ISO/TC 92/SC 4
Fire safety engineering

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Background: This document prepared by Vladimir MOZER (Slovakia) was considered at the FRA TG Meeting convened by V. MOZER and held in Linz (Austria) on Tuesday 12th April 2016 (10:30-12-30).

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Fire risk assessment – ISO TC 92 Fire safety SC 4 Fire safety engineering

Current standards review and future development recommendations

A report to TG1 of ISO TC 92 / SC 4

Objectives

The objectives of this report are to:

1. Summarise current state of fire risk standardisation at ISO level.
2. Propose updates, revision and other changes to current and development of new FRA standards.
3. Categorise the updates and development activities in order of importance and identify timescales of their realisation.

The purpose of this document, once agreed upon, is to scope further works on the development of fire risk assessment standards within the ISO TC 92 Fire safety / SC4 Fire safety engineering subcommittee.

1. Current fire risk assessment standards review

The current ISO 16732 Fire risk assessment standards suite comprises:

ISO 16732-1:2012	Fire safety engineering. Fire risk assessment. Part 1: General
ISO/TR 16732-2:2013	Fire safety engineering. Fire risk assessment. Part 2: Example of an office building
ISO/TR 16732-3:2013	Fire safety engineering. Fire risk assessment. Part 3: Example of an industrial property

All standardised guidance relating to fire risk assessment is provided in the general principles document (ISO 16732-1:2012) and is complemented by two example TR documents (ISO/TR 16732-2 and 3).

ISO 16732-1:2012 provides a general description of fire risk assessment and the steps which are to be followed during the process of FRA application in fire safety design. Although some parts of the document (e.g. Sections 4, 5 and selected Sub-sections in Sections 6, 7 and 8) are general, i.e. relevant to all methods of fire risk assessment, the majority of the document is relevant primarily to quantitative fire risk assessment methods. This includes scenario selection, probability/frequency estimation, consequence estimation, uncertainty and sensitivity treatment, etc. The guidance is primarily theoretical with mentioning certain calculation approaches, e.g. ETAs, but without more detailed description of particular tools and their application.

ISO/TR 16732-2:2013 provides an example of FRA application in an office building. This example is primarily based on the work of Yung and Hadjisophocleous, namely the FIRECAM model; various papers and reports provide further description on this particular case. The TR provides good description on the assumptions made, input data, scenario selection etc., however, the actual risk calculations are done by the FIRECAM model, which is not readily available at the moment (NRC's

download link does not work). Some expansion of this part of the document would be of benefit to the end user not familiar or not able to obtain a copy of FIRECAM. Risk is evaluated on the relative basis, i.e. against prescriptive code design fire risk which is assigned the value of 1. The example provides also fire cost expectation for the 5 design options specified.

ISO/TR 16732-3:2013 provides an example of the application of FRA in an industrial property, namely a propane storage, reception and shipment facility. The example focuses primarily on the possibility and consequence of BLEVE (Boiling Liquid Expanding Vapour Explosion). Assumptions, input data (or their sources), scenario identification and selection are described in an appropriate level of detail as well as the risk calculation for the selected options. Risk estimation is and acceptance evaluation is provided, in this case against an absolute criterion – BLEVE frequency.

The above technical reports are valuable complementary documents, however, it is proposed that further such TRs are based on, or linked to, the existing example documents to provide all inclusive (start-to-finish) guidance on performance-based fire safety design, including the application of FRA.

Given the above overview of the current standards constituting the ISO 16732 FRA suite, a general update proposed is proposed, focusing primarily on introduction of ready-to-use FRA tools, both qualitative and quantitative, complemented by guidance on their application as part of performance-based fire safety design.

2. Proposed updates to the fire risk assessment standards suite

The following structure of the fire risk assessment standards suite is proposed for consideration:

Number of standard	Proposed title	Action
ISO 16732-1:xxxx	Fire safety engineering. Fire risk assessment. Part 1: *General*	Restructure / add content
ISO 16732-2:xxxx	Fire safety engineering. Fire risk assessment. Part 2: *Qualitative and semi-quantitative methods*	Develop
ISO 16732-3:xxxx	Fire safety engineering. Fire risk assessment. Part 3: *Quantitative methods*	Develop
ISO 16732-4:xxxx	Fire safety engineering. Fire risk assessment. Part 4: *Efficiency and cost-benefit evaluation of fire safety design*	Develop
ISO 16732-5 to 9:xxxx	Reserved for future FRA standard development should the need arise	--
ISO 16732-1X(10+):xxxx	Fire safety engineering. Fire risk assessment. Parts 10+: *Examples of FRA use*	Renumber / Develop

The above structure of the FRA standard suite should provide complete and universal guidance for the fire engineer from the selection of the appropriate approach for the specific design task through its application, data sourcing, addressing variability and uncertainty to efficiency and cost-benefit evaluation. There are three types of documents proposed:

1. General principles documents – theory documents;
2. Method-specific documents - toolkit documents;
3. Example documents.

