PROPOSED APPROACH TO CALCULATE SAFETY DISTANCES FOR HYDROGEN FUELLING STATION IN ITALY

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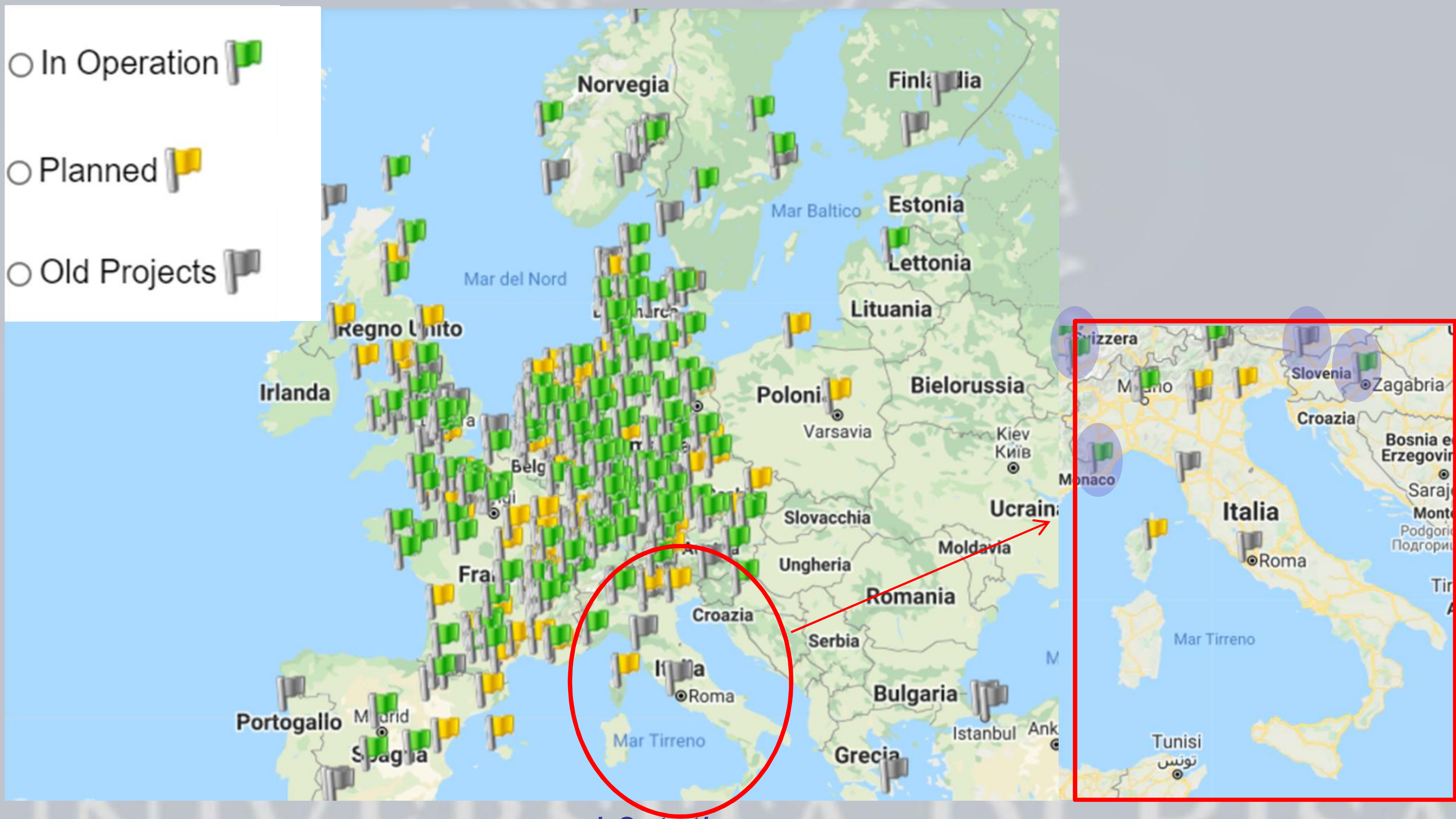
PRESENTATION OUTLINE:

- Introduction (motivation)
- Italian regulation on hydrogen filling stations
  - Safety distances according to D.M. 23/10/18
  - Strengths and weaknesses of the Italian approach
  - Definition of safety distances and potential source of hazards
  - Introduction of the Fire safety engineering approach in the Italian regulation
- Example of application of the proposed approach
  - Calculation of “External safety distance” for the source of hazard “Dispenser”
- Conclusions

Introduction (Motivation)



www.h2stations.org

Italian regulation on hydrogen filling stations

Quantity of H2 in the plant

Above the threshold of application of the "Seveso Directive" 2012/18/UE

5.000 kg < x < 50.000 kg

Compliancy to **land use regulation**
Notify the authority (*180 gg before starting construction*)

x > 50.000 kg

Compliancy to **land use regulation**
Notify the authority
Preliminary Safety report (*to get authorization to start building of the plant*)
Safety report (including detailed Safety analysis) (*to get authorization to start operating of the plant*)

Below the threshold of application of the "Seveso Directive" 2012/18/UE

x < 5.000 kg

Approval by Fire Brigade Command of the province in which the station is located

Compliancy with D.M. 23 October 2018 "*Fire prevention technical rule for the design, construction and operation of hydrogen filling station*"

- Exclusion zones
- Minimum design requirement
- Compliance with "safety distances"

Italian regulation on hydrogen filling stations

D.M. 23/10/18 "*Fire prevention technical rule for the design, construction and operation of hydrogen filling station"*

Hydrogen fuelling station cannot be built:

- urban settlement of a historical, artistic nature and of particular environmental value or portions of them, including the surrounding areas, which can be considered an integral part of the settlement.
- In areas where the building index is higher (or planned to be higher) than $3m^3/m^2$
- Areas identified as "public green areas"

Historical city

Historical villas

Public parks

Residential areas

Safety distances according to D.M. 23/10/18

Potential Source of Hazard	Protection Distance [m]	Internal safety Distance [m]	External safety Distance [m]
Compressor	**15**		**30 (*)**
Storage	**15**	**15**	**30**
Tube trailer	**15**	**15**	**30 (*)**
Dispenser	**15 (**)**	**12**	**30 (**)**

(*) Can be reduced by 50% if between the compressor room openings and the target non combustible shield are installed (not applicable in case of building or areas used by the community)
(**) Can be reduced by 50% if in between the dispensing unit and the target non combustible shield are installed (not applicable in case of building or areas used by the community)

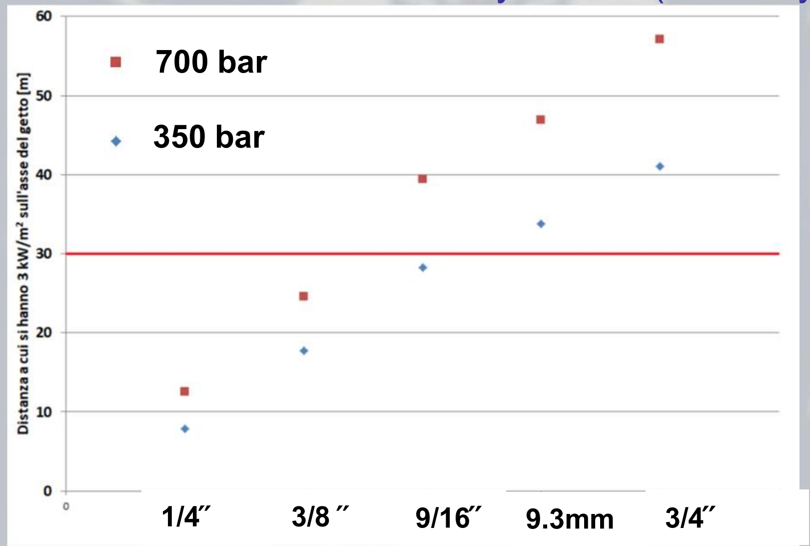
The Decree allows to apply the **"Fire safety engineering"** as described by **D.M. 9 May 2007** to calculate lengths of **safety distances** other than the one imposed

The Decree mentions the ISO 19880 "Gaseous hydrogen -- Fuelling stations General requirements" **standard** as a reference in case of requests of derogation from the provisions listed in the decree.

