.
Switchgear room	Room containing 6 kV buses, 6 kV breaker, or power supply to valves and smaller pumps and fans (mainly 400 V and 220 V supplies etc.). The type of breaker is described in the narrative description fields and by use of the field "component where the fire started".
Battery room	Rooms containing a large number of batteries
MCR	Main unit control room or reserve/emergency control room
Room for ventilation	Rooms containing fans and filters
Room for off-gas equipment	
Process room	Rooms containing pumps, valves, mostly mechanical equipment; whether or not this equipment is part of a safety system does not affect the classification as "process room".
Staircase and/or corridors	
Office	
Workshop	Plant area where maintenance activities can be performed and materials/and equipment for these activities can be temporarily stored
Storage for nuclear waste	
Storage for combustibles (liquids, gas, etc.)	
Elevator shaft	
Diesel generator room	
Transformer room/bunker	E.g. main transformers, auxiliary transformers, start-up transformers located at switchyard
Hydrogen cylinder bunker	E.g. containing process supply systems.

Switchyard	Switchyard includes outside area containing circuit breakers, disconnectors, measuring devices, busbars, etc. Transformers located at the switchyard are coded with the type of room "Transformer room/bunker".
Other type of room	This code shall be used if the predefined codes are not applicable. The coding shall be complemented by a descriptive text that describes the type of room.
Unknown	There is no information on the type of room where the fire started.

3.2.4 Component where the fire started

The types of components listed below are representatives of components used in risk analysis models. The components can be looked upon as "main components" or a "function". The number of types is therefore limited. Within the component boundaries several sub-components normally can be identified. The coding procedure should follow the examples given below:

- A short circuit in a coil (relay or electronic circuits) inside an electrical cabinet has caused a fire; select code "electrical cabinet" and describe in the narrative description field all specific circumstances.
- A lubrication oil pipe connected to the turbine generator broke and resulted in a turbine hall fire; Select code "turbine generator".

Code/Text	If a code is not available, select one of the following alternatives: • "Other component" and describe type of component by use of narratives • Unknown • Not applicable. No component can be linked to the fire (as cause of the fire, as fire load or damaged by the fire).
Codes	***Definitions***
Battery	Each bank of interconnected sets of batteries located in one place (often referred to as "Battery Room") should be counted as one battery set. Cells may not be counted individually.
Boiler	Boilers are generally well-defined items. All ancillary items associated with each boiler may be included as part of the boiler. Control panels that are installed separate from a boiler may be included in the "electrical cabinets" code.
Breaker	A breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow. Circuit breakers are made in varying sises for different voltage levels.

(Segmented) Bus duct	The high voltage power transformers typically installed in the yard belong to this code. They include plant output power transformers, auxiliary shutdown transformers, and start-up transformers, etc. Isolation phase bus ducts are also included in this code to simplify fire frequency analysis. This category applies to a bus duct where the bus bars are made up of multiple sections bolted together at regular intervals (transition points). Here, the bus bars are contained within open-ended sections of metal covers that are bolted together to form a continuous grounded enclosure running the full distance between termination points. Segmented bus ducts are able to accommodate tap connections to supply multiple equipment termination points. The key parameter for the use of this code is the location where fire is manifested. This code shall be used if the fault is manifested at any transition points along the bus duct length (i.e. bolted connections). Fires which occur at the termination points at the end device shall be treated in accordance with the end device.
Cable (fires caused by welding and cutting)	This code is applied for all exposed cables (i.e., cables that are not in conduits or wrapped by non-combustible materials) which are ignited by welding and cutting activities.
Cable run (self-ignited)	This code applies to all exposed cables (i.e., cables that are not in conduits or wrapped by non-combustible materials) which are self-ignited
Instrumentation and/or control (I&C) cables	These cables typically include I&C cables on a cable tray or other low voltage cables for low power equipment. Add current level (control cable) in milli Amps and voltage level in the narrative description field, if possible
Power cables	This typically covers 6 kV, 500 V or 200 V power cable on a cable tray. Types of cables should be described in the narrative description field (IEEE/non-qualified, fire retardant, fire retardant cable coating).
Component (other than cable) ignited by hot work	
Compressor	This code covers the large air compressors that provide plant instrument air included in the Internal Events PRA Model. These compressors are generally well-defined devices. They may include an air receiver, air dryer, and control panel attached to the compressor. These items should be considered part of the air compressor. If portable compressors are part of the model, those compressors should also be included in the equipment count for this code. Note that compressors associated with the ventilation systems are not part of this code. Small air compressors used for specialised functions are also not part of this code.

Diesel generator	Diesel generators are generally well-defined items that include a set of auxiliary subsystems associated with each engine. All diesel generators that are included in the electric power recovery model should be counted here. In addition to the normal safety-related diesel generators, this may include the technical support center diesel generators, security diesel generators, etc. It is recommended that each diesel generator and its subsystems be counted as one unit. The subsystems may include diesel generator air start compressors, air receiver, batteries and fuel storage, and delivery system. It is recommended that the electrical cabinets for engine and generator control that stand separate from the diesel generator be included as part of "electrical cabinets." Control panels that are attached to engine may be counted as part of the engine.
Dryer	Clothes dryers are generally well-defined units.
Electrical cabinet:	Electrical cabinets represent such items as switchgears, motor control centres, DC distribution panels, relay cabinets, control and switch panels (excluding panels that are part of machinery), fire protection panels, etc. Electrical cabinets in a nuclear power plant vary significantly in sise, configuration, and voltage. Sise variation range from small-wall mounted units to large walk-through vertical control cabinets, which can be 20' to 30' long. The configuration can vary based on the number of components that contribute to ignition, such as relays and circuit cards, and combustible loading, which also affects the fire frequency. Electrical cabinets shall be separated based on the classification of the fire (HEAF or non-HEAF and by voltage ranges). A clear definition of HEAF (high energy arcing fault) is provided in 3.1.7.
High or medium voltage (non-HEAF, $\geq$ 1 kV)	This code shall be used for fires occurring in high or medium voltage electrical cabinets which do not produce a high energy arcing fault. Typically these are cabinets used for 6 kV breakers or 400 V motor breakers. Normally this type of cabinet is located in the switchgear room.
High or medium voltage (HEAF, $\geq$ 1 kV)	This code shall be used for fires occurring in high or medium voltage electrical cabinets which do produce a high energy arcing fault. Typically these are cabinets used for 6 kV breakers or 400 V motor breakers. Normally this type of cabinet is located in the switchgear room.
Low voltage (non-HEAF, < 1 kV)	This code shall be used for fires occurring low voltage electrical cabinets which do not produce a high energy arcing fault. Typically these are cabinets used for instrumentation and control, logic build-up, regulation, etc. The type of cabinet can be described in narrative description fields. Normally this type of cabinet is located in relay rooms.

