6 Engineering

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6 Engineering

Safety. Engineering. Excellence.

Hydrogen Safety Engineering in Design - DSEAR

Delivered by:

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Safety Engineering Technical Authority

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Introductions

Nick Howard – Safety Engineering Consultant
MSc BEng (Hons) AMIChemE FS Eng (TÜV Rheinland)
PgCPD Hydrogen Safety Technologies

21 years experience:
- Battery Production
- Power Generation (Conventional & Nuclear)
- Nuclear Decommissioning
- Biofuels
- Oil & Gas
- Petrochemicals
- Chemicals
- Food & Drink

14 years in Process/Technical Safety

6 Engineering Ltd

Independent Safety Engineering Specialists

Founded in 2011

Based in North-East England

3 types of safety in design:

1. Project Safety

2. Product Safety

3. Process Safety

1. Project Safety

Ensuring that the construction and installation is planned and executed in a safe manner:

Applicable legislation (*inter alia*):
The Construction (Design and Management) Regulations 2015 (SI 2015/51)

2. Product Safety

Ensuring that the product is designed such that it is installed and can be used in a safe manner:

Applicable legislation (*inter alia*):
The Supply of Machinery (Safety) Regulations 2008 (SI2008/1597)

3. Process Safety

Keeping the process inside its containment:

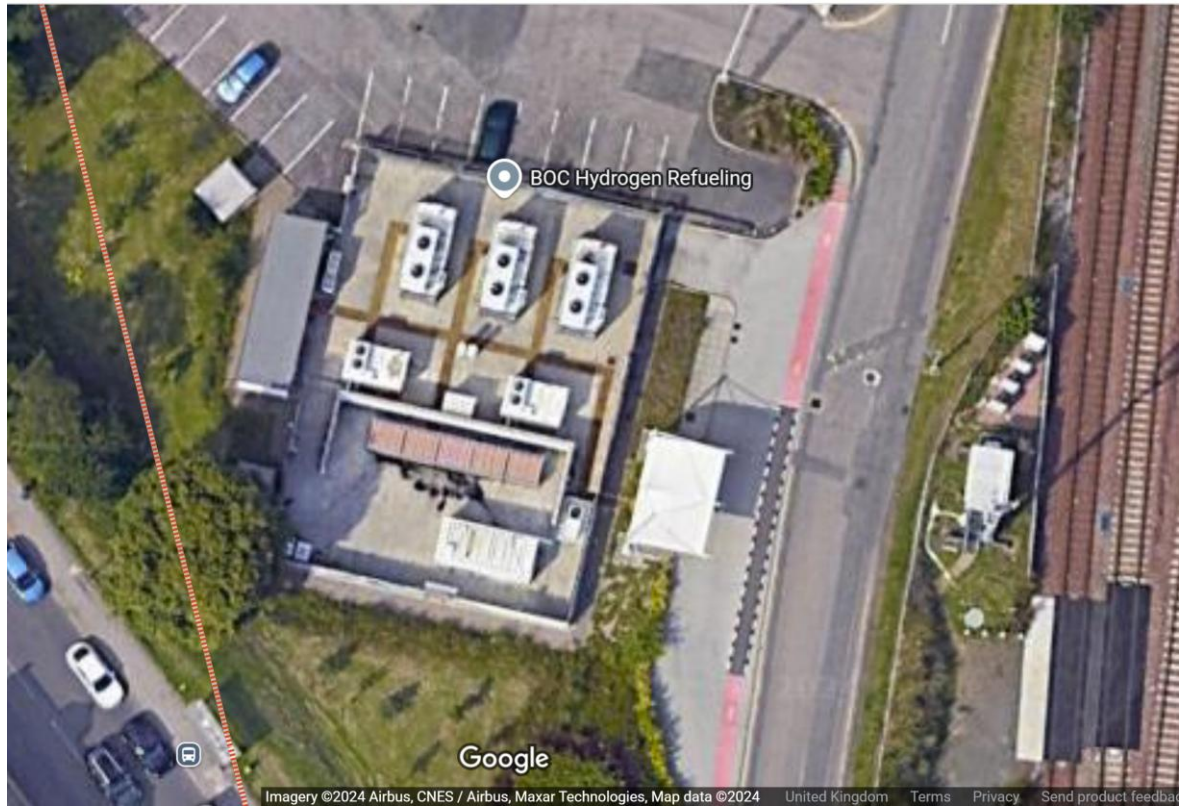
Applicable legislation (*inter alia*):
Well… it depends…

Key UK Process Safety Legislation:

- COMAH: The Control of Major Accident Hazards Regulations 2015 (SI 2015/483)
- PSSR: The Pressure Systems Safety Regulations 2000 (SI 2000/128)
- DSEAR: The Dangerous Substances and Explosive Atmospheres Regulations 2002 (SI 2002/2776)

An example application of DSEAR:

- Kittybrewster site, Aberdeen: hydrogen production and refuelling station
- Produces up to 350kg of hydrogen per day
- Refuels buses and cars up to 700bar