Strengths and weaknesses of the Italian approach

Strengths

- Homogeneous application on the National territory
- Simple rules imply low investment costs for safety studies (no safety analysis required)



Weaknesses

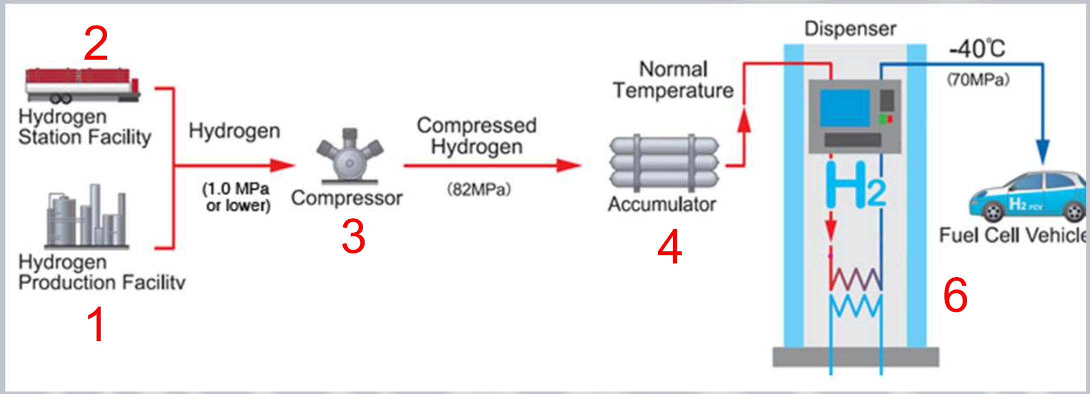
- External safety distance not compatible with most of urban installation sites
- Land “free of targets” required to comply with external distance is very high
- No differences on the length of safety distances depending on the maximum pressure in the plant (350 bar or 700 bar)
- No differences on the safety distances depending on the size of the plant (pipe dimensions etc.)
- Between the “mitigations” wall protections are considered but no mention is made of safety systems or measures aimed to limit the release in case of a leak (i.e. decreasing the frequency of occurrence of a worst case scenario)

Definition of safety distances

ISO 19880 Gaseous hydrogen -- Fuelling stations General requirements.	**Italian fire protection regulation** (D.M. 30/11/83)
Restriction distances Minimum distance from hydrogen equipment or the area around where certain activities are restricted or subject to special precaution (e.g. no open ignition sources)	The «restriction distance» has ho equivalent in the italian regulation (the definition is similar to an ATEX zone)
Clearence distances Minimum distance between the fuelling station equipment and the vulnerable target within the fuelling station site boundary	**Distanza di sicurezza interna (Internal safety distance)** Minimum distance, established by the ergulation, measured horizontally between the respective perimeters of the various **sources of hazard** of the plant
Installation layout distances Minimum distance between the various equipment of the hydrogen installation required to prevent escalation to other equipment to other equipment in case of an accident	
Protection distances Is to prevent damage to the hydrogen fuelling station equipment from external hazards not accounted for the installation layout distance	**Distanza di protezione (Protection distance)** Minimum distance measured horizontally between the **sources of hazard** of the plant and the fence (when required) or the boundary of the area
External risk zone Distance (or area) outside the fuelling station which is to be protected from hazards caused by the fuelling station (people and construction offsite are regarded to be target)	**Distanza di sicurezza esterna (External safety distance)** Minimum distance measured horizontally between the perimeter of each source of hazard of the plant and the perimeter of the nearest building or other public or private activity (including future building area)

Potential sources of hazard

ISO 19880 Gaseous hydrogen -- Fuelling stations General requirements.	**Italian fire protection regulation** (D.M. 23/10/18)
1) On-site hydrogen production unit as applicable	**1) Hydrogen production unit, in present**
2) Hydrogen delivery system, including mobile storage and remote fill points as applicable	**2) Tube trailer**
3) Compressors	**3) Compressors**
4) Storage	**4) Storage**
5) Piping connection (not welded)	**5) Piping**
6) Dispensers	**6) Dispensers**
	7) Hydrocarbon delivery system, if present



5 (ISO)

5 (Italy)

“Fire safety engineering approach”
According to D.M. 9 Maggio 2007

First Phase
- Identification of the representative conditions of the risk posed by the plant
    - Definition of the **Safety objectives**
    - Definition of the “**performance levels**” (to meet the objectives)
    - Definition of the **accidental scenario**

Second Phase
- Description of the **design criteria** to compensate the risks
- **Quantitative analysis** of the selected scenarios

The Ministerial Decree do not provide frequency threshold or other risk acceptance criteria to select accidental scenarios, nevertheless suggests to take into account events that can “**reasonably**” occur.

