MCMC MTSFB TC G037:2022

TECHNICAL CODE

FUEL CELL SYSTEM - STATIONARY BACKUP POWER SOLUTION FOR TELECOMMUNICATION SITES

Developed by

Malaysian Technical Standards Forum Bhd

Registered by

MCMC

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Development of technical codes

The Communications and Multimedia Act 1998 ('the Act') provides for Technical Standards Forum designated under section 184 of the Act or the Malaysian Communications and Multimedia Commission ('the Commission') to prepare a technical code. The technical code prepared pursuant to section 185 of the Act shall consist of, at least, the requirement for network interoperability and the promotion of safety of network facilities.

Section 96 of the Act also provides for the Commission to determine a technical code in accordance with section 55 of the Act if the technical code is not developed under an applicable provision of the Act and it is unlikely to be developed by the Technical Standards Forum within a reasonable time.

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A technical code prepared in accordance with section 185 shall not be effective until it is registered by the Commission pursuant to section 95 of the Act.

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The Technical Code was developed by Hydrogen Sub Working Group under the supervision of Green ICT, Environment and Climate Change Working Group of the Malaysian Technical Standards Forum Bhd (MTSFB), constituted by representatives from the following organisations:

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Shan Poornam Metals Sdn Bhd

Sustainable Energy Development Authority (SEDA)

Telekom Malaysia Berhad

UCSI University

Universiti Kebangsaan Malaysia

Universiti Teknologi MARA

Universiti Tun Hussein Onn Malaysia

Foreword

This technical code for Fuel Cell System - Stationary Backup Power Solution For Telecommunication Sites ('This Technical Code') was developed pursuant to section 185 of the Act 588 by the Malaysian Technical Standards Forum Bhd ('MTSFB') via its Green ICT, Environment and Climate Change Working Group.

This Technical Code shall continue to be valid and effective from the date of its registration until it is replaced or revoked.

FUEL CELL SYSTEM - STATIONARY BACKUP POWER SOLUTION FOR TELECOMMUNICATION SITES

0. Introduction

The telecommunications sector continues to grow rapidly in Malaysia with the increased demand of network coverage and high speed internet in parallel with the number of mobile phone users. In order to support the demands, this industry requires an increase in the number of telecommunication sites including the mobile phone towers and site facilities.

To maintain service reliability, the telecommunications companies rely on backup power to prevent power outages and to ensure a constant power supply to the towers and related facilities. General practice for the telecommunication sites worldwide require a minimum of 48 hours of power backup for indoor deployment and 4 hours of power backup for outdoor deployment under the following criteria such as:

a) location which requires travelling time of less than 2 hours to reach during Battery on Load (BOL); and

b) outdoor equipment cabinet.

For outdoor locations other than (a) and (b), a minimum of 8 hours power backup is proposed. Despite of the 48-hour requirement, most of the international telecommunication sites are aiming for a longer duration power backup up to 72 hours. Besides the commonly used battery and diesel generator, fuel cell technology can also be considered as a backup power device because it lasts longer and is more predictable.

This Technical Code is developed as a guide to facilitate the telecommunications industry in installing the fuel cells onsite as a power backup unit, as well as carrying out decarbonisation exercises for their infrastructure system through the utilisation of hydrogen The targeted users include manufacturers, engineers, installers, regulators, and maintenance workers. The minimum operational and safety requirements specifically for fuel cell system shall be in accordance with MCMC MTSFB TC G036.

1. Scope

This Technical Code provides guidance on the deployment of stationary fuel cell system as a backup power solution for telecommunication sites.

This Technical Code will only cover the stationary fuel system in the aspects of:

a) general configuration;

b) installation and site considerations;

c) safety requirements;

d) maintenance; and

e) permitting route.

This Technical Code shall be read together with MCMC MTSFB TC G036 for general operational and safety requirements and MCMC MTSFB TC G023 for hydrogen storage for fuel cell system.

For the installation and site considerations, the input fuel used in the stationary fuel cell system is either hydrogen, methanol, natural gas or propane.

The requirements for portable, propulsion and micro fuel cell systems are not covered in this Technical Code.

2. Normative references

The following normative references are indispensable for the application of this Technical Code. For dated reference, only the edition cited applies. For undated references, the latest edition of the normative reference (including any amendments) applies.

See Annex A.

3. Abbreviations

For the purposes of this Technical Code, the following abbreviations apply.

ANSI	American National Standards Institute
AIAA	American Institute of Aeronautics and Astronautics
BOL	Battery on Load
BS	British Standard
DOSH	Department of Occupational Safety and Health
IEC	International Electrotechnical Commission
IFC	International Fire Code
ISO	International Organisation for Standardisation
HSE	Health and Safety Executive
LFL	Lower Flammability Limit
LOC	Limiting Oxygen Concentration
LPG	Liquefied Petroleum Gas
MS	Malaysian Standard
NFPA	National Fire Protection Association
NIOSH	The National Institute for Occupational Safety and Health
RVP	Reid Vapour Pressure
SDS	Safety Data Sheets
UFL	Upper Flammability Limit

4. Terms and definitions

For the purposes of this Technical Code, the following terms and definitions apply.

4.1 Authorised person

A person who has been given the permission or mandate for approval to undertake any task on behalf of the manufacturer.

4.2 Building owner

Individual, company, corporation, authority, government entity, or any entity that holds title to subject building.

4.3 Buoyancy

Vertical force exerted on a body of a low-density gas by the surrounding heavier static gas, typically air.

4.4 Combustible materials

Item capable of combustion even though flame-proofed, fire-retardant treated, or plastered.

4.5 Combustion

A chemical reaction between flammable substance with oxygen gas, releasing energy in the form of heat, light, radiation and possibly pressure waves.

4.6 Competent person

A person who has been certified by the authority body as competent to supervise the operation of a fuel cell system.

4.7 Component

Any part of a complete item or system.

4.8 Control devices

Equipment which works with sensor in the control system.

4.9 Danger zones

An area in which there is a high risk of harm.

4.10 Electrical equipment

Material, fittings, devices appliances, fixtures, apparatus and the like used as part of, or in connection with an electrical installation.

4.11 Emergency

Unintended circumstance, bearing clear and present danger to personnel or property, which requires an immediate response.

4.12 Explosion

Sudden outburst that causes injuries and damages to the overall system.