Key DSEAR Regulations:

- Regulation 5 – Risk Assessment
- Regulation 7 – Hazardous Area Classification
- Regulation 8 – Accidents, Incidents and Emergencies
- Regulation 9 – Procedures and Training

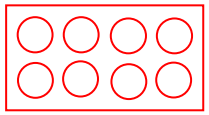
Hazardous Area Classification:

- Step 1: pick a standard, e.g.:
  - IGEM/SR/25 Ed. 2 (+ HSE's 'Development of Hydrogen Supplement for use with IGEM/SR/25'
- Step 2: select the appropriate zoning distance from the table (based on a 0.25mm^2 release):

Pressure (Barg)	Outdoor Freely Ventilated		Outdoor Confined or Congested		Indoor Adequately Ventilated	
	Normal	Adverse	Normal	Adverse	Normal	Adverse
>750 and ≤1000	14	40	18	45	22	60
>500 and ≤750	13	35	16	40	20	50
>300 and ≤500	11	30	13	35	17	40
>200 and ≤300	8	23	11	30	14	35
>100 and ≤200	7	19	8.5	23	12	30

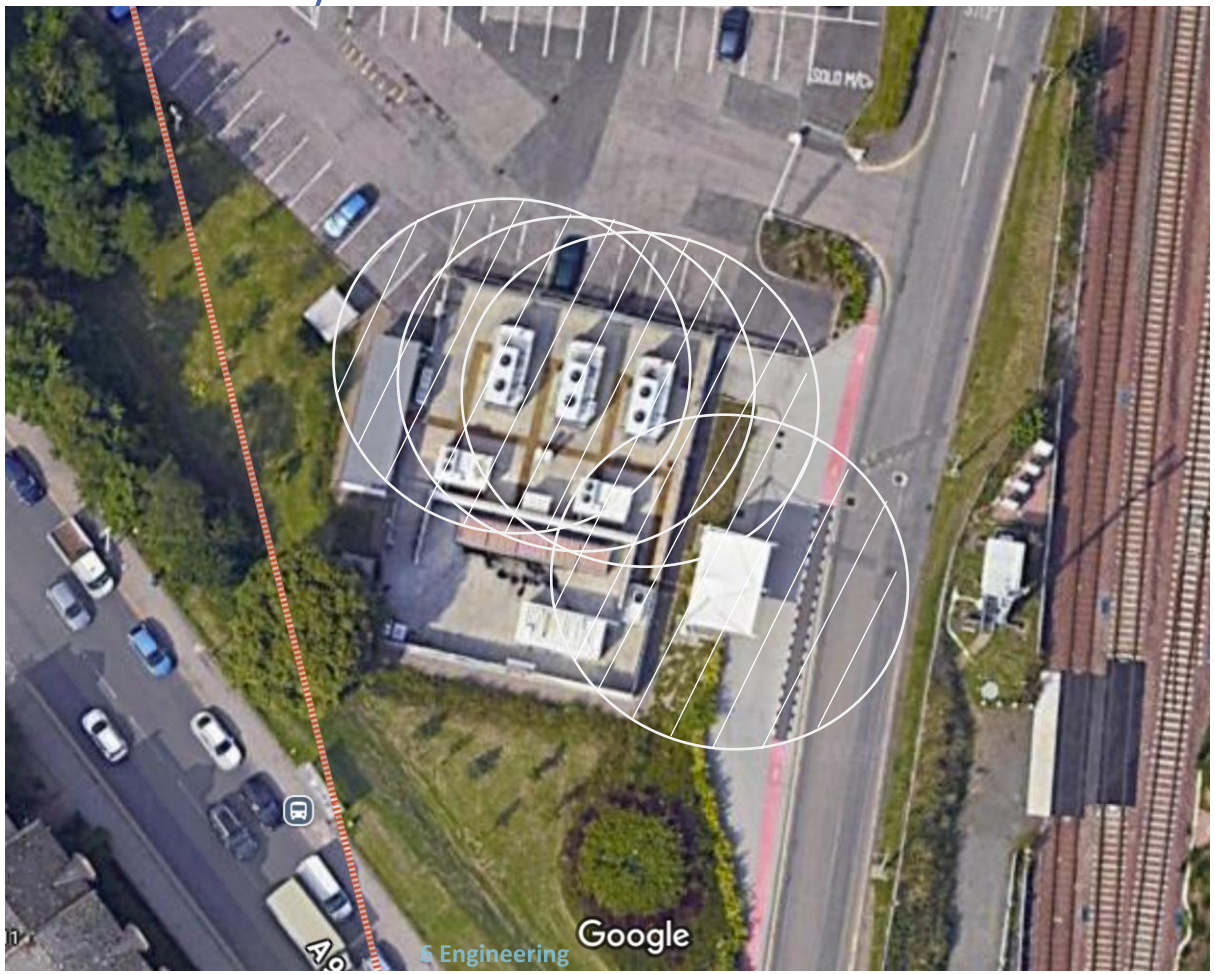
Hazardous Area Classification

- Step 3: Apply the zones

Gases Zone	Gases	Zone Description
Zone 0		Continuous Release
Zone 1		Release Expected Frequently or For Long Periods
Zone 2		Release Expected Infrequently