Example of application of the proposed approach

Calculation of "external safety distance" for the source of hazard "Dispenser"

First Phase

Dispenser

Safety objectives → Safeguarding human lives

Performance levels Ref. D.M. 9 Maggio 2001

Accidental scenario	Lethality	Start of lethality	Irreversible injuries	Reversible injuries	Damage to structures
Jet-fire (Heat-flux) [kW/m^2]	**12.5**	**7**	**5**	**3**	**12.5**
Flash-fire	**LFL**	**½ LFL**			
VCE (overpressure) [bar]	**0.3**	**0.14**	**0.07**	**0.03**	**0.3 (0,6)**

Accidental scenario → Jet-fire

Hypothesis: no significant overpressure from delayed ignition in open environment without significant obstacles that can accelerate the flame front

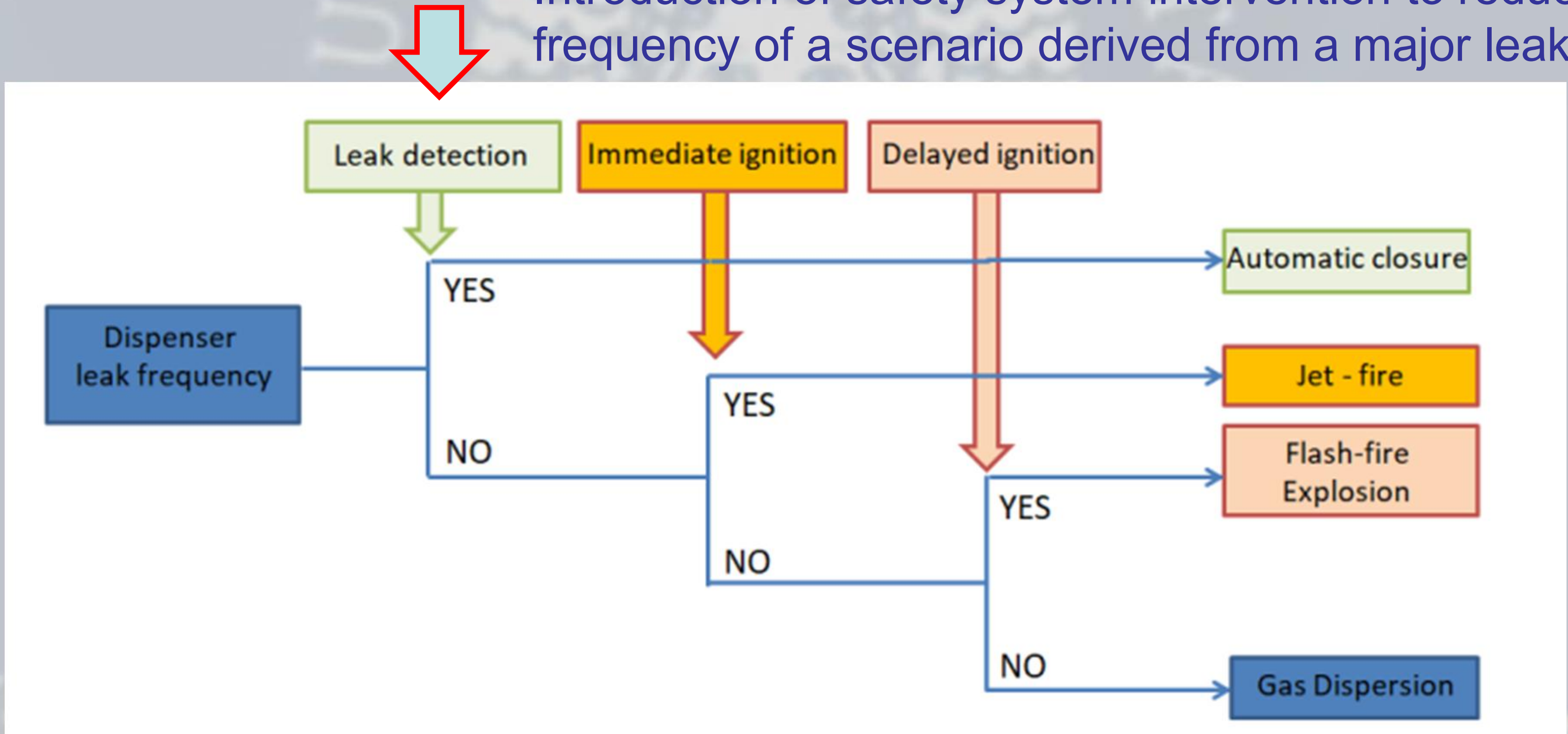
Example of application of the proposed approach

