Probabilistic fire risk assessment in ESS Preliminary Safety Analysis Report – challenges and opportunities – OECD fire

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Agenda

- Statistic input
- Requirements
- Example on waste building
  - Safety documentation application #2
- How to improve statistics

Stronger statistics important to justify the probabilistic analysis

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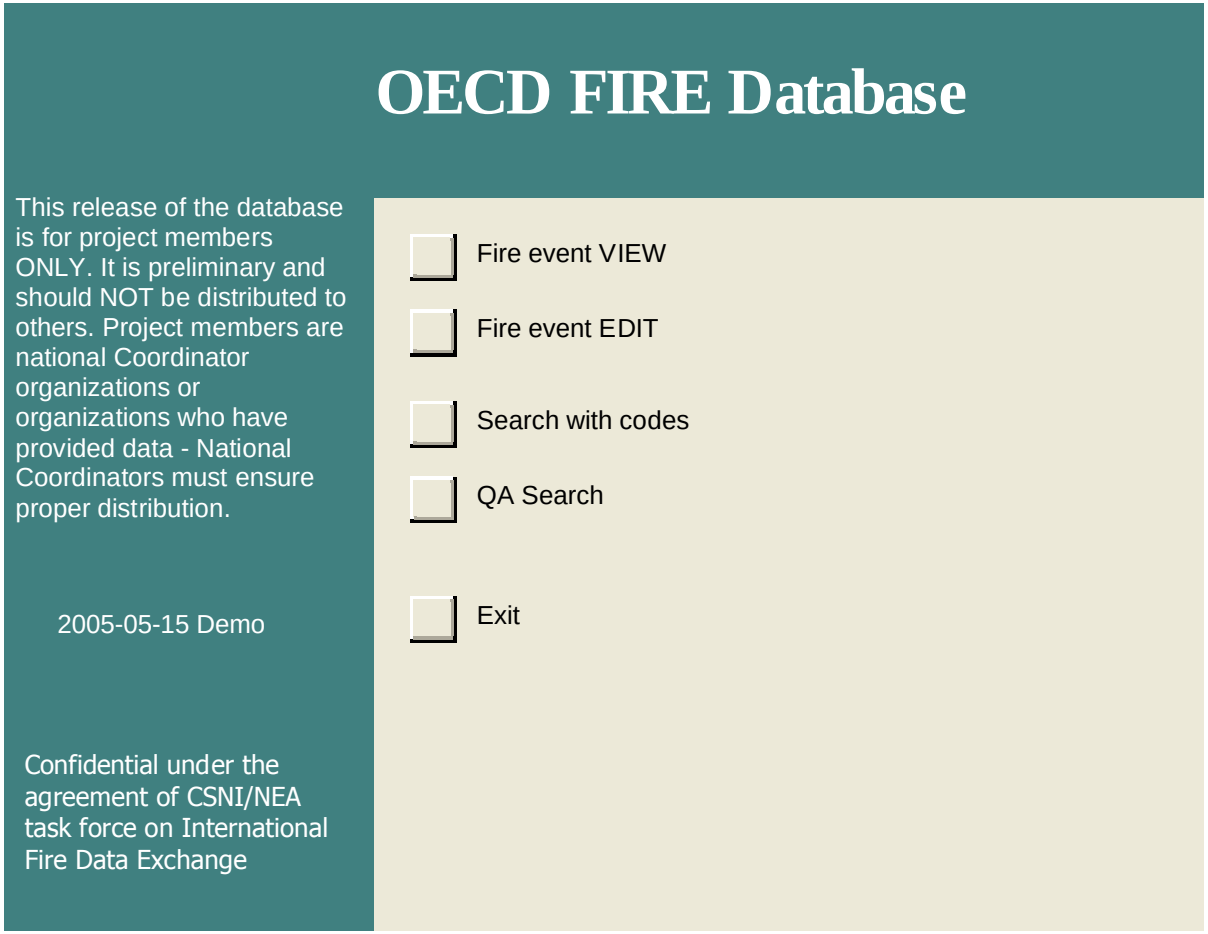

Why statistics ?