Low voltage (HEAF, < 1 kV)	This code shall be used for fires occurring low voltage electrical cabinets which do produce a high energy arcing fault. Typically these are cabinets used for instrumentation and control, logic build-up, regulation, etc. The type of cabinet can be described in narrative description fields. Normally this type of cabinet is located in relay rooms.
Electric motor (not in pump)	This code includes any electric motor with a rating greater than 5 hp. This code does not include electric motors that are attached to equipment already identified and counted in other codes (i.e. reactor coolant pumps, air compressors, dryers, pumps, RPS MG sets, and motors of ventilation subsystems equipment, such as fans or filters). That is, motors associated with a piece of equipment counted as a part of another ignition scores code are not counted separately as motors, but rather, are considered as an integral part of the larger equipment item (the pump., the compressor, etc.).
Equipment (fixed) for illumination	This code includes any fire which occurs as the direct result of fixed illumination equipment. This includes lighting ballast fires and fires caused by fixed lighting failures.
Fan	This code includes components such as air conditioning units, chillers, fan motors, air filters, dampers, etc. A fan motor and compressor housed in the same component are counted as one component. Do not count ventilation fans if the drive motor is 5 hp or less.
Filter	This code applies to all fires in filters for gases, which are mainly part of the ventilation sub-systems. But which van also be installed independently of the ventilation ducts, e.g. in the off-gas system.
Fixed heater	This code applies to all fires caused by fixed heaters installed throughout the plant for various reasons. This includes radiative heaters, convection heaters and fan heaters which are permanently installed in a specific plant area. Portable heaters are captured in a separate code.
Hydrogen containing vessel	Hydrogen storage tanks are generally well-defined items. Multi-tank hydrogen trailers, because they are interconnected, should be counted as one unit.
Iso-phase duct	This code applies to bus ducts where the bus bars for each phase are separately enclosed in their own protective housing. The use of the iso-phase buses is generally limited to the bus work connecting the main generator to the main transformer. The potential effects of the iso-phase faults appear to be unique in comparison to the end device fires (transformer or exciter). Care should be taken to evaluate the fire scenario before coding the event as an iso-phase duct fault or coding as a fire associated with the end device. That is, the fire should be evaluated in conjunction with the definition of a HEAF event and careful consideration as to the initiating component.

Junction box	An electrical junction box is a container for electrical connections, usually intended to conceal them from sight and deter tampering. A small metal or plastic junction box may form part of an electrical conduit wiring system in a building, or may be buried in the plaster of a wall, concealed behind an access panel or cast into concrete with only the lid showing. It sometimes includes terminals for joining wires.
Miscellaneous hydrogen containing equipment (e.g. piping)	This code includes hydrogen fires in miscellaneous systems other than hydrogen cylinder storage, generator cooling, and battery rooms. Care should be taken to make sure this code is distinguished from the turbine generator hydrogen fires.
Off-gas/hydrogen re-combiner	This code includes all fires which occur in the off-gas systems and hydrogen re-combiner systems.
Oil separator or oil stripper	This code applies to all fires caused by equipment for separating oil (so-called oil strippers or oil separators) installed throughout the plant.
Portable equipment	This code typically applies to e.g., heaters, low power electric equipment, portable lights, etc. This code should take care to distinguish between portable heaters and fixed heaters as well as portable illumination equipment and fixed illumination equipment. The intent of this code is to capture fires which occur as the direct result of the interim use of portable equipment
Pumps	This code includes fires at pumps. Details see sub-codes below. It is assumed that above a certain sise, fire ignition is the same for all pumps. Pumps below 5 hp are assumed to have little or no significant contribution to risk. Fires at smaller pumps are coded as “Other component” with additional clarification given.
Electrically driven or turbine driven	This code includes motors, pumps and support equipment for cooling, lubrication, etc. This code excludes pumps with a rating of 5 hp or less. Turbine driven pump, such as auxiliary feedwater pump (BWR, some PWR)
Reactor coolant pump (RCP, for PWR)	The reactor coolant pumps (RCPs) are distinct devices in PWRs that vary between two and four, depending on primary loop design.
Main feedwater pump	Main feedwater pumps are generally well-defined items. All ancillary items associated with each pump should be included in this code.
Rectifier, inverter, or battery charger	These are generally well-defined items associated with DC buses.
RPS motor generator sets	In PWRs, the RPS MG sets are well-defined devices. The electrical cabinets associated with the MG sets are not included as part of these items.

Transformer:	Care should be taken to evaluate the fire scenario before coding the event as a transformer fire or coding as a fire associated with an iso-phase bus duct. That is, the fire should be evaluated in conjunction with the definition of a HEAF event and careful consideration as to the initiating component.
High voltage (voltage ≥ 50 kV)	High-voltage power transformers typically installed in the yard belong to this code. They include plant output power transformers, auxiliary shutdown transformers, and start-up transformers, etc.
Oil involved, catastrophic	The catastrophic failure of a large transformer is defined as an energetic failure of the transformer that includes a rupture of the transformer tank, oil spill and burning oil spattered at a distance from the transformer.
Non-catastrophic	Similar to the “catastrophic” code, this code includes the high-voltage power transformers typically installed in the yard. This code shall be used for fires which do not involve a rupture of the transformer tank, oil spill and burning of oil spattered at a distance from the transformer.
Medium or low voltage (voltage level < 50 kV)	This code includes all transformers that are not integral parts of another code. Control power transformers and other small transformers, which are sub-components in electrical equipment, should be ignored. They are assumed to be an integral part of the larger component. Examples of transformers accounted for in this code include transformers attached to AC load centres, low voltage regulators, and essential service lighting transformers.
Dry	Dry medium or low voltage transformers are typically cabinet external transformers with lower fire load.
Oil filled	Oil filled medium or low voltage transformers are typically cabinet external transformers using oils as coolant.
Transient material	This code should be used to classify transient fires of materials as e.g., trash cans, stored personal protection materials, additional outage load such as temporary scaffolding, etc., which are specifically initiated by hot work activities. This would not cover transient fires where the source of the fire is unknown such as self-ignited rags.
Turbine generator:	
Exciter	The turbine generator exciter is a well-defined item. Generally, there is only one exciter per unit.
Hydrogen	This code is limited to the complex of piping, valves, heat exchangers, oil separators and often skid-mounted devices that are associated with turbine generator hydrogen. Caution: It is important to have a clear definition of the turbine generator system boundaries to distinguish between turbine generator hydrogen fires and miscellaneous hydrogen fires being included in a separate code.

Oil involved	Similar to hydrogen, this code is limited to the complex of oil storage tanks, pumps, heat exchangers, valves, and control devices belong to the turbine generator oil system.
Valve	This code covers large valves that include hydraulic fluid powered mechanisms. (e.g., main steam isolation valves, turbine stop valves, etc.).
Other component	This code shall be used if the predefined codes are not applicable. The coding shall be complemented by a descriptive text that describes the type of component.
Unknown	A component can be linked to the fire, but the type is unknown.

3.2.5 Ignition mechanism

Code/Text	Use available codes to identify the ignition mechanism. Multiple alternatives can be selected. If a code is not available, select one of the following alternatives: - "Other " and describe type of ignition mechanism by use of narratives - Unknown. There is no information on ignition mechanism.
Codes	***Definitions***
Mechanical	Mechanical failure, machinery breakdown.
Electrical	Short circuit, short to ground, arcing, etc.
Self-ignition	E.g. oil in insulation (auto-oxidation), cable ignition
Hot component	Example: oil on hot pipes (no mechanical failure); "Hot component" can be a hot steam pipe or a hot component due to loss of cooling.
Hot work	Welding, cutting, etc.
Other	Other types of ignition mechanism such as lightning, explosions, external sources
Unknown	There is no information on the ignition mechanism.