Calculation of "external safety distance" for the source of hazard "Dispenser"

Second Phase

Definition of the design criteria

Introduction of safety system intervention to reduce the frequency of a scenario derived from a major leak



Example of application of the proposed approach

Calculation of “external safety distance” for the source of hazard “Dispenser”

Second Phase

Quantitative analysis

HYRAM Software toolkit (cited by ISO 19880)

Developed by SANDIA National laboratories

Provides a basis for conducting quantitative risk assessment and consequence modelling for hydrogen infrastructure and transportation systems.

Failure frequencies

Completed distribution data are provided by Hyram, Mean vaule adopted

Component / Item	Leak size 0.01% -0.1% - 1%	Leak size 10%	Leak size 100%
Hoses	… - … - …	1,53E-04	7,32E-05
Flanges	… - … - …	3,73E-05	1,55E-05
Joints	… - … - …	6,64E-06	5,94E-06
Instruments	… - … - …	1,81E-04	1,12E-04
….	… - … - …	….	….

Ignition frequencies

Release flow rate [kg/s]	Immediate ignition	Delayed ignition
<0.125	0.008	0.004
0.126 – 6.25	0.053	0.027
> 6.25	0.230	0.120

Consequence model (Jet-fire) / dispersion / overpressure in confined environment)

Example of application of the proposed approach

Calculation of "external safety distance" for the source of hazard "Dispenser"

Dispenser

Components	Nr. of Items
Hose	1
Valves (including nozzle and break away)	11
Instruments	4
Length of pipes [m]	10
Flanged connections	4
Non-flanged connections	12
Heat Exchanger	1 (*)