4.13 Explosive atmosphere

A mixture of dangerous substances in the form of gases, vapour, mist or dust within the air under atmospheric conditions. During the occurrence of ignition, the combustion spreads to the entire unburned mixture and causes explosion.

4.14 External temperature

Temperature outside of the building or fuel cell system.

4.15 Facility

A group of buildings or equipment used for specific operations at one geographic location.

4.16 Fire

Sustained burning of a fuel jet as manifested by any or all of the following: light, flame, heat and smoke.

4.17 Fire barriers

Barriers in terms of doors, interior flooring, interior ceiling or interior walls that extend and concealed spaces from outside or another areas or spaces in which are designed to divide portions and impede fire over a designated period of time.

4.18 Flame

Zone of combustion of a gas or vapour from light and heat are emitted.

4.19 Flammable gases

A gas or a gas mixture having a flammable range with air at 20 °C and a standard pressure of 101.3 kPa

4.20 Flammability

Degree to a material is ignitable in an oxidising atmosphere.

4.21 Flue gas venting

Any equipment or tool such as duct, pipe, or opening to convey exhaust gases to the outdoors

4.22 Fuel cell

Electrochemical device that converts the chemical energy of a fuel and an oxidant, both externally supplied, to electrical energy (direct current power) heat and other reaction products.

4.23 Fuel cell system

Generator system that uses fuel cell module to generate electric power and heat.

4.24 Hazard

A source or a situation with the potential for harm in terms of human injury or ill health, damage to property, damage to the environment or a combination of these.

4.25 Ignite

Cause to burn or to catch fire.

4.26 Indoor installation

The location where a fuel cell system is sited, whether as a unit or built as an assembly, which is completely surrounded and enclosed by walls, a roof and a floor.

4.27 Local authorities

Rural and town board and local, city, municipal, district and town councils, or other similar local authority established by any written law and includes an authority in charge of a federal territory established by any written law.

4.28 Flammability limits

Lower Flammability Limits (LFL) and Upper Flammability Limits (UFL) concentration thresholds of fuel gas in a flammable mixture at a given temperature and pressure that will sustain propagation of a combustion wave.

4.29 Machinery

Machinery includes steam boilers, unfired pressure vessels, fired pressure vessels, pipelines, prime movers, gas cylinders, gas holders, hoisting machines and tackle, transmission machinery, driven machinery, materials handling equipment, amusement device or any other similar machinery and any equipment for the casting, cutting, welding or electro-deposition of materials and for the spraying by means of compressed gas or air of materials or other materials, but does not include:

a) any machinery used for the propulsion of vehicles other than steam boilers or steam engines;

b) any machinery driven by manual power other than hoisting machines;

c) any machinery used solely for private and domestic purposes; or

d) office machines.

4.30 Manufacturer

A person who designs, manufactures, imports or supplies any plant for use at work, or formulates, manufactures, imports or supplies any substance for use at work.

4.31 Operator

A person employed on any service involving the management or operation of, or attendance on, any machinery.

4.32 Outdoor installation

The location where a fuel cell and fuels system are sited, whether as a unit or built as an assembly, which is located outside building or that has only partial weather protection (maximum coverage of a roof and up to 25 % enclosing walls).

4.33 Pipeline

The physical facilities or any part of the physical facilities through dangerous substances, which may cause fire, explosion or adverse health effects to any person (other than petroleum or petroleum products) in the form of liquid or vapour or any combination of liquid or vapour are transported and includes pipes, pumps, compressors, meters, regulators and fabricated assemblies.

4.34 Purge

Process using an inert gas i.e., nitrogen to prevent the existence of a hydrogen/air mixture.

4.35 Refilling mode

A condition where the gases that should be supplied are in low levels and require refilling.

4.36 Replacement mode

A condition where the equipment or tools are not in their peak performance and require replacement.

4.37 Risk

A combination of the likelihood of an occurrence of a hazardous event with specified period or in specified circumstances and the severity of injury or damage to the health of people, property, environment or any combination of these caused by the event.

5. General configuration of the stationary fuel cell system

5.1 Basic schematic diagram of the stationary fuel cell system for telecommunication sites

The comparison between traditional and stationary fuel cell backup power solution system is shown in Figure 1.

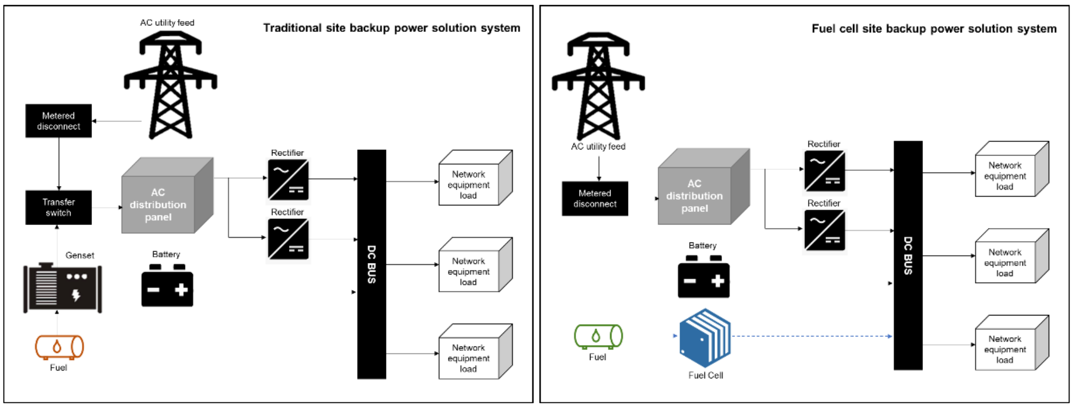

Figure 1. Basic schematic diagram of traditional and stationary fuel cell backup power solution system for the telecommunication sites

Depending on the targeted operational hours, the dimension of the fuel cell system is varied accordingly. For example, an installation of 4 kW outdoor fuel cell system targeted for 72 hours backup power capacity needs a fuel cell cabinet that contains 2 units of a 2 kW fuel cell chassis (dimension of 53.3 cm x 54.6 cm x 66 cm each) and 6 tanks of hydrogen (approximately 80 ℓ). This system also requires a separated hydrogen storage module as shown in Figure 2.

