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CHIEF FIRE & RESCUE ADVISER

Fire and Rescue Authorities Operational Guidance

GRAs
generic risk assessments

GRA 2.1
Rescues from confined spaces

2.1.2 silos

Generic Risk Assessment 2.1

Rescues from confined spaces

2.1.2 silos

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Scope

Generic Risk Assessment 2.1.1 in this series and *Confined Space Regulations (1997)* provide detailed information relating to the work of fire and rescue personnel in confined spaces.

This assessment examines only those hazards, risks and controls that are specific to incidents involving rescues from silos (see definition below for what constitutes a silo) and similar structures and should be read within the context provided by *Generic Risk Assessment 2.1 Rescues from confined spaces*.

Rescue activities which involve other specific significant hazards are covered in other generic risk assessments.

Reference is made throughout the document to other generic risk assessments and to other technical sources.

As with all generic risk assessments this assessment provides a starting point for Fire and Rescue Authorities to conduct their own within the context of local conditions and existing organisational arrangements such as integrated risk management plan and standard cover.

Incidents at all types of silos can, by their very nature, involve access into confined spaces, often with the additional hazards of unstable materials, and an atmosphere incapable of supporting life.

The aim of this document is to identify the specific hazards, outline the factors which must be considered as part of a dynamic risk assessment and describe the Command and Control procedures to be followed at silo incidents.

For the purposes of this risk assessment a silo can be is defined in the following as:

SILO: “A container or tower, often cylindrical in shape, used for the storage of silage, grain, powders, pellets, sawdust, foodstuffs, chemicals, crops and fluids like sewage digester tanks.”, and silage is any crop harvested while green for fodder and kept succulent by partial fermentation in a silo. Silos are often bespoke designs capable of handling all types of materials from the finest powders to the most cohesive substances.

This generic risk assessment will be reviewed for its currency and accuracy three years from date of publication. The Operational Guidance Strategy Board will be responsible for commissioning the review and any decision for revision or amendment.

The Operational Guidance Strategy Board may decide that a full or partial review is required within this period.

Significant hazards and risks

To carry out a rescue from a silo it may be necessary to effect an entry. This will mean entering into a confined space as defined by the *Confined Space Regulations 1997*. In addition to those hazards identified in *Generic Risk Assessment 2.1 Rescues from confined spaces*, personnel entering the silo will be at risk of serious injury from hazards that may arise from the following factors that are specific to rescues in silos.

Design and construction

Silos are in widespread use both in industry and agriculture and come in various shapes and sizes. A new design concept is 'horizontal silos' that may be temporary or fixed in nature. They may vary in height from 3 to 30 metres and hold between 5 and 5,000 tonnes. In addition, they can be located in or outside of a building and multiple silos may be interconnected. The most common type of silos are:

- hopper bottom – for grain, powders or pellets
- square – for grain or crops
- round storage – for grain
- sealed store – for silage.

NOTE:
Hopper bottom silos are often connected to burners and / or boilers which can present an increased risk to firefighters.

The materials used for construction can have a bearing on the behaviour of the silo in regards to load movements and increases in internal pressure borne out of content movement whilst attempting rescue operations. The materials will perform differently if fire is involved. Silos can be constructed of a combination of the following:

- concrete
- steel – plates or reinforcement for concrete
- aluminium
- glass reinforced plastic – usually only for domes or caps
- brick
- timber.

Some silos are lined with a vitreous or plastic protective material to prevent corrosion and/or abrasion. They are designed to store large amounts of substances ranging from foodstuff, coal, sawdust, process materials through to fertilisers. Depending on the substance to be stored in the silo, explosion relief valves may be fitted (ATEX legislative requirements).

Silos incorporate various features, which may include:

- internal and external ladders
- airtight doors and hatches
- mixing systems – augers to turn contents over
- discharge systems – MECHANICAL: augers, cutters, vibratory and aeration systems
- intake systems – chutes, augers, bucket elevators, etc
- power supplies – electrical, hydraulic or compressed air
- support bars/internal strengthening.