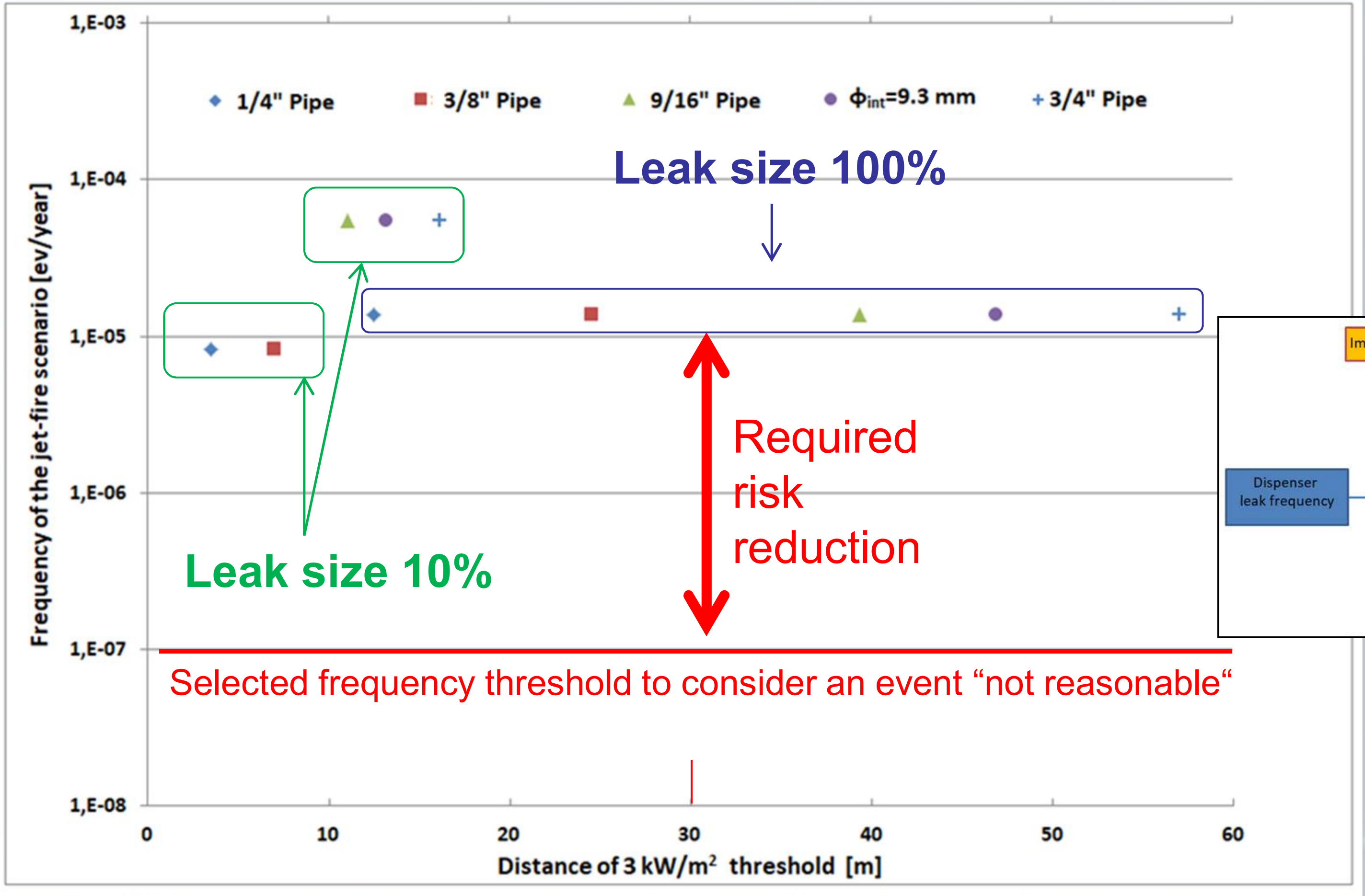
(*) Components and connections of the Heat exchanger had been considered in the previous lists

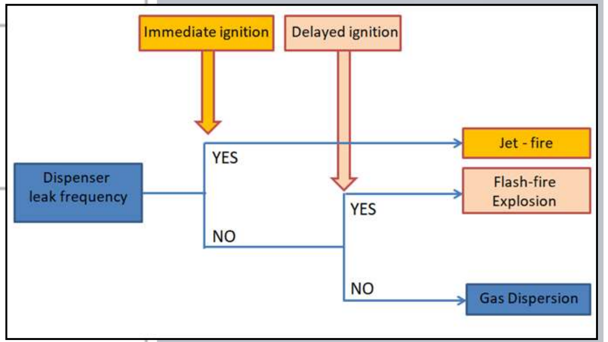
Component / Item	Leak size 10%	Leak size 100%
Dispenser	1.03 E-03	2.56 E-04

Cumulative leak frequency for the potential source of hazard "Dispenser"

Example of application of the proposed approach

Calculation of “external safety distance” for the source of hazard “Dispenser”