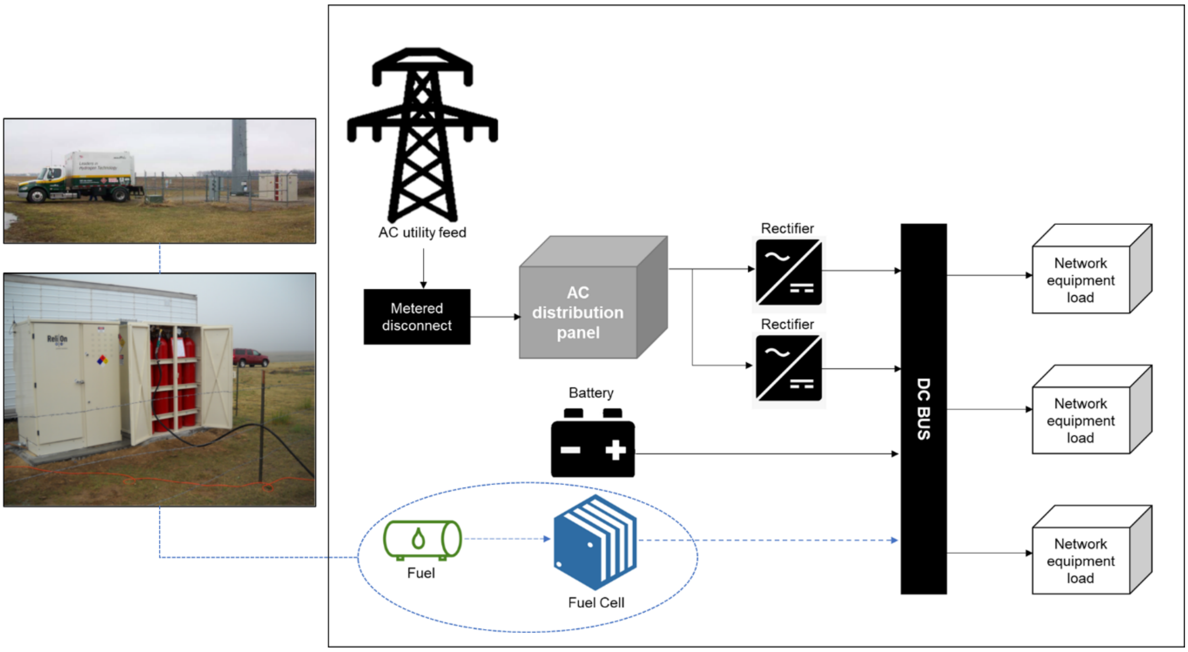

Figure 2. A complete fuel cell backup power system

The floor size of the backup power system depends on the duration of backup requirement, which is based on site remoteness and equipment load.

6. Installation and site considerations

6.1 General requirement

6.1.1 Risk analysis identification

The malfunctioning of the fuel cell system's components that may result in a dangerous situation should be identified and updated regularly.

The manufacturer of a fuel cell and its components, or their authorised person, shall ensure that a risk assessment is carried out in order to determine the health and safety requirements that apply to the equipment. The equipment shall then be designed and constructed taking into account the results of the risk assessment.

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6.1.2 Protection against mechanical hazards

The installation of mechanical components of the fuel cell system shall consider the following aspects:

a) risks of loss of stability;

b) risks of break up during operation;

c) risks due to falling or ejected objects;

d) risks due to surfaces, edges or angles;

e) risks related to combined equipment;

f) risks related to variations in operating conditions;

g) risks related to moving parts;

h) choices of protection against risks arising from moving parts; and

i) risks of uncontrolled movements.

6.1.3 Protection against electrical hazards

The electrical equipment, together with its components, shall be made to ensure that it can be safely and properly assembled and connected. The following shall be addressed:

a) protection against hazards arising from the electrical equipment;

b) protection against hazards that may be caused by external influences on the electrical equipment;

c) electricity supply;

d) static electricity; and

e) electromagnetic compatibility.

6.1.4 Protection from flammable gas appliance hazards

The protection from flammable gas appliance hazards shall be in accordance with the essential safety requirements of all applicable legislations and standards.

6.1.5 Protection against fire and explosion hazards

The manufacturer shall safeguard against risk of fire and explosion in accordance with all applicable legislations and standards.

Although the legislations do not specifically specify the protection for the stationary fuel cell system, the legislations require that risks from dangerous substances, e.g. flammable gases, are assessed and controlled.

6.1.6 Protection against pressure-related hazards

The protection against pressure-related hazards requires the following aspects to be addressed:

a) strength of equipment;

b) provisions to ensure safe handling and operation;

c) means of examination;

d) means of draining and venting;

e) materials for pressure vessels;

f) wear;

g) assemblies;

h) provisions for filling and discharge;

i) protection against exceeding the allowable limits of pressure equipment;

j) safety accessories;

k) manufacturing procedures;

l) marking and labelling; and

m) operating instructions

At elevated temperatures and pressures, hydrogen attacks mild steels severely, causing decarburisation and embrittlement. This is a serious concern in any situation involving storage or transfer of hydrogen gas under pressure. Proper material selection, e.g. special alloy steels and technology are required to prevent embrittlement.

6.1.7 General health and safety requirements

General health and safety requirements should be addressed with respect to:

a) materials and products;

b) external temperatures;

c) errors of fitting;

d) extreme temperatures;

e) noise;

f) vibrations;

g) external radiation;

h) emissions of hazardous materials and substances;

i) risk of being trapped in a machine;

j) risk of slipping, tripping or falling; and

k) lightning.

6.1.8 Control system requirements

For a device appliance equipped with safety and controlling devices, the functioning of the safety devices shall not be overruled by the controlling devices.

All parts of appliances that are set or adjusted at the stage of manufacture shall be appropriately protected, where it should not be manipulated by the user or the installer.

Levers and other controlling and setting devices shall be clearly marked and provided with appropriate instructions to prevent any error in handling. Their design shall preclude accidental manipulation.

The surface temperature of knobs and levers of appliances shall not present a danger to the user.

Other areas that need to be addressed in the design of the control system are:

a) safety and reliability of control systems;

b) control devices;

c) starting;

d) stopping;

e) selection of control or operating modes; and

f) failure of the power supply.

6.2 Installation of fuel cell system

The fuel cell system shall be properly installed and regularly serviced in accordance with the manufacturer's instructions to ensure that it can be safely and properly operated.

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6.2.1 Location

Ideally, for industrial applications, the fuel cell system should be located outdoors. For indoor installations, the fuel cell system should be located in a well-ventilated area, where combustible materials are minimised.

