Consideration should be given to siting walkways at a level to optimize escape routes in the event of inundation. This should be balanced against the risk of smoke inhalation in the event of a fire.

Electrical supplies to the pumping equipment should be located above a floodable level so that the pumps can be operated to recover the tunnel when they are required. If this cannot be achieved, then the electrics should be protected to at least IPx7.

The risk that an underground structure will be flooded from an access shaft, other passage or adjoining tunnel or utility should be considered in advance.

NOTE 3 This is obvious when making sewer connections but is less obvious when tunnelling in proximity to water mains and sewers which can fail without warning due to ground movement.

Shafts and tunnel workings should be provided with a communication system to make flood warnings effective. Immediate action to be taken if the shaft is threatened with flooding should include:

a) withdrawal of all persons from below ground, if necessary;

b) closure of all working openings situated below possible flood level, after all persons have been withdrawn;

c) arrangements for continuous monitoring of water levels, with inspection of any points of risk;

d) strengthening of any vulnerable points, using sandbag protection where appropriate;

e) preparation and putting into use of, as appropriate, emergency pumps, or any other standby plant;

f) preparation of isolation of the electrical supply to the threatened workings;

g) informing third parties whose apparatus/structures may cause harm to the general public if damaged; and

h) assessing the risk that contaminants could have been brought into the structure under construction.

14.16 Recovery of the situation following inundation

The cause of inundation should be established and steps should be taken to prevent further inundation before re-entry is considered. Re-entry procedures should include:

- ensuring the structure is stable;
- ensuring that the atmosphere is fit for respiration and free from potentially explosive gases;
- ensuring that plant and electrical equipment are safe; and
- as early as practicable, all strutting, timbering and supports in the structure, together with walkways, stairways and gantries should be inspected and made safe.

After submergence, all machinery and plant should be carefully inspected and reconditioned as necessary. Electrical cables and equipment, in particular, require special care in drying out, and should be tested prior to use. Hydraulic oil tanks should be drained and refilled. If the risk of flooding is persistent, compressed air should be used, instead of electricity, for power in the tunnel.

15 Ventilation

15.1 General

The principal objective of the ventilation system should be the provision of a healthy and safe working environment for all in the tunnel without the need for recourse to respiratory protective equipment on a routine basis. A balanced ventilation system to provide fresh air and to mitigate the risk from atmospheric contaminants including heat, should be designed in advance, with the capacity and flexibility to allow growth and adaptation as excavation progresses.

NOTE 1 Experience shows the quantity of fresh air required is usually determined not by life support requirements but by the need to counter atmospheric contaminants and to provide cooling.

*NOTE 2 Attention is drawn to The Construction (Design and Management) Regulations 2015 [1] for requirements on the supply of fresh or purified air for safety. The Regulations give no figures for minimum requirements for the fresh air supply (see **15.2**). Additionally, there are requirements that any equipment used to conform with the requirement to provide a safe environment is equipped with audible or visual warning of any failure of the plant.*

The design and installation of the ventilation should be overseen by a ventilation specialist. The following factors should be taken into account when determining ventilation requirements:

- the tunnelling technique to be adopted, mechanized or conventional;
- the nature and quantity of toxic, asphyxiant or radioactive gases foreseeably likely to be present;
- the quantity of flammable gas foreseeably likely to be present and any zoning as required by the Dangerous Substances and Explosive Atmosphere Regulations 2002 (DSEAR) [30];
- the nature and quantity of dust foreseeably likely to be present. SCL works will require a decision on extraction or forced main ventilation;
- the likely need to deal with heat and/or humidity;
- the number of persons working underground and their locations;
- plant and equipment in the tunnel and whether it is diesel or electrically powered;
- the physical layout of the tunnel or tunnel complex, how it will change as construction proceeds and how the demands and constraints these changes might impose on the ventilation;
- the prevention of secondary exposure by directly ducting contaminants from the tunnel; and
- background levels of contaminants likely to enter the tunnel in the ventilation system.

As construction proceeds the effectiveness of the ventilation system should be reviewed at regular intervals and all necessary steps taken to ensure its continuing fitness for purpose.

NOTE 3 High humidity is characteristic of tunnels. Increased air temperatures can result from any plant working in a tunnel, from the use of explosives and from grouting and concreting operations. The natural ground temperature also greatly influences the air temperature.

