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Method for the justification of fire partitioning in water cooled nuclear power plants (NPP)

Méthode de justification de l'efficacité de la sectorisation incendie des centrales nucléaires utilisant l'eau comme fluide caloporteur

Reference number
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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 6, *Reactor Technology*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This corrected version of ISO 18195:2019 incorporates the following corrections:

— In 5.4.5.4, a few formatting corrections were made;

— In 6.4.7, Figure 13 has been corrected and the key modified accordingly.

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Introduction

This document is intended to provide a technical specification to verify the adequacy of the performance of fire partitions in nuclear power plants. The intended audience of this document are fire safety engineers and project designers. Nuclear authorities are also concerned considering that this method is to be used in the process of fire hazard nuclear safety demonstration. The method presented herein includes a combination of standardized testing and ad hoc testing with numerical and empirical calculations. Users of this document are expected to be appropriately qualified and competent in the fields of fire safety engineering, risk assessment and fire resistance standardization.

This document specifies a new methodology to Nuclear Power Plant (NPP) designers, fire safety professionals and nuclear safety authorities. This methodology aims to verify the adequacy of the performance of fire barriers in nuclear power plants in order to avoid fire propagation. This method is a potential tool for risk-informed, performance-based assessment.

NOTE This method is based on the EPRESSI method developed by EDF in collaboration with Efectis France fire safety laboratory in France for EPR reactors[39].

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Method for the justification of fire partitioning in water cooled nuclear power plants (NPP)

1 Scope

The document provides:

— guidelines for determining the thermal effects to consider on fire barriers inside a given room;

— guidelines for determining the global performance of the fire barriers based on standard test characterization;

— guidelines for assessing the need for additional tests to verify the robustness of the solution.

Requirements of applicable standards, numerical tools validation and verification (V&V), and the expected qualification of fire resistance laboratories are detailed.

The limitations of the method's applicability and scope are discussed.

The purpose and justification of this document is to describe a new methodology for the verification of the efficiency of fire barriers, which is initially based on a standardized fire resistance test.

The significance of this work relates to the fact that the present methodology will enhance the level of safety by providing more realism to hazards analysis in combination with standardized test data. It completes the standard ISO-fire rating required for justifying the performance.

The most relevant benefit of this method concerns the determination of the global performance of a barrier in a fire of extended duration compared to the classification given by the ISO-fire rating.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12749-2, *Nuclear energy, nuclear technologies, and radiological protection — Vocabulary — Part 2: Radiological protection*

ISO 12749-3, *Nuclear energy, nuclear technologies, and radiological protection — Vocabulary — Part 3: Nuclear fuel cycle*

ISO 12749-4, *Nuclear energy, nuclear technologies, and radiological protection — Vocabulary — Part 4: Dosimetry for radiation processing*

ISO 12749-5, *Nuclear energy, nuclear technologies, and radiological protection — Vocabulary — Part 5: Nuclear reactors*

ISO 13943, *Fire safety — Vocabulary*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO 13943, ISO 12749-2, ISO 12749-3, ISO 12749-4, and ISO 12749-5 and the following apply.

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ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Terms and definitions

3.1.1
credited combustible
part of the potential combustible material that will actually participate to the fire development

3.1.2
design basis fire
fire which may break out in any fire source of the plant and which has the severest consequences (duration, severity)

Note 1 to entry: For a given room, it is a fire taking into account all available fuel in this room liable to burn. Its characteristics are calculated taking into account the characteristics of the rooms and fuels.

3.1.3
fire volume
volume inside a building, composed or one or several rooms and designed to prevent the extension of a fire through its boundaries

Note 1 to entry: One of the means of preventing the extension of the fire is to keep it within a limited volume, either physically, by partitions opposing the fire propagation, either spatially, by boundaries associated with the remoteness of the components, with active protection systems (sprinklers), or with passive protection systems (structural features, cable wraps).

3.1.4
fire cell
fire volume (3.1.3) consisting of one or more rooms, bounded by separations guaranteeing that a fire occurring inside cannot extend to the outside or that one occurring on the outside cannot spread to the inside for a given period of time

Note 1 to entry: The boundaries of a fire cell may be either fire-resistant physical barriers, wall, ceiling and floor or *spatial separation* (3.1.15) through openings with a certain configuration and distance rules between combustible sources guaranteeing geographical separations with adjacent rooms and other fire areas. The non-propagation assumption has to be verified (by fire influence studies).

3.1.5
fire compartment
fire volume (3.1.3) consisting of one or more rooms, bounded by material *partitions* (3.1.10) whose fire resistance guarantees that a fire occurring inside cannot extend to the outside or that one occurring on the outside cannot spread to the inside for a given period of time

Note 1 to entry: All the partitions of a fire compartment shall be fire-resistant physical barriers, walls, ceilings, or floors.

