IEA TCP Task 43- Subtask Safety Distances: State of the Art

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Introduction

Objectives:

1. Review available methodologies and develop recommendations for a methodology for safety distances for large scale GH2 and LH2 systems and applications also considering the different vulnerability of potential targets

2. Show common basis and develop recommendations for harmonization of such methodologies

3. Define reference document for minimal requirements for safe hydrogen deployment

Purpose : to give an insight on different *methodologies and recommendations* developed *for hydrogen (mainly) risk management and consequences assessment* of accidental scenarios.

Need for unified/harmonized approach

In scope

- Review of safety distance methodologies for the following industry use cases:
  - Electrolysers (Gaseous hydrogen) - large scale and on-site production
  - Hydrogen refuelling stations (Gaseous hydrogen) (GtG and LtG HRS, LtL)
  - Marine bunkering (Liquid hydrogen)
  - Liquid storage of capacity >10t (airport, ports, hydrogen liquefiers, HRS etc applications)

- Review of safety distance methodologies for the following regions :
  - Japan
  - USA, Canada
  - Europe – France, Belgium, Netherlands, Germany, UK, Denmark, Sweden, Austria
  - Australia

Survey

INFORMATION REQUEST

IEA Subtask C – Safety Distance Methodologies

Introduction

The purpose of this survey is to obtain information on applicable Regulation, codes and standards per country with regard to safety distances for **industrial electrolysers**, **hydrogen refuelling stations** and **marine bunkering**.

In order to establish an overview of applied rules and values for safety distances for the largest number of countries. This work is performed in the framework of the working group IEA Subtask C "Safety Distance Methodologies".

Instruction for completion

Please simply fill out the following form per country. Try as far as possible to complete all boxes.

CONTACT INFORMATION	*Name* *Company* *Position* *Email*

I- GENERAL DESCRIPTION

USE CASE *Please only fill this in if your use case is one of the following:* *Industrial electrolyser & storage* *Hydrogen refuelling station* *Marine bunkering*	***Describe the use cases of hydrogen in your company:*** ***Specify the quantity of hydrogen on site (GH2 or LH2):*** ***Specify the country of location:***
REGULATION FOR INSTALLATION	***Describe the mandatory standards and requirements on safety distances with regards to applicable national regulations. Please give references & methodology (values or insert relevant tables):*** ***Describe your company specific approaches to safety distances (e.g. if internal safety distances have been developed and how):***

II- ADDITIONAL INFORMATION

RATIONALE	*Please describe here the rationale behind the safety distances specified (where applicable):* *Methodology (Consequence based, risk based etc.):* *Assumptions:* *Scenarios considered (full bore rupture, small leaks etc.):* *Basis for safety distance/harm criteria:* *Please give any additional detailed information on methodology used to determine safety distances:*
MITIGATION MEASURES	*Please give detailed information on safety measures that can be used to reduce safety distances (restricted orifice, ventilation, vent panels, solenoid valve etc.):* *Passive mitigation measures; please give detailed description* *For example: Design features / Access restriction / Occupancy limits / Ignition hazard protection / Natural ventilation / fire walls…* *Active mitigation measures (example : safety loops…); please give detailed description* *For example: Mechanical ventilation / Fire or gas detection / Automatic shutdown / Fire alarms* *Are these mitigation measures defined in some regulation, codes or standards (which one, please give a reference)?*
ADDITIONAL REQUESTS	*In addition to the previous requirements, are you aware about specific request on safety distances from customers, authorities, third parties?*