As the mechanical efficiency of a ventilation system can be seriously impaired by poor duct design installation and maintenance, all necessary steps should be taken to prevent unwanted reductions in airflow. This should be done by means such as using proper joints in duct lines, using rigid bends at major changes in duct alignment, rigid fittings at bifurcations, etc.

Discharge or intake points should be moved at regular intervals to maintain system efficiency and to reflect the advancing tunnel faces.

Regular inspection and maintenance of the ventilation system should be undertaken with any leaks, damage, restrictions to airflow, etc., being expeditiously repaired.

Procedures should be set out for regularly testing the operation and efficiency of each ventilation system particularly in long tunnels. The tests should also be used to determine whether the system continues to meet operational requirements, taking account of changes in tunnel length or configuration since the previous check. Appropriate modifications should be made as necessary.

Procedures should also be set out for the withdrawal of personnel where necessary. These procedures should be rehearsed periodically. In general, any unintended interruption in the ventilation should result in the cessation of works and the withdrawal of personnel until the ventilation is restored. For the control of dust by extraction ventilation, a minimum average velocity of at least 0.3 m/s should be maintained in the air-body along the tunnel to prevent the movement of dust against the direction of air flow. This should be increased to at least 0.5 m/s for the flow of dust laden air to maintain dust capture and prevent precipitation of dust. Because of the very limited zone of influence of an extraction duct, multiple intakes should be considered to ensure adequate dust capture across the working face. To avoid the need to enter under unsupported ground, mechanical handling or extension of the ducts should be considered.

For the control of dust by forced ventilation, an overlap system should be employed at the face with local extraction into de-dusters as necessary. De-dusting should be sufficiently effective that respiratory protective equipment is not required outbye the de-duster units. Adjacent to the face, the objective should be to maintain an average flow towards the face of at least 0.3 m/s and transversely across the face of 0.5 m/s towards the de-duster intakes.

A nominal velocity of 2.0 m/s should be considered to prevent layering of methane where it occurs (see **12.2**).

The blockage effect of plant and machinery should be taken into account when trying to achieve these velocities and local air movers or brattices should be provided to ensure these velocities are achieved.

It should be recognized that within the first few diameters of any drive, there are difficulties in containing dust due to the effects of general turbulence in the air body and local arrangements might be necessary.

15.2 Guidelines for fresh air supply quantities

A minimum fresh air supply of 0.3 m^3/min per person should typically be sufficient to maintain a respirable atmosphere. Additional ventilation should be provided to take account of the construction plant or equipment used, and to mitigate the effects of exhaust emissions and/or heat generated. Only fresh air should be used for ventilation to improve the quality of air in the tunnel and oxygen should never be discharged to counteract low oxygen levels.

For ventilation to control exposure to diesel engine exhaust emissions, the requirements should be based on actual emissions, number and type of machines and operating patterns.

*NOTE Previously, a minimum supply of at least 3.0 m^3/min per working kilowatt was recommended for diesel powered machines with stringent emission controls (see **24.8.1**), however even this flow rate can be insufficient to control nitrogen oxide levels. Furthermore, the likely future reduction in exposure limits (see **15.4.3**) will further increase fresh air requirements. Methods for calculating flow rates required to dilute nitrogen oxides are set out in the Br Tunnelling Society publication "Occupational exposure to nitrogen monoxide in a tunnel environment - Best Practice Guide" (April 2008) [N1].*

The ventilation supply should be designed to maintain atmospheric contaminants within acceptable levels and depends on the type and capacity of construction plant being used. Stringent controls on emissions and the adoption of other good practices should reduce the volume of air required.

For mechanized tunnels information on the heat output from the TBM should be provided by the manufacturer. Consideration should be given to providing local draw off points or the use of air movers to allow the adequate ventilation of all workplaces on the TBM; particularly to counteract heat generated by the machine.

If methane or another potentially explosive gas is present, additional considerations should apply. In this case the danger of explosion is of primary importance and the air supplied should mix and dilute the gas, wherever it appears, to levels significantly below the LEL (see **12.5**).

Recommended minimum air velocities, averaged across the tunnel section, should be 0.3 m/s to prevent backflow of dust, 0.5 m/s to transport dust where it is produced, or a nominal velocity of 2.0 m/s to prevent layering of methane where it occurs (see **12.2**). The blockage effect of plant and machinery should be taken into account when trying to achieve these velocities and local air movers or brattices should be provided to ensure these velocities are achieved.