Key focus is on FRA integration into the overall performance-based design approach, where direct links with the other available and future FSE standards needs to be highlighted and supported by examples.

Further sections of this report briefly summarise the scope of the individual standards and their proposed core contents. At this stage, the items listed and their chronological order is only indicative and open for modification.

ISO 16732-1 Fire safety engineering. Fire risk assessment. Part 1: General

The general principles document should be an introductory document for other parts of the FRA standards suite. Alongside terms and definitions, it should provide information on the various FRA methods available, their selection and recommended use, stakeholders and their roles, etc. A good example of such structure is NFPA 551 Guide for the evaluation of fire risk assessments. No particular method should be described in depth, e.g. not listing recommended features of a checklist.

The general principles document should cover the following topics (list not exhaustive):

1. Categorisation of fire risk assessment methods (e.g. from Ramachandran and Charters).
2. Applicability of FRA, i.e. Cases in which the use of FRA is beneficial or necessary and which FRA method is most appropriate for the task at hand, e.g. design fire scenario selection.
3. List of "links" with other ISO FSE standards.
4. Standard fire risk management diagram and its application in the various FRA methods.
5. Risk and fire risk definitions and expressions in quantitative, semiquantitative and qualitative way (eg SFPE FRA guide) :
   - Quantitative – FR = $\sum(P_i$ or $F_i \cdot C_i)$ [expected fire loss / damage per year, prob of fatality / fatalities etc];
   - Semi-quantitative – FR index, matrices, contours, BFSEM;
   - Qualitative – Narrative expression, checklist score (FR acceptable / unacceptable).
6. Fire risk to life, property (including business continuity and heritage) and environment.
7. Stakeholders and their roles in FRA.
8. Fire risk perception.
9. Risk acceptance (absolute criteria, risk equivalence, ALARP, de minimis…).
10. Fire risk assessment objectives and acceptance criteria in general; method-specific details should be included in the "toolkit" documents.
11. Brief introductory description of the individual methods and their recommended use in FSE.

ISO 16732-2 Fire safety engineering. Fire risk assessment. Part 2: Qualitative and semi-quantitative methods

The second part of the FRA standard suite should provide the user with information on the qualitative and semi-quantitative methods ("tools") and their application. In more complex cases these methods may be used as preliminary assessment taken prior to the full quantitative assessment, e.g. Qualitative Design Review (QDR) as defined in BS 7974. On the other hand, in simpler cases, these mehods may suffice without full quantitative assessment. There are standards / guidance documents covering the topic of qualitative document, e.g. Introduction to qualitative fire risk assessment by the CFPA Europe and the Fire safety risk assessment series by HM Government, UK, HTM 86, HTM 05-03 Part K by NHS or Fire risk assessments for complex buildings guide by Kingfell. However, there is information available in literature, e.g. Quantitative risk assessment in fire safety by Charters and Ramachandran or Fire risk assessment in buildings by David Yung, to name a few.

The qualitative and semi-quantitative methods document should cover the following topics (list not exhaustive):

Qualitative FRA methods - Narrative FRA structured / unstructured, Checklists

The above methods usually comprise the following steps:

1. Identify fire hazards
2. Identify people at risk
3. Evaluate, remove, reduce, and protect from risk
4. Record, plan, inform, instruct and train
5. Review

The new standard should provide guidance on how to compose a structure of a narrative FRA or a checklist in relation to the five steps identified, what sort of language and descriptors to use and the Annexes would include examples of such fire risk assessments.

Semi-quantitative FRA methods – FR indexing, matrices, contours, BFSEM, Fire safety evaluation system etc.

It is understood that all of the above items cannot be covered in one document. It is therefore proposed that the fire risk matrices and contours and a simpler fire risk-indexing schedule are described in more detail. The other semi-quantitative FRA methods would be briefly described, covering their main features, applicability, structure of input and outcomes. For further detail the user would be refered to the original publication or standard, e.g. NFPA 101A for the fire safety evaluation system. Annexes would include examples of such fire risk assessments.