In designing the installation, consideration should be given as to whether it is necessary to separate the rooms or spaces that enclose the fuel cell installation from other building areas by fire barriers.

Use of appropriate protective devices for openings (i.e. doors, shutters, windows, service entries, etc.) should also be considered. Voids or openings between the room where the fuel cell is enclosed and adjacent rooms, which combustion products could pass should be avoided. The shared walls should be gas-tight. A check should be made that any automatic fire suppression system installed has been correctly specified for the room or space in which the fuel cell system and associated components are located. All installations, including any type of burner should comply with building and fire regulations.

For outdoor installations, weather protection may be required. Hydrogen storage cylinders and vessels located outdoors need to be protected from extreme temperatures (below - 20 °C and above 50 °C). Permanently installed hydrogen vessels shall be provided with substantial supports, constructed of non-combustible material, which is securely anchored to firm foundations of non-combustible material and protected from accidental impact, e.g. from a vehicle. Transportable compressed gas cylinders and vessels shall be secured against accidental dislodgement and protected from accidental impact. The area around hydrogen installations should be kept free of dry vegetation and combustible matter. If weed killers are used, chemicals such as sodium chlorate, which are potential source of fire hazard, should not be selected for this purpose.

6.2.2 System purging

Purging of the system with a suitable medium should be conducted prior to start-up or after shutdown, in accordance with the product application manual specified by the manufacturer.

Systems should be suitably purged using an inert gas (i.e. nitrogen) to prevent little or no mixing between the purge gas and the displaced air. Purging can be implemented by sweep purging, evacuation or repeated pressurisation and venting cycles, using appropriately engineered and sited vent and purge connections. Consideration should also be given to the asphyxiation hazards of using inert gases.

6.2.3 Ventilation

Suitable means shall be provided for the ventilation system according to 7.3.1 of MCMC MTSFB TC G036.

Natural or forced (mechanical) ventilation can be used to prevent the formation of potentially explosive mixtures. Natural ventilation is the preferred method due to its intrinsic reliability. If forced ventilation is used, then the reliability of the system has to be considered.

For indoor spaces and rooms, appliances which are not fitted with devices to avoid a dangerous accumulation of unburned gas or combustion products such as flues should be used only in areas where there is sufficient ventilation to avoid accumulation of substances to dangerous levels.

6.2.4 Pressure systems

Suitable means shall be provided for testing and venting of pressure equipment. The risk assessment for the installation should cover the pressurising and venting operations. Adequate means shall also be provided to permit cleaning, inspection and maintenance in a safe manner of all pressure systems.

6.2.5 Materials selection for installation

Materials used for the installation of fuel cell equipment shall be suitable for such application during the scheduled lifetime unless replacement is foreseen.

In the construction and installation of a fuel cell system, asbestos or asbestos-containing material shall not be used.

Hydrogen gas dissolved in liquids will permeate into adjoining vessel materials; including piping systems and flue gas venting. At elevated temperatures and pressures, hydrogen attacks mild steels severely, causing decarburisation and embrittlement. Adequate allowance or protection against corrosion or other chemical attacks shall be provided, taking into account of the intended and reasonably foreseeable use within the scheduled lifetime of the equipment, if necessary. It is therefore highly recommended for hydrogen to be handled or stored using pressure-compatible materials, such as special alloy steels used for pipe work, vessels, etc.

6.2.6 Piping systems

All fuel cell handling equipment and piping shall be identified and appropriately labelled. It is essential that the piping and its associated joints and fittings to comply with the requirement specified in the related standards.

Pipe routing should reflect consideration of factors such as risk from impact damage, formation of flammable mixtures in poorly ventilated areas, heat sources, etc. Consequently, there should be no mechanical joints where pipe work passes through enclosed ducts, cavity walls, etc.

Piping should preferably be routed above ground. If underground pipe work is unavoidable, it should be adequately protected against corrosion. The position and route of underground piping should be recorded in the technical documentation to facilitate safe maintenance, inspection or repair. Underground hydrogen pipelines should not be located beneath electrical power lines.

Pipe work should be cleaned before being placed into service using a suitable procedure for the type of containment, which provides a level of cleanliness required by the application.

6.2.7 Mechanical and thermal hazards

Equipment shall be designed and constructed to minimise the risk of injuries from moving parts and hot surfaces. If there are moving parts, appropriate guarding should be provided to prevent accidental contact or ejection of failed components. Hot components need to be insulated or a means to prevent accidental contact is to be provided.

6.2.8 Slipping, tripping or falling hazards

Access to the equipment should be as such that there are no slipping, tripping or falling hazards for any person delivering supplies, e.g. gas cylinders, undertaking maintenance or carrying out repairs to the installation.

Rooms or enclosures containing equipment should be fitted with measures to prevent a person from being accidentally trapped within it or, if that is impossible, with a means of summoning help.

6.2.9 Chemical hazards

Adequate measures shall be taken with the use of suitable protection on the parts that have the potential to be exposed to erosion, abrasion, corrosion or any other forms of chemical hazards. Frequent inspection and replacement should be in place for continued safe use.

6.2.10 Electrical safety

The fuel cell system shall be designed in accordance with the power requirement at the dedicated site following the electrical product application manual specified by the manufacturer or other relevant standards.

6.2.11 Electromagnetic compatibility (EMC)

For commercially available equipment, or combinations of equipment made into a single unit, intended for an end user and liable to generate electromagnetic disturbance, or the performance of which is liable to be affected by such disturbance, it should comply with the requirement specified in the relevant standards.

6.2.12 Lightning protection

Outdoor installations may need protection against lightning strikes. This can be achieved by fitting a system for conducting the resultant electrical charge to the earth and by ensuring all equipment are electrically bonded and earthed.

6.2.13 Gas venting

The gas venting system shall be included in the fuel cell system to transfer products of combustion from fuel utilisation equipment to the outside atmosphere.

The manufacturer shall provide either a complete gas venting system or the product's technical document to allow selection of an appropriate gas venting system. The gas venting system shall comply with the requirements as specified in IEC 62282-3-100.

6.2.14 Manual handling

Equipment, or each component part thereof, shall:

a) be capable of being handled and transported safely; and

b) be packaged or designed so that it can be stored safely and without damage.

During the transportation of the equipment and/or its component parts, there shall be no possibility of sudden movements or of hazards due to instability as long as the equipment and/or its component parts are handled in accordance with the instructions.