The dimensions of the silo will be a consideration as this will inform any forward control point the correct location in case of potential collapse

Entry and egress

Access to silos is usually by external ladders running alongside the outside wall. The access hatch on top of the silo can be restrictive in size. This can make the setting up equipment and access to a casualty difficult for fire personnel.

The topography of the silo may prevent the provision of tripods, quadpods or other means of rope/line access equipment. Consideration as to the provision of specialist vehicles for high anchors must be factored

Working at height

Personnel and equipment are at risk from falling down both inside and outside of the silo. In addition to the injuries that may be sustained to the individual, or the damage to the equipment, there is the added risk of striking the casualty or other personnel.

Internal conditions

Due to the nature of their construction, access to silos is extremely limited and natural lighting is virtually non-existent. Both these factors increase the risk of injury to personnel when gaining access to and moving around inside. Once inside, hazardous conditions and the difficult egress increases the psychological stress on personnel.

The nature of the internal conditions in silos may result in certain specific hazardous atmospheres:

- toxic
- oxygen deficiency/enrichment

- hot/humid
- explosive/flammable
- off gassing emissions (silage fermentation products) airborne dusts
- fungi
- moulds
- reduced ullage space.

Should a source of ignition be provided, the suspension of fine particles or dust in an oxygenated atmosphere produces a potentially explosive environment.

Only intrinsically safe electrical equipment should be taken into the inner cordon defined by the Incident Commander. This includes communications equipment, such as incident ground radios, pagers, mobile phones, matches and lighters.

Associated machinery

Machinery is used to move the contents of silos, such as:

- external conveyor belts and augers which bring the material to and from the silo
- internal augers which control the unloading of the contents of the silo
- agitators
- electrical cutters
- suction/ blowing pipes.

MASS TRANSFER

Mass transfer is usually carried out by suction piping used for materials such as cement, grain, sugar, pulverised fuel, plastic pellets etc. Grain elevators and fuel silos are often filled in this way. As with any small-grained material, there is the risk of a dust explosion. There are often various systems preventing the dust from attaining the right explosive mixture and of venting the pressure if it does explode.

REMOVAL OF SILAGE

Silage is removed from a silo by an electrically driven rotating cutter. This may either be lowered onto the surface of the silage by means of a winch or permanently fitted in the base of the silo.

Materials stored

Firefighters must anticipate that the materials stored in a silo might not be capable of bearing their weight. They must also be aware of contents 'bridging'. This is a phenomenon whereby a seemingly solid material is only a bridge or crust over a void where contents have collapsed or have been emptied from below.

Even solid substances may act in a fluid-like manner and it should be assumed that this might happen whether the outlet valve is closed or opened.

There is always the danger of slippage or collapse of the materials.

Ullage space in the top of a silo could be reduced if personnel/equipment are introduced into the space.

On wetting, it is a characteristic of some grain to swell considerably (as is the case with rice) and tend to push the walls outward and endanger the silo. Even if the grain does not swell, water allowed to sink into grain storage will stay there, steadily being absorbed by the grain and increasing its weight. The added load on the structure/floor may again compromise the silo's structural integrity.

Other associated hazards involving silo contents are:

- fire and explosion
- oxygen deficient atmosphere
- asphyxiation due to immersion in the silo contents, or the fumes given off
- crushing injury from silo contents
- impact injuries sustained by collapsing materials falling from silo walls
- inhalation of dust from the silo's contents
- exposure to bio-hazards
- fixed installations (some silos have carbon dioxide flooding systems installed).

Manual handling

The risk of musculoskeletal injury to personnel arises from:

- Load – lifting or lowering, pushing and pulling
- Individual – the number, weight and size of casualties/casualty
- Task – removal of contents rescue of casualty
- Environment – restricted access, poor lighting
- Equipment – the weight and size of the equipment, and use of augers
- Psycho-social – moral pressure
- Rapid fatigue.