Participant	Participant A	Participant B	Participant C	Participant D	Participant E	Participant F	Participant G	Participant H
Use Case	HRS, Electrolysers, Storage	Electrolysers	Electrolyser	HRS, Electrolysers, Storage	Electrolysers	HRS	HRS	Any H2 installations
Country	France	Global	EU, Australia, Japan	Sweden	Global	Netherlands, Germany, UK	France	USA
Regulation	ICPE 4715/1416	No legal mandatory standards found for electrolysers	BCGA GN 41 'Separation Distances in the Gas Industry'	MSBFS 2020	No legal mandatory standards found for electrolysers	PGS 35 TRBS-3151 APEA/BCGA/EI Guidance – UK 'Blue Book'	national regulation, standards are used to evaluate the failure probability	NFPA-2
Company Methodology For Safety Distances	Consequence based at feasibility stage Risk based at detailed design stage	Consequence based at feasibility stage Risk based at detailed design stage	Follow BCGA separation distances	Follow MSBFS 2020 approach which is consequence based	Consequence and risk based approach	Follow safety distances in relevant standards	Safety distance objective is to prevent any consequences on target (human beings). The evaluation is risked based, consequences and probabilities are taken into account.	Consequence-based distances using a risk-informed leak size
Leak Scenarios	Feasibility: Full bore (external safety distance) 10% diameter leak (internal safety distance) Detailed design: Same approach but further refinements	50mm leak for consequence analysis Small/Medium/Large/FBR leak for risk based	Prescribed safety distances from BCGA 41 followed	3% leak - asset damage 10% leak - single fatality 100% leak - multiple fatalities	Small leak (% of pipe diameter depending on country specific RCS)/medium/large leaks for risk based analysis	Safety distances based on 10% leaks of typical pipe diameters at HRS for PGS 35 Unknown for Germany & UK	Full bore rupture and 10% of the diameter leak, thermal aggression on storage	Multiple leak sizes (from 0.01%-100% of flow area) for the risk-informed analysis, but then setback distances themselves use a constant 3% (now 1%) fractional leak size for gaseous hydrogen and 5% for liquid hydrogen
Harm Criteria	French Regulations used in France only Company specific harm criteria based on NFPA 2020 used in other regions **People**: 4.7kW/m2 & 50mbar **Buildings**: 25kW/m2 & 140mbar **Equipment**: 25-40kW/m2 & 200mbar	**People**: 5kW/m2 & 140mbar **Buildings**: 70-140mbar **Equipment**: 37.5kW/m2 & 200mbar **Risk Based:** 10-4/yr or 10-5/yr LSIR contour inside fence **Societal Risk:** PLL, FN-curve at specific location	**People**: 70mbar & Thermal Effects from Table 3 from EIGA Doc 211/17 **Equipment**: 35kW/m2	**People**: 309degC for individuals, 115degC for areas with groups of people **Buildings**: Flame impingement Equipment: 10 - 30kW/m2 depending on equipment size and pressure	French regulations: **Thermal radiation**: 3kW/m2, 5kW/m2, 8kW/m2 **Overpressure**:20mbarg, 50mbarg, 140mbarg, 200mbarg:	Dutch standards (PGS 35) **People**: 3kW/m2 (public), 10kW/m2 (1% lethality) **Buildings**: 10-35kW/m2 **Equipment**: 10-35kW/m2	French regulation (29/09/2005) **Thermal radiation** : 3 kW/m^2, 5 and 8 kW/m^2 **Overpressure** : 50 mbar for non-reversible effect, 140 and 200mbar for 1 to 5% of lethality	**Thermal Radiation**: 4.732 kW/m2 exposure of employee for 3 minutes 9 kW/2 for LH2, 4.732 kW/m2 for GH2 for cars and exposed persons not servicing the system and combustible buildings 20 kW/m2 for non-combustible buildings and other hazardous materials **Overpressure** (only considered for LH2): 70mbar, 137mbar, 170mbar