3.2.6 Root cause

Code	Use available codes to identify the root cause (the most basic reason for the fire ignition). Multiple alternatives can be selected. If a code is not available, select one of the following alternatives: • "Other" and describe type of root cause by use of narratives • Unknown. There is no information on root cause. Root cause codes (categories) are used in IAEA-TECDOC-1112 Root cause analysis for fire events at nuclear power plants.
Codes	***Definitions***
Equipment	Design, operational failure, maintenance

Human	Fire caused by non-observance of procedures, e.g. due to welding, cutting, not-appropriate treatment of flammable / combustible materials, etc.
Procedures	Fire caused by deficient procedures
Other	Other type of root cause than equipment, human error or procedures. This could also include external events, such as earthquake, high winds, vehicle collision, etc.
Unknown	There is no information on the root cause.

3.2.7 Type of fire detection

Code(s)	By which means was the fire detected? Use available codes and describe by use of the narrative description field. Multiple alternatives can be selected. Indicate only the detection means being involved.
Codes	***Definitions***
Fire alarm system	Automatic fire detection by fire alarm systems
Fire guard/watch	Manual fire detection
Plant walk down	Manual fire detection
Other personnel	Manual fire detection
Indirect signals	E.g. fire induced influence on process instrumentation
Signals from the fixed extinguishing systems	Signals from the fixed extinguishing systems
Undetected	An identified self-extinguished fire
Unknown	There is no information on fire detection.

3.2.8 Detector type

Code(s)	If the fire alarm system was actuated, what type of detector indicated the fire? Multiple alternatives can be selected. Indicate only the actuated detector types.
Codes	***Definitions***
Optical detector	Optical including optical smoke detecting devices (ionisation detector coded separately below). A device that senses visible or invisible particles of combustion.
Heat detector	Temperature gradient, (fix temp.). A device that detects abnormally high temperature or rate-of-temperature rise.
Flame detector	A device that senses the presence of a flame
Ionisation detector	The principle of using a small amount of radioactive material to ionise the air between two different charged electrodes to sense the presence of smoke particles. Smoke particles entering the ionisation volume decrease the conductance of the air by reducing ion mobility. The reduced conductance signal is processed and used to convey an alarm condition when it meets preset criteria.
Infrared detector	

Other type of detector	
No detector actuation	The fire was detected by other means. Example, heat detectors did not alarm immediately, plant personnel detected the small fire.
Not applicable	Use this code for rooms where no detector exists.
Unknown	

3.2.9 Detection system performance

Code	Performance of detection systems
Codes	***Definitions***
Normal	Normal performance of the detection system
Fire detectors were not involved	Criteria for automatic actuation of fire detectors were not met. Detectors were not actuated (correct performance) but would have worked as intended (e.g. in case of low amount of smoke, low temperatures, etc.), fire was detected by other means (e.g. indirect signals, humans being present).
Malfunction	The detection system did not work as designed (complete failures or partial failures). Such as delayed automatic detection, unsuitably located detector, etc.
Not applicable	The fire was detected by other means (e.g. people available in the fire compartment), because detectors were not installed in the fire compartment.
Unknown	

3.2.10 Fuel/Combustibles/Fire loads

Code(s)		Identify the type of combustible(s)/fuel(s) that was (were) involved in the initial phase of the fire. Fuel properties (quantity and material) relevant to combustion in the narrative description field. Multiple alternatives can be selected.
Codes		***Definitions***
Permanent combustibles:		The fuel is permanently available at the fire location. The coding shall be complemented by a descriptive text.
Gas:		
	Hydrogen	
	Other gases	The coding shall be complemented by a descriptive text that characterises the type of gas.
Liquid:		
	Flammable liquid	Liquid with low ignition temperature, e.g. gasoline or other mineral oils. If possible, add ignition temperature limits in narrative description field.

	Hardly inflammable liquid	Fire retardant (hardly inflammable according to internationally harmonised classifications as e.g. CLP Guideline) liquid, normally with high ignition temperature, e.g. lubrication oil, grease, hydraulic fluid, fuel oil, etc. If possible, add ignition temperature limits in narrative description field.
Solid:		
	Cable insulation materials	
	Wood	
	Paper	
	Trash/waste	
	Plastics / polymeric materials	
	Other insulations	
	Charcoal	
	Other solid material	The coding shall be complemented by a descriptive text that describes the type of solid combustibles.
Transient combustibles:		The fuel is only temporarily available at the fire location (transient fire loads). The coding shall be complemented by a descriptive text that describes the type(s) and configuration of the transient combustibles, such as scaffolding, staging area, etc.
Gas		
Liquid		
Solid		
Unknown		

3.2.11 Ignition phase comments

Text: In this text field specific comments concerning the ignition phase can be added such as: • Reflections made, • Clarification of coding.

3.3 Extinguishing phase

This section describes the course of the event after the fire alarm has been signalled. The section provides instructions how to describe OECD FIRE event scenarios. The fire's or the smoke's influence on the plant are described in section 3.4

3.3.1 Type of extinguishing

3.3.1a Fire extinguishing means used

Code	Identify the type of fire extinguishing means used for fire suppression. Multiple codes can be selected.
Codes	***Definitions***
Manual fire fighting	The fire was extinguished by use of e.g. portable fire fighting equipment or by use of water from fire hydrant and/or hose.
Fixed system - automatic actuation	The fixed extinguishing system/s was/were actuated automatically (either by the fire detection system or, e.g., for sprinklers, by temperature increase).
Fixed system - manual actuation	The fixed extinguishing system/s was/were actuated manually.
Controlled burn out	An active decision has been made to not directly extinguish the fire.
Fire source isolation	If the fire source is an electrical arc, the fire (arc) can be extinguished by disconnection of electrical power source. Another example for the fire source isolation is the isolation of the oil or hydrogen source.
Self-extinguishing	
Not applicable	
Other means	
Unknown	

3.3.1b Type of fire extinguishing system/equipment used

Code	Identify the equipment used for fire extinguishing. Multiple codes can be selected.
Codes	***Definitions***
Fixed systems:	
Wet pipe sprinkler	Wet pipe sprinklers are fixed systems consisting of a network of overhead pipes releasing water through nozzles onto the fire, when a predetermined temperature has been reached, The only operating components are the automatic sprinklers and (commonly, but not always) the automatic alarm check valve. An automatic water supply provides water under pressure to the system piping. All of the piping is filled with water. Until sufficient heat is applied, causing one or more sprinklers to fuse (open), the automatic sprinklers prevent the water from being discharged.

