Excavation

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Contents

1 Scope

This Safe Work Procedure is valid for all activities carried out during construction, pre-/ commissioning and start-Up phases as well as for repair work and small-scale modifications.

This Safe Work Procedure must be applied to all projects where COMPANY has an overall responsibility for construction and commissioning.

In addition to typical construction sites this Safe Work Procedure also applies to all prefabrication and sub construction areas (e.g. Package Units) in COMPANY's area of responsibility.

2 Purpose

This Safe Work Procedure defines responsibilities and workflow before and during the execution of construction and commissioning activities on sites under COMPANY's responsibility.

The purpose of this Safe Work Procedure is to set out clear procedures and safety requirements for excavation works (including horizontal directional drilling) in order to ensure that such works are carefully planned and safely executed to prevent injurious accidents, occupational illnesses, environmental damages and any further detrimental consequences.

3 Definitions and Abbreviation

COMPANY	Linde Engineering (LE)
CONTRACTOR	Non-Linde third party performing work for the Engineering Division on one of its LE Entity Sites or Project Construction Sites. Couriers providing a delivery service (for example DHL, UPS or FedEx) are not regarded as Contractors.
Benching	Method of protecting employees and equipment from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps (usually with vertical surface between the steps).
Competent Person	A competent person is - trained in excavation safety and qualified (by recognised degree, certificate, professional standing or by extensive knowledge), - professionally experienced, - capable of identifying existing and predictable hazards in the surroundings or working conditions which are dangerous to employees related to the subject matter.
Excavation	Any man-made cut, cavity, trench or depression in the earth surface formed by earth removal
PPE	Personal Protective Equipment
Protective System	Method of protecting employees and equipment from cave-ins. Protective systems are: Benching and sloping systems, support systems, shield or shoring systems or any other system which provides proper necessary protection.
Shoring	temporary structural elements that serve to transfer loads during an excavation to avoid the risk of collapse
HDD	Horizontal Directional Drilling is a minimal impact trenchless method of installing underground utilities such as pipe, conduit, or cables in a relatively shallow arc or radius along a prescribed underground path using a surface-launched drilling rig. The technique is routinely used when conventional trenching or excavating is not practical or when minimal surface disturbance is required.

In the following referenced document numbers with the originator code "&A?" in this project always refer to project documents with entity originator code of this document.

4 References

Document	Title
BS-6301:2009	Excavations and trenches, embankments, sheeting, clearance

5 Risk Management

5.1 Risk Assessment

Before start of the construction and commissioning period COMPANY and CONTRACTORS have to carry out documented risk assessments considering their activities for excavations and inside excavations.
The risk assessment is a precondition for issuing CONTRACTOR's work permit (acc. to &A?-W-SC 9601 "Permit to Work System").

5.2 General requirements

5.2.1 Prior to start

Proposed work plan must be submitted by CONTRACTOR in advance to COMPANY in order to establish the location of underground facilities such as electrical, gas, sewer, communication, fuel and water lines. Copies of available drawings of existing underground facilities shall be attached to the excavation work permit (acc. to &A?-W-SC 9601 "Permit to Work System").
Before commencing excavation works a thorough search by appropriate means (such as hand excavation of a searching trench) for buried services must be conducted. Drawings of underground facilities have to be considered. The course of underground facilities, if any, must be marked on the surface by clearly visible means.
While the excavation is open exposed existing underground installations must be marked and protected and/or supported to safeguard employees working inside the excavation.
Any overhead power lines, where excavation equipment cannot maintain the minimum safety distance, must be de-energized and visibly grounded or insulated by barriers.
Warning signs and adequate physical barriers or protective covers must be provided for all excavations.
If an excavation is in or close to roads or walkways warning lamps must be installed at the outside barrier for the hours of darkness.
A work permit (acc. to &A?-W-SC 9601 "Permit to Work System") must be obtained with all necessary supporting documents (e.g. underground facilities drawings, risk assessment).

5.2.2 Requirements during excavation work

5.2.2.1 Fall Protection

If the excavation is more than 1,2m/4ft deep and the slope is ≥ 60° the edge of the excavation must be hard barricaded to protect personnel from falling into the excavation. The barricade must be hard (e.g. wood or scaffold material) and must be:

- 0,6m/2ft from the edge of excavation if the barrier consists of handrail, midrail and toe board
- 2 m/ 6ft from the edge of the excavation if the barrier consists only of one rail.

Ditches and trenches with a width of > 0.8 m /2,6ft must be equipped with bridges/walkways (>0.5m/1.6ft width) for easy crossing the trench. If the depth is > 1.2 m/4ft the bridges must be equipped with handrails.

