HyTrEc

Hydrogen Transport Economy for the North Sea Region

HYDROGEN EDUCATION - SAFETY AND STORAGE

2015

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HOW DANGEROUS IS HYDROGEN?

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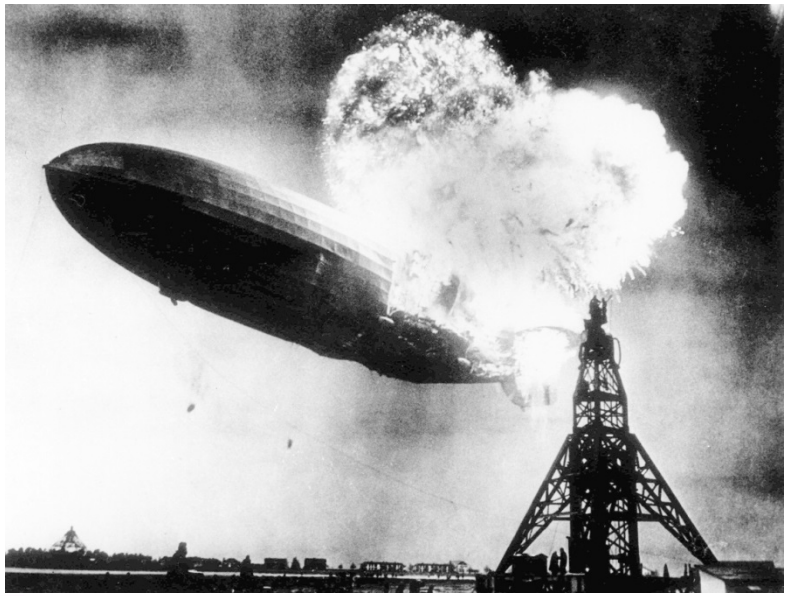
- Hindenburg
- Explosions
- Fires



THREE IMPORTANT STEPS…

1. Understand explosions and fires
2. Understand hydrogen
3. Preventive actions

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MECHANISMS FOR EXPLOSIONS AND FIRES

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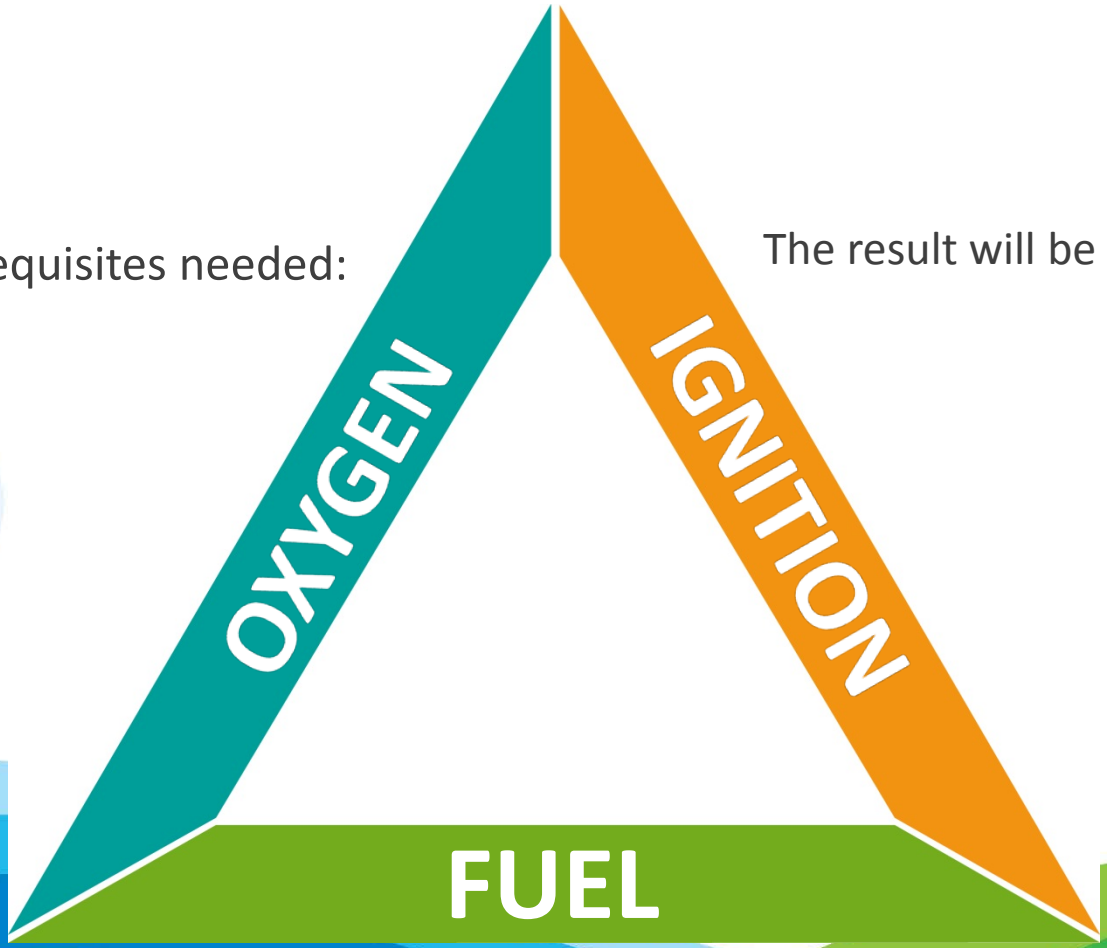
Tree prerequisites needed:



The result will be a fire or an explosion.

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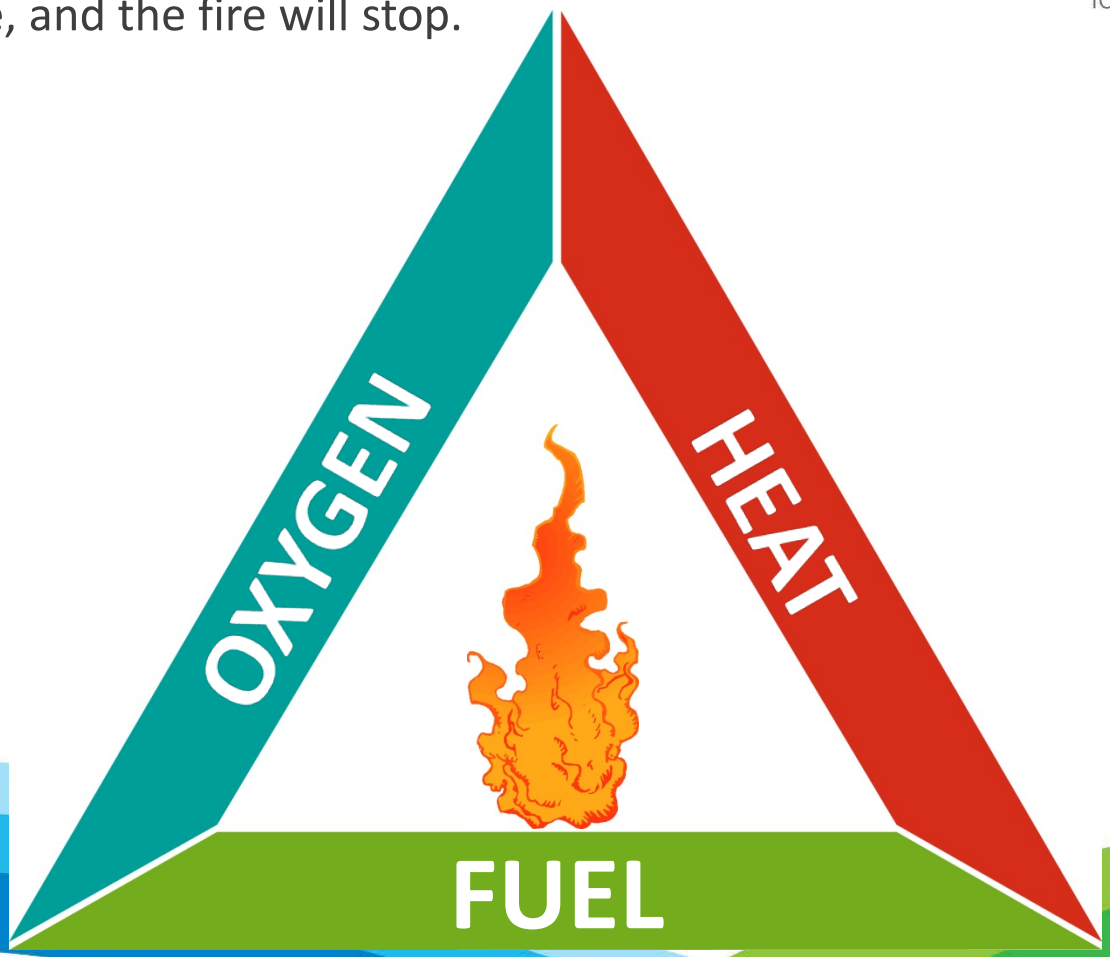
FIRE