Dry pipe sprinkler	Dry pipe sprinklers are fixed fire extinguishing systems consisting of a network of overhead pipes releasing water through nozzles onto the fire. Water is not present in the piping until the system operates. The piping is pressurised with air, at a relatively low "maintenance" pressure compared with the water supply pressure. When one or more of the automatic sprinklers is exposed to sufficient heat, it operates, allowing the maintenance air to vent from that sprinkler. As the air pressure in the piping drops, the pressure differential across the dry pipe valve changes, allowing water to enter the piping system.
Pre-action sprinkler	Pre-action systems are hybrids of wet, dry, and deluge systems, depending on the exact system goal. There are two sub-types of pre-action systems: single interlock, and double interlock. The single interlock systems operation is similar to dry systems except that these systems require that a “preceding” and supervised event prior to the “action” of water introduction into the system’s piping due to opening of the pre-action valve. The operation of double interlock systems is similar to deluge systems except that automatic sprinklers are used. These systems require that both a “preceding” and supervised event and an automatic sprinkler actuation take place prior to the “action” of water introduction into the system’s piping.
Spray water deluge	Deluge systems are fixed water based fire extinguishing systems that have open sprinklers, i.e. the heat sensing operating element is removed during installation, so that all sprinklers connected to the water piping system are open. Water is not present in the piping until the system operates. Because the sprinkler orifices are open, the piping is at ambient air pressure. To prevent the water supply pressure from forcing water into the piping, a *deluge valve (mechanically latched)* is used in the water supply connection. Water flows from all sprinklers simultaneously.
Water mist	Fixed water based systems using water sprays with very small droplet sise
Foam system	A foam fire extinguishing system is a fixed water based system, discharging a mixture of water and low expansion foam concentrate, resulting in a foam spray from the sprinkler.
Carbon dioxide	Fixed gas extinguishing systems using CO_2 as extinguishing agent
Halon	Fixed gas extinguishing systems using Halon gas as extinguishing agent
Other inert gas	Fixed gas extinguishing systems using special inert gases, such as Inergen (a composition of N_2, Ar, and CO_2) as extinguishing agent
Other gases	Other type of fixed gas extinguishing systems. The coding shall be complemented by a text describing the type of the fixed gas system.
Water hose	Water from fire hydrant and/or hose with fixed water supply
Other fixed system	
Portable means:	
Dry chemical	Portable fire fighting equipment, dry chemical (powder)
Gas	Portable fire fighting equipment, gas (e.g. carbon dioxide, etc.)

Foam (water based)	Portable fire fighting equipment:, foam (water based)
Other equipment	Other portable fire fighting equipment. This also includes water supply from fire trucks, etc. The coding shall be complemented by a text describing the type of equipment.
Not applicable	
Unknown	

3.3.2 Fire extinguishing systems/equipment performance

3.3.2a Fixed fire extinguishing system performance

Code	Performance of fixed fire extinguishing systems. Manual fire fighting performance by use of e.g. portable fire fighting equipment or by use of water from fire hydrant and/or hose is coded under 3.3.4.
Codes	***Definitions***
Actuation (as intended)	The fixed extinguishing system was actuated according to the design requirements and was effective in suppressing the fire. This includes automatically as well as manually actuated systems, including automatic systems actuated manually prior to automatic actuation conditions being reached. For automatic systems actuated manually because of failures in the automatic actuation mechanism (e.g. the fire detection system) the code "malfunction" should be used.
Malfunction	The fixed extinguishing system did not work as designed. This includes situations involving malfunctions in: • System actuation, • Failure to discharge when actuated manually, and, • General failure to suppress the fire when operating.
No actuation	Fixed fire extinguishing systems were not used because the criteria for automatic actuation of fixed extinguishing systems were not met and other fixed extinguishing systems were not actuated manually because of successful fire fighting with manual extinguishing systems, or other types of fire extinguishing (fire source isolation, fire self-extinguished, controlled burn out, etc.). Details associated with the event should describe any information why the automatic actuation criteria were not met and why manual actuation was not initiated
No fixed extinguishing equipment present	No fixed extinguishing systems were installed in the room where the fire occurred.
Unknown	

3.3.2b Portable fire fighting equipment performance

Code	Performances of portable fire fighting equipment and other equipment used by the fire brigade such as water hoses, etc. Manual fire fighting performance is coded under item 3.3.4.
Codes	***Definitions***
Normal	The portable fire fighting equipment worked as designed.
Malfunction	The portable fire fighting equipment did not work as designed.
Not applicable	The of portable fire fighting equipment was not used because of other types of fire extinguishing (fire source isolation, fixed fire extinguishing systems performance successful, fire self-extinguished, controlled burn out, etc.).
No portable fire fighting equipment present	Portable fire fighting equipment was neither present in the room where the fire occurred nor in the vicinity of the fire compartment.
Unknown	

3.3.3 Who extinguished the fire successfully

Code	Identify who extinguished the fire. Multiple alternatives can be selected. Identify the number of fire brigade members or number of fire engines brought to fight the fire, give the number in narrative description field.
Codes	***Definitions***
Self-extinguished	
Fixed system - automatic actuation	Fire was successfully extinguished by the fixed (stationary) fire extinguishing system, actuated automatically.
Fixed system - manual actuation	Fire was successfully extinguished by the manually actuated fixed (stationary) fire extinguishing system.
Fire guard/watch	
People available in the fire area	
Shift personnel	
On-site plant fire brigade	
External (off-site) fire brigade participated	
External (off-site) fire brigade was notified for backup	
Unknown	

3.3.4 Fire suppression performance

3.3.4a Manual fire fighting performance

Code	Manual fire fighting performance
	Remark: Water hose attached to a fixed hydrant is a special case, because it is treated as fixed system that requires manual action. The manual action has to be assessed here.
Codes	***Definitions***
Initial attack successful	Only one initial manual fire attack by a portable fire extinguisher or by use of water hoses and hydrants, (but not the manual actuation of a fixed extinguishing system) was needed to successfully extinguish the fire.
Not applicable	No manual fire fighting was needed because the fire was extinguished by a fixed fire extinguishing system (automatically or manually actuated) or by other means (fire source isolation, self-extinguished, controlled burn out, etc.),
Unknown	

3.3.4b Fire extinguishing performance

Codes	***Definitions***
Initial attack successful	Independent of the type of extinguishing (fixed fire extinguishing system, manual fire fighting means including the use of fire hoses and hydrants, etc.,) the fire was successfully extinguished by only one initial attempt.
Several attacks needed	The fire could not be extinguished by the initial attempt. Several attempts (either by different means (different fixed systems, fixed systems combined with manual means, different manual fire fighting means) or by the same) were needed to successfully extinguish the fire.
Not applicable	No fire extinguishing was needed because the fire extinguished by other means (fire source isolation, self-extinguished, controlled burn out, etc.).
Unknown	

3.3.5 Extinguishing phase comments

Text
In this text field specific comments concerning the extinguish phase can be added such as: • Reflections made, • Clarification of coding.

3.4 Functional consequences and corrective actions

3.4.1 Operational mode due to the fire

Code/Text	Plant operational mode just after the fire
Codes	***Definitions***
Construction phase	
Power operation	Power level > than 5 % of full power level
Hot stand by	Power level 0 (residual heat system not connected)
Shutdown mode	The shutdown modes normally include several sub-modes such as hot shutdown (RHR connected), cold shutdown, refuelling shutdown and service/ maintenance shutdown (outage) (refuelling included), if possible add sub-mode in the narrative text field. The water level in the primary circuit is also important for events during shutdown operation of PWR (e.g. Mid-Loop Operation).
Start-up mode	
Decommissioning	
Unknown	

3.4.2 Fire influence/ fire effects due to heat, hot gases, fire by-products or pressure build-up or due to consequential functional effects on components

Remarks:

1. Generally, multiple codes have to be selected.

2. If the fire is outside of plant buildings the code "Adjacent rooms affected" has to be chosen if adverse effects of the fire have spread beyond the direct vicinity of the origin of fire.