ISO 16732-3 Fire safety engineering. Fire risk assessment. Part 3: Quantitative methods

The second part of the FRA standard suite should provide the user with information on the quantitative methods (“tools”) and their application. Since there is a wide variety of quantitative FRA methods the document should be structured such that it covers them in the order of increasing complexity:

1. statistical models based on distributions;
2. logic trees (FTAs, ETAs);
3. network and stochastic models;
4. Monte-Carlo analysis;
5. Beta reliability method, etc.

A good example of such standard is PD 7974-7:2003 Application of fire safety engineering principles to the design of buildings – Part 7: Probabilistic risk assessment. Since it is acknowledged that data availability and quality is the greatest issue with quantitative FRA methods, there should be a section on this topic. In this regard, the existing guidance, currently contained in ISO 16732-1 could be used and expanded as required. Significant amount of information on this topic may be found in various sections of SFPE Handbook of fire protection engineering, Risk analysis in building fire safety engineering by Hasofer et. al., Quantitative risk assessment in fire safety by Charters and Ramachandran, Evaluation of fire safety by Rasbash et. al., to name a few. As regards data for quantitative FRA, it is questionable whether to include any (in the form of Annexes) in the first issue of the standard.

ISO 16732-4 Fire safety engineering. Fire risk assessment. Part 4: Efficiency and cost-benefit evaluation of fire safety design

The second new document introduced to the suite is Part 4. The scope of the document is to provide the user with tools to evaluate the efficiency and cost-benefit ratio of their design alternatives to select the most appropriate one for a given set performance objectives / criteria. Guidance would be provided on approaches to efficiency evaluation, e.g:

1. present worth;
2. annual cost;
3. rate of return;
4. cost-benefit analysis.

In order to be able use the above approaches, guidance would be provided on identification and quantification of the various monetary aspects of the design alternatives (fire protection measures) and associated fire scenarios (probability- and consequence-related). It is important that guidance is provided in relation to life safety, property protection and environment protection, e.g. whether it is desirable/necessary to quantify the value of human life, how to quantify impact of fire on environment, relevance of costs to the individual stakeholders, etc.

The above topics are extensively covered in Economics of fire protection by Ramachandran , SFPE Handbook of fire protection engineering (mainly section Engineering economics) and other books, reports and papers.

3. Information resources

The *SFPE Fire risk assessment engineering guide* and *NFPA Guidance document for incorporating risk concepts into NFPA codes and standards* contain comprehensive literature lists categorised into sub-topics which may be used to save time. Additional “reading lists”, particularly for newer references, may be obtained through scientific article databases, e.g. ScienceDirect, Springer etc.

4. Approach and timescales

Since the aim of this report is to set out the future structure of the ISO FRA standard suite, the primary intention is to reach consensus on the scope of the individual documents at this stage. Once agreement has been reached, the following sequence of tasks is proposed:

1. Identify links and utility of FRA within the other standards and documents of the FSE standards suite – cooperation with WG chairmen of SC4 required.
2. Restructure and update the general principles document.
3. Draft the contents of the “toolkit” and example documents and the links among them. The following order of importance is proposed:
   3.1. Quantitative methods;
   3.2. Qualitative methods;
   3.3. Efficiency and cost-benefit evaluation;
   3.4. Examples.
4. Creation of the individual documents in the above order of importance.

The expected duration of the above tasks is shown in the following table:

	Task	Year 1				Year 2				Years 3+
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
1.	Identify links with other ISO FSE standards									
2.	Review and update of ISO 16732 -1 General principles		First draft of contents	1st draft	1st draft	2nd draft open PWI	2nd draft incl. comments	Open NWI - finalize	Final version	
3.	Draft contents of toolkit and example documents							3.1 / 3.2	3.3 / 3.4	
4.	Creation of individual documents									

Project group online meetings will be held every two months (more often if a task requires so) via Webex (account already created). SC4 would be updated on the progress regularly at scheduled meetings.

Given the scope and extent of works, it is expected that once Task 1 and Task 2 (Year 1) have been completed, a TG or WG is created for subsequent tasks. This should ensure that the TG or WG has a clear strategy and set of objectives to which they can work and PWIs or NWIs may be properly assigned.

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