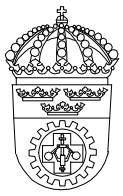

WORK IN CONFINED SPACES

General Recommendations of the Swedish National Board of Occupational Safety and Health on Work in Confined Spaces

Adopted 19th April 1993

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The following General Recommendations are issued by the National Board of Occupational Safety and Health on the implementation of the Work Environment Act (SFS 1977:1169).

1. Background

These General Recommendations apply to all work in confined spaces and are intended as a general description of risks and preventive measures in that connection. There are certain types of work for which the Board has issued special rules, some of which are listed under the heading "Other relevant rules etc."

1.1 General

Several serious accidents, some of them fatal, have occurred in Sweden during recent years in connection with work in confined spaces.

Most of the accidents have been due to the absence or incorrect use of respiratory protective equipment. Some have been caused by fire.

The term "confined space" refers to a space which it is difficult to enter and leave and in which, owing to insufficient ventilation, a hazardous atmosphere is liable to form.

Spaces which can be confined in this sense include, for example, storage tanks, silos, wells, process vessels, digesters, sewerage, gas or liquid lines (pipelines), mine galleries, tunnels, culverts, basements and suchlike.

A confined space is often a temporary workplace.

1.2 Hazards of work in confined spaces

The atmosphere in a confined space can entail a variety of hazards in connection with work. Deleterious, explosive or flammable fumes or gases can occur in hazardous concentrations, as can high or low concentrations of oxygen. Dust can also constitute a hazard. The various risks are dealt with in greater detail below.

Deleterious, explosive and flammable fumes and gases

Hazardous concentrations of deleterious, explosive or flammable fumes and gases can emanate from a variety of sources. Deleterious fumes and gases can, for example, cause irritation to the eyes and respiratory passage, giddiness, dyspnoea, confusion or loss of consciousness.

- Fumes and gases from other activities in the vicinity can penetrate the space. Gases and liquids can escape through the gaskets between piping sections and then evaporate. A closed gas valve may allow gas to escape, since a metal cone does not always provide a perfect seal against a metal seat.

- Gases and fumes from leaking containers below ground can spread through the soil and emerge through wells, deep shafts and similar spaces. Hot work near a space of this kind is always hazardous if a rise of temperature in the leaking substance leads to fire, explosion or the formation of deleterious gas.

- Evaporating residues from previous activity may be present in the space. Some process vessels and containers are designed in such a way that they cannot be completely emptied. Evaporating residues may be present in piping opening into the space.

- Rusty bottom sludge and, to some extent, the rusty walls of a container as well, can absorb hazardous components from a stored product. The components may evaporate later on, e.g. during cleaning. Components of this kind include, for example, tetraalkyllead, which is used to improve the knock rating of petrol and is highly toxic.

- Hydrogen sulphide and other gases can form during microbiological activity and cause poisoning. Risks of this kind can occur, for example, in silage and silos in agriculture and in drains and sewers, especially in stagnant water.

- Work in a confined space can give rise to hazardous fumes and gases. Work of this kind includes, for example:

  o Welding and cutting.
  o Metal-coating.
  o Use of products containing solvents.

- Exhaust gases can be a problem in a confined space. These are emitted, not only by vehicles, but also by combustion-powered tools.

Excessive or insufficient oxygen concentration

Abnormal concentrations of oxygen in a confined space can pose an accident risk. Air normally contains 21 per cent oxygen by volume. In confined spaces, the concentration of oxygen tends to be insufficient rather than excessive.

Excessive oxygen concentration

An elevated concentration of oxygen causes flammable substances to ignite more readily. Textile fibres and even hair can absorb oxygen, which increases their ignitability. Elevated concentrations of oxygen occur mainly in the vicinity of leaking equipment for oxygen, such as gas-welding units and distribution pipes.

Insufficient oxygen concentration

An oxygen concentration of 17-15 per cent by volume can cause symptoms such as tiredness and elevated pulse rate. If the concentration falls below this level, the person affected may have difficulty in escaping and may be in danger of asphyxiation. Reasons for low oxygen concentrations in a confined space may, for example, include the following:

- When other gases are conveyed to the space, the oxygen content declines. This may have been done deliberately, e.g. by filling the space with inert gas and in this way reducing the risk of fire and explosion. It may also be due to leakage, inadvertent operation or suchlike.

- Gases and fumes which are heavier than air drift easily at ground level and accumulate in spaces below ground - pits and suchlike - where they can cause oxygen deficiency. Gases which are normally light can also become heavy at

low temperatures, e.g. in an escape of the liquid phase of condensed gas. The vaporized gas is very cold and heavy.