3. Each event has to be associated with at least one of the categories highlighted in the table below by bold face print. If nothing is known about the nature of “impacted” or “affected” only the bold faced heading has to be checked, otherwise the applicable sub-headings have to be additionally checked (multiple coding possible).

Code	Identify the influence due to heat or hot gases, or fire by-products, etc. on systems and components. Use specified codes. If feasible, identify the names of SSCs affected by the fire and direct, indirect and/or consequential effects. Identify the different direct, indirect and/or consequential effects (definition see below) and provide that information in the narrative description fields.
Codes	***Definitions***
	Direct Effects – Impact on systems, structures or components due to heat or combustion by-products (e.g. smoke, humidity, pressure build-up, etc.) from a fire

		Indirect Effects – Impact or consequences, other than due to heat or combustion by-products (e.g. smoke, humidity, etc.), to systems, structures or components due to fire and response to the fire; e.g. damage due to flooding from fire fighting activities, equipment intentionally de-energised in order to facilitate fire fighting efforts.
		Consequential Effects – Consequences arising due to *Direct Effects* from fire; e.g. spurious actuation of components due to fire damage to cables
None		No systems, structures or components were impacted or affected by the fire and/or its effects.
	Single component impacted	A single component was deteriorated, damaged, or destroyed by the fire and/ or its effects.
	by direct fire effects	.
	by indirect fire effects	
	by consequential fire effects	
	Multiple components impacted	More than one component was deteriorated, damaged, or destroyed by the fire and/ or its effects.
	by direct fire effects	
	by indirect fire effects	
	by consequential fire effects	
	Total loss of the room where the fire occurred	All equipment became unavailable by the fire and/or its effects in the room where the fire originated.
	Fire confined to one room	The fire and its effects were limited to the room where the fire originated.
	Adjacent rooms affected	Systems, structures or components in rooms adjacent to the room where the fire originated were impacted or affected by the fire and/or its effects. However, the fire did not propagate to other fire compartments.
	by direct fire effects	
	by indirect fire effects	
	by consequential fire effects	
	More than one fire compartment affected	The fire and/or its effects propagated from the original fire compartment where the fire originated to at least one other compartment via (rated) fire barrier elements.

	by direct fire effects	
	by indirect fire effects	
	by consequential fire effects	
	Structural influence or collapse	Structures or structural elements (including typical ones belonging to fire barriers (e.g. a fire door or damper) or buildings were damaged, failed or did collapse.
	by direct fire effects	
	by indirect fire effects	
	by consequential fire effects	

3.4.3 Fire by-products influence

Code	Identify the damage caused by fire by-products (e.g. smoke, soot, acidic products) spreading to the plant; typically smoke or soot on electrical cards, relays or breakers, shortcuts due to lack of insulation, etc.
Codes	***Definitions***
Damage of componen by fire by-products	Damage to components by fire by-products. Describe in the narrative description field the fire by-products influence on systems and components
Fire by-produc influence on huma actions and accessibility	Fire by-products have affected actions by plant personnel or accident mitigating actions, visibility or accessibility. Describe in the narrative description field fire by-products influence, in particular on people’s movement, smoke influence on main control room habitability-
Unknown	

3.4.4 Secondary effects

Code	Identify the collateral secondary effects, e.g. from extinguishing. Use available codes
Codes	***Definitions***
None	No secondary effects
Flooding	Flooding from sprinklers etc.
Others	E.g. electric components failed due to extreme low temperature from fire extinguishing by carbon dioxide.
Unknown	

3.4.5 Impact on safety trains

Code	Identify the number of safety trains inadmissibly affected in their required function by the event including the information on the total number n of safety trains present.
Codes	***Definitions***
No safety trains affected	No loss of the required safety train functionality.
One safety train affected	Loss of the required functionality of one safety train. There is no impact to the required function of the remaining safety trains. Text input should identify the total number of trains and their function(s).
More than one safety train affected	Loss of the required functionality of more than one, but not all safety trains. Text input should identify the total number of trains inadmissibly affected, the required function(s) of trains, and total number of safety trains.
All safety trains affected	Loss of the required functionality of all safety trains. Text should identify total number of safety trains and their required function(s).
Unknown	

3.4.6 Corrective actions

Code(s)	This field describes the actions taken by the licensee to prevent the fire event from re-occurring. Multiple alternatives can be selected. The following coding is used:
Codes	***Definition***
No corrective actions	
Procedures modification	Modifications to general administrative /procedure controls. Modifications to specific maintenance /operation practices
Design modifications	Design modifications such as addition of diversity. This includes diversity in fire detection and fire fighting equipment, types of equipment, procedures, equipment functions, manufacturers, suppliers, personnel, etc. or modification of the equipment barrier (functional and/or physical interconnections). Physical restriction, barrier, or separation.
Unknown	

3.4.7 Comments on consequence and corrective actions

Text: In this text field specific comments concerning consequence and corrective actions as well as lessons learned can be added such as: • Reflections made; • Feedback for database coding.

3.5. References

Identify references, which have been used to describe the OECD FIRE event.

NOTE: **References are documented in the "table of correspondence – references list" separately from the OECD FIRE DB.**

3.5.1 References

Examples of relevant references	Describe reference ID and how to find the reports.
Local fire brigade report	
Operation log	
Fire root cause analysis	
Investigation report	
LER report	

3.5.2. Registrar

Text	Name of the initial creator of the OECD FIRE event record

3.5.3 Date of OECD FIRE event description (YYYY-MM-DD)

Alpha-numeric	Date when the OECD FIRE event record was first created. Year/month/day

3.5.4 Date of OECD FIRE event revision (YYYY-MM-DD)

Alpha-numeric/ Text	Date and cause (text) of OECD FIRE event revision

3.6. Significance index

To be implemented in the next CG version

APPENDIX A: GLOSSARY OF TECHNICAL TERMS

Glossary

This report defines the terminology and abbreviations used in OECD FIRE Project documents. Codes used to classify OECD FIRE events should be defined in the OECD FIRE Coding Guidelines and are therefore omitted in this document. Reference to the source of the definition is given in many cases.

Abbreviations used

Below abbreviations used in OECD FIRE documents can be found. Codes for classifying the OECD FIRE events are defined in the OECD FIRE Coding Guidelines.

OA: Operating Agent

NC: National Coordinator

CG: OECD FIRE Coding Guideline

PRG: OECD FIRE Project Review Group

LER: Licensee Event Report

Terminology and technical terms used for the Project

Below the terminology specially used for the OECD FIRE Project is provided.

Other technical terms used in the OECD FIRE Project shall use and apply definitions according to NFPA Glossary of Terms (Fire term definitions) [1] and IAEA Safety glossary for terminology used in NPPs [2]. Both documents are available on the OECD FIRE home page. Some terms from [1] and [2] often used in the OECD FIRE Project are also listed below.

- **Classify:** Assignment of key words to a fire event based on OECD narrative descriptions or related references

- **Codes:** In order to make the data searchable and to make it easier to develop statistical conclusions, the data are classified with codes according to the OECD FIRE Coding Guidelines.

- **Coding Guidelines (CG):** The guide provides instruction how to describe a fire event by use of a narrative description. The guide also defines codes to be used for classifying the event.