5.2.2.2 Water accumulation

Employees must not work in excavations in which water is accumulating unless adequate precautions have been taken to protect employees against the hazards of water accumulation. These precautions include special support or shield systems to protect from cave-ins, de-pumping to control the level of accumulating water and the use of adequate PPE indicated in the risk assessment (e.g. safety harness and lifelines).
If water is controlled or prevented from accumulating by the use of a water de-pumping system, the water removal equipment and operations must be monitored by a trained attendant to ensure proper operation. If the accumulation of water inside the excavation is supposed to induce cave-ins the monitoring of the de-pumping equipment must be ensured for 24h/day.

5.2.2.3 Adjacent buildings

Where the stability of adjoining buildings, walls or other structures is endangered by excavation operations support systems such as shoring, bracing or underpinning shall be provided as determined by the responsible engineer during risk assessment to ensure the continuous stability of such structures.

5.2.2.4 Access and egress

A stairway, ladder or ramp or other safe means of access must be provided in all excavations that are 1.2 m/4ft or more in depth. The access must be positioned in adequate intervals of lateral travel for employees, not more than 6m/20ft in distance. If possible, at least two access and egress points must be established.
All walkways, ramps or bridges, where employees are required or permitted to cross over an excavation, must be equipped with standard guardrails. If the distance between a bridge and the bottom of the excavation is more than 2m/ 6ft the guardrails must be constructed with handrail, mid-rail and toe-board.
During excavation work with heavy equipment employees are not allowed to work inside the excavation; the access to the excavation has to be blocked in a safe manner.

5.2.2.5 Hazardous atmospheres

Excavations that exceed 1.2m / 4ft in depth and require personnel to enter or perform works must be considered as confined spaces, therefore the "Confined Space Entry Procedure" (See Doc No. &A?-W-SC 9612) must be implemented.
All excavations greater than 1.2m / 4ft in depth must be atmospherically tested prior to employees entering the excavation or trench. Excavations at locations where hazardous substances can be reasonably expected to exist, such as running process plants in the vicinity, must be air monitored on a continuous base. If necessary (e.g. if hazardous dusts or gases or oxygen deficient atmosphere cannot be avoided) CONTRACTOR must provide appropriate respiratory protection according to the risk assessment and the PPE regulations indicated there.

5.2.2.6 Material and equipment

Light equipment (e.g. small machines, light vehicles, pick-ups) must not be placed closer than 1m /3ft to a sloped excavation and not closer than 0.6 m/2ft to a shored excavation.
Heavy equipment (e.g. cranes, trucks, excavators) must not be placed (including outriggers) closer than 2 m/6ft from the edge of an excavation.
Soil or other material piled, grouped or stacked outside the excavation must be stored properly to prevent from rolling or falling into the excavation not closer than 0.6m/2ft from the edge of the excavation.

5.2.2.7 Inspection

A competent person shall make daily, and as required throughout the shift, inspections of excavations, trenches, adjacent areas and protective systems. After adverse weather conditions, such as rainstorms or thunderstorms, or after unusual working conditions (e.g. heavy equipment travel, vibrations) the inspection must be repeated prior to start of any work inside excavations.
If the competent person finds evidence of a situation that could result in a possible cave-in, failure of a protective system or other hazardous condition, employees are not permitted to work inside such excavation or trench (e.g. by withdrawing the Permit to Work) until safety measures had been

agreed and implemented to rectify the situation and to bring the excavation or trench back to safe working condition.
These inspections must be properly documented and the record must be kept at the access point of the excavation.

5.3 Protective Systems

5.3.1 Requirements for protective systems

Each employee working in an excavation must be protected from cave-ins by an adequate protective system. Exceptions are only if the excavation is carried out in stable rock or it is less than 1.2 m/4ft in depth and examined by a competent person and classified in written form as stable with no indication of potential cave-in.
The sides and the ends must be sloped to a safe angle (dependant on the soil conditions) or supported with timber, sheeting or support systems if the depth of excavations exceeds 1.2m/4ft to prevent them from collapsing.

5.3.1.1 Soil Classification

Dependant on the nature of the soil sloping has to be executed in a certain angle. The soil can be classified into 4 categories:

- Stable Rock – natural solid mineral, can be excavated with vertical sides. Stable rock remains intact while exposed.
- Type A – Cohesive undisturbed soil (e.g. clay, silty clay, clay loam). Fissured, disturbed or already sloped soil requires classification in lower types.
- Type B – e.g. silt loam, angular gravel, sandy clay loam. This type includes also previously disturbed soils except those to be classified in Type C.
- Type C – e.g. granular soils, sand, loamy sand, submerged soil.