Key control measures

Planning

Planning is key to enhancing the safety of firefighters and others likely to be affected by Fire and Rescue Authorities operations. Each Fire and Rescue Authority's strategic plan will set standards and identify the resources required to ensure safe systems of work are maintained.

Planning is underpinned by information gathering, much of which will be gained through inspections or visits by fire and rescue personnel – for example, those covered by section 7(2)d and 9(3)d of the *Fire and Rescue Act 2004 and the Fire Scotland Act 2005* section 9(2) (d).

Site-specific plans

Site-specific plans must be considered for locations where the hazards and risks are significant.

Fire and Rescue Authorities must consider the benefits of using consistent systems and formats to record information from all sources. Consideration must also be given to how timely access will be provided to inform and support operational decision-making.

Information needs will vary in proportion to the size and nature of the incident. The capacity of fire and rescue personnel to assimilate information will vary in relation to the complexity of the incident. Therefore, arrangements may need to be flexible and be based on more than one system.

Competence and training

When formulating a competence and training strategy, Fire and Rescue Authorities must ensure the following points:

- Those specific risk assessments for this incident type are suitable and sufficient. In addition those tasked with carrying out the assessment and developing procedures are competent to do so
- That personnel are adequately trained to deal with hazards and risks associated with the generic risk assessment
- That level and nature of training undertaken is shaped by an informed training needs analysis, taking account of Fire and Rescue Authorities, guidance on the competency framework, national occupational standards and any individual training needs.

Training and development programmes must:

- Follow the principles set out in national guidance documents
- Generally be structured so that they move from simple to more complex tasks and from lower to higher levels of risk. Typically cover standard operational procedures as well as ensuring knowledge and understanding of equipment and the associated skills that will be required to use it
- Consider the need for appropriate levels of assessment and provide for continuous professional development, to ensure maintenance of skills and to update personnel whenever there are changes to procedure, equipment, etc
- Involve personnel engaged in other processes that support the emergency response, such as planners devising procedures and people procuring equipment.

Specific training requirements for rescues from silos will include the standard operating procedure and the equipment to be used.

Training outcomes must be evaluated to ensure that the training provided is effective, current and meets defined operational needs as determined by the Fire and Rescue Authority's integrated risk management plan.

Site-specific tactical exercises must be undertaken with other agencies or personnel likely to assist at an actual incident.

Command and control

The Incident Commander must follow the principles of the current national incident command system. Prior to committing personnel into any hazard area, the Incident Commander must take account of the information available about the incident to make operational decisions in what are recognised as sometimes dangerous, fast moving and emotionally charged environments.

Risk assessment

On arrival at the incident, as part of the initial risk assessment the Incident Commander will need to determine whether further assistance should be immediately requested ie:

- site-specific information from competent persons or preplanning material
- aerial appliance (for access to high level openings)
- specialist rescue teams – rope rescue, urban search and rescue, technical rescue units and specialist cutting equipment to create access for firefighters and exit for contents
- mechanical lifting aid (hoists, tripods etc)
- atmospheric monitoring
- medical professionals.

Safe systems of work

Fire and Rescue Authorities have a range of standard operating procedures for dealing with rescues in silos. The operational procedure adopted will depend upon the conditions encountered at each individual incident. Firefighters must not enter the risk area to rescue a casualty without appropriate and proportional control measures in place and authorisation from the incident or sector commander.

Access

It is likely that access to the interior of the silo will be difficult and possibly only through a small opening at high level. Where access is inadequate, entry may be aided by the use of an aerial appliance. Consideration must be given to create access via forced entry measures.

The use of solid access equipment, lowering down ladders should always be considered first – however, this should be done with caution, as sometimes the surface is not stable enough to hold the weight. Those entering would still need to have an appropriate 'safe working at height' system employed ie harness, line attached.

