



Lusail Real Estate Development Company

Health, Safety, Security, Environment, Logistics & Quality Department

Lusail Construction Safety Management Procedure – Underground Construction

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1. Description

This element of the LCSMP details Lusail requirements for construction of underground tunnels, shafts, chambers, and passageways. This element applies to all Lusail personnel, Contractors, Developers, Consultants and subcontractors working on the Lusail project.

This procedure also applies to cut-and-cover excavations that are both physically connected to ongoing underground construction operations and covered in such a manner as to create conditions characteristic of underground construction.

2. Definitions

Term	Description
Job Hazard Analysis (JHA)	A process used to identify the hazards or potential hazards associated with each step of a job or work plan to uncover hazards and then eliminate, control, or remove them before the work is started.
Gassy	A hazardous classification that applies if any of the following conditions exists: <ul style="list-style-type: none"> • Air monitoring discloses 10% or more of the lower explosive limit (LEL) for methane or other flammable gases measured at 12 inches from the roof, face, floor, or walls in any underground work area for three consecutive days. • An ignition of methane or of other flammable gases is emanating from the strata that indicates the presence of such gases. • The underground construction operation is both connected to an underground work area that is currently classified as gassy and is also subject to a continuous course of air containing the