15.3 Quality of air

NOTE 1 Fresh air contains approximately 20.9% oxygen, 79.0% nitrogen and 0.04% carbon dioxide by volume. The remainder includes argon and other gases.

The tunnel atmosphere should be considered as oxygen-deficient when the concentration of oxygen falls below 19%.

The important physical aspects of air quality which should be taken into account are temperature, humidity and velocity. The air as supplied should be as cool and dry as is reasonably practicable, as during its passage into the tunnel its temperature tends to become that of the tunnel walls and it takes up moisture in the tunnel.

Wherever possible, the wet-bulb temperature in any working area should not be allowed to exceed 27 °C.

NOTE 2 A lower temperature can contribute greatly to comfort and efficiency.

If strenuous physical effort, e.g. hand excavation, is required in conditions of high temperature, humidity or low air velocity, the risk of heat strain should be assessed and medical advice sought on appropriate mitigation measures.

Air with a reduced oxygen concentration or deoxygenated air should be treated as a potentially hazardous contaminant. Its likely occurrence should be calculated particularly when tunnelling in carbonaceous strata, the Lambeth group or similar strata with high sulfide content. The likelihood of its occurrence can vary with changes in barometric pressure; falling barometric pressure in particular should be considered to give an increased risk of its occurrence. Deoxygenation of air should also be considered foreseeable when tunnelling in other ground types such as permeable organic deposits (see **11.5.4**).

NOTE 3 Previously deoxygenation was considered to be due to oxidation of glauconitic minerals in the Thanet Sands. Whilst this source of deoxygenation has not been conclusively disproved, research has shown that deoxygenation of air in the Upnor formation by so called "green rust" can also occur (Journal reference: Newman, T. G., Ghail, R. C., and Skipper, J. A., 'Deoxygenated gas occurrences in the Lambeth Group of central London, UK' Quarterly Journal of Engineering Geology and Hydrogeology May 2013).

Precautions should be taken where these strata are encountered in partially saturated conditions, as fluctuations in tunnel pressure either in response to changing meteorological conditions or when compressed air in use in the vicinity is removed or reduced in pressure can result in deoxygenated air being released from the ground into the tunnel.

Another source of deoxygenated air which can affect those on the TBM and for which ventilation should be provided is the gas release from the air bubble of slurry TBMs.

*NOTE 4 Attention is drawn to The Health and Safety at Work, etc. Act 1974 [12] and to The Control of Substances Hazardous to Health Regulations 2002 [36], which require levels of airborne contaminants (as defined in Guidance Note EH40 [37]) to be reduced as low as reasonably practicable. Attention is also drawn to the workplace exposure limits for airborne contaminants set out in Guidance Note EH40 [37] (see **15.6**.)*

15.4 Atmospheric monitoring

15.4.1 Monitoring equipment

Continuous atmospheric monitoring should be undertaken for oxygen concentration along with monitoring for the presence and concentration of all foreseeable atmospheric contaminants either from the ground or from the tunnelling process. Monitoring should be undertaken in real-time typically by means of fixed monitoring stations. The system should have multi-level alarm and data logging capability. Monitoring stations should be connected to the tunnel data and communications network. Monitoring stations should normally incorporate an alarm sounder.

In mechanized tunnelling, there should be monitoring stations on the TBM whilst in conventional tunnelling there should be a monitoring station close to the face. Additional monitoring stations should be provided in all tunnels as necessary. Real time concentrations should be displayed locally at the monitoring station, to the TBM operator, at the access control point to the tunnels and in the site offices. Data from the monitoring system should be stored for the duration of the contract.

Portable monitoring instruments should be used to supplement the fixed monitoring network and may be used for routine monitoring purposes in small-diameter, short life-span tunnels and headings.

All personnel should be within the range of audible and visual alarms protecting their work area.

Monitoring should be undertaken using instruments conforming to BS EN 50104, and for flammable gases to BS EN 60079-29-1. Routine calibration and functional checks on monitoring equipment should be undertaken in accordance with the manufacturer's recommendations.

15.4.2 Alarm settings for atmospheric monitoring equipment

NOTE Guidance on exposure limits is given in publications such as the HSE's EH40 [37].

While there should be no ambiguity about the point at which evacuation occurs and the action to be taken to achieve this, supervisory staff in tunnels should be made aware of developing unsafe situations by the use of the multi-level alarm capability so that an investigation can be carried out and corrective action taken before evacuation becomes unnecessary.