NBSG Report 2009:008 "Fire Event Trees Construction Based on OECD Fire Database" – 310 incidents from 10 countries

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Table 1. List of cause/initial event

Event	number
Heater	11
Hot work	23
Oil on insulation	20
Material/Component/design	20
Human error/carelessness	27
Filter	4
Generator	8
Kitchen/changing room/office etc	4
Garbage	5
Lamp/Light	3
Electrical motor	3
Electrical fault	36
Poor Maintenance	5
Oil	5
Bearing	5
Procedure	6
Fan	3
Pump	3

Event tree accuracy

NBSG Report 2009:008 “Fire Event Trees Construction Based on OECD Fire Database”

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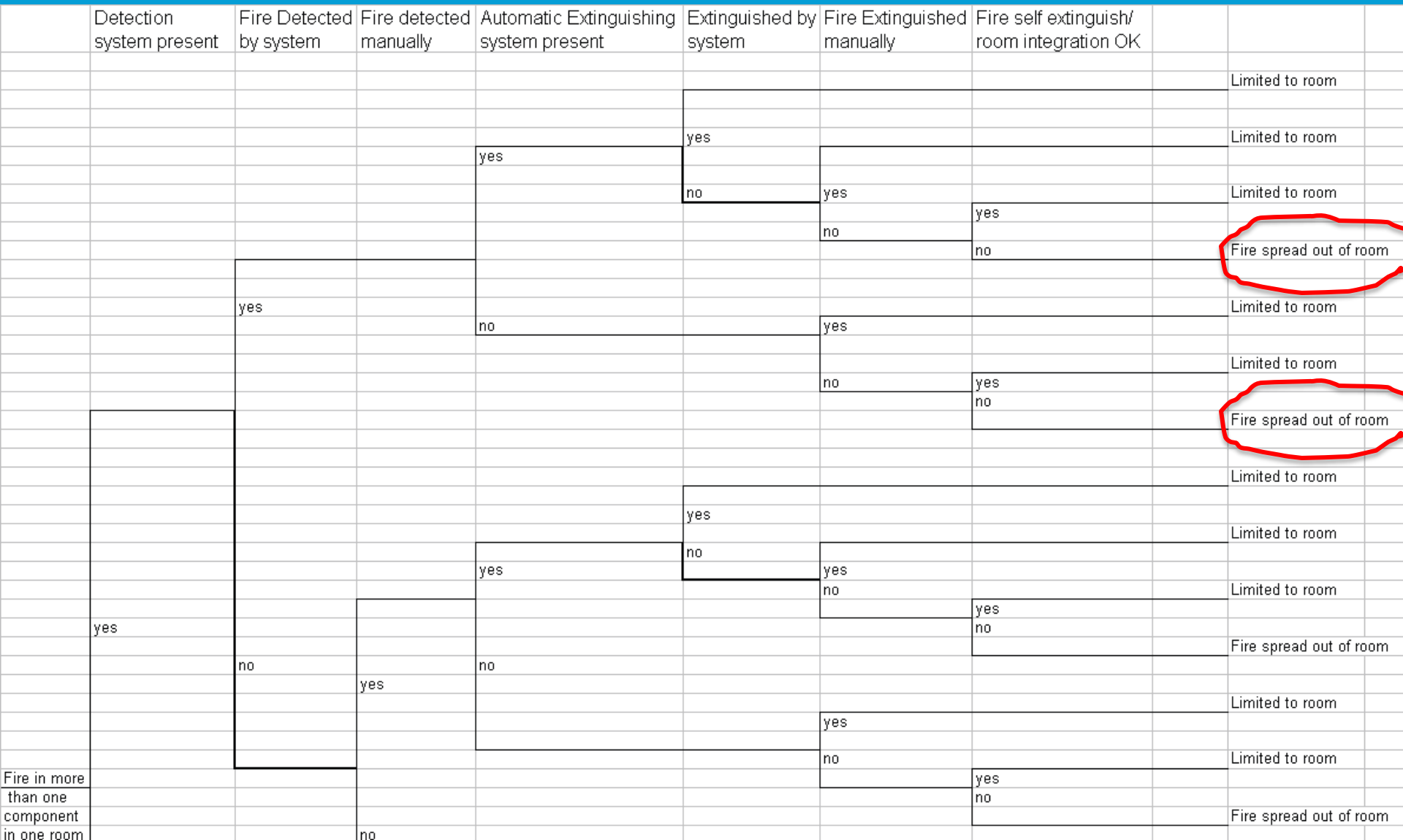