Take away one, and the fire will stop.



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EXPLOSION

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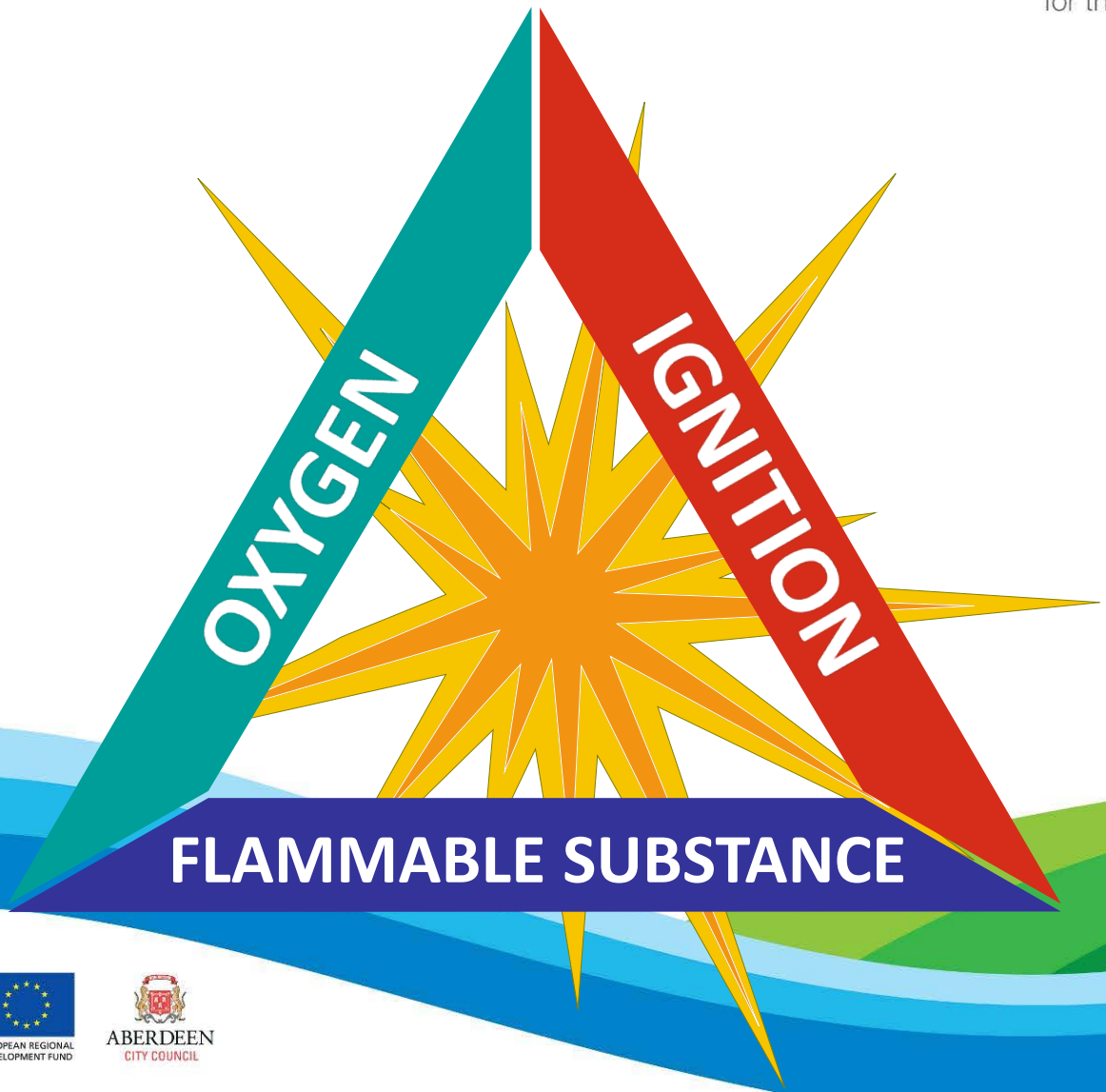

