European Train the Trainer Programme for Responders

Glossary

The information contained in this lecture is used to explain the abbrevitations and terminologies used in the lectures on all levels I - IV

This lecture is part of a training material package with materials at levels I – IV : Firefighter, crew commander, incident commander and specialist officer. Please see the lecture introduction regarding competence and learning expectations

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Disclaimer

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Summary

The nomenclature, abbreviations and definitions of the terms used in all lectures were summarised.

Keywords

Nomenclature, abbreviation, definition

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1. Nomenclature and abbreviations

ACH	Air change per hour
ALARP	As low as reasonably possible
APU	Auxiliary power unit
BEV	Battery electric vehicle
BLEVE	Boiling liquid expanding vapour explosion
CCTV	Closed-circuit television
CEP	Clean energy partnership
CFD	Computational fluid dynamics
CFRP	Carbon fibre reinforced plastic
CGH2	Hydrogen stored as compressed gas
CHP	Combined heat and power
CNG	Compressed natural gas
CVR	Cockpit voice recorder
DCS	Distributed control system
DDT	Deflagration-to-detonation transition
DIC	Driver's information centre
DOE	Department of energy of the US
EIGA	European industrial gases association
EMSA	European maritime safety organization
ELT	Emergency locator transmitter
ESD	Emergency shut-down device
FCH	Fuel cell and hydrogen
FC	Fuel cell
FCEV	Fuel cell electric vehicle
FCTO	Fuel cell technologies office
FCV	Fuel cell vehicle
FDR	Flight data recorder
FED	Field effect gas detectors
FRP	Fibre-reinforced polymer/plastic
GH_2	Gaseous hydrogen

GHG	Greenhouse gas
GSE	Ground support equipment
GTR	Global technical regulations
HAZOP	Hazard and operability study
HE	Hydrogen embrittlement
HEM	Homogeneous equilibrium
HFM	Homogeneous frozen model
HGV	Heavy goods vehicle
HNEM	Homogeneous non-equilibrium flash model
HPV	Hydrogen-powered vehicle
HRR	Heat release rate
HRS	Hydrogen refuelling station
HSE	Hydrogen safety engineering
HSL	Health and safety laboratory
HTI	Heat transfer index
HTS	High-temperature shift
ICE	Internal combustion engine
IMO	International maritime organization
IR	Infrared
JIVE	Joint initiative for hydrogen vehicles across Europe
KIT	Karlsruhe institute of technology
KHI	Kawasaki heavy industries
KSC	Kennedy space centre
LDL	Lower detonation limit
LES	Large eddy simulation
LFL	Lower flammability limit
LH_2	Liquified hydrogen
LHRS	Liquid hydrogen refuelling station
LLNL	Lawrence Livermore national laboratory
LNB	Leak-no-burst
LNG	Liquid nature gas

LPG	Liquid petroleum gas
MEA	Membrane electrode assembly
MEMS	Micro electro mechanic system
MIE	Minimum ignition energy
MLI	Multi-layer insulation
NBP	Normal boiling point
NP	Neutral plane
NTP	Normal temperature and pressure
NWP	Normal working pressure
PEM	Proton exchange membrane
PPE	Personal protective equipment
PPP	Pressure peaking phenomenon
PRD	Pressure relief device
PRT	Rapid phase transition
PRV	Pressure relief valve
PSV	Pressure safety valve
QDR	Qualitative design review
QRA	Quantitative risk assessment
RANS	Reynolds-averaged Navier-Stokes
RCS	Regulations, codes and standards
RHTI	Radiative heat transfer indices
RMPP	Risk management prevention plan
SCC	Stress corrosion cracking
SD	Separation distance
SDO	Standard development organisation
SLH_2	Slush hydrogen
SIL	Safety integrity level
SMR	Steam methane reforming/reformer
SNL	Sandia National Laboratory
SOFC	Solid oxide fuel cell
SS	Stainless steel

STP	Standard temperature and pressure
SUV	Sport utility vehicle
TCO	Total cost of ownership
TDU	Thermal dose unit
TPL	Thermal protection layer
TPRD	Thermal-activated pressure relief device
TRL	Technology readiness level
TSS	Technical sub-systems
UAV	Unmanned aerial vehicle
UDL	Upper detonation limit
UFL	Upper flammability limit
UV	Ultraviolet
UVCE	Unconfined vapour cloud explosion
VCE	Vapour cloud explosion
ZND	Zeldovich, von Neumann and Doring model

2. Definitions

Acceptance criteria are the terms of reference, against which safe design of a FCH facility/infrastructure is assessed.