Ionization radiation requirements

ESS-0000004

Rad safety “Probabilistic Requirement”

ESS- 0015358 SSM licensing conditions

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Demonstrate how to avoid:

- > 0,1 mSv to public within a return time of 100 years
- > 1 mSv to public within a return time of 10 000 years
- > 20 mSv to public within a return time of 1 000 000 years
- > 100 mSv to public within a return time of 10 000 000 years

Public at 300 m from Target

Reference values – environmental/ public impact

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Event class	Reference value (mSv)
Anticipated events (H2)	0.1
Unanticipated events (H3)	1.0
Improbable events (H4A)	20
Events with multiple failures (H4B)	20
Highly improbable events (H5)	100

H2 – anticipated fire

To be expected from statistics is:
Fire ≈ within a return time of 4 years

References:
- OECD database
- Existing Lab experience

Definition of Fire

To be expected from statistics is:
Fire + Jeopardize of radiation barrier < 100 years return time

References:
- OECD database
- Existing Lab experience

Probabilistic requirement – H3

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Unanticipated events (H3):

events and circumstances outside the specified conditions and restrictions which are not expected to occur during the facility's lifetime. The frequency range is greater than or equal to **10^{-4} but less than 10^{-2}** per year,

Deterministic requirements

Statistics is useless if you can not validate the circumstances

Statistics based on this….

Is no good to justify this……

ESS-0004722

Fire- & Explosion Safety Program

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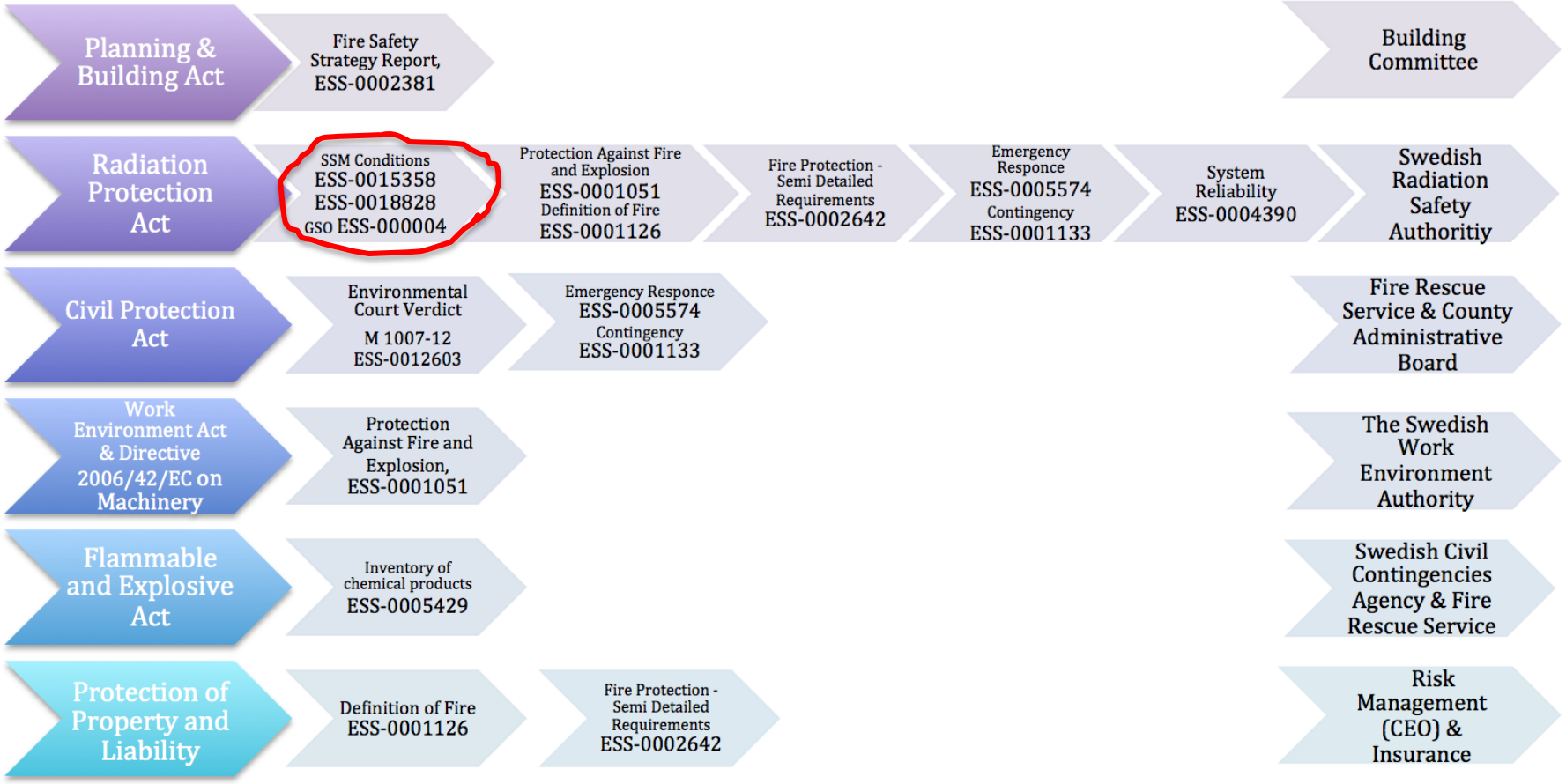