The alarm settings and responses in Table 7 should be adhered to. Where the atmospheric monitoring equipment does not have the capability for multiple level alarms, the alarm settings and response should be as for Level 2 Alarms in Table 7.

Table 7 — *Alarm settings and responses*

Hazard	Level 1 Alarm (Warning)	Level 2 Alarm (Evacuation)
Oxygen (deficiency)	19.5% by volume	19% by volume*
Oxygen (enrichment)	22% by volume	23% by volume
Flammable gas	5% LEL[A)]	10% LEL[A)]
Toxic gas	50% STEL	100% STEL*
Interpretation of alarm and response	There is a threat to safety from the atmosphere but it remains safe without donning a self-rescuer and evacuating. Action should be taken to ascertain the cause of the threat and put mitigating measures in place.	There is an atmospheric problem. Tunnel should be evacuated in accordance with emergency plan.

For conditions marked * (oxygen deficiency or the presence of toxic gas), self-rescuers should be put on immediately.

A) In the general body of air and until explosion protected equipment has been installed (see 12.5 action level 1).

15.4.3 Limits for potentially explosive gases where no specific guidance is given

Where flammable or potentially explosive gases such as those listed in 15.4.2 (other than methane), or gas mixtures, occur, and no specific guidance is given in 15.4.2 or any other standard reference material, the recommendations in Clause 12 should be followed. In particular, the recommendations given in 12.5 relating to specific concentrations of the gas, in terms of percentage of LEL, should be followed.

15.5 Unoccupied tunnels and stagnant areas

NOTE Toxic gases, mixtures deficient in oxygen, or explosive mixtures can accumulate in areas where there is little circulation of air, such as unventilated tunnels, shafts, sumps or headings. Gases denser than air, such as carbon dioxide, tend to flow to low points and remain there. Methane is less dense than air but, when mixed with other gases, can accumulate at any level in a tunnel. The risks are particularly high when disused or abandoned tunnels or shafts need to be entered, but they are also present when a tunnel or shaft is re-entered after a brief shutdown, such as a weekend.

No one should enter an unoccupied tunnel unaccompanied. Persons entering should be in possession of atmospheric monitoring and personal protective equipment (self rescuers), having first established that a ventilation system is working and that the return airflow has been tested and is safe.

For operational tunnels, the natural ventilation flow should be monitored.

For tunnels with no ventilation or return flow, a bespoke safe system of work should be devised. Additional personnel should be on call and such operations should be planned on a "permit to work" and "confined spaces entry" basis.

Factors that should be taken into account include:

a) the competence of the personnel;

b) whether the passages to be entered can form a gas sump;

c) the nature of the ground and its potential for harmful or explosive gases;

d) the length of time during which the tunnel has been unoccupied;

e) the natural ventilation of the tunnel; and

f) the difficulty of rescue.

Sewers, whether in use or abandoned, can be particularly hazardous and should be entered only with the approval of the local water and sewage undertaker and in accordance with normal sewer entry procedures.

15.6 Hazardous gases

15.6.1 General

The hazardous nature of gaseous contaminants in the tunnel atmosphere should be taken into account, as some are toxic, flammable/potentially explosive, radioactive or asphyxiant. It should be recognized that some contaminants display a combination of toxic and potentially explosive properties. It should also be recognized that the monitoring and control of such gases in a tunnel atmosphere can be difficult because the concentrations rarely remain constant throughout a working day.

Guidance Note EH40 [37] deals comprehensively with the toxicity of airborne contaminants and should be consulted for information on maximum exposure limits and workplace exposure limits for a wide range of contaminants at atmospheric pressure.

NOTE It includes a full explanation of the terms "maximum exposure limit" and "workplace exposure limit". The potential for explosion is not dealt with in EH40 [37] but information on flammability limits can be found in publications such as the "Gas Encyclopaedia" published by Air Liquide (http://encyclopedia.airliquide.com/encyclopedia.asp).

Expert occupational health advice should be sought in assessing the effects of complex mixtures such as fuel residues, not dealt with in Guidance Note EH40 [37].

Individuals vary greatly in their sensitivity or susceptibility to toxic substances, and as the factors controlling this variability are not well understood, it should not be assumed that conditions which are safe for some individuals are safe for all.