Soil classification must be done by a competent person. Any tests carried out for the soil classification have to be documented, signed by the competent person and maintained on file.

5.3.2 Types of protective systems

5.3.2.1 Sloping and benching

The maximum allowable slope of an excavation up to 6m/20ft depth must be in accordance with the following requirements:

- Stable Rock – Vertical (80°)
- Type A – 60 °
- Type B – 45
- Type C – Horizontal/Vertical = 3:2 (34°)

Sloping and benching of excavations deeper than 6m/20ft must be subject to calculation and approval by CONTRACTOR and COMPANY.
Bench dimensions in excavations with a maximum depth of 6m/20ft shall not exceed 1.2m/4ft and the maximum allowable angle of the excavation side must be maintained.

5.3.2.2 Shoring

Shoring may be of timber, aluminium or any other suitable material, such as steel sheet piling.
Design and selection of shielding or shoring systems must be approved by CONTRACTOR's competent person prior to construction. Shoring in trenches or excavations must be determined in

accordance with the soil classification. Determination of a support system has to consider the loads the system has to withstand.
Pre-manufactured materials and equipment used for shoring systems must be used and maintained according to the manufacturer's recommendations and in a manner preventing employees from exposure to hazards. Shoring must protrude the soil surface at least 0.1 m /0.3ft. It must be free from damages or defects that might impair the proper function. Documentation of the approval of materials and equipment by the competent person has to be maintained on site.
The support system must be installed and removed in a manner that protects employees from cave-ins or from being struck by members of the support system. The members of the support system have to be securely connected together to avoid sliding, falling or other kind of failure. Removal of a support system must start at the bottom of the excavation and must continue slowly to indicate any kind of failure of the remaining system. Employees are not allowed to work within supported shields during installation or removal of the shields.

The risk and preventive measures to be implemented during installation and dismantling of the support system must be prepared by CONTRACTOR and approved by COMPANY in advance.

6 HDD (Horizontal Directional Drilling)

In addition to the requirements described on this procedure, the following requirements must be implemented when performing an HDD.

Prior start:
1. Probing the HDD path is free of any underground facility using the flowchart described in appendix 1.
2. COMPANY management together with engineering should define the appropriate method for each specific HDD to reduce the risk of finding any unknown underground facility to an acceptable level and to ensure that the information received is accurate (e.g. hydrovacing, probing, etc..). See appendix 2 for more detailed information about the different tools and methods and their application
3. If any underground facilities are known, CONTRACTOR has to ensure that they are properly marked and identified prior start the activity
4. COMPANY will decide if any additional probing is needed for a more accurate information of the already known underground facilities.

7 Training

Training must be done to a worker prior doing excavation or HDD work. This must include but not be limited to:

- Hazards involving heavy equipment near excavations:
  1. Make personnel familiar with blind spots on equipment.
  2. If required, use spotters.
- Soil conditions when excavating:
  1. Be aware of moisture content and soil changes when excavating.
  2. Dealing with different types of soil types (hard ground, clay, granular material, wet clay, organic deposits with high moisture content).
  3. Caution when dealing with frozen soil.
- Protecting workers against cave-ins with methods such as:
  1. Sloping the trench walls.
  2. Trench boxes
  3. Shoring

8 Referenced Documents

Document	Title
&AZ-W-QR 9604	Job Safety Analysis

&AZ-W-SC 9601.001	General Work Permit
&AZ W-SC 9601.009	Excavation Permit
&AZ W-PQ 9601	HSE Program Site

9 Documentation and Records

This document and relevant records shall be controlled as defined in “Preparation of Internal Documents” (&AZ-Q-PP 1050.060.010 (EN)), “Distribution of Documents” (&AZ-Q-PP 1050.063.010 (EN)) and “Archiving of Documents” (&AZ-Q-PP 1050.066.010 (EN)).

10 Revisions

Proposals for revisions of this Safe Work Procedure should be forwarded in writing to the Global Construction department 'Construction and Commissioning HSE'.

11 Distribution

This Safe Work Procedure will be administered and distributed by the Global Construction department 'Construction and Commissioning HSE'.