Defence in depth (DID)

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SSM Ch4

1. **prevent** deviations from normal operations
2. **detect** deviations
3. **minimise the impact**
4. ensure that radioactive **emissions** to the environment are **as low as reasonable**
5. **mitigate** the radiological **consequences**

IAEA NS-G-1.7

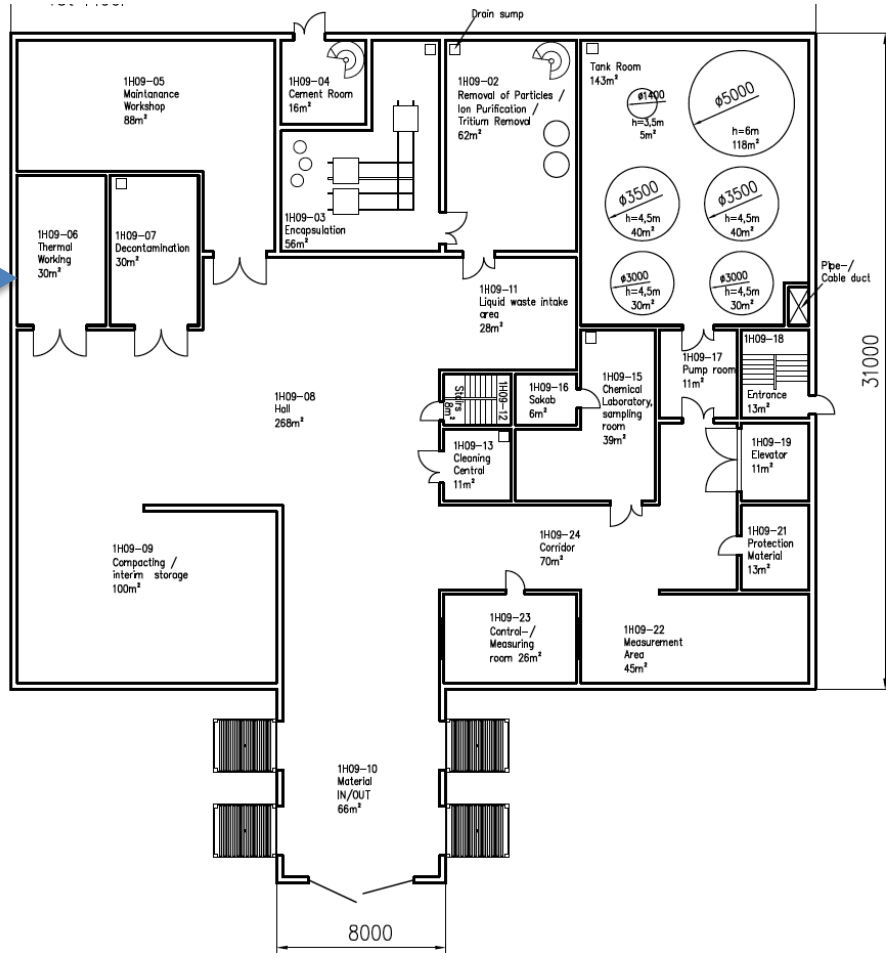
- Prevent fires from starting
- Detect & extinguish quickly
- Prevent spread