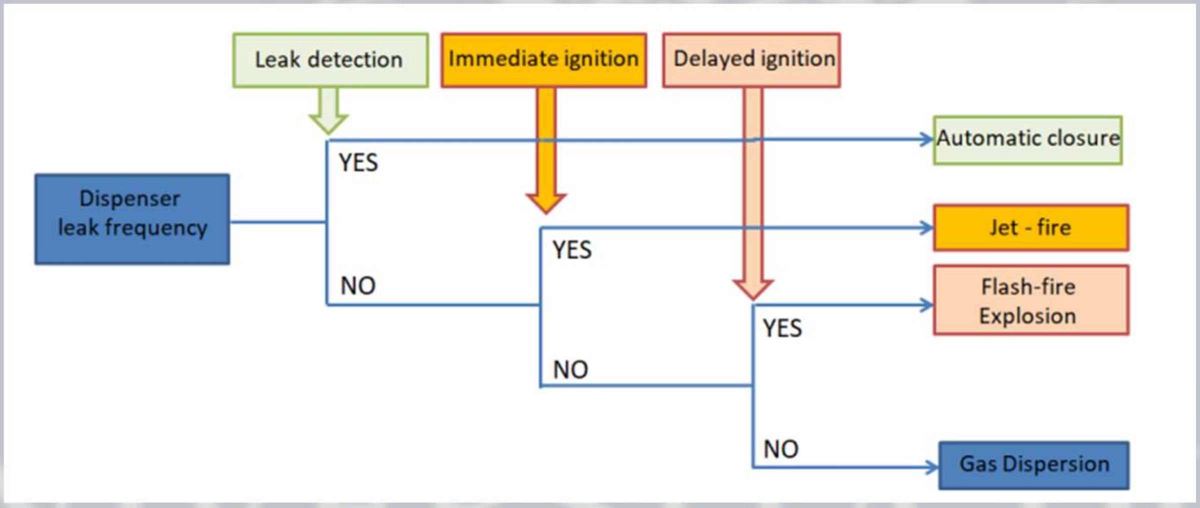
Example of application of the proposed approach

Calculation of “external safety distance” for the source of hazard “Dispenser”

Introduction of safety system
SIL 2 based on required risk reduction

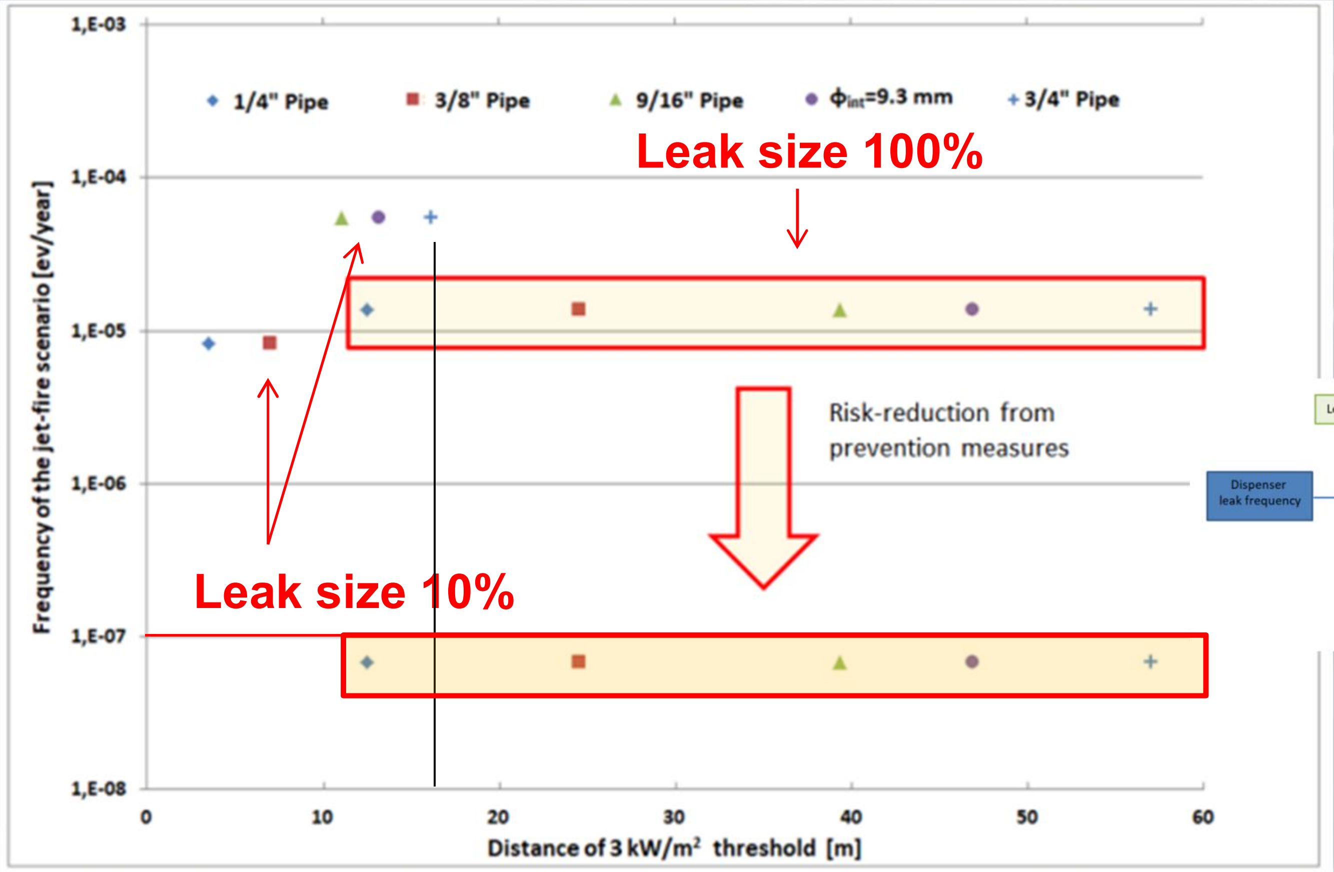
SIL LEVELS ACCORDING IEC 61508 / IEC 61511