The Incident Commander must consider this problem and if necessary request the attendance of mechanical lifting aids.

Some sites are equipped with mechanical devices that may be utilised in the rescue operations. Recognition of the device load capabilities and competence of operators must be considered.

Consideration must be given in using rescue equipment to create an opening for access.

At no time must the equipment or operator be redeployed whilst personnel are in the silo.

Breathing apparatus

Entry into the silo must only take place if it is not reasonably practicable to achieve a rescue without such entry.

Breathing apparatus must be worn. Where there is any possibility of the atmosphere becoming deficient or persons being buried, the atmosphere must be regularly checked with gas monitoring carried out as soon as reasonably practicable. The Incident Commander will determine following their risk assessment if crews will be deployed before gas monitoring is in place. The results of the risk assessment and any gas monitoring would inform whether breathing apparatus is required.

Working in a silo

PLANT

Plant (ie conveyors or feeders) must be stopped, isolated and locked-off. Vehicles must be prevented from tipping into any access point. Particular attention must be given to the power supplies of automatic self-actuating control devices. Where a 'Permit to Work' system is in place then the owner of the permit must work with the Fire and Rescue Authority to ensure that plant remains isolated as required.

When dealing with an incident the re-energising of the system must only be carried out on the direct instruction of the Incident Commander.

VENTILATION

Increased ventilation will have an effect on the presence of any flammable, harmful or suffocating gases or dusts inside the silo and may or may not improve the internal conditions. The prospect of improved conditions needs to be weighed against the possibility of creating greater risk from the movement of dust or greater volatility of flammable gases. Explosive and flammable atmospheres may be encountered at openings and intrinsic equipment must be used in risk areas.

VIBRATION

Constant watch should be kept on any contents lodged up against the silo walls. These may become dislodged by vibration, caused by internal or external movements or by wetting. This may in turn alter their behavioural characteristics or cause them to release or give off vapour or dust that may be toxic or explosive.

ROPES AND HARNESSES

Where ropes and harnesses are deployed, Fire and Rescue Authorities must work to the safe working at height / rope rescue requirements. Consider the early recall of local and regional specialist rescue teams including urban search and rescue who can supply extended ventilation and access equipment.

TECHNIQUES FOR MOVING AROUND

EMPTY SILOS

Be aware that some silos have sloping top / bottoms that may be slippery under foot and present a potential for a fall onto the machinery at the base.

SILOS WITH CONTENTS

Whenever possible, firefighters must avoid having to place their weight on the materials inside by favouring standing on fixed structures and solid parts. If this cannot be achieved then alternative methods should be adopted to work safely.

CASUALTY MANAGEMENT

Weight of equipment and any casualties may be an excessive load for personnel to lift. Consideration must be given to the use of a hoist or pulley during operations and other initiatives.

Safety Officer(s)

The early appointment of one or more Safety Officer(s) will help ensure that risks are either eliminated or reduced to an acceptable level.

A safety decision-making model must be used to brief Safety Officers regarding the nature of the incident, the allocated task and prevailing hazards and risks. The Incident Commander must confirm that the Safety Officer understands:

- Their role and area of responsibility
- Allocated tasks
- Lines of communication
- Identified hazards and the risks posed
- Actions or precautions taken to remove/ mitigate the risks
- Incident Commander's plan.

Those undertaking the Safety Officer role must:

- be competent to perform the role
- ensure personnel are wearing appropriate personal protective equipment

- monitor the physical condition of personnel and/or general or specific safety conditions at the incident, in accordance with their brief
- take any urgent corrective action required to ensure safety of personnel
- update the Incident Commander or senior safety officer regarding any change in circumstances
- not to be engaged in any other aspect of operations, unless this is required to deal with a risk critical situation.

The role of a Safety Officer can be carried out by any of the Fire Authority roles, but the complexity of the task, size of the incident and scope of responsibility must be considered by the Incident Commander when determining the supervisory level required.