Considering the weight, size or shape of the equipment or its various component parts, which prevents them from being moved by hand, the equipment or each component part shall:

a) be fitted with attachments for lifting gear;

b) be designed so that it can be fitted with such attachments; or

c) be shaped in such a way that standard lifting gear can easily be attached.

If the equipment or one of its component parts is to be moved by hand, it shall:

a) be easily moveable; or

b) be equipped for picking up and moving safely.

Special arrangements should be made for the handling of tools and/or machinery parts because even if it is lightweight, it could be hazardous. The manufacturer shall specify special means for handling.

6.3 Site considerations

The fuel cell system and associated equipment shall be suitably located to allow access for service, maintenance, fire department and emergency. They also shall be supported, anchored and protected so that they will not be adversely affected by weather conditions (rain, seismic events and lightning) or physical damage. Furthermore, the placing of any components of the fuel cell system shall not adversely affect required building exits, under normal operations or in emergencies.

Besides the general installation procedures for the stationary fuel cell system, the site considerations shall also depend on the fuel being used.

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6.3.1 Hydrogen

For ground-based sites, replacement and refilling modes are both viable options for refuelling gaseous hydrogen. The refilling mode is desirable as it avoids moving heavy storage containers; however, site accessibility can limit its use. Although a slower and more labour-intensive mode of refuelling, cylinders can be moved safely by handcart through spaces that cannot be navigated by a vehicle.

For rooftop sites, replacement and refilling modes are both viable options, but more challenging than for ground-based sites. It is assumed in both cases that the hydrogen storage is on the roof with the fuel cell, as in many cases, there is no suitable space available around the building at ground level or inside the building. For the fill-in-place mode, hydrogen piping can be installed from the storage tanks down the outside of the building to ground level where the delivery truck can connect a refilling hose if allowed by the building owner. For the replacement mode, cylinders (steel or carbon composite) can be taken up an elevator, after which there may be some stairs to roof level. During a power outage or other times when elevators are not operational, cylinders can be carried using a cylinder hand-truck up the stairwell if the building is not too high.

For both ground-based and rooftop sites, compressed gas fuel such as hydrogen is almost always stored separately from the fuel cell cabinet. Compressed gas fuel cell systems tend to have a larger physical footprint compared to liquid-fuelled systems, where fuel can be stored in the base of the fuel cell enclosure. Therefore, storing hydrogen in higher pressure carbon composite tanks can help to reduce the footprint required for fuel.

For hydrogen storage, the effective footprint (i.e. the physical occupied footprint plus the clearance area required for regulatory compliance) of the hydrogen solution tends to be the largest of available options, taking appropriate setback distances into account.

Hydrogen is a very safe fuel to be used on a rooftop, as it is the most buoyant of all gases (relative density of 0.0693 relative to air), and disperses quickly (diffusion coefficient of 0.61 x 10^{-4} m^2/s, compared to gasoline diffusion coefficient range of 0.006 – 0.02 x 10^{-4} m^2/s). In the unlikely event of a leak, hydrogen rises up into the open air and rapidly dilutes to non-combustible concentrations. The LFL of hydrogen is 4 %, which is higher than the LFL of gasoline at 1.2 %.

6.3.2 Methanol

For ground-level sites, methanol fuel can be delivered and dispensed easily from containers such as drums or pails or directly from a fixed-tank fuel truck, if the truck can get close enough to the site that it can be reached by a hose.

For rooftop sites, liquid methanol or water fuel can be transported by elevator in drums, pails, or jugs to the top floor, after which there may be stairs to the roof level. During a power outage or at other times when elevators are not operational, fuel can be carried up the stairwell in pails or jugs, whichever is more manageable for the service personnel.

As a liquid fuel, methanol or water fuel has a higher energy density than a gaseous fuel, thus occupies less volume and can be integrated into the fuel cell cabinet, reducing the physical footprint. For quantities less than approximately 227 ℓ (60 gallons), there are no setback requirements, so the effective footprint can be very small, which is particularly advantageous for rooftops where available area is scarce and expensive.

The LFL of methanol is 6.7 % higher than the LFL of all the other fuels considered in this Technical Code by volume (see Annex B), meaning that more of it needs to accumulate before it can ignite. Methanol vapour density is slightly heavier than air (1.11:1), but it disperses 50 % faster than propane (with a diffusion coefficient of 0.15 x 10^{-4} m^2/s, compared to the gasoline diffusion coefficient range of 0.006-0.02 x 10^{-4} m^2/s) and similar to natural gas. The volatility of methanol is relatively low (32 kPa Reid Vapour Pressure (RVP) versus 48 - 62 kPa RVP for gasoline).

Methanol's relatively neutral buoyancy in air, low volatility, higher dispersion relative to propane and gasoline and its flammability only at high concentrations, are properties that contribute to its safety in general, particularly to be used on rooftops. Consideration should also be given to the toxicity level of methanol gas usage and shall comply with the following regulations:

a) Department of Occupational Safety and Health, *Guidelines on the Monitoring of Airborne Contaminant for Chemicals Hazardous to Health 2002*;

b) Department of Occupational Safety and Health, *A manual of Recommended Practice on Assessment of The Health Risks Arising from The Use of Chemicals Hazardous to Health at The Workplace 2018*; and

c) The National Institute for Occupational Safety and Health, *Emergency Response Safety and Health Database – Methanol: Systemic Agents 2011.*

6.3.3 Natural gas

As no fuel needs to be transported, there are no special transportation considerations for rooftop sites relative to ground-level sites.

Piped natural gas can be used both at ground-based sites and rooftop sites, as long as the infrastructure is available, and the building owner and local authorities allow it. However, natural gas infrastructure is often present only in residential and commercial buildings, so natural gas is a good option for rooftops, but simply may not be available at standalone ground-based telecom sites. If natural gas service is available, consultation with the gas company and landlord is advised to ensure that:

a) the gas service meets the pressure or flow-rate requirements of the fuel cell; and

b) the landlord or other tenants agree to share the gas supply.

Natural gas is lighter than air (0.55 methane to air relative density), and its dispersion rate (diffusion coefficient of 0.16 x 10^{-4} m^2/s, compared to gasoline diffusion coefficient of 0.006–0.02 x 10^{-4} m^2/s) is comparable to that of methanol vapour. Natural gas leaks tend to rise in air and disperse 8 to 27 times faster than gasoline.