Ambient pressure cycling test is a test for hydrogen tanks not failing before reaching 11,250 fill cycles (representing a 15-year life of use in commercial heavy-duty vehicles).

Auto-ignition temperature is the minimum temperature required to initiate the combustion reaction of fuel-oxidiser mixture in the absence of an external source of ignition.

Blow-down is a process where the storage pressure decreases with time during a leak.

Blow-off is the flame extinguishment at a high velocity without a lift-off.

Blow-out is the flame extinguishment at high velocity with a lift-off.

Blow-out limit is a fuel flow velocity limit beyond which a lifted flame blows out.

Bonfire test is a test for the tank venting through the non-reclosing TPRD and not failing when exposed to a bonfire of 20 minutes duration.

Brush discharge is a discharge between a charged insulator and a conducting earthed point.

Catastrophic rupture is that gaseous hydrogen from a high-pressure storage container before its walls are weakened by high temperatures.

Cell size is the parameter that characterises the detonation sensitivity of a hydrogen-air mixture.

Corona discharge is a silent, usually continuous, discharge with a current but without a plasma channel.

Deflagration is a term to describe 'to burn down', which is subsonic combustion propagating through heat transfer; hot burning material heats the next layer of cold material and ignites it. It is the process following the weak ignition in a combustible mixture, which propagates at a subsonic speed into fresh, unburned mixture.

Detonation is the phenomenon of combustion zone propagating at the velocity higher than the speed of sound (supersonic) in the unreacted mixture. It is the worst case of accidental hydrogen combustion.

Drop-back is the reattachment to the nozzle of a lifted flame by a decrease of lift-off velocity.

Effective diameter is the jet diameter at the location where expansion down to 1 bar takes place, in an under-expanded jet.

Expanded jet is the jet with a pressure at the nozzle exit equal to atmospheric pressure.

Expansion coefficient is the ratio of the unburnt mixture density to the density of combustion products at the same pressure.

Fire-resistance rating is a measure of time for which a passive fire protection system can withstand a standard fire resistance test.

Flame lift-off is the condition, in which the flame and a burner become separated.

Flame speed is the velocity of the flame with the respect to a fixed observer.

Flammability range is the range of concentrations between the lower and the upper flammability limits. The *lower flammability limit* (LFL) is the lowest concentration, and the *upper flammability limit* (UFL) is the highest concentration of a combustible substance in a gaseous oxidizer that will propagate a flame.

Flashing is a process occurs when LH_2 at a high pressure is transferred from trucks and rail cars to a low-pressure vessel.

Flashpoint is the lowest temperature, at which the fuel produces enough vapours to form a flammable mixture with air at its surface.

Froude number *(Fr)* is the dimensionless number equal to the ratio of inertial to gravity force.

Hazard distance is the minimum distance, which separates "specific targets (e.g. people, structures or equipment) from the consequences of potential accidents related to the operation a hydrogen facility".

Hydrostatic burst test is a test for tank burst, for which the pressure typically more than 2.25 times of the working pressure.

Incapacitation is a condition, under which humans do not function adequately and unable to escape untenable conditions.

Laminar burning velocity is the rate of flame propagation relative to the velocity of the unburnt gas that is ahead of it, under stated conditions of composition, temperature, and pressure of the unburned gas.

Leading point is the leading edge of flame front, typically a flamelet structure, which is responsible for the propagation of flame.

Leak-before-break test is the test for the tank failing by leakage or shall exceed the number of filling cycles.

Lift-off height is the height from the nozzle exit to the base of a lifted flame.

Lift-off velocity is the fuel flow velocity causing a flame to be detached from the nozzle.

Mach number is the dimensionless number equal to the ratio of the local flow velocity to the local speed of sound.

Maximum experimental safe gap of flammable gases and vapours is the lowest value of the safe gap measured, according to IEC 60079-1-1 (2002), by varying the composition of the mixture.