Although immediate incapacitation as a result of exposure to the workplace exposure limit concentrations is considered unlikely, the occupational ill-health which can arise from such exposure should not be overlooked. Concentrations of all atmospheric contaminants should be kept as low as is reasonably practicable (see **15.3**).

15.6.2 Simple asphyxiant

COMMENTARY ON ***15.6.2***

Certain gases and vapours, when present in air in sufficient quantities, act as simple asphyxiant. Without other significant physiological effects, they reduce the oxygen concentration by dilution to such an extent that life cannot be supported. Some simple asphyxiants also present an explosion hazard, e.g. methane.

The concentration of asphyxiant, e.g. carbon dioxide, should be monitored directly and not by reliance on monitoring the oxygen concentration alone (see **15.3** and **15.4.1**), because the asphyxiant displaces both oxygen and nitrogen in the air in proportion to their volumetric concentrations and, as there is approximately four times as much nitrogen as oxygen in air, a gross underestimation of the asphyxiant concentration can result if direct measurement of its concentration is not undertaken.

NOTE Apart from physical displacement of oxygen by carbon dioxide, methane, etc., chemical depletion of oxygen in a confined space can occur due to combustion or corrosion leaving an asphyxiant atmosphere.

Nitrogen gas vented from ground freezing operations is hazardous and should not be allowed to accumulate as that can lead locally to an asphyxiant atmosphere being formed.

15.6.3 Atmospheric contaminants commonly encountered in tunnelling

COMMENTARY ON ***15.6.3***

The workplace exposure limit quoted in this subclause are those specified in Guidance Note EH40 [37].

Relevant information on these gases is summarized in Table 8.

15.6.3.1 Carbon monoxide (CO)

COMMENTARY ON ***15.6.3.1***

Carbon monoxide is highly toxic and rarely occurs naturally. It is always produced during the burning of carboniferous materials, especially in fires with restricted air supply. It can also appear in a tunnel environment owing to slow combustion of coal and timber or from spontaneous combustion.

The most common sources of carbon monoxide which should be considered in tunnelling are internal combustion engine emissions and blasting fume. Petrol engines should not normally be used in tunnels under construction, as their exhaust emissions can contain up to 10% carbon monoxide (see **24.8.2**).

NOTE 1 Carbon monoxide is potentially explosive in concentrations of between 12.5% and 74.2%.

NOTE 2 Diesel engine exhaust emissions usually have a much lower concentration of carbon monoxide, the amount depending upon the size of the engine, its state of maintenance and its mode of operation. Diesel engines can be used underground (see ***24.8.1****).*

To minimize the quantity of carbon monoxide generated by blasting, care should be exercised in the choice of explosive and in the use of appropriate stemming and means of detonation.

The current long-term (8 h time-weighted average) workplace exposure limit is 30 ppm,[2] but short-term (15 min) exposures of up to 200 ppm are permissible.

NOTE 3 From 2023, these limits will be reduced to 20 ppm and 100 ppm respectively (see Table 8).

15.6.3.2 Carbon dioxide (CO_2)

Naturally occurring sources of carbon dioxide which should be considered in tunnelling include carboniferous strata, particularly where acid groundwater acts on limestone or other calcareous rock.

NOTE 1 The presence of pyrites in the rock can exacerbate the effects of acid groundwater.

Other sources which should be considered include the exhaust from internal combustion engines, the combustion of carbonaceous materials and from the detonation of explosives.

Carbon dioxide is heavier than air and thus accumulations should be expected in low areas and sumps. The concentration of carbon dioxide should always be measured directly and never inferred from the oxygen concentration.

*NOTE 2 Carbon dioxide often acts as a simple asphyxiant (see **15.6.2**). The long-term workplace exposure limit is 5 000 ppm, but short-term exposures of up to 15 000 ppm are permissible. Where carbon dioxide occurs naturally underground, it is often associated with oxygen deficiency (known as "blackdamp" in mining). "Blackdamp" is defined as an atmosphere containing higher concentrations of carbon dioxide and nitrogen than normally occur in air.*

15.6.3.3 Nitrogen oxides

*COMMENTARY ON **15.6.3.3***

The principal oxides of nitrogen encountered are nitrogen monoxide (NO) and nitrogen dioxide (NO_2).

Sources of nitrogen oxides which should be considered include blasting fume, welding and diesel engine exhaust fumes.

NOTE 1 Although both oxides are toxic, nitrogen dioxide is the more toxic of the two. It attacks the lung tissue insidiously without major preliminary symptoms, and can cause collapse shortly afterwards, with symptoms of acute broncho-pneumonia.