Safety Officers must wear nationally recognised identification to indicate that they are undertaking the 'Safety Officer' role.

Fire and Rescue Authorities must ensure that training and other measures (such as aide memoires) are in place and available to support those personnel liable to undertake this role.

Consideration to the design and layout of the silo will determine the position of the safety officer.

Personal protective equipment

Fire and Rescue Authorities must ensure that any personal protective equipment provided is fit for purpose and meets all required safety standards. As with all protective garments, consideration must be given to their compatibility when worn with other garments and protective items. Consideration must also be given to the selection of suitable sizes and gender specific requirements of personal protective equipment.

Personal protective equipment must also take account of the need for rescuers to be visible against the operational background, including night working, and for the Incident Commander and other managerial and functional roles (defined in the national incident command system) to be distinguishable.

All personnel must use appropriate levels of personal protective equipment provided by the Fire and Rescue Authority and respiratory protective equipment as determined by the safe system of work.

In addition to the practical risks involved in firefighting, personnel may be exposed to blood-borne infections when dealing with casualties. The risk can be minimised if personnel ensure good personal hygiene and carry out good occupational infection protocols.

Where chemicals/radiation etc risks are identified, correct personal protective equipment must be provided and selected.

It should be noted that conditions in silos can be very hot with the potential of crews suffering from heat exhaustion when wearing full personal protective equipment. The risk assessment will determine if personal protective equipment can be relaxed.

Post incident

The following measures must be considered to help eliminate or remove risks after an incident, as appropriate to the nature and scale of the incident.

- Any safety events; personal injuries, exposure to hazardous substances or near-misses must be recorded, investigated and reported in line with legislative requirements such as *Reporting of Injuries, Diseases and Dangerous Occurrence Regulations 1995, as updated in April 2012*
- Arrangements must be in place to either remove all contamination from personal protective equipment or ensure its safe and appropriate disposal and to check that personal protective equipment maintains the agreed levels of integrity and protection for the wearer throughout its lifecycle
- As appropriate, occupational health support and surveillance follow-up
- Conduct a debrief to identify and record any 'lessons learned' from the incident, that must be fed back centrally to identify continuous improvement
- Consider any changes required to safe systems of work, appliances or equipment in the light of any lessons learned from debriefs or from safety events. If changes are agreed a communication strategy must be developed to ensure all affected personnel are informed
- Consider the need to review existing information held on a premises or location, or the need to add a new premises or location into future pre-planning eg by adding to a visit or an inspection programme
- Personnel must be supported and monitored to identify whether they are experiencing any adverse affects/signs and symptoms of stress and to check whether they would benefit from accessing counselling and support services.

Technical references	
1	Home Office Guide to Operational Risk Assessment
2	Confined Space Regulations ACOP1997
3	GRA 5.5 Confined Spaces Home Departments 1998
4	Home Office Technical Bulletin 1/97 Breathing Apparatus
5	DCO/L and DFM/L 9/97 Management of Physiological Stress
6	DCO/L 1/1998 Safe work in confined spaces
7	HSE, 8/91 Violence to staff: Leaflet IND(G) 69(L)
8	DCO/L 15 1997 Incidents involving silos
9	Fire and Rescue Service Manual Volume 2 Fire Service Operations Safe Work at Height
10	Fire and Rescue Service Manual Volume 2 Fire Service Operations Incident Command
11	DCO/L 14/1999 Positive pressure ventilation
12	DCOL 3/95 and DFM Letter 2/1995. Use of Breathing Apparatus in Confined space.
13	Grain dusts in maltings (Maximum Exposure Limits) HSE. HMSO 1993 I
14	Technical bulletin 1/1990 Rope Rescue procedures and equipment HMSO 1993
15	Dear Firemaster' Letter 1/1998- F Scottish Office. Home and Health Department Edinburgh; Scottish Office, 20 Jan 98. Incidents involving agricultural and industrial silos
16	Dear Firemaster' Letter 11/1997 Incidents involving silos
17	BSI BS 7885 Code of Practice – Safe Entry Into Silos Agriculture Information Sheet 26, Managing Confined Spaces on Farms 2000
18	HS (G) 103 HSE, Safe Handling of Combustible Dusts