The LFL of methane (the principal constituent of natural gas) is slightly lower (5 % by volume) compared to that of methanol and higher than the LFL of gasoline and propane. The high buoyancy of natural gas, coupled with its relatively high LFL and good dispersion properties are factors that contribute to its safety.

6.3.4 Propane

For ground-level sites, propane tanks can be swapped, or the fuel can be dispensed directly from a propane bobtail truck if the truck can get close enough to the site that it can be reached by a hose.

For rooftop sites, propane can be transported by elevator in smaller tanks, after which there may be some stairs to the roof level. During a power outage or at other times when elevators are not operational, fuel can be carried up the stairwell in tanks with manageable size by the service personnel.

Since propane exists as a liquid under pressure, propane has a higher energy density than a gaseous fuel, and thus occupies less volume. The fuel tank is often external to the system, adding to the physical footprint; however, the high energy content and volumetric density of propane enable long run times in a relatively small fuel storage space. No setback requirements apply to tanks smaller than approximately 454 ℓ (125 gallons); however, in prime power applications, larger tanks are desirable to reduce the frequency of refuelling visits.

Propane vapour is heavier than air (1.56 relative density), so propane vapour tends to pool and not disperse well (diffusion coefficient of 0.10 x 10^{-4} m^2/s, compared to gasoline diffusion coefficient range of 0.006–0.02 x 10^{-4} m^2/s). The LFL of propane is comparable (2.1 % by volume) to the LFL of gasoline. Leaks are in gaseous form, as propane cannot exist in liquid form at atmospheric pressure.

In practice, propane systems can be difficult to site on rooftops for the same reason gasoline combustion-engine generators are not permitted on rooftops: the safety concerns of heavier-than-air vapours, low LFL, and high volatility are similar. Propane is common for residential and commercial use, and siting propane systems is straightforward for ground-based installations.

6.3.5 Fuel comparison

Some properties of hydrogen, methanol-water, propane, and natural gas for fuel cells are compared in the Table B.1 (see Annex B). The data reflect information at the time of publication of the referred document from Telecommunications Industry Association USA.

The footprint versus operating time with a 5 kW load is shown in Table 1 below for 6 different potential fuel options.

Table 1. Potential fuel options for 5 kW load

No.	Fuel Cell Type	Fuel	Total Cylinder / Total Volume	Cylinder Material	Pressure (bar)	Refuelling Configuration
1.	Hydrogen fuel cell	Hydrogen	8 cylinders	300 series steel	~ 165 (2,400 psi)	Swappable
2.	Hydrogen fuel cell	Hydrogen	8 cylinders	90 ℓ carbon composite	~ 345 (5,000 psi)	Fill-in-place cabinet
3.	Hydrogen fuel cell	Hydrogen	16 cylinders	large steel	~ 207 (3,000 psi)	Fill-in-place cabinet
4.	Hydrogen fuel cell	Methanol	Approximately 223 ℓ (59 gallons) internal tank (located within fuel cell enclosure under fuel cell equipment - no incremental footprint for fuel)	N/A	N/A	N/A
5.	Hydrogen fuel cell	Methanol	Approximately 1041 ℓ (275 gallons) intermediate bulk container external tank	N/A	N/A	N/A
6.	Propane fuel cell	Propane	Approximately 473 ℓ (125 gallons) propane tank	N/A	N/A	N/A

Figure 3 below outlined the comparison between footprint and operating time with 5 kW load for six different fuel cell systems.

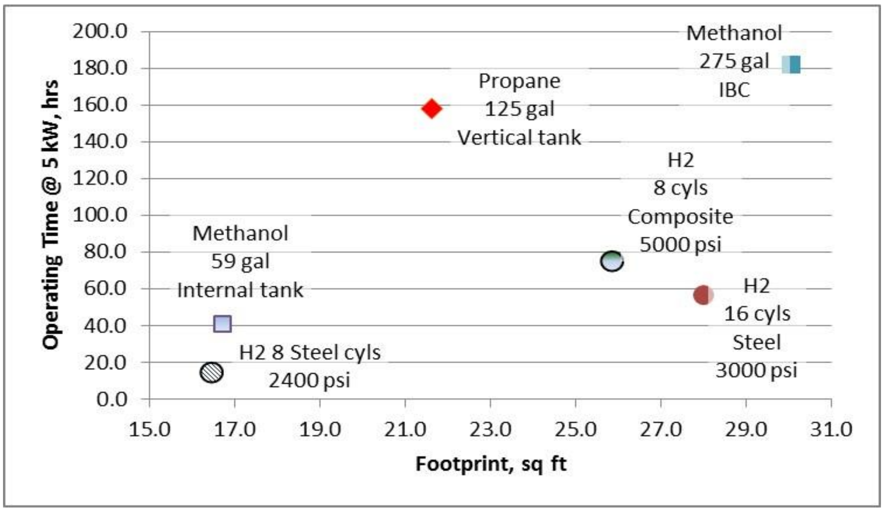

Figure 3. Comparison between footprint and operating time with 5-kW load for 6 different fuel cell systems

7. Operational or maintenance considerations

Maintenance works shall be performed regularly at suitable intervals.

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7.1 Equipment maintenance

Adjustment and maintenance points shall be located outside danger zones. It shall be possible to carry out adjustment, maintenance, repair, cleaning and servicing operations while equipment is at a standstill. If one or more of the above conditions cannot be fulfilled for technical reasons, measures shall be taken to ensure that these operations can be carried out safely. A connecting device to mount diagnostic fault-finding equipment shall be provided for automated equipment and other equipment, if necessary.

Automated equipment components that have to be changed frequently should be capable of being removed and replaced easily and safely. Access to the components should enable these tasks to be carried out with the necessary technical means in accordance with a specified operating method.

Particular attention should be given to the design and location joints in the system that may require regular maintenance, or where mechanical joints will be frequently disturbed or prone to break as the likelihood of leaks in these areas is increased.

7.2 Access to operating positions and servicing points

Equipment shall be designed and constructed in such a way as to allow a safe access to all areas where intervention is necessary during operation, adjustment and maintenance of the equipment.

7.3 Isolation of energy sources

Equipment shall be fitted with means to isolate it from all energy sources. Such isolators should be clearly identified. They shall be capable of being locked if reconnection could endanger people. Isolators shall also be capable of being locked where an operator is unable to check that the energy is still cut off, from any of the points to which he has access. In the case of equipment capable of being plugged into an electricity supply, removal of the plug is sufficient, provided that the operator can check that the plug remains removed, from any of the points to which he has access.