Nitrogen monoxide (NO) exposure should be controlled with a target long-term average exposure of 3 ppm but not exceeding 5 ppm. Short-term exposure should not exceed 15 ppm. The Br Tunnelling Society publication, *Occupational exposure to nitrogen monoxide in a tunnel environment Best Practice Guide* [N1], should be adhered to.

NOTE 2 However, the 4th Indicative Occupational Exposure Limit Value Directive (IOELV) [70] requires that from 2023, exposure should be limited to 2 ppm.

NOTE 3 Nitrogen dioxide (NO_2), because of uncertainty over its chronic pulmonary effect, currently has no long-term workplace exposure limit, however, HSE recommends that long-term exposure should be controlled to 1 ppm. The 4th Indicative Occupational Exposure Limit Value Directive (IOELV) [70] requires that as from 2023, exposure is controlled to 0.5 ppm

NOTE 4 Nitrogen monoxide converts to nitrogen dioxide, slowly but spontaneously, in air and sunlight. In tunnels this conversion is much slower and these changes are unlikely to be significant in normally ventilated tunnels. In general, the emissions from diesel engines are dominated by nitrogen monoxide.

2 1 ppm = a volumetric fraction of 1 × 10^{-6}

Table 8 — *Summary of most commonly encountered atmospheric contaminants*

Contaminant		Relative density (with respect to air)	Hazard	W.E.L. A)		Explosive limits		Principal sources
				Long-term limit B)	Short-term limit C)	Lower %	Upper %	
Carbon monoxide	CO	0.97	Toxic	30 ppm 20 ppm **	200 ppm 100 ppm **	12.5	74.2	Explosives, engines
Carbon dioxide	CO_2	1.53	Asphyxiant	5 000 ppm	15 000 ppm	N/A	N/A	Natural, engines, welding explosives
Nitrogen monoxide	NO	1.04	Toxic	3 ppm* 2 ppm **	15 ppm*	—	—	Explosives, engines
Nitrogen dioxide	NO_2	2.62	Extremely toxic	0.5 ppm **	1 ppm **	—	—	Explosives, engines and welding
Methane	CH_4	0.55	Explosive and asphyxiant	—	—	4.4	17	Natural
Hydrogen sulfide	H_2S	1.19	Toxic and explosive	10 ppm	15 ppm	4.3	45.5	Natural
Sulfur dioxide	SO_2	2.26	Toxic	2 ppm	5 ppm	—	—	Natural
Propane Butane Acetylene Ethane		1.55 2.05 0.91 1.05	Explosive and asphyxiant	— 600 ppm — ---	— 750 ppm — --	2.2 1.5 1.5 3.0	9.5 8.5 100 12.4	Leakages and firedamp inflow
Ammonia	NH_3	0.59	Toxic	25 ppm	35 ppm	15.0	28.0	Organic material
Volatile organic compounds	Various	—	Toxic and explosive	—	—	approx. 1.0 D)	—	Contaminated land
Organic solvents	Various	—	Toxic	—	—	—	—	Industrial discharge
Oxygen deficiency	O_2	1	Asphyxiant	—	< 19% O_2	—	—	Natural, induced
Oxygen enrichment	O_2	1	Increased fire risk	—	> 23% O_2	—	—	Stored oxygen in tunnel, airlocks
Petrol/diesel vapour	—	> 2.0	Explosive	—	—	approx. 1.0	7.5	Spillage

Table 8 *(continued)*

Contaminant		Relative density (with respect to air)	Hazard	W.E.L. [A)]		Explosive limits		Principal sources
				Long-term limit [B)]	Short-term limit [C)]	Lower %	Upper %	
Ozone	O_3	1.66	Toxic	—	—	—	—	Welding
Radon [***]	Rn	—	Radioactive	N/A	N/A	—	—	Natural

A) Workplace exposure limits (see Guidance Note EH40 [37] for further information).

B) 8 h, time-weighted average.

C) 15 min.

D) Dependent on constituents.

* Limit agreed between HSE and Br Tunnelling Society

** From August 2023

*** Seek specialist guidance as permitted exposure is governed by The Ionising Radiations Regulations 2017 [39] which come into effect where radon is present above the defined level of 400 Bq/m^3. Employers are required to take action to restrict resulting exposures. This level is unlikely to be reached where ventilation is satisfactory.