- **Compulsory information:** Most fields in the database are compulsory, which means that the information should be provided unless either it takes an unreasonable time to retrieve this information or it is unknown.

- **Description fields:** Except for the narrative description fields the database contains a number of description fields, often with predefined codes. Examples of description fields are; “Title of event”, “Root cause” and “Detector type”.

- **Detect:** (1) Sensing the existence of a fire, especially by a detector from one or more products of the fire, such as smoke, heat, ionised particles, infrared radiation, and the like. (2) The act or process of discovering and locating a fire [1].

- **Explosion:** (1) The sudden conversion of potential chemical energy into kinetic energy with the production and release of gases under pressure, or (2) the release of gas under pressure. These high-pressure gases then do mechanical work such as moving, changing, or shattering nearby materials [1].

- **Fire alarm system:** A system or portion of a combination system consisting of components and circuits arranged to monitor and indicate the status of fire alarm or supervisory signal initiating devices and to initiate appropriate response to these signals [1]

- **Fire compartment**: A building or part of a building comprising one or more rooms or spaces, constructed to prevent the spreading of fire to or from the remainder of the building for a given period of time. A fire compartment is completely surrounded by a fire barrier [2].

- **Fire department:** An organisation providing rescue, fire suppression, and related activities, including emergency medical operations; this includes any public, private, or military organisation engaging in this type of activity [1]

- **Fire extinguished:** The point in time when there is no longer any abnormal heat or smoke being generated in material that was previously burning [1]

- **Fire frequencies:** The number of occurrences per time unit, at which observed fire events have occurred

- **Fire Hazard Analysis (FHA):** An analysis to evaluate potential fire hazards and appropriate fire protection systems and features to mitigate the effects of fire in any plant location

- **Fire load:** The heat of combustion of the combustibles. The fire load [MJ] is calculated as product of mass of combustibles and corresponding calorific value.

- **Fire load density:** Summarised fire load [MJ] per floor area [m^2] of the corresponding room or fire compartment

- **Fire scenarios:** A description of a fire and any factors affecting or affected by it from ignition to extinguishment, including, as appropriate, ignition sources, nature and configuration of the fuel, ventilation characteristics and locations of occupants, condition of the supporting structure, and conditions and status of operating equipment [1]

- **Ignition:** The initiation of combustion evidenced by glow, flame, detonation, or explosion, either sustained or transient. The moment when a fire first occurs [1]

- **Ignition source:** Any item or substance capable of an energy release of type and magnitude sufficient to ignite any flammable mixture of gases or vapours that could occur at the site [1]

- **Incipient fire:** Small or initial phase of fire, which can evolve to a fully developed fire if nothing is done

- **Licensee Event Report (LER):** Report that the nuclear power plant has to send to the authority to report incidents

- **Member country:** A country member of the OECD

- **Narrative description:** A textual description of the fire event

- **National Coordinator:** Each participant shall nominate one or more national coordinators who shall be responsible for the administration of the OECD FIRE Project within his/her respective country.

- **Observation period:** The period of time for which fire events should be collected

- **OECD FIRE Database:** MS ACCESS® database where all events downloaded from the web interface are stored. This database is distributed on a CD to project members.

- **OECD fire event:** Defined in the CG as:

  - A process of combustion characterised by the emission of heat accompanied by (open) flame or smoke or both

  - Rapid combustion spreading in an uncontrolled manner in time and space

- **Off-site fire department:** A fire brigade located in a nearby city or village. The fire brigade organisation is independent from the NPP organisation.

- **On-site fire brigade:** A fire brigade located at the NPP site or in the vicinity of the NPP. The fire brigade organisation is often subordinate to the NPP organisation.

- **Operating Agent:** The Operating Agent (OA) operates the databank and verifies that the data from the national coordinators complies with the OECD FIRE Coding Guidelines.

- **Participant:** An organisation that has signed and complies with OECD FIRE Project Terms and Conditions

- **Probabilistic Fire Safety Analysis (Fire PSA):** A comprehensive, structured approach to identifying failure scenarios, constituting a conceptual and mathematical tool for deriving numerical estimates of risk [2]

- **Project archive:** All documents and databases generated within the project are stored in the Operating Agent server. All participants of the project can download the documents.

- **Project Review Group:** All national coordinators together constitute the OECD FIRE Project Review Group (PRG).

- **Project website:** The OECD FIRE Project has a website, where all referenced documents generated by the project are available for all participants. The address is **www.nea.fr/download/fire.** The website is password protected. OECD-NEA provides participants with username and password.

- **Reporting routines:** Reporting routines are either routines for reporting between a nuclear power plant and the authority or internal routines for describing and distributing the fire event at the nuclear power plant.

- **Reporting thresholds:** This refers to the incident reporting level between utilities and authorities. What is to be reported is normally defined in the technical specifications (utilities document) as well as when or for which incidents information should be sent to the authorities.

- **Safety component:** Component included in the Final Safety Analysis Report (FSAR)

- **Safety system:** A system important to safety, provided to ensure the safe shutdown of the reactor or the residual heat removal from the core, or to limit the consequences of anticipated operational occurrences and design basis accidents [2]

- **Self-extinguishing fires:** The fire extinguishes by itself without any fire extinguishing efforts.

- **Sequence of events:** A narrative description in form of a bullet list sorted by date and time of action

- **Significant damage:** Nuclear safety is inadmissibly impaired.

- **Suppression:** The sum of all the work done to extinguish a fire from the time of its discovery [1]

- **Technical specification:** Rules that state how the nuclear power plant should be operated

- **Web interface:** A web-based interface where data should be entered when submitting fire data to the project. The address is **https://www.nea.fr/fire**. Username and password can be requested by sending an email to webfire@nea.fr.

References

[1] Nuclear Fire Protection Association (NFPA)
NFPA 97 Standard Glossary of Terms Relating to Chimneys, Vents, and Heat-Producing Appliances, 2003 Edition (US$ 27.00)

[2] International Atomic Energy Agency (IAEA)
Safety glossary: Terminology used in nuclear, radiation, radioactive waste and transport safety, Version 1.2, September

APPENDIX B: NATIONAL REPORTING LEVELS

Criteria for Reporting Fires in NPP in the OECD FIRE Member Countries

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
Canada				
/ AECB	Draft Reg. Guide R-99 Reporting Requirements for Operating nuclear power plants	9 Declaration of an alert or emergency, within the nuclear power plant, where personnel or resources are mobilised by the licensee in response to an unexpected occurrence of a radiological condition, chemical spill, **fire**, or **potentially explosive mixture of gases** that creates an actual hazard to the safe operation of the plant or the safety of persons. 10 The occurrence of any unusual external conditions at the site, including **fire**, flood, plane crash, **gas explosion**, **gas release**, high winds, missile or ice conditions, which results in operational transients.		2003
/ CNSC	Reg. Standard S-99 Reporting Requirements for Operating nuclear power plants (March 2003)	11 Quarterly Operation report (6.4.1): (t) a description of any **fires** that occurred at the nuclear power plant and an assessment of their safety significance Glossary: "**Fire**: any uncontrolled combustion, not restricted to open flame, that causes personal injury, death, property damage or results in the mobilisation of the response emergency team." 12 Unscheduled reporting (6.3.1) External event (38): The occurrence of any unusual external conditions at the site, including **fire**, flood, plane crash, **gas explosion**, **gas release**, high winds, missile or ice conditions that resulted in or had significant potential to result in operational transients at the nuclear power plant.	2003	
Czech Republic		Three levels of records about fire events exist:		