12 Appendix 1: Decision flow chart

Decision flow chart to assess the risk of finding un-expected underground facilities

Safety Recommendations to decide on how to proceed with trenchless techniques for working in open excavations
Horizontal Directional Drilling when initial safety conditions are not met during planning phase

ACTIVITY WORKFLOW	POTENTIAL HAZARDS	INITIAL RISK EVALUATION	CONTROL MEASURES	HIERARCHY OF THE MEASURES	RESIDUAL RISK EVALUATION
Obtention of relevant information about services/utilities in the site from client/ owners /operators Plan not available Plans inaccurate, not up-to-date Plans scale, content and style unclear Instruction in how to read and interpret plans unclear Reservations / limitation to supply copies of plans All parties involved in plan or information not consulted ? No information available BUT work has to be undertaken (e.g old process plant or emergency case) Yes	Damage to (underground) services/utilities, which can directly or indirectly pose a risk to people's health and safety.	L3 C3 High	A representative must be requested to be sent to the site to provide information.	O	L3 C3 High
			If the plans or other information have proved to be inaccurate, inform the Client /owners /operators.	O	
			Work must be carried out as though there are underground services/utilities in the area. (see execution part)	O	
Detection of the services/utilities identified as being in the work area No proper studies plan prior detection activities No plan and information are available Likelihood of underground services/utilities being present is important ? Area is congested ? Brownfield Area ? Old process plant without proper management of change ?	Damage to (underground) services/utilities, which can directly or indirectly pose a risk to people's health and safety.	L3 C3 High	Site Inspection must be carried out prior work start: It involves looking for physical signs at site (e.g inspection hatches, reinstated excavations, etc.).	T	L2 C2 Medium
Detection tool selection criteria considered - the training, skill, and experience of the operator; - the characteristics of the device being used; - the calibration and reliability of the detecting device - the type, length and depth of the service; - the magnitude of the current being carried in cable; - the effects of other nearby services; - the nature of surface conditions, - the nature of the ground conditions; - whether or not a signal generator is being used.		L3 C3 High	Detection Survey must be carried out out prior work start in addition to site inspection. It involves using detection tools to identify position and route of utilities/services. (see 'Comments' on detection tools)	T	L2 C2 Medium
Probing template not used Probing template density insufficient		L3 C3 High	Physical identification / Probing must be carried out prior work start in addition to site inspection and detection survey It involves digging trial holes to positively identify the underground services/utilities location and depth.It may also involve passing a tracing device through a pipe or tunnel.	T	L2 C2 Medium
Exposure /uncover identified service/utilities Damaged services/utilities with detection tools Unappropriate digging methode Striked service/utilities with exposure technique (e.g. hand-held power tool, mechanical or vacuum excavation...) Unclear type, position, status of underground services/utilities Ground conditions unstable / changing	Damage to (underground) services/utilities, which can directly or indirectly pose a risk to people's health and safety.	L3 C3 High	Ensure safe digging method is used to uncover cable or pipes (See Comments on Digging Methods) Keep making frequent and repeated use of locators during the course of the work as service/utilities location is likely to become more accurate as cover is removed.	T	L2 C1 Low
Position, orientation and depth uncertained Doubt about the identity of an exposed service Risk of damage during the course of exposure work		L3 C3 High	Expose service/utilities only once a detecting device has been used to determine position and route. Ensure consideration is given to possibility for cables and piping to be uncovered not to conform established system in place (See Comments on position and depth of pipes and cables) Once exposed, service/utilities may need to be supported.	O	L2 C1 Low
		L3 C3 High	Ensure adequate PPEs are worn. - in case of electrical risk: electrical isolated shoes and gloves. - in case of gas leak risk: respiratory mask, gas detector, ATEX PPEs, flame-retardant clothing, etc	P	L2 C2 Medium
Confirmation/identification of exposed services/utilities status (e.g. lived, pressurised...) Old, non-utility services or other pipelines may not conform to system ? Colours may look different under poor or artificial lighting ? Ducts could include any of the services ? Proceed with HDD	Damage to (underground) services/utilities, which can directly or indirectly pose a risk to people's health and safety.	L3 C3 High	Check exposed services/utilities status when work near the service begins as the status of the service may change, eg an electricity cable may become live or a pipe pressurised, etc.	O	L2 C1 Low