1st part of the PSAR documentation (validate DID)

Waste building example

Representative H3 event

- Dropped transport container with target material
- Fire in **waste building**
- Fire in HEPA filter or cyclone filter for the He cooling circuit



Release factor assumed on nuclide inventory:

Volatiles 10% of the inventory

Aerosols <1% of the inventory

What to do if frequency of rad exposure is not acceptable!

- Improve fire frequency statistics ?
- Improve accuracy on nuclide inventory ?
- Improve barrier ?

- The ESS-0002642 improve barrier!

2nd part of the PSAR documentation (Risk screening)

Method - Input from risk analyses

List PIE as addressed in [4] & [5] at designated building (Ch 3.1, 4.1, 5.1)

Interpret maximum radiation exposure possible ref. [22]

Estimate maximum consequences for rescue workers and public & tag unacceptable consequence CR1, CR2, CR3 ...etc.

Suggest redesign of machine/building (Ch. 6) OR Increase protection of barriers as necessary (Ch. 3.3, 4.3 & 5.3)

Method - Critical for barrier integrity

Identify DID active systems necessary for barrier integrity in case of fire or explosion in H3 [2] or more frequent. Also secondary effects are considered.

Adopt SF & CCF & EQ on components necessary for protection of barriers

Apply features as necessary. Tagged as “SF" or "CCF" or "EQ"

Fire or explosions [5]/[4] Identity of Top Event	Equipment involved in the scenario & estimated frequency based on ref [4], [5]	Estimated radiological release from fire scenario if not contained or shielded but with presumption proton beam is shut down when rescue operation is initiated Estimations are based on Ref [22] Acceptable (A)/ Not Acceptable (NA)			
		Rescue workers without breathing apparatus **acc. level 50 mSv**		**Public at 300 m distance or external residual water systems** **acc. level 5 mSv (H3)** **20 mSv (H4)**	
		Direct Radiation	**Air Contamination**	**Air Contamination**	**Solids in residual fire fighting water**
22/-	**Hot Cell** Irradiated tungsten wheel, HEPA- filter and electrical equipment Frequency H3	(NA) **CR4**	(NA) **CR5**	(NA) **CR6**	(NA) **CR7**
23/-	**High Bay** Hydrogen fire or plastic shielding	(A)	(A)	(A)	(A)