SECTION 2

Summary of Generic Risk Assessment 2.1

Rescues from confined spaces

GRA 2.1.2 silos

Ref. No.	Activity	Hazard	Risk	Persons at risk	Control measures
1.0	Access/egress to and from silo platform	Working at height	Slips, trips and falls whilst climbing or lowering down from silo Serious injury	Fire and rescue personnel Medical professionals	Incident Command Safe working at height equipment, trained personnel and procedures Consider aerial appliance for access Consider on site equipment / expertise Personal protective equipment.
1.1	Access/egress to and from silo platform	Working at height	Impact with moving objects Serious injury Equipment falling from height	Fire and rescue personnel Medical professionals Non Fire Authority personnel Casualty	Incident Command Use of anchor points All personnel to wear appropriate personal protective equipment / safe working at height equipment Hazard zones established.

Ref. No.	Activity	Hazard	Risk	Persons at risk	Control measures
2.0	Entry and working in silo	Internal conditions Oxygen deficient, hot, humid Explosive Noise Lack of means to descend Poor lighting	Sprains and strains whilst trying to manoeuvre through the opening Serious injury Asphyxiation Death	Fire and rescue personnel Medical professionals Casualty	Incident Command Isolate machinery Use of mechanical aids Breathing apparatus equipment and procedures Safe working at height equipment and procedures Where available regular atmospheric testing, (four-way gas monitor). NOTE: This equipment will not detect potential dust explosions Suitable personal protective equipment Medical professionals in attendance Use intrinsically safe lighting and communications Ensure combustion engines are not depleting oxygen supply and causing carbon monoxide build up.
2.1	Entry and working in silo	Dangerous machinery Worm screw feeder (auger) top or bottom loader Electricity supply	Electrocution Trapping / crush injuries Serious injury	Fire and rescue personnel Medical professionals Casualty	As above for 2.0 Liaison with on-site specialists Isolate, lock off where possible all non essential services, confirm and monitor Incident Command Suitable personal protective equipment including safety harness where required.

Ref. No.	Activity	Hazard	Risk	Persons at risk	Control measures
2.2	Entry and working in silo	Nature of stored material Voids, bridging Fluidity of contents	Crushing injuries Asphyxiation Serious injury Death	Fire and rescue personnel Medical professionals Casualty	As above for 2.0 Incident Command Safe working at height equipment Consider use of specialist teams for advice or use Thermal imaging equipment Suitable personal protective equipment Breathing apparatus and procedures.
2.3.	Entry and working in silo	Manual handling	Sprains and strains Fractures Abrasions and contusions Rapid fatigue Hernias Trapped nerves Spinal disc injuries Burns	Fire and rescue personnel Medical professionals Non Fire Authority personnel	As above for 2.0 Trained crews Appropriate mechanical aids Correct lifting techniques Incident Command Crew rotation Suitable personal protective equipment Adequate lighting.

Ref. No.	Activity	Hazard	Risk	Persons at risk	Control measures
2.4	Entry and working in silo	Stress/ fatigue	Exhaustion Psychological effects	Fire and rescue personnel Medical professionals Non Fire Authority personnel Casualty	As above for 2.0 Incident Command Physical fitness of crews Suitable personal protective equipment Crew rotation Provision of welfare facilities if incident is prolonged Post incident welfare facilities – hot debrief, counselling.
2.5	Entry and working in silo	Bio-hazard, body fluids, vermin waste	Disease / ill health / death	Fire and rescue personnel Medical professionals Non Fire Authority personnel Casualty	As above for 2.0 Incident Command Personal protective equipment Consider decontamination post incident Welfare facilities.