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
/ REZ **Czech Republic**	Legislative act about fire	A) *Regulatory body for fire safety (DFRCCR)* Unique to the Czech Republic is that exists another regulatory body (fire regulatory body), the "Directorate of Fire Rescue Corps Czech Republic" (separate from SONS) reports to the "ministry of the interior" with primary responsibility for fire protection. Fire events are reported under the same system as other incidents and events. Specifically, fire reports are required to the regulator within 8 hours. Fire events are reported according to legislative rules. Reports include: 1. Place of the fire 2. Character of place 3. Year of putting in operation 4. Time of ignition fire 5. Fire loss 6. Number of intervening fire force 7.Cause of fire 8. Cause of propagation fire 9. Corrective actions and prevention, etc. B) *Regulatory body for nuclear safety energy (SONS):* SONS (State Office for Nuclear Safety) fire protection inspections are based on equipment performance data, and operational history. Fire is not explicitly mentioned but if a fire should affect a safety component or unit operations, the event should be reported. *C) OEF on NPP:*		

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
(contd.)	protection No.133/1985, § 5 Fire definition according to § 51 Directive of Ministry of Interior CR No.21/1996.	OEF (Operation Experience Feedback) system is based on IAEA and WANO guidelines. Reporting criteria are translated from IAEA NS-G-2.11. Basic reporting criteria include: Fires, failures and spurious initiations of fire protection and fire detection systems Reporting duty due to every fire (report for *regulatory body for fire safety)* Reporting duty due to fire which is I accord with fire definition (report for *Regulatory body for fire safety)* A fire or an explosion has occurred at the plant site and at the same time satisfy following: *"The fire is each undesirable burning leading to the injury or kill of persons or animals. The fire is also each undesirable burning leading to the fire material damage."* According to methodical directive of the Head Fire Director of 1997 as fire are not considered: 1. Explosives explosions, if there it is not accompanied with fire of materials and constructions. 2. Burning of coils of electric rotating machines as a result of short circuit, if burning has not propagated outside coil volume. 3. Glowing of electric installation, if it has not propagated outside of installation. Ignitions, which occur during manufacturing, if the technological procedure could not exclude such cases and their liquidation is technically ensured, under assumption that burning will not spread outside the anticipated part of the technology, or the cases are not exclusively specified as operational accidents.	1985 1996	

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
Finland / STUK	Reg. Guide YVL 1.5 Rev. 8 Sept; 2003	The Regulatory Guide 1.5, "Reporting nuclear facility operation to the Radiation and Nuclear Safety Authority" is published 8 September 2003. This Guide is in force as of 1 March 2004 until further notice. It replaces the earlier version of the Guide YVL 1.5, issued on 11 January 1995. (The wording was quite similar also in all the older versions of the reporting guide, thus similar criteria are assumed since the first NPP started its commercial operation in Finland, 9th May 1977. Anyway, the Finnish fire data is provided to this project by the utilities and they will submit "all fires" according to the criteria given in this guideline: Chapter 2.1 and the beginning of Chapter 3). Accordingly to Chapter 3.2 (item q.) Special report is provided if "**A fire, an explosion or a chemical damage has occurred at the plant site**." Nowadays STUK's annual report of nuclear safety covers events with safety significance including also a summary of fire brigade alarms.	1977	

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
France		*Before 1994, fire events reported along NEA-IAEA/IRS Guidelines*	1978	1994
/ EDF	EDF DI 060 (8 June 1994) The Autorité de Sûreté Nucléaire (ASN) and the Institut de Radioprotection et de Sûreté Nucléaire (IRSN), its technical support organisation, agree to these criteria.	Any fire event or situation caused by a fire event: 2 solicitation of external help (fire brigade call); 3 bodily injury; 4 material damage in excess of EUR 1500; 5 use of more than one hand-held fire extinguisher; 6 use of fire hose or mobile (non-portable) fire extinguisher; 7 true actuation of fire suppression device; 8 fire event within the nuclear island or in an auxiliary building; 9 fire event affecting or potentially affecting a safety-relevant component; 10 Fire event generating information of generic interest to safety. 11 It has to be underlined that one the criteria "solicitation of external help (fire brigade call)" that is a demanding criteria, has been specified later (beginning of years 2000). As all the fires events that can be provided to the data base occurred after 1994, it is not necessary to add older criteria.	1994	

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
Germany				
/ BMU	AtSMV Anlage 1 Meldekriterien für meldepflichtige Ereignisse in Anlagen zur Spaltung von Kernbrennstoffen. (Reporting Criteria for Reportable Events in Installations for Fission of Nuclear Fuels) Bn	In addition to the fire events reported to the authorities due to the following criteria, all fire events in German NPP GRS knows about will be reported (these events are incomplete up to now but might become complete in the future).		
		"**Any fire**." There are three classes of reportable events. They differ in their importance to safety and in the way they have to be reported. Fires belong to the class A events (immediately significant), but actually they were reported as class B (potentially significant) sometimes also as class C (other events).	1975	1985
		"**Any damage to systems and components** by plant internal fire, explosion or flood **that affects normal operation** (of the affected system or component)." There are three classes of events reflecting the significance in terms of safety. In contrast to the 1975 version most events show up in all three classes, depending on the systems affected and/or the severity of the event. The cited definition for fire events corresponds to the lowest level (N). A fire has to be reported as type E event, if systems or components important to safety are affected. There are no S class fires.	1985	1991
		"Internal fire, explosion or flood **causing the unavailability** of a **safety sub-system** or a redundancy of a **system or component important to safety**." The system is similar to the 1985 version using event classes S, E, and N. However, the new structure is such that the safety significance defines sub-classes of the event type. E.g., there is the event type 3.2 "fire, explosion, or flood" which is subdivided into the classes S, E, N.	1991	

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
Japan / JNES	Law for Regulations of Nuclear Source Material Nuclear Fuel Material and Reactors (LRNR) The Electric Utility Industry Law (EUIL)	*LRNR, Corresponding Ordinance: When there is a failure of equipment etc. important to safety by the fire. Excluding the concerned failure is due to the measure of fire extinguishing or prevention of the spread of fire;* *EUIL, Corresponding Ordinance: Electrical fire accidents.* *Both Laws have not changed but the Corresponding Ordinance article numbers were changed in 2003.*	1965	September 2003
		LRNR Article 62-3, Corresponding Ordinance Article 19-17, Item 4: When there is a failure of equipment etc. important to safety by the fire. Excluding the concerned failure is due to the measure of fire extinguishing or prevention of the spread of fire; EUIL Article 106, Corresponding Ordinance Article 3, Item 2: Electrical fire accidents.	September 2003	
Korea / KINS	Reg. Guide 2008-29 Reporting criteria for event or failure within the nuclear facility	13 The occurrence of any unusual external conditions at the site, including **fire**, leakage of the radioactive material, which results in operational transients. 14 The occurrence of **fire**, leakage, robbery, loss etc. of the radioactive material while it is wrapped or transported.	2008	
Netherlands / KFD	NPPs technical specifications	Fire is not explicitly mentioned but if a fire should affect a safety component, the event should be reported as LER report to KFD (if the component function is degraded).		