After the energy is cut off, it shall be possible for any energy remaining or stored in the circuits of the equipment to dissipate normally without risk to people. As an exception to the requirement mentioned earlier, certain circuits may remain connected to their energy sources in order to hold parts, to protect information, to light interiors, etc. In this case, special steps shall be taken to ensure the operator's safety.

7.4 Operator intervention

Equipment shall be designed, constructed and equipped that the need for operator intervention is limited. If operator intervention cannot be avoided, it should be possible to carry it out easily and safely. If needed, operator intervention can only be carried out by an authorised person.

7.5 Emergency planning

It is recommended that an emergency plan should be in place wherever compressed gaseous or cryogenic fluids are produced, handled or stored in accordance with NFPA 55. This emergency plan should include the following:

a) The type of emergency equipment available and its location.

b) A brief description of any testing or maintenance programs for the available emergency equipment.

c) An indication that hazard identification labelling is provided for each storage area.

d) The location of posted emergency procedures.

e) A list, including quantities, of compressed gases and cryogenic liquids and their materials Safety Data Sheets (SDS) or equivalent.

f) A facility site plan including the following information:

    i) storage and use areas;

    ii) maximum amount of each material stored or used in each area;

    iii) range of container sizes;

    iv) the location of gas and liquid conveying pipes;

    v) locations of emergency isolation and mitigation valves and devices;

    vi) on and off positions of valves for those that are not self-indicating; and

    vii) a storage and distribution plan that is legible and drawn approximately to scale showing the intended storage arrangement, including the location and dimensions of walkways.

g) A list of personnel who are designated and trained to act as a liaison with the emergency services and who are responsible for the following:

   i) aiding the emergency services in pre-emergency planning;

   ii) identifying the location of compressed gases and cryogenic fluids stored or used;

   iii) accessing SDS; and

   iv) knowing the site emergency procedures.

8. Marking, labelling and packaging

For marking, labelling and packaging requirements of the fuel system and fuel cell system, the manufacturer shall comply with the applicable laws and shall refer to Table 2 below:

Table 2. Marking, labelling and packaging requirements

No.	Systems	Standards
1.	Fuel	a) MCMC MTSFB TC G023 b) IFC 5303.4 c) NFPA 55
2.	Fuel Cell	a) ISO 3864-2 b) IEC 62282-3-100 c) ANSI/CSA America FC 1-2004

9. Permitting route

Currently there is no formalised route for the approval of a hydrogen and fuel cell stationary installation.

9.1 General permitting checklist

The permitting route required for a particular installation should be proportionate to the scale and complexity of the installation.

The approval checklist below is intended to apply to both new-build and retro-fitted commercial or industrial installations.

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9.1.1 Step 1 - Risk assessment

Undertake a risk assessment to identify the hazards and the measures to be implemented to eliminate or mitigate their effects. The principal hazards will be the ones related to fire and explosion, but other hazards, e.g. electrical, pressure and weather related (for outdoor installations), will also need to be considered. The hazards arising throughout the lifetime of the installation have to be covered by the assessment. This would include hazards associated with the installation of the equipment, start-up and shutdown of the equipment, delivery of consumables (e.g. gas cylinders) as well as the maintenance and repair of the equipment. Guidance on how to undertake a risk assessment can be found in Annex C.

9.1.2 Step 2 - Legislations

The equipment used in the installation shall comply with the essential health and safety requirements of all applicable legislations and standards. The related codes and standards for hydrogen and fuel cell can be referred to Annex B of MCMC MTSFB TC G036.

The processes are in place to protect public safety, public health and the environment. An example of the permits and purposes for these multiple permitting processes are shown in Table 3 below.

Table 3. Example of fuel cell permitting

Permit	Permit Scope
Construction	Permit to construct in general: address safety construction issues
Drainage	Permit to construct drainage: modification to sewer drainage
Site grading	Permit to construct grading: modification to site elevation
Electrical Building	Modification to electrical service
Demolition Building	Demolish structures required for dispenser construction
Air emission impacts	Air quality permit or no impact declaration
Fire safety	General fire code compliance

9.1.3 Step 3 - Installation issues

The equipment is to be installed and maintained by a competent person. At present, there is no national scheme in place for training and assessing the competency of persons to install fuel cell systems, although some manufacturers do have schemes to train installers and service engineers.

9.1.4 Step 4 - Emergency responders

The local fire brigade is to be informed of the location and type of installation and to be given the opportunity to visit the installation. Particular interest would be the location and quantity of any hydrogen stored at the site.

9.2 Permitting processes

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The permitting processes can be broken down into seven stages that help define the overall process and the timeline for completing all the required components.

a) Preliminary project scoping.

b) Facility design.

c) Approval process.

d) Facility construction.

e) Facility start-up.

f) Facility operation.

g) Facility maintenance.

The required permits address all these phases, but the permitting structure does not correlate on a one to-one basis with the chronological steps required to build and operate a fuel cell.

The administrative process for reviewing and approving projects may vary by jurisdiction, but there are common elements which are as follows:

a) Pre-submittal review and feedback.

b) Review and feedback to applicant.

c) Formal submission of application.

d) Public meeting (on an as-needed basis determined by both administrative law and the jurisdiction's determination as to whether public input should be solicited).

e) Make adjustments in the permit application (as needed) based on public input.

f) Review of modified application and feedback to application.

g) Resubmittal of modified application.

h) Issuance of permit.

i) Project construction.

j) Site inspection to determine the project built as shown in final design plans.

k) Periodic inspections to determine ongoing compliance.

The pre-submittal review is a critical step in this process. Significant problems could be identified and potentially averted during this process. Examples of problems that could be averted are:

a) Identification of problems at the proposed site that the applicant is not aware of.

b) Identification of requirements the project should meet that the applicant had not evaluated in the draft application.

c) Any history of issues with similar projects in the jurisdiction.

Annex A
(Informative)

Normative references

The following normative references are indispensable for the application of this Technical Code. For dated reference, only the edition cited applies. For undated references, the latest edition of the normative reference (including any amendments) applies.