- Oxidation processes consume atmospheric oxygen. Naked lights, welding and fire are three such examples. Oxygen deficiency can also occur when reducing substances like sulphides, sulphites, carbon and dithionites are stored in the open. Oxidation of certain sulphurous rocks can reduce the oxygen content in tunnels and shafts which are left unventilated for long periods. The air in closed tanks which have been out of use may have low oxygen content due to the formation of rust and the oxygen consumption which this entails. In silos for chips, sawdust and suchlike, oxygen is consumed through the oxidation of e.g. turpenes.

- Living microorganisms such as bacteria and fungi are consumers of oxygen. These can occur, for example, in sewers and manholes, in warm and damp culverts and tunnels, in mine galleries and in silos for chips and silage.

- In unventilated, waterlocked spaces like tunnels and mine galleries, oxygen deficiency may occur, due to oxygen dissolving in water more readily than nitrogen.

Dust

Dust is a potential hazard accompanying work in confined spaces.

- Inhalation of dust containing microorganisms such as bacteria or fungi can lead to toxically or allergically induced disorders. Microorganisms multiply in moist, warm environments with suitable nutritional conditions.

- If the dust is combustible and dry, there is a risk of fire and dust explosion if it whirls up.

2. Planning of work

Work in confined spaces must be planned, arranged and conducted in such a way as to avert the risk of disease and accidents. It may be appropriate to draw up instructions for the conduct of work. If the work is of a solitary kind, good working instructions and adequate vocational experience are highly important. If the

individual firm lacks the competence or equipment for this type of work, there are specialist firms which can be engaged for clearance and repair jobs of different kinds.

General provisions concerning the planning, direction and follow-up of activities by the employer in order to guarantee compliance with the requirements of work environment legislation are contained in the Ordinance on Internal Control of the Working Environment, issued by the National Board of Occupational Safety and Health (AFS 1992:6).

It is an advantage for the space to be designed in such a way that strenuous work postures and working movements can be avoided. This aspect is best taken into account during construction and alterations.

3. Work in confined spaces

3.1 Assessment of the danger

Atmospheric oxygen content at the workplace should be between 20 and 22 per cent by volume.

In order to assess the risks which the atmosphere in a confined space may entail, apart from that of abnormal oxygen concentration, one needs to know which hazardous substances are present there.

If there is flammable gas or vapour present, it is important to take into consideration the risk of fire or explosion; further to this point, see the Ordinance on Organic Solvents (AFS 1990:14) and on Motor Fuels (AFS 1992:18) issued by the National Board of Occupational Safety and Health.

Information concerning substances and their properties and health hazards is normally obtainable from the previous user of the space. Some information concerning the properties of substances can be obtained from product information sheets or other data sheets issued, for example, by manufacturers, suppliers or trade associations.

It may be necessary to measure concentrations of air contaminants, as well as oxygen content, in order to assess the level of risk. It is important to establish that

the atmosphere is free from ignitable fumes and deleterious concentrations of air contaminants, and also that there is no oxygen deficiency.

3.2 Demarcation of working areas

Before work begins in a confined space, the requisite area should be blocked and any warning signs put up. It is important that access routes to the place should be kept clear, for the contingencies of evacuation and rescue.

The size of the area to be blocked will depend on the nature of the work and on local conditions such as the type of underlay or the traffic.

If the work also includes excavation, the risk of collapse must be taken into account.

A warning sign may be needed which explains the risk occurring in the space. An additional sign with supplementary information may be necessary. If the work is done by a different enterprise from the one conducting operations at the workplace, it may be appropriate for the additional sign to give the name of the enterprise concerned, together with its telephone number and the name of its principal representative at the site.

3.3 Emptying, ventilation and segregation of confined spaces

Emptying

If the confined space forms part of an industrial process, it can normally be emptied using the process pumping system, if there is one, and then by drainage. If the space has a special device for pumping out, collecting and sedimenting residues of substances, that device should be used. Otherwise remaining liquid can be taken care of after a hatch, if there is one, has been opened. If a hatch is opened to a space where there may be a danger of fire, it is important that there should be no risk of ignition.

Ventilation

The ventilation should be started up as soon as a hatch to the space has been opened. The best ventilation is obtained if the space can be opened at the top and bottom. Depending on the character of the enclosed space where the work is to be done, use will be made of an exhaustion device or of fresh air injection. The fan

equipment used should be of an explosion-proof design. Since fumes and gases are often heavier than air, the best result will be obtained with the exhaustion near the bottom of the space. If the space contains gases which are lighter than air, it should be possible to ventilate the space from above.

In thundery weather it is important to bear in mind the risk of ignition if fumes from flammable liquids are being aired out. Work may have to be suspended and the space closed.