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
Spain / CSN	Guia de Seguridad no. 1.6 - Sucesos notificables en Centrales Nucleares en explotación. (Safety Guide n. 1.6 Reporting events for operating NPPs).	• Fire in the plant lasting more than 10 minutes from the time of detection [Section 3.1.5] • Fire in the plant with the potential to impact plant safety or with the potential to impair the plant personnel's ability to safely operate the plant [Appendix: reporting form for abnormal events]	January 1990	November 2006
	Instrucción IS-10 Criterios de notificación de sucesos al Consejo por parte de las centrales nucleares. (Instruction IS-10 Reporting criteria of events to the CSN from NPPs).	2.0 Fires that are confirmed with duration below 10 minutes and incipient fires that activate the corresponding detection systems, provided that they occur in cubicles, areas or fire zones in which structures, systems or safety-related components are located [Section 5.E.4]. 3.0 Uncontrolled fire situated to less than 5 Km away from plant's fence and it moves towards the plant [Section 5.H.1]. 4.0 A fire in the plant lasting more than 10 minutes activates the Internal Emergency Plan (PEI). Any activation of the PEI involves the report to the CSN.	November 2006	
Sweden / SKI	NPPs technical specification	Fire is not explicitly mentioned but if a fire should affect a safety component the event should be reported as a LER report to Swedish Radiation Safety Authority (SSM) (if the components function is degraded). In addition to these events all fire are reported which have activated the fire alarm. Swedish observation time starts in 1977.	August 1977	

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
Switzerland				
/ HSK	Reg. Guide HSK-R-15	No formal reporting requirements	1969	1980
	Berichterstattung über den Betrieb von Kernkraftwerken (1980, 1981)	Any fire or explosion if it either (1) causes a scram or (2) if it does not cause a scram but if there is an oil leakage with a risk of ignition or (3) if there is a major oil leakage	1981	1984
	Reg. Guide HSK-R-15 (1984, 1987)	Any fire or explosion in a building containing safety relevant (classified) equipment	1985	1994
	Reg. Guide HSK-R-15 (1994, 1999, 2004)	Any fire or explosion within the perimeter of the plant.	1995	

Country / Organisation	Source Document	Reportable Fire Event	Start Date	End Date
USA				
/ NEIL	NEIL Loss Control Standards (Sept. 2002)	12 Any fire involving activation or malfunction of a fixed fire extinguishing or detection system OR any physical damage loss in excess of $100,000.00 13 Impairments to fire suppression systems, which exceed, or are expected to exceed 48 hours	2002	
/ USNRC	10 CFR 50.73 Licensee event report system.	• Any event that posed an actual threat to the safety of the nuclear power plant or significantly hampered site personnel in the performance of duties necessary for the safe operation of the nuclear power plant including fires, toxic gas releases, or radioactive releases.		
	10 CFR 72.75 Reporting requirements for specific events and conditions.	• Non-emergency notifications: Four-hour reports. Each licensee shall notify the NRC as soon as possible but not later than 4 hours after the discovery of any of the following events or conditions involving spent fuel, HLW, or reactor-related GTCC waste: (1) An event that prevents immediate actions necessary to avoid exposures to radiation or radioactive materials that could exceed regulatory limits, or releases of radioactive materials that could exceed regulatory limits (e.g., events such as fires, explosions, and toxic gas releases). (6) An unplanned fire or explosion damaging any spent fuel, HLW, and/or reactor-related GTCC waste, or any device, container, or equipment containing spent fuel, HLW, and/or reactor-related GTCC waste when the damage affects the integrity of the material or its container.		

APPENDIX C: RELEVANCE INDEX DEFINITION

Relevance Indices are implemented to characterise the quality of fire event reports collected in the OECD FIRE Project.

The rationale to introduce relevance indices is twofold:

- The Operating Agent wants to have a mechanism that allows filtering out issues in the reports for which more information must be sought.
- The user desires to have knowledge of the completeness of the information in the database and of the degree of confidence he can put in the information in the database if he wants to analyse data for various purposes.

The relevance indices essentially are "completeness indices", i.e. they measure how complete and detailed the reported information is and by what kind of references it is supported.

The relevance index grades are to be derived from information in the "event description", "sequence of events", from the fire phase comment fields, and from the respective coded fields, if the latter contain information beyond that in "event description", "sequence of events" and fire phase comment fields. This qualification process requires to examine event descriptions and event sequence descriptions with respect to the six listed items and to assign the appropriate quality index to each of the listed items as part of the database.

The assignment of grades in the database will be made after quality control is completed.

Predefined relevance indices are assigned only to a limited number of important items, for example:

- Total
- Causes of fire (Concerned fields: 3.2.1, 3.2.4, 3.2.5, 3.2.6)
- Fire scenario (Concerned fields: 3.1.7, 3.1.8, 3.1.10, 3.2.7, 3.2.9, 3.2.10, 3.2.11, 3.3.2a, 3.3.2b, 3.3.4, 3.3.5)
- On-site fire brigade response (Concerned fields: 3.1.7, 3.1.8, 3.1.10, 3.1.11, 3.1.12, 3.3.1, 3.3.2b, 3.3.4, 3.3.5)
- Off-site fire brigade response (Concerned fields: 3.1.7, 3.1.8, 3.1.10, 3.1.11, 3.1.12, 3.3.1, 3.3.2b, 3.3.4, 3.3.5)
- Consequences of fire (Concerned fields: 3.1.10, 3.4.1, 3.4.2, 3.4.3, 3.4.4, 3.4.5, 3.4.7)
- Customise the grouping of fields: a software tool is implemented to groups any fields together.

Assignment of grades:

The calculation of the total index is based on the set of all narrative fields and most of the coded fields.

The calculation of the indices 2 through 6 is based on subsets of the indices used for the calculation of 1.

Each index is calculated as the sum of the numerical attributes of its relevant indices.

Three different grades "H" (High), "M" (Medium) and "L"(Low) can be assigned to each narrative and coded field. The corresponding numerical attributes (values) differ for the various fields are defined below.

Note: The narrative fields 3.1.9, 3.2.11, 3.3.5, 3.4.7 have been added after the first events were inputted in the database. Previously only 3.1.7 was available for event description. This explains the different rating system in place. From now on, the system covers all narrative fields.

For events inputted before Sept 2004, the rating system is:

- Narrative field 3.1.7 : H~30, M~14, L~5
- Sequence of events field 3.1.8 H~10, M~5, L~0
- Coded fields: H~2, M~1. L~0

For events inputted after Sept 2004, the rating system is:

- Narrative field 3.1.7 : H~30, M~14, L~5
- Sequence of events field 3.1.8 H~10, M~5, L~0
- Narrative fields 3.1.9, 3.2.11, 3.3.5, 3.4.7: H~4, M~2. L~0
- Coded fields: H~2, M~1. L~0

"H" is assigned to 3.1.7, if this field contains a detailed and complete description that does not necessitate further explanations in other fields.

"M" is assigned to 3.1.7, if the description is complete and detailed, but is distributed over all five narrative fields. Thus, the maximum that can be attained by the narrative fields plus the sequence of events field is 40, regardless of how the information is spread out over the five narrative fields.