SIL Safety Integrity Level	PFDavg Average probability of failure on demand per year (low demand mode)	RRF Risk Reduction Factor	PFDavg Average probability of failure on demand per hour (high demand or continuous mode)
SIL 4	$\geq 10^{-5}$ and $< 10^{-4}$	100000 to 10000	$\geq 10^{-9}$ and $< 10^{-8}$
SIL 3	$\geq 10^{-4}$ and $< 10^{-3}$	10000 to 1000	$\geq 10^{-8}$ and $< 10^{-7}$
SIL 2	$\geq 10^{-3}$ and $< 10^{-2}$	1000 to 100	$\geq 10^{-7}$ and $< 10^{-6}$
SIL 1	$\geq 10^{-2}$ and $< 10^{-1}$	100 to 10	$\geq 10^{-6}$ and $< 10^{-5}$

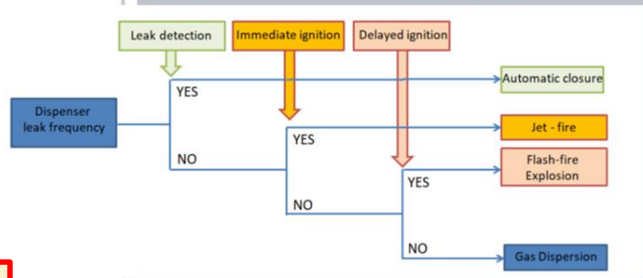


Example of application of the proposed approach

Calculation of “external safety distance” for the source of hazard “Dispenser”



Safety related system



Summary of application of the proposed approach

Assess the **safety objective** and related **performance level** for each safety distance to be calculated

⇩

Assess the reference **scenario or scenarios** related to the potential source of hazard under investigation

⇩

Calculate the **cumulative leak frequency** for the components of **potential source of hazard** using HyRAM data for 100% and 10% Leak size

⇩

Assess the **Safety Integrated Function** required to shut-off the release

⇩

Assess the **risk reduction and related SIL** level needed to consider **"not credible"** a scenario derived from 100% leak size rupture

⇩

Calculate the distances derived from a 10% leak size scenario

Conclusion

- The proposed approach, based on the application of the “Fire safety engineering” as defined by the Italian regulation, can maintain a **simple** and **uniform** approach as well as **reduce the costs compared to a full safety analysis of the plant**
- The proposed approach refers to decrees or standards already included or cited by the Italian regulation.
- The proposed approach allows to calculate external safety distances other than those imposed by the Italian regulation by **taking into account the presence of “safety related systems”**
- Reducing the frequency of occurrence of a rupture scenario by introducing a safety related system allows to shorten the safety distances at the same time enhancing the overall safety of the installation.

Future development

- Future steps of the present work will consist in a more extensive application of the proposed approach to the hazardous sources of the fuelling station defining for each "safety distance"
  - Safety objectives
  - Performance levels
  - Accidental scenarios

- A critical step has been identified in defining a criteria for the selection of the **threshold frequency** of occurrence of an accidental scenario that can allow to consider it "not reasonable"

Thank you for your attention

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