Maximum allowable working pressure *(MAWP)* is the maximum pressure, to which any component or portion of the pressure system can be subjected over the entire range of design temperatures [5].

Minimum Ignition Energy *(MIE)* of flammable gases and vapours is the minimum value of the electric energy, stored in the discharge circuit with as small a loss in the leads as possible, which (upon discharge across a spark gap) just ignites the quiescent mixture in the most ignitable composition.

Normal temperature and pressure *(NTP)* conditions are temperature of 293.15 K and pressure of 101.325 kPa.

Nominal working pressure is a gauge pressure, which characterises typical operation of a system.

Non-premixed flame (often called a *diffusion flame*) is the flame, in which the oxidiser and the fuel are not mixed prior to reaching a flame front. During combustion oxidiser combines with a fuel by diffusion. The flame speed is limited by the rate of diffusion.

Occupants are people present within the boundaries of a FCH facility/infrastructure including personnel involved in its operation and maintenance as well as the customers/visitors.

Ortho- para-hydrogen conversion is the conversion of hydrogen between ortho- to para-hydrogen.

Overpressure is the pressure in a blast wave above the atmospheric pressure, or the pressure within a containment structure that exceeds the maximum allowable working pressure of the containment structure.

Permeation is the movement of atoms, molecules, or ions into or through a porous or permeable substance.

Penetration test is the test for the tank not rupturing when an armour piercing bullet or an impactor with a diameter of 7.62 mm or greater fully penetrates its wall.

Place of safety is a predetermined place inside or outside an FCH facility/infrastructure, in which persons are not in immediate danger from the effect of hydrogen release, fire or explosion.

Premixed flame is the flame, in which the oxidiser has been mixed with the fuel prior to the reaching the flame front. Combustion of premixed fuel and oxidiser forms a thin flame front due to the reactants being readily available.

Public are people present outside the boundaries of an FCH facility/infrastructure.

Quenching distance is the maximum distance between two parallel plates that will extinguish a flame passing between them. The quenching distance decreases with the pressure and temperature increase. It also depends on the mixture composition.

Quenching gap is the spark gap between two flat parallel-plate electrodes at which ignition of combustible fuel-air mixtures is suppressed. The quenching gap is the passage gap dimension requirement to prevent propagation of an open flame through a flammable fuel-air mixture that fills the passage.

Rarefaction wave is also called a relief wave, an unloading wave, and a Taylor wave. It is the progression of particles being accelerated away from a compressed or shocked zone. It travels in the direction opposite to the acceleration of the particles.

Residual thermal leak is the heat leakage loss proportional to the ratio of surface area to the volume of the storage vessel.

Reynolds number *(Re)* is the dimensionless number that gives a measure of the ratio of inertial to viscous forces.

Sensitive area is the establishment, infrastructure or equipment containing inventories of dangerous substances that can become a source of harm when targeted by a hydrogen incident/accident.

Sloshing is a motion of LH_2 in a vessel due to acceleration or deceleration, which occurs during its transportation by tankers. Some of the impact energy of the liquid against the vessel is converted to thermal energy.

Spark discharge is a single plasma channel between a high potential conductor and an earthed conductor.

Survivability is the maximum exposure that may be received with a negligible statistical probability of fatality/damage and without impairment of an individual's ability to escape.

Tenability is the maximum exposure to hazards from a hydrogen incident/accident that can be tolerated without violating safety goals.

Threshold is the maximum intensity or dose for a given hazard that corresponds to a specific physiological (for humans) or structural (for structures and equipment) response.

Throttled expansion is to describe the majority of gases are usually cooled when expanded from high to low pressure through a porous plug, a small aperture or a nozzle.

Under-expanded jet is a jet with a pressure at the nozzle exit above the atmospheric pressure.

Under-ventilated fire is characterised by relatively high hydrogen release rate when oxygen is consumed at a faster rate than it can be replenished through the ventilation. In the case where there is insufficient ventilation the flame will be ventilation-controlled.

Visible flame length *i*s the centerline distance from the tip of the nozzle to the flame end.

Well-ventilated fire is characterized by a relatively low hydrogen release rate and complete combustion of hydrogen within the enclosure.