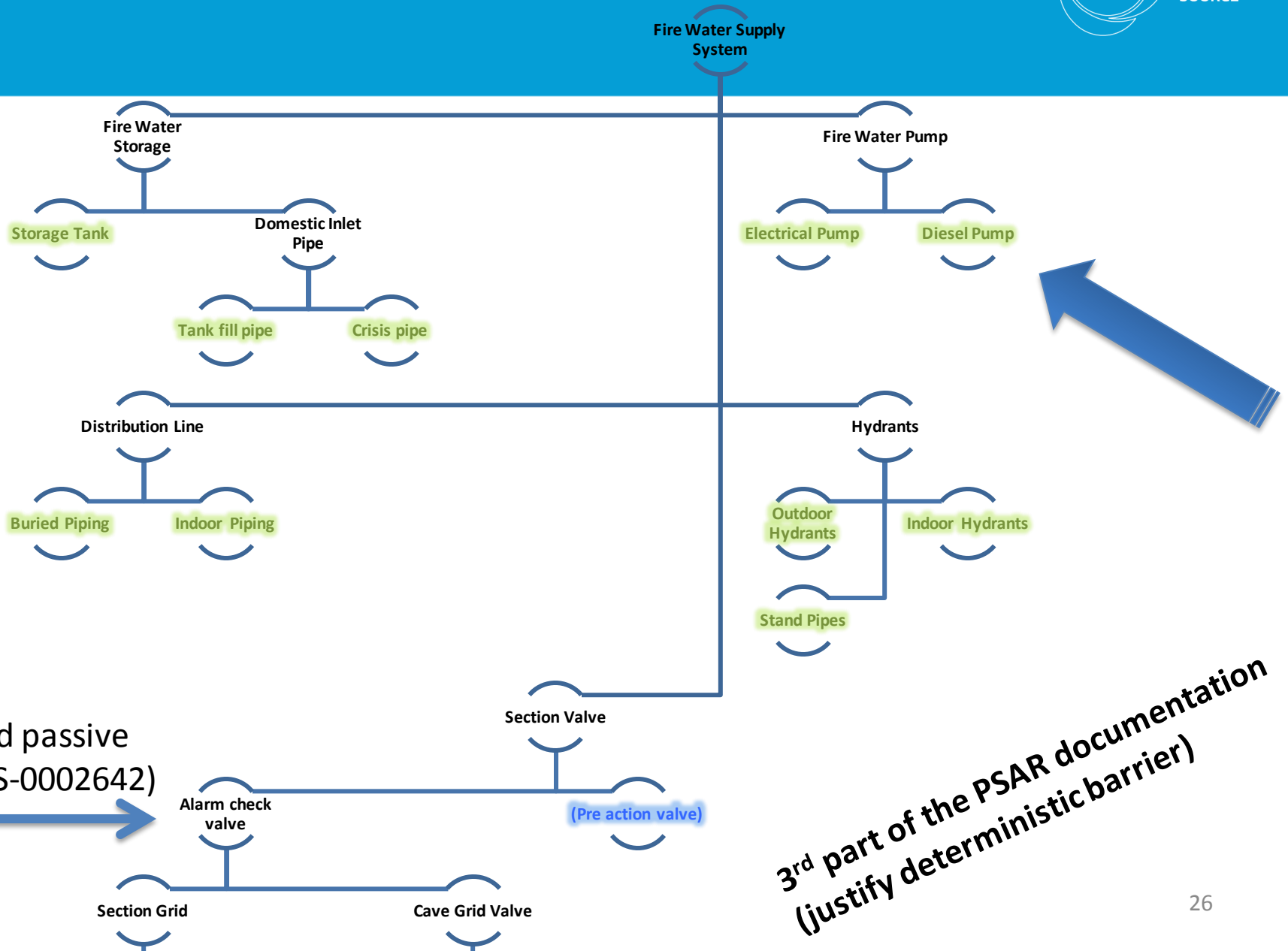
Evaluate building envelope

Where is the barrier ?