Ventilation then continues, as a rule until the work has been completed, unless it is reliably established before then that the atmosphere in the space has a permanently acceptable concentration of oxygen and is sufficiently free from hazardous air contaminants.

Contaminants in the exhaust air may, depending on their quantity or hazardous properties, need to be destroyed, e.g. in a combustion device.

Segregation

Shut-off valves for piping and starting devices for machinery and other devices which can affect the safety of the confined space must be protected against inadvertent operation. The shutting off of piping by disconnecting part of it or by flange sealing is preferable to turning off by means of a valve only. In certain activities, the use of flange sealing is established practice, for example, for the segregation of a pressure-retaining device, and also in petrochemical industry.

If the space has cathodic corrosion protection and there is a risk of ignition, it is important that the electric current should have been turned off long enough to allow time for depolarization.

Packaged hazardous substances in a confined space, e.g. in underground storage premises, may, subject to an assessment of the nature of the packaging, the type of work and any other circumstances involved, be allowed to remain there while work is in progress. Gas cylinders, other than those containing air, should not be left in such a space. Following a leakage of oxygen, there is a serious risk of ignition. Emissions of gases other than oxygen cause oxygen deficiency and may possibly entail other hazards, depending on the properties of the gases.

3.4 Admittance

The employer must ensure that the confined space is inspected with reference to hazards to life or health, so that an assessment can be made of the advisability of working there. It is often appropriate for the employer to issue internal rules making admittance to the space subject to special permission from the supervisory personnel. If two or more enterprises are active simultaneously at the workplace, it is important for the employer, before granting any such permission, to consult other entrepreneurs about activities which may have a bearing on safety.

In many cases, permission can be given by word of mouth. If it is subject to conditions, e.g. regarding the work to be done, it should be issued in writing. Written permission is the established practice among contractors engaged by mining companies.

Conditions to which permission is subject may include the following:

- stipulation of a certain kind of personal protective equipment,
- prohibition of footwear with iron tips or studs or clothing which can become electrostatically charged,
- prohibition of matches, cigarette lighters or suchlike,
- a stipulation that live parts are to be earthed,
- restrictions on the use of certain tools or implements.

Written permission should also indicate whether a guard is needed. Considering the possibility of rescue measures in the confined space, the conditions for admittance should also apply to the guard. It is important that the guard should be properly trained and should have accurate information and knowledge concerning the way in which work proceeds inside the confined space. If there is a risk of fire, e.g. in connection with hot work, the place of the guard may have to be taken by a fire watcher and suitable extinguishing equipment procured. If the guard does not have visual contact with the person inside the space, a suitable signalling system must be arranged. See also the Ordinances on Organic Solvents (AFS 1990:14) and Motor Fuels (AFS 1992:18) issued by the National Board of Occupational Safety and Health.

If the work is to take the form of solitary work, the employer must ensure that the employee has the knowledge and sufficient experience to assess the danger of the situation before entering the space.

3.5 Cleaning

The need for cleaning will depend on the requirements of cleanliness and safety which the work involves. For example, welding in a confined space also requires the immediate surroundings to be sufficiently free from combustible substances for there to be no risk of ignition.

Cleaning in itself can entail greater risks than the actual work. A risk assessment should be undertaken in each individual instance. Factors which should be taken into account include, for example, the cleaning method, the length of time the work is expected to take and other preventive measures which are possible.

When cleaning is done using powerful jets of liquid and the space contains flammable fumes or gases, the atmosphere in the space is liable to become electrostatically charged. Flushing should therefore proceed with caution. If a heated flushing liquid is used, it should be borne in mind that flammable fumes and gases ignite more readily at elevated temperatures.

4. Protective equipment

Safe work in a confined space demands suitable protective equipment. The need for equipment for life-saving and evacuation, e.g. a lifting harness, a line and a person specially detailed to operate it, as well as facilities for conveying an injured person to hospital etc., are other important points to bear in mind.

Suitable eye protection, e.g. safety goggles or a face shield, can be used to protect the eyes from splinters and spatter. If both eye protection and respiratory protective equipment are needed, a full mask is preferable to a combination of safety goggles and face mask.

It is important to choose respiratory protective equipment according to the risk situation involved.

A respiratory protective device with a modified dust filter may afford sufficient protection from dust, e.g. during the scraping and grinding of old anti-fouling paint.

Respiratory protective devices with gas filters are used mainly for brief periods of work with solvents, glue and suchlike, when the risk of oxygen deficiency can be excluded. It is important to use a filter with an adequate safety factor for the substance concerned.

If there is a risk of oxygen deficiency or of heavy concentrations of air contaminants, compressed air equipment is needed.