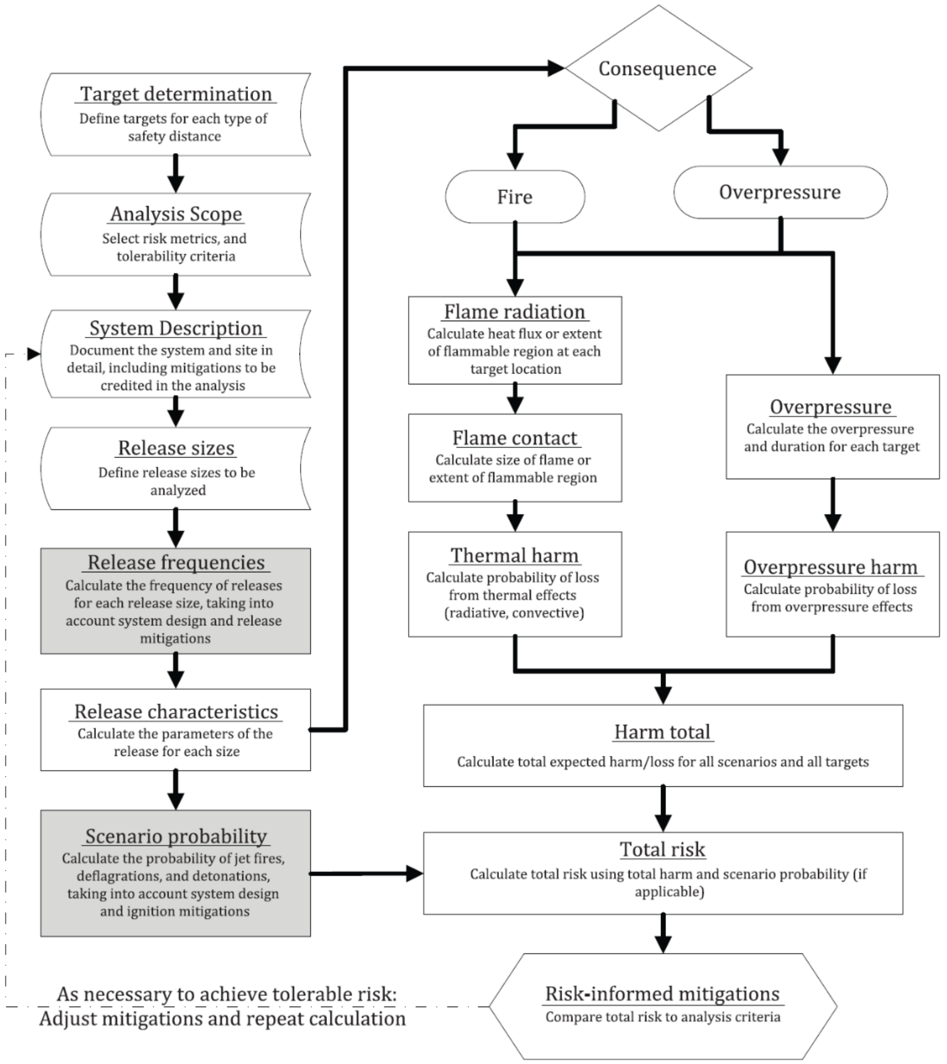
Survey Themes & Gaps

- **Themes:**
  - RCS takes precedence over company standards/approaches. If there is clear guidance available, companies will use that
  - Majority of standards focus on HRS
  - In the absence of any specific guidance, consequence modelling is a popular approach for determining initial safety distances
  - Risk based approach and CFD in use in detailed engineering for refining safety distances

- **Gaps:**
  - Harm criteria
    - Radiation vs. temperature
    - **People**: Overpressure criteria varies from 50mbar – 140mbar to not considered
    - **Equipment:** Thermal radiation criteria varies from 10kW/m2 – 40kW/m2. Some consider overpressure
  - Leak scenarios
    - Range of hole sizes for consequence & risk based approaches
  - Explosion severity limits to be considered (LFL vs 8% vs 10% in air)

- Prioritise based on factors that have the largest influence on safety distance

Approach towards harmonization



NOTE 1 Grey shading denotes an analysis step that is used only in full-QRA approach.

NOTE 2 Concave rectangle denotes an analysis step.

NOTE 3 Rectangle denotes a calculation step.

NOTE 4 Diamond denotes branching.

Items to harmonize

Consequence models

- **Harm criteria**
- **Scenarios**
- Assumptions
  - **leak sizes** & frequencies
- QRA database
  - acceptance criteria
  - Individual vs cumulative approach

Hydrogen Council

Ongoing Work

- Harm Criteria
  - Review basis of harm criteria across major markets
  - Review of threshold criteria for thermal and overpressure effects
    - Radiation - Inclusion of time and convection effects
    - Overpressure: Application of time and influence of overpressure on human beings

- Review the severity concentration for hydrogen explosion

- Electrolyser scenarios
  - Alignment major/most impacting scenarios to determine alkaline and PEM electrolyser safety distances
  - Lessons learned from electrolyser incidents in industry
  - To be summarised in position paper on electrolyser system safety and safety distances

Next steps

- You are welcome to join the subtask and submit inputs to the survey

- Future work:
  - Alignment on leak scenarios for HRS and LH2 safety distances
  - Consistency on harm criteria for determining safety distances