1. A fire is postulated (H3)
2. The building does not resist a full scale fire

Barrier design

Single Failure & Common Cause Failure



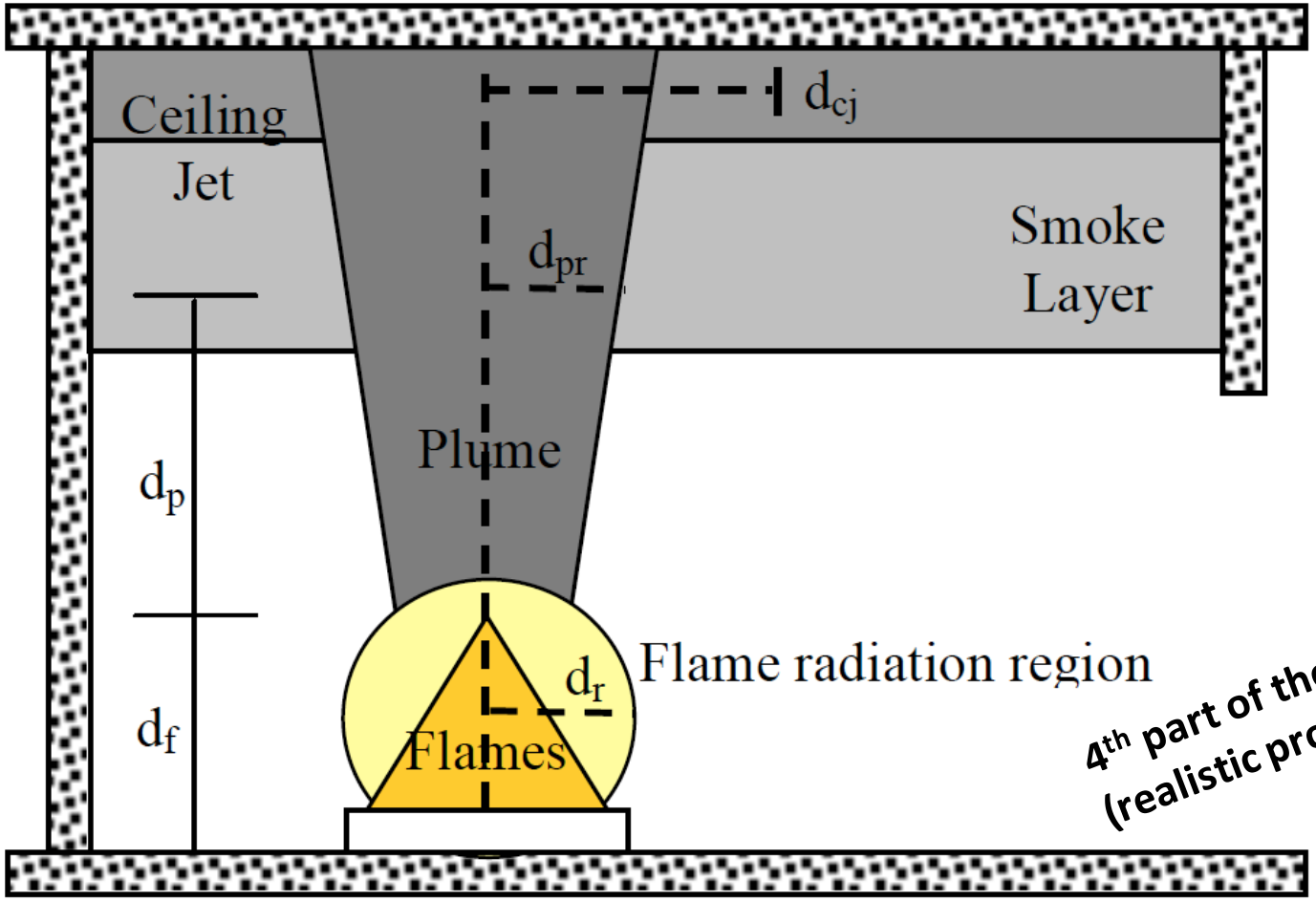
claimed passive
(ref ESS-0002642)

3rd part of the PSAR documentation (justify deterministic barrier)

Seismic/below frostline/pressure from heavy goods transport => High density PE 16 bar

Zone of influence & severity factor

Ref. EPRI/NRC-RES Fire PRA Methodology CR6850



4th part of the PSAR documentation (realistic probabilistic justification)

General information

OECD FIRE ID FI-19980129

3.1.1 Event title

Olkiluoto 2 - Oil fire due to oil leakage from the instru ment valve of pressure measurement in turbine building

3.1.2 Plant	FI-4	OL2	This	Reporting	Fire brigade org.

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

1998-01-29 00:20

3.1.10 Operation mode prior to ev ent Power operation

3.1.11 Supression time (HH:MM)	**Supression time clarification**

3.1.12 Duration time (HH:MM)	**Duration time clarification**

3.1.7 OECD FIRE Event description

Plant: Olkiluoto 2
Operational mode: Power operation, reactor power prior the fire 100%, after the fire 25 %.
Location: turbine building