13 Appendix 2: Detection tools and methods application

Description of different detection tools and methods and their application

COMMENTS	
DECTECTION TOOLS **Hum detectors** - for magnetic field radiated by electricity cables which have a current flowing through them. - do not respond to: - cables where there is little or no current flowing - direct current cables; - some wellbalanced high voltage cables, where these generate relatively little field (which in turn may be further screened by the cable sheathing); - pot-ended cables **Radio frequency detectors** - for low frequency radio signals, which may be picked up and re-emitted by long metallic pipes and cables. - may generate false reading or signal if other metallic objects (e.g. abandoned pipes, cables) are present. It may re-radiate the signal and results may vary appreciably according to locality, length of the underground cable or pipe and distance from the termination and geographical orientation. **Transmitter/receiver instruments** where a small portable transmitter or signal generator can be connected to a cable or pipe, or placed very close to it so that the signal is introduced into it. The receiver, typically the same radio frequency detectors mentioned above, can then detect this signal. Usually the location of some part of the cable or pipe needs to be already known so that the transmitter can be properly positioned. A direct connection is not required but accuracy will be greatly improved if a direct connection can be made. Some signal generators can be sent along pipes. They can provide useful information in difficult situations where the techniques using hum detectors and radio frequency detectors have not been successful. Use of signal generators will significantly increase the accuracy of the service location. **Metal detectors** - to locate flat metal covers, joint boxes etc, - may well miss round cables or pipes. **Ground probing radar (GPR)** - to detect anomalies in the ground. When these anomalies can be plotted into a continuous line it may indicate a cable, duct or pipe. - should be supported by information available about the services present and also, preferably, by the use of other more conventional forms of detecting device. Knowledge of ground conditions is important. - Consider using probing template with appropriate / higher density of holes. - Ground probing radar technique, alone, would not determine the precise nature of the service/utilities GPR is strongly relying on knowledge of ground conditions. **Drill assisted Ground probing radar** It is a ground penetrating radar system mounted on the tip of a modified, conventional, commercial Horizontal Directional Drilling rig. The radar can detect, and avoid unmapped objects and also confirm the position of pre mapped objects. **Radio frequency identification (RFID)** - to mark or 'tag' new services/utilities. These markers can be programmed with information about the particular service and its depth, and this information can be read by detecting devices. Radio frequency identification (RFID) accuracy depends on the marker being properly attached to the service. As a developing system, RFID will often be found on new services so will not necessarily assist with older services. RFID marker systems may require specific detecting tools that may not be compatible with one another.	**DIGGING METHODS** Hand-held power tools When using hand-held power tools ensure the service/utilities has already been exposed by digging under the surface to be broken out and it is at a safe depth (at least 300 mm) below the bottom of the hard surface material; or physical precautions have been taken to prevent the tool striking the service. Ensure that hand-held power tools are only used 500 mm or more away from the indicated line of a service buried in or below a hard surface. Mechanical excavation When using mechanical excavation, another person should assist the excavator driver, from a position where they can safely see into the excavation and warn the driver of any services or other obstacles. This person should remain outside the operating radius of the excavator arm and bucket Vacuum excavation (e.g water jetting, HydroVac and high-velocity air jets) When using vacuum excavation especially with congested area where mechanical excavation and use of hand tools is difficult, ensure appropriate controls are in place for ejected soil and other material and also to prevent old and fragile service/utilities to be damaged. Vaccum excavation is limited to small area to uncover Hand tools Use hand tools for final exposure of the service/utilities by horizontal digging, as the force applied to hand tools can be controlled more effectively. Use insulated tools when hand digging near electric cables. **POSITION AND DEPTH OF PIPES AND CABLES** Electrical Cables Most underground cables are laid in trenches between 450 mm and 1 m deep but cables may be found at shallow depths. Some high-voltage cables will be deeper. Some lines of 11 kV or greater can be laid out as separate single-phase cables, spread out up to 600 mm across, particularly near cable joints. At collieries, some electricity cables can be yellow or blue and may be mistaken for other services. On some building sites some electricity cables can have been placed in yellow service pipes or blue water pipes. Mind possibilities of electrical arc. Gas Pipeline Locate PE gas pipes by hand digging before mechanical excavation begins. This may also be necessary for metallic pipes if they have not been successfully located by a pipe-detecting device. This is particularly important for service connection pipes, which will not be marked on plans. The depth of cover for gas mains laid in a roadway is normally about 750 mm, and for those laid in a footway about 600 mm. The depth of cover for gas service connections is normally about 450 mm in both roads and footways. However, on private property, the depth of cover for the service connection may be less, about 375 mm. High-pressure gas transmission pipelines are usually buried with at least 900 mm cover. Gas pipes are generally laid directly in the ground, although in certain soils selective backfill may have been used as a bed and pipe surround and, on occasion, pipes may be laid in ducts. Ductile iron pipe will sometimes be found wrapped in loose-fit polyethylene (PE) sleeving as protection against corrosion. PE mains may be inserted into redundant iron gas mains and PE service connection pipes may be inserted into yellow convoluted ducting on new housing estates Water Pipes Always treat continuously welded steel pipes as if they contain a hazardous or high-pressure fluid. Where there is any doubt about the identity of an exposed service treat it as an electricity cable or gas pipe until proved otherwise.