Hazardous Area Classification

- Step 3: Apply the zones: 13m Zone 2 (outdoors, freely ventilated, not adverse conditions)

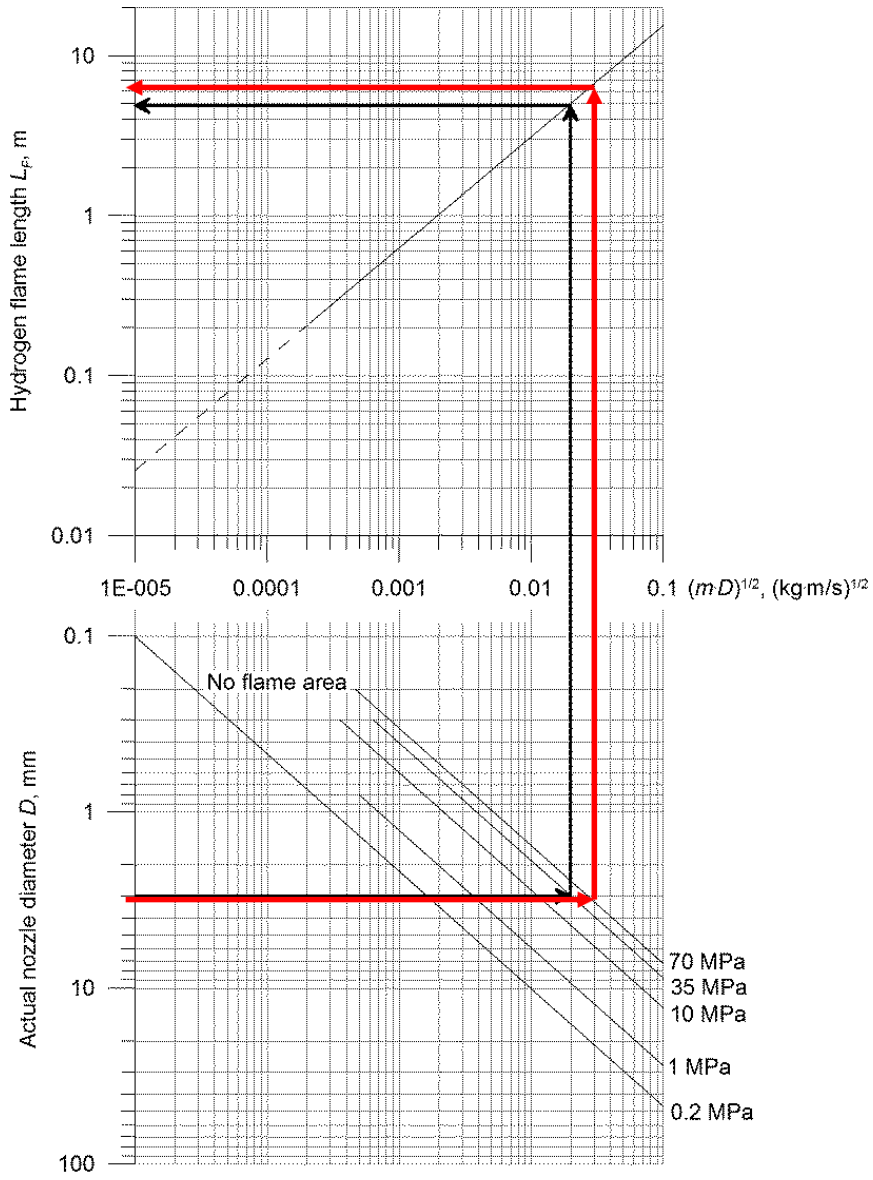


What if a release ignites?

- Delayed ignition leading to explosion. Overpressure (and hence damage) depends on degree of confinement
- Immediate ignition leading to jet fire. Damage due to heat and physical impingement is mainly in the direction for the flame
- Jet fire length from a 3mm release at 700bar is ~6.5m

Jet fire length

- Jet fire length can be estimated using the nomogram developed by Molkov, 2009. (Ulster University)
- The graphical estimation of jet flame length using the nomogram requires only two parameters of a leak, e.g. storage pressure and actual diameter of the leak, which are usually available and do not require any calculations



Typical Hazard Studies

- HAZID – Hazard Identification Study
- FMECA – Failure Modes, Effects & Criticality Analysis
- Consequence analysis – dispersion, fire & explosion modelling
- HAZOP – Hazard & Operability Study
- LOPA – Layer of Protection Analysis
- SIL Allocation & Verification Calculations
- Functional safety assessments
- Safety case
- ALARP demonstration
- Pre-Startup Safety Review

Any Questions?