On 28.1.1998 the control room personnel observed during regular checking of the plant parameters that an oil level in the turbine oil tank w as decreasing. According to plant computer the level decrease had started at

3.1.8 Sequence of events

Time	Description
1998.01.28 18:30	Indirect indication - oil level decreasing, process computer
1998.01.29 00:20	Localisation of oil leakage

Ignition phase

OECD FIRE Events

Edit

OECD FIRE ID JP-20021212

3.2.1 Building where the fire started	Turbine building	
3.2.2 Room/Plant area where the fire started		
3.2.3 Type of room where the fire started	Other	Turbine floor
3.2.4 Component where the fire started	Turbine generator	
3.2.5 Ignition mechanism	Hot component	
3.2.6 Root cause	Equipment	

Press CTRL and select one or mode codes from the list

Equipment
Other
Human error
Unknown

Select Codes

3.2.7 Type of fire detection Plant walk down

Press CTRL and select one or more codes from the list

Fire alarm system
Fire guard/watch
Plant walk down
Indirect signals

Select Codes

3.2.8 Detector Type Unknown

Press CTRL and select one or more codes from the list

Flame detector
Heat detector
Infrared detector

Select Codes

Extinguishing phase

OECD FIRE Events

Edit

OECD FIRE ID JP-20021212

3.3.1 Type of Extinguishing

Fixed system - Automatic actuation;Manual fire fighting

Press CTRL and select one or more codes from the list

- Fire source isolation
- Fixed system - Automatic actuation
- Self extinguishing
- Fixed system - Manual actuation
- Other means

Select Codes

Type of system/equipment used

Halon;Dry chemical (Portable)

Press CTRL and select one or more codes from the list

- Carbon dioxide
- Other fixed system
- Water mist
- Spray water deluge
- Foam system

Select Codes

3.3.2 Fire extinguishing system performance

Normal

3.3.3 Who extinguished successfully the fire

External fire brigade

Press CTRL and select one or more codes from the list

- People available in the fire area

Consequence

OECD FIRE Events

Edit

OECD FIRE ID JP-20021212

3.4.1 Operational mode due to the fire	Shutdown mode
3.4.2 Heat or hot gases influence	None
3.4.3 Smoke influence	None
3.4.4 Secondary effects	None
3.4.5 Corrective actions	
Press CTRL and select one or more codes from the list	Procedure modification Design modifications No corrective actions
	Select codes
3.4.6 Comments on consequence and corrective actions	

New research – Improve statistics on fire

- Lack of data from proton accelerators and similar laboratories has pushed the importance to also display data from the nuclear industry as background information for consideration.
- An interregional exchange of information, to increase the accuracy on decision support activities for prevention of fire- and explosion accidents, is considered as the proper path for justification.
- The OECD FIRE project or equal systematic activity is recommended to also include proton accelerators and similar laboratories.
- The regulators should get involved!

ESS- 0015358 SSM licensing conditions

- *Anticipated events (H2):* events and circumstances outside the specified conditions and restrictions which can be expected during the facility's lifetime. The frequency range is greater than or equal to **10^{-2} per year**,
- *Unanticipated events (H3):* events and circumstances outside the specified conditions and restrictions which are not expected to occur during the facility's lifetime. The frequency range is greater than or equal to **10^{-4} but less than 10^{-2}** per year,
- *Improbable events (H4A):* events and circumstances outside the specified conditions and restrictions which are not expected to occur. The frequency range is, excluding external hazards, greater than or equal to **10^{-6} but less than 10^{-4}** per year. For external risk sources, the frequency range is greater than or equal to 10^{-5} but less than 10^{-4} per year,
- *Events with multiple failures (H4B):* events and circumstances outside the specified conditions and restrictions in the frequency range greater than 10^{-4} per year, analysed in combination with common cause failures in the safety group instead of a single failure,
- *Highly improbable events (H5):* events and circumstances that can potentially lead to significant radioactive emissions to the surrounding area.