MCMC MTSFB TC G023, Hydrogen Storage and Safety with Fuel Cell as Power Generator for Information, Communications and Technology Infrastructure

MCMC MTSFB TC G036, Fuel Cell System - General Operational and Safety Requirements

IEC 62282-3-100, Fuel cell technologies: Stationary fuel cell power systems - Safety

RR715, Health and Safety Executive (HSE) Installation permitting guidance for hydrogen and fuel cell stationary applications: UK version

Telecommunications Industry Association (TIA) USA Reference Guide - Regulations, Codes, and Standards for The Deployment of Stationary Fuel Cells

Annex B
(Informative)

Comparison of fuel attributes

Table B.1 below listed the comparison of fuel attributes.

Table B1. Comparison of fuel attributes

Type	Hydrogen	Methanol/Water	Propane	Natural Gas
Small fuel cell status[1]	Commercial	Commercial	Early commercial	Early commercial
Fuel cell module size[2]	0.2 - 10 kW	0.3 - 7.5 kW	0.25 - 5 kW	0.25 - 5kW
Small fuel cell vendors	Many	Few	Few	Few
Typical usage	Backup power	Backup power	Prime power	Prime power
Fuel state	Compressed gas	Stable liquid	Liquid under pressure	Compressed gas
Density relative to air[3]	0.0693	1.11	1.56	0.55
Lower flammability limit[4]	4 %	6.7 %	2.1 %	5 %
Reid vapour pressure[5]	N/A (gas)	32 kPa	N/A (gas)	N/A (gas)
Diffusion relative to gasoline[6]	30 - 102 faster	7.5 - 25 faster	5 - 17 faster	8 - 27 faster
Mode of transport	Steel or composite cylinders	Plastic or metal totes, drums, pails, jugs	Portable tanks or bobtail truck	Piped infrastructure
Mode of storage	Steel or composite cylinders	Integrated tank or external metal tank	Integrated tank or external pressurized tank	N/A
Mode of refuelling	Cylinder swap or fill-in-place	Pour or pump liquid	Swap tanks or refill with propane-specific nozzles/valves	No refuelling – direct feed from piped infrastructure

Notes:

1. “Commercial” means products that are available for sale in meaningful numbers, are supported with service and spare parts, and have evidence of deployment in significant numbers. “Early Commercial” means products that are available for sale, but no evidence exists yet of deployment in significant numbers.
2. Modules can be cascaded for higher site power requirements.
3. For reference, typical gasoline density is 3 - 4 relative to air: http://tsocorp.com/wp-content/uploads/2012/12/Gasoline-Unleaded-Regular.pdf
4. For reference, compare to typical gasoline LFL of 1.2 %: https://www.mathesongas.com/pdfs/products/Lower-(LEL)-&-Upper-(UEL)Explosive-Limits-.pdf
5. For reference, compare to typical gasoline RVP of 48-62 kPa: http://www.epa.gov/otaq/fuels/gasolinefuels/volatility/standards.htm
6. For reference, diffusion coefficient of gasoline ranges from 0.006-0.02x10-4 m2/s: http://www.jocet.org/papers/012-J30011.pdf

Table B1. Comparison of fuel attributes (*concluded)*

Type	Hydrogen	Methanol-Water	Propane	Natural Gas
Minimum quality	99.95 % industrial-grade hydrogen	Methanol: IMPCA specifications; Water: ASTM 1125, ASTM D5907, IMPCA 004-08, ASTM D4517; 61 %-63 % methanol by weight	HD5 HD5 spec propane consists of: Minimum of 90 % propane, Maximum of 5 % propylene - propylene is used in the manufacture of plastics, and Other gases constitute the remainder (iso-butane, butane, methane, etc.	Contact gas company or landlord to assure adequate pressure and flow rate for application
Ground-based site considerations	Suitable given sufficient space for fuel storage respecting setback limits	Integrated tank less than approximately 227 ℓ (60 gallons) allows deployment in tight spaces	Suitable given sufficient space for fuel storage	May not find natural gas service at all ground sites
Rooftop-based site considerations	Safe given hydrogen properties; fuel logistics challenges, especially when elevator not available	Safe given methanol properties; liquid fuel simplifies fuel logistics - delivering to site and carrying up to the roof	May be challenges due to properties of propane; small tank delivery enables service to roof when elevator not available	If natural gas service is available, no site visits required for fuel delivery; current architectures more suitable for prime power than backup power

Annex C
(Informative)

Steps of risk assessment

An example of the necessary steps to complete a risk assessment is given below. This is not the only way to perform a risk assessment but this method helps to assess health and safety risks in a straightforward manner. The law does not expect all risks to be eliminated, but protection of people as far as 'reasonably practicable' is required. This guidance on how to undertake a risk assessment is reproduced from HSE document with permission of the Health and Safety Executive under the terms of the Open Government Licence.

a) Step 1 - Identify the hazards.

The types of hazards identified and the methods used will vary according to the complexity of the installation.

Areas to be considered when identifying the hazards may/will include site location, site evaluation, hydrogen storage location, security, choice of materials, access, deliberate attack and vandalism, impact, ventilation, fire protection, location of safety sensors and connection to grid.

A suitable emergency plan should be drawn up in the event of a leak or fire.

b) Step 2 - Decide who may be harmed and how.

For each hazard identified in Step 1, assess who might be harmed and how.

c) Step 3 - Evaluate the risks and decide what to do about them

Consideration should be given in removing the hazard and if that is not practical, how the hazard can be reduced or controlled.

d) Step 4 - Record and implement the findings

The risk assessment should show that all significant hazards have been recorded and addressed. It should also show how the hazards can be eliminated, or if they cannot be eliminated, how their effects will be minimised. Employees should be informed about the outcome of the risk assessment. The precautions taken should be reasonable and if there is a residual risk, it should be low.

e) Step 5 - Review the risk assessment and update if and when necessary

Records of the installation, maintenance checks and servicing should be kept.

Any changes to the installation, work activities, process or incidents should be recorded, followed by a review of the risk assessment and implementation of additional safety measures, if necessary.

A risk assessment can be considered as "suitable and sufficient" if it has:

a) correctly identified all the hazards;

b) disregarded inconsequential risks and those trivial risks associated with life in general;

c) determined the likelihood of injury or harm arising;

d) identified those who may be at particular risk, such as pregnant ladies, elderly or disabled persons;

e) taken into account any existing control measures;

f) identified any specific legal duty or requirement relating to the hazard;

g) provided sufficient information to decide upon appropriate control measures, taking into account;

h) the latest scientific developments and advances;

i) enabled the remedial measures to be prioritised; and

j) remain valid for a reasonable period of time.

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Acknowledgements

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