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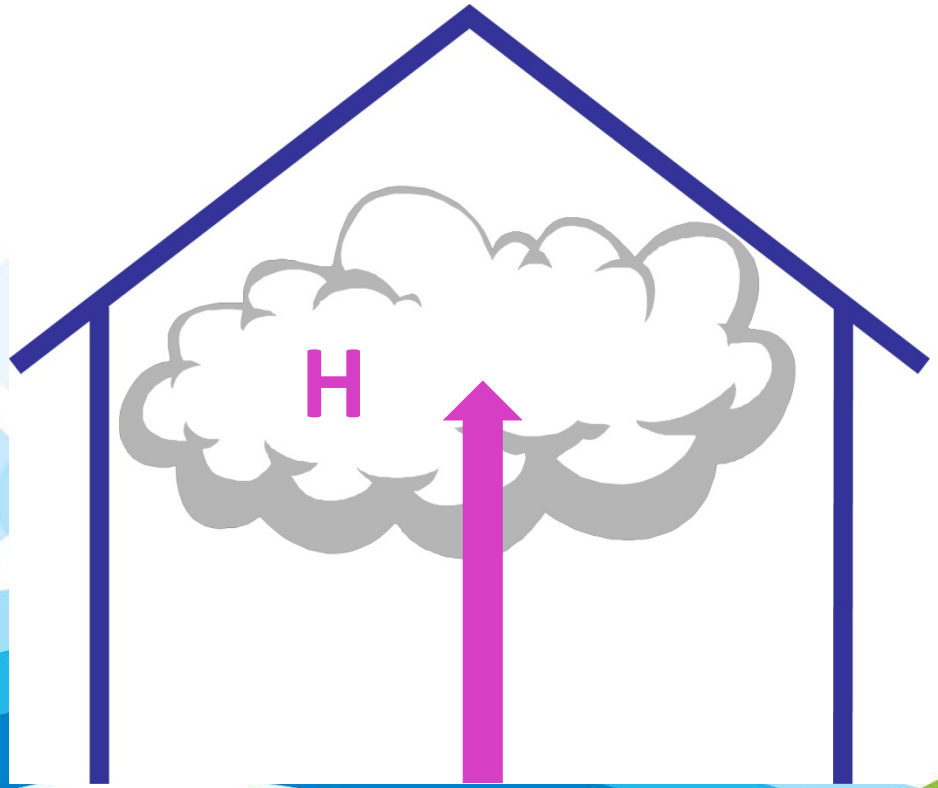
HYDROGEN

- Lightest element on the periodic table, **H**



H 1																	He 2
Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
Cs 55	Ba 56	La 57	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Fr 87	Ra 88	Ac 89															

Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103

EXPLOSION INTERVALS

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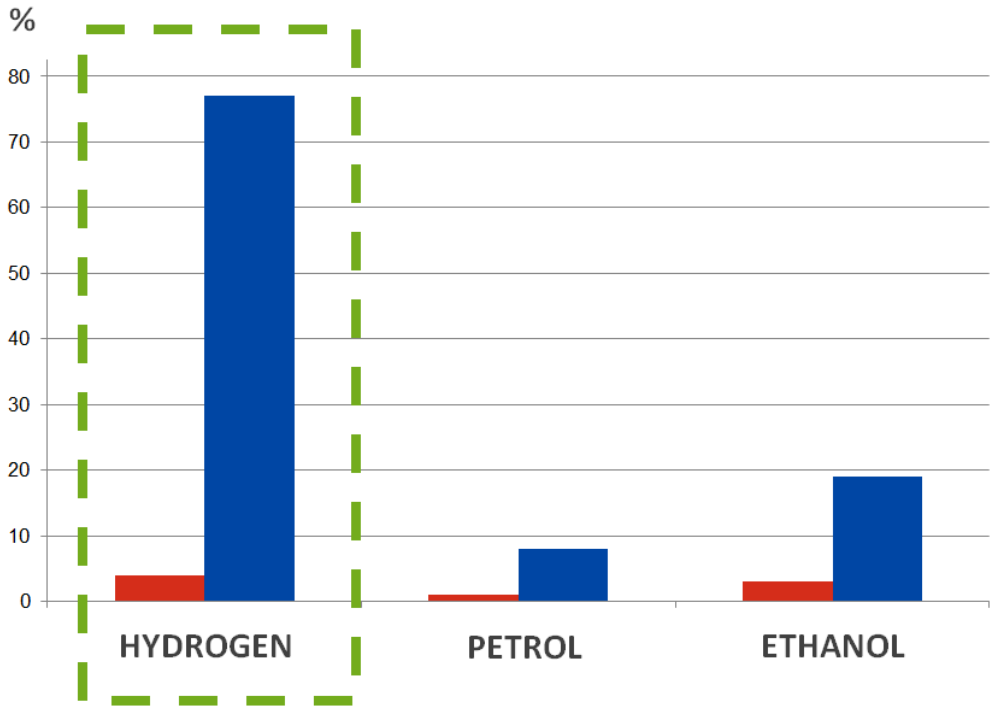
Definition of explosion intervals:

- LEL = Lower Explosion Limit
- UEL = Upper Explosion Limit



Extremely wide explosion interval!

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THERMAL IGNITION TEMPERATURE

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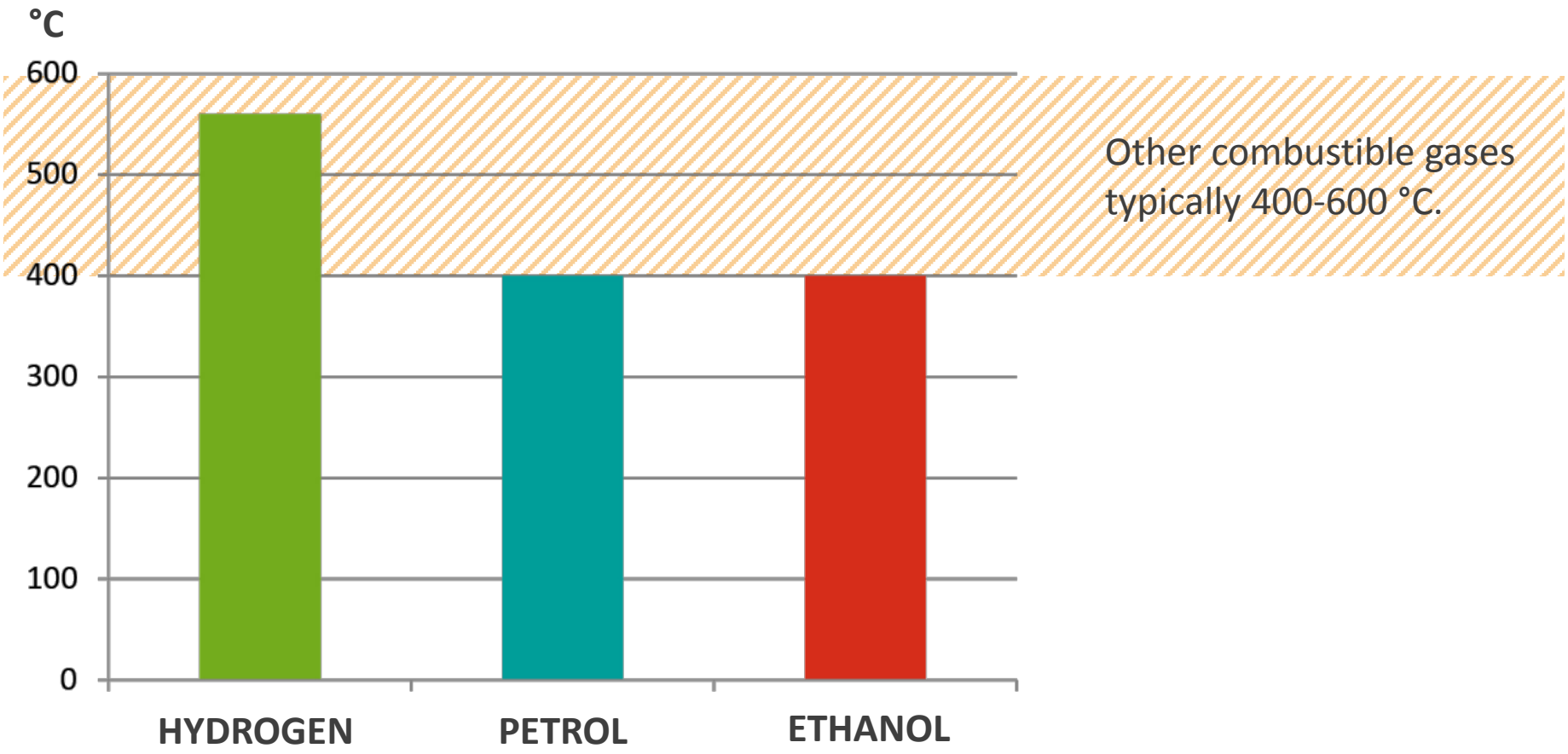
Definition: The minimum surface temperature capable to ignite the mixture.