3.1.6
fire resistance rating
time during which the fire *partitioning elements* (3.1.9) (partitions, walls, floors, doors, dampers, caulking of penetrations, enclosures of cable racks, etc.) can fulfil their assigned role, despite the effect of a standard fire

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3.1.7
low heat load threshold
LHLT
threshold which is introduced to avoid calculations in case of rooms that have too small quantity of combustible material and are neither PFL nor PFG

Note 1 to entry: See 5.4.5.3.

3.1.8
"neither PFG nor PFL" criterion
criterion that is met when the quantity of combustible material is not sufficient to generate a significant fire and does not present risks for spreading to secondary fire sources

Note 1 to entry: By extension, a room is said to be "neither PFG nor PFL" when the concentration of combustible masses in it is not enough to generate a widespread fire (with no necessity of further verification).

3.1.9
partitioning elements
features (partitions, fire walls, ceilings, floors, ducts, seals of openings such as doors, shutters, dampers, hatches as well as seals of cable bushings and piping sleeves) which make up a *partition* (3.1.10)

3.1.10
partition
set of *partitioning elements* (3.1.9) which fully bound the relevant area by *physical separation* (3.1.13)

3.1.11
possibility of a fire getting generalized
PFG criterion
criterion for a fire source when its burning is likely to result in flashover and a generalized fire

Note 1 to entry: By extension, a room is said to be PFG when a fire breaking out in an unfavourable part of the room may result in flashover and generalized fire in the whole room.

3.1.12
all possible fires remaining localized
PFL criterion
criterion for a fire source when its burning shall not result in flashover or propagate to other parts of the *room* (3.1.14)

Note 1 to entry: A fire meeting this criterion remains localised and goes out spontaneously. By extension, a room is said to be PFL when a fire breaking out at the most unfavourable part of the room cannot result in flashover nor propagate to other parts of the room; it remains localised and goes out spontaneously.

Note 2 to entry: The hypothesis of a fire source or room being PFL assumes a single fire source representation but the non-propagation to other fire sources inside or outside the room need a confirmation using a spread temperature threshold (STT).

3.1.13
physical separation
installation of two items of equipment in two distinct *rooms* (3.1.14) of which at least one is inside a *fire compartment* (3.1.5), or protection of one of them by an insulating thermal casing to prevent the simultaneous loss of both items of equipment due to a single fire

3.1.14
room
<common meaning> single volume identified by the user inside the building with no structural separation assumed inside

Note 1 to entry: Its boundaries may or may not be completely closed.

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3.1.15
spatial separation
installation of two items of equipment in different *rooms* (3.1.14) or at an adequate distance free of any fuel to prevent fire from spreading

3.1.16
spread temperature threshold
STT
threshold that is considered in the method to determine if there is a risk of spreading of a PFL fire source into a PFG fire source

Note 1 to entry: The STT applies to the hot gas layer (see 5.4.5.4).

3.1.17
standard time temperature curve
temperature-time curve used for the relevant fire resistance standard tests

Note 1 to entry: In the scope of document, this curve is defined according to ISO 834-1:1999, Figure 7. The curve follows the Formula $T = T_0 + 345 \log (8t + 1)$ with t the time (min) and T_0 the initial temperature.

3.2 Symbols

Symbol	Meaning	Unit
A	surface (structures)	m^2
Ao_i	surface of the vertical opening i of the room	m^2
AT	total surface of the walls of the room (excluding surface of openings)	m^2
β_1, β_2	pyrolysis rate coefficients	$kg \cdot s^{-1}$
α	growth factor (heat release rate)	$kJ \cdot s^{-3}$
D	equivalent diameter: $D = \sqrt{4S/\pi}$	m
Ho_i	maximum height of the vertical opening i of the room = distance between the top of the opening and the floor of the room	m
ΔH_C	heat of combustion of a fuel	$kJ \cdot kg^{-1}$
$K\beta$	product of the extinction coefficient of the flame K and a correction factor β	m^{-1}
L	length of the rack	m
M	mass of combustible cables	kg
$\dot{m}$	mass loss rate (= rate of pyrolysis)	$kg \cdot s^{-1}$
$\dot{m}_{max}$	maximum mass loss rate: $\dot{m}_{max} = \frac{\dot{Q}_{max}}{\Delta H_C}$	$kg \cdot s^{-1}$
n_{rack}	number of racks	
$\dot{Q}$	heat release rate	kW
$\dot{Q}_{max}$	maximum heat release rate of the fire source	kW
S	surface (liquid pool)	m
S_t	stoichiometric ratio of a fuel	g_{O2}/g_{fuel}
t	time	s
t_d	Time where the performance curve starts to decrease	s or h
T, θ	temperature	°C or K
T_0	initial ambient temperature	°C or K

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