Respiratory protective equipment such as compressed air apparatus with safety pressure is needed in certain cases, e.g. for admittance to tanks which have previously contained petrol with tetraalkyllead added and have not been properly cleaned since, so that the rust layer is present on the inside of the tank.

When using compressed air apparatus which can be connected to the main compressed air supply system of the workplace, it is essential to check the quality and quantity of the compressed air. It is also important to check that the equipment cannot be inadvertently turned off, and to take steps for the avoidance of confusion, if piping systems also exist for gases other than air. A connection error can be deadly dangerous.

5. Tools and implements

Tools and implements used for work in a confined space should be made of or coated with chemically resistant material or material which will not react dangerously with substances in the space. If sparks are liable to cause ignition, tools of hard rubber, plastic, wood or suchlike are safer than "sparkless" tools made of metallic materials. Electrical equipment may also need to be checked for adjustment to spaces where there is a risk of explosion; on this point, reference is made to the high-voltage regulations in STEV-FS 1988:1[1].

If there is a risk of fire, pneumatic equipment is preferable to electrical equipment, and the risk of overheating must then be borne in mind.

To prevent gas from escaping in the event of a hose failure, it is important thatequipment used for gas welding or cutting should have a fail-safe hose valve.

When using a lifting belt and line for work in a confined space, it is important that lifting and lowering should be done with a lifting device which has a dependable anchorpoint. The lifting equipment must have sufficient carrying capacity. A guard should be on duty and there should be contingency arrangements for summoning rescue personnel.

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1 See page 17.

Appendix

Other relevant rules etc.

The Statute Book of the Swedish National Board of Occupational Safety and Health

AFS 1980:11	Measures against Air Contaminants
AFS 1981:5	Dust Explosions
AFS 1982:3	Solitary Work
AFS 1982:9	Evacuation
AFS 1982:13	Personal Protective Equipment
AFS 1984:15	Sewer Systems
AFS 1985:10	Manholes on Certain Tanks
AFS 1985:17	Hazardous Substances
AFS 1986:17	Rock Work
AFS 1986:26	Shipyard Work
AFS 1988:3	Occupational Hygiene Measurements of Air Contaminants *)
AFS 1989:6	Large-scale Handling of Chemicals *)
AFS 1990:13	Occupational Exposure Limit Values *)
AFS 1990:14	Organic Solvents
AFS 1992:6	Internal Control of the Working Environment *)
AFS 1992:9	Welding and Thermal Cutting
AFS 1992:15	Safety Signs at Workplaces *)
AFS 1992:18	Motor Fuels *)
AFS 1992:20	Liquid Manure *)

*) Available in English

Rules issued by other authorities etc.

The Swedish National Inspectorate of Explosives and Flammables

SÄIFS 1989:3	Regulations of the National Inspectorate of Explosives and Flammables on the Classification of Flammable Liquids etc.
SÄIFS 1989:7	Regulations of the National Inspectorate of Explosives and Flammables on the Marking of Containers etc. with Flammable Gases or Liquids SÄIFS 1989:7 replaced by SÄIFS 1992:3 from 93-07-01
SÄIFS 1992:3	Regulations of the National Inspectorate of Explosives and Flammables on the Marking of Containers with Flammables [*])

The Swedish National Chemicals Inspectorate

KIFS 1986:3	The Chemicals Inspectorate's regulations with respect to Classification and Labelling in connection with Transfer of Chemical Products Hazardous to Health [*])

The Swedish National Energy Administration

STEV-FS 1988:1	The Swedish regulations for Design and Maintenance of Electrical Installations (amended in 1988:2, 1989:1, 1990:1)

The Swedish National Board of Housing, Building and Planning

BFS 1988:18	Regulations for New Buildings [*])

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[*]) Available in English

Swedish Standards

SS 421 08 20	Classification of Hazardous Areas
SS 421 08 21	Electrical Installations in Explosive Gas Atmospheres
SS 421 08 22	Equipotential Bonding in Explosive Gas Atmospheres
SS-IEC 529	Classification of Degrees of Protection provided by Enclosures

Manuals, reports etc.

The Swedish National Board of Occupational Safety and Health

Manuals	
H6	Chemical Hazards
H7	Dig Safer
H9	Your Personal Protective Equipment

The Work Environment Association

List of personal protective equipment approved by the National Board of Occupational Safety and Health.

The Swedish Fire Protection Association

Manual; Gas Detection (J Hermelin)
Hot work on Containers, Tanks and Pipings.

IVF (The Swedish Institute of Production Engineering Research)

Safety Valve for Leakage connected with Gas Cutting (No. 84 80 11, J Larin)

TYA/Transporthälsan (Health and Safety Services in the Transport Trade)

Instruction for Personnel Cleaning Tanks