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EXPLOSION GROUPS

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Explosion group	Comment	Example
IIA	hardest to ignite	Petrol, Ethanol
IIB	medium risk	
IIC	easiest to ignite	Hydrogen

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SUMMARY – fire and explosion

- Very light
- Wide explosion interval
- Easy to ignite

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OTHER SAFETY ASPECTS

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- Hydrogen cause embrittlement to many materials.
- Correct materials must be used to avoid catastrophic failures.

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PREVENTIVE ACTIONS

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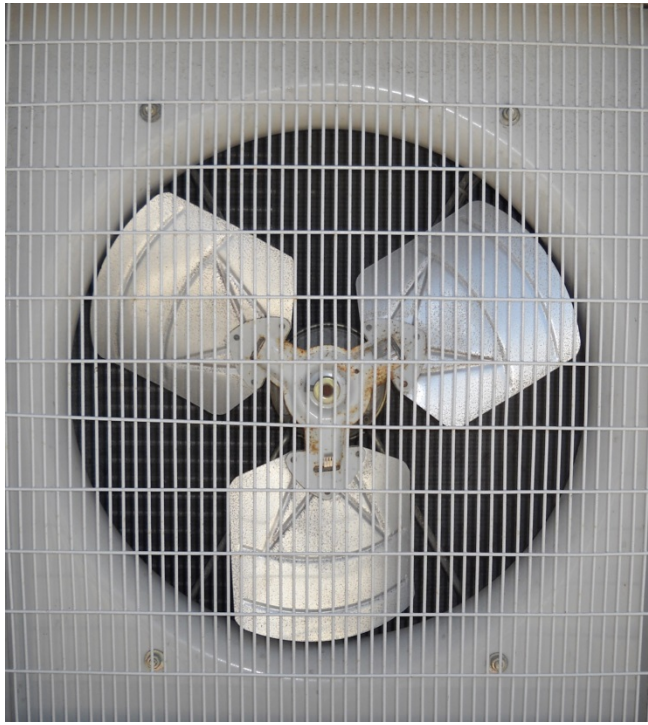

Avoid explosive atmosphere through

- Outdoor handling
- Good ventilation

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SECURE IGNITION SOURCES

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- Hot surface
- Mechanically generated sparks
- Static electricity

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USER INSTRUCTIONS

- Handling hydrogen
- Handling equipment
- Using correct tools
- Avoiding static electricity
- …

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DIRECTIVES REGARDING EXPLOSION SAFETY

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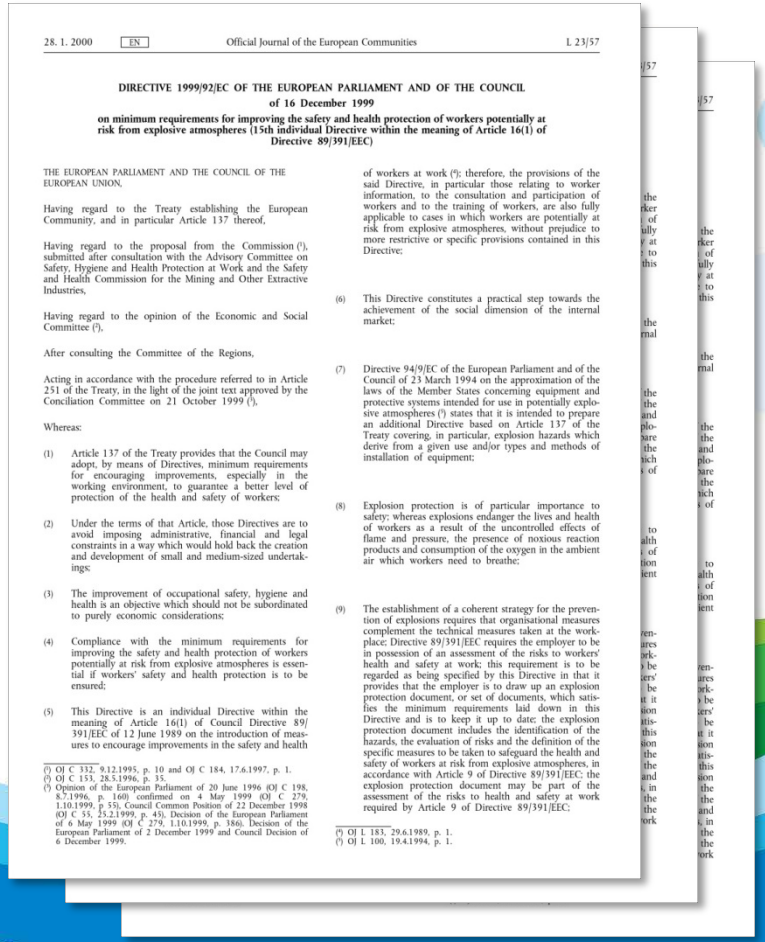
Safety and health protection of workers

- Directive 1999/92/EC

Equipment and protective systems

- Directive 94/9/EC
- Directive 2014/34/EU



28. 1. 2000 EN Official Journal of the European Communities L 23/57

DIRECTIVE 1999/92/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 1999

on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 137 thereof,

Having regard to the proposal from the Commission (1), submitted after consultation with the Advisory Committee on Safety, Hygiene and Health Protection at Work and the Safety and Health Commission for the Mining and Other Extractive Industries,

Having regard to the opinion of the Economic and Social Committee (2),

After consulting the Committee of the Regions,

Acting in accordance with the procedure referred to in Article 251 of the Treaty, in the light of the joint text approved by the Conciliation Committee on 21 October 1999 (3),

Whereas:

(1) Article 137 of the Treaty provides that the Council may adopt, by means of Directives, minimum requirements for encouraging improvements, especially in the working environment, to guarantee a better level of protection of the health and safety of workers;

(2) Under the terms of that Article, those Directives are to avoid imposing administrative, financial and legal constraints in a way which would hold back the creation and development of small and medium-sized undertakings;

(3) The improvement of occupational safety, hygiene and health is an objective which should not be subordinated to purely economic considerations;

(4) Compliance with the minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres is essential if workers' safety and health protection is to be ensured;

(5) This Directive is an individual Directive within the meaning of Article 16(1) of Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (4); therefore, the provisions of the said Directive, in particular those relating to worker information, to the consultation and participation of workers and to the training of workers, are also fully applicable to cases in which workers are potentially at risk from explosive atmospheres, without prejudice to more restrictive or specific provisions contained in this Directive;

(6) This Directive constitutes a practical step towards the achievement of the social dimension of the internal market;

(7) Directive 94/9/EC of the European Parliament and of the Council of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres (5) states that it is intended to prepare an additional Directive based on Article 137 of the Treaty covering, in particular, explosion hazards which derive from a given use and/or types and methods of installation of equipment;

(8) Explosion protection is of particular importance to safety; whereas explosions endanger the lives and health of workers as a result of the uncontrolled effects of flame and pressure, the presence of noxious reaction products and consumption of the oxygen in the ambient air which workers need to breathe;

(9) The establishment of a coherent strategy for the prevention of explosions requires that organisational measures complement the technical measures taken at the workplace; Directive 89/391/EEC requires the employer to be in possession of an assessment of the risks to workers' health and safety at work; this requirement is to be regarded as being specified by this Directive in that it provides that the employer is to draw up an explosion protection document, or set of documents, which satisfies the minimum requirements laid down in this Directive and is to keep it up to date; the explosion protection document includes the identification of the hazards, the evaluation of risks and the definition of the specific measures to be taken to safeguard the health and safety of workers at risk from explosive atmospheres, in accordance with Article 9 of Directive 89/391/EEC; the explosion protection document may be part of the assessment of the risks to health and safety at work required by Article 9 of Directive 89/391/EEC;

(1) OJ C 332, 9.12.1995, p. 10 and OJ C 184, 17.6.1997, p. 1.
(2) OJ C 153, 28.5.1996, p. 35.
(3) Opinion of the European Parliament of 20 June 1996 (OJ C 198, 8.7.1996, p. 160) confirmed on 4 May 1999 (OJ C 279, 1.10.1999, p. 55), Council Common Position of 22 December 1998 (OJ C 55, 25.2.1999, p. 43), Decision of the European Parliament of 6 May 1999 (OJ C 279, 1.10.1999, p. 386), Decision of the European Parliament of 2 December 1999 and Council Decision of 6 December 1999.
(4) OJ L 183, 29.6.1989, p. 1.
(5) OJ L 100, 19.4.1994, p. 1.

HYDROGEN SAFETY IN REAL LIFE

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- Fuel cell vehicle
- Fuel stations
- Tunnels and parking garage
- Distribution of hydrogen

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FUEL CELL VEHICLES

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Legislations securing the safe usage

Allowed to be used in the same way as other vehicles

- Tunnels and underground areas
- Ferries

Risks

- Electrical risks (high energy batteries)
- Fire or explosion (high pressure fuel tanks)

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FUEL STATIONS

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Designed for hydrogen

- Good ventilation
- Proper material selection

Dispenser

- Leak proof connection between dispenser and car
- Automatic shut off valves in case of sudden leakage

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TUNNELS AND PARKING GARAGES

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Hydrogen leakage can be trapped

- Ventilation
- Amount of leakage

Safety systems in fuel cell vehicles

- High pressure tanks placed in safe area
- Shut off valves in case of accidents
- Leak detectors

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DISTRIBUTION OF HYDROGEN

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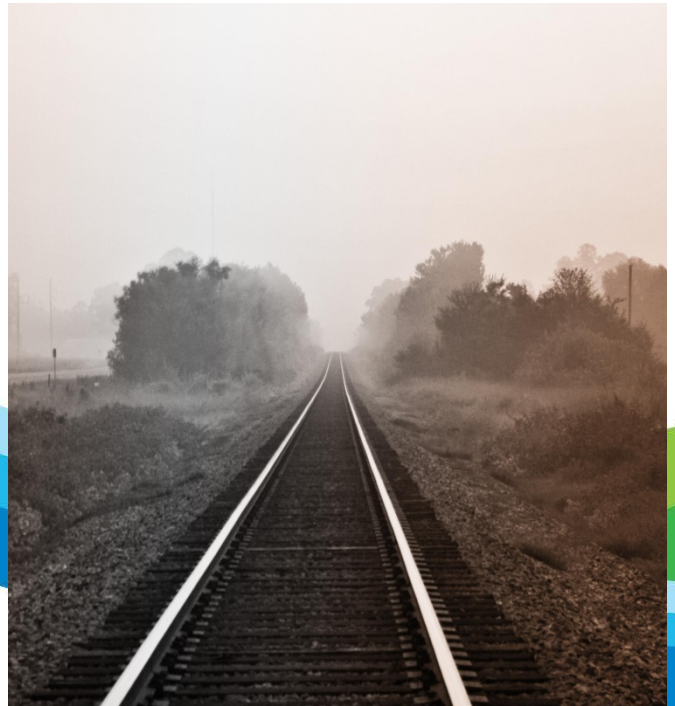
- Larger volumes can create a severe situation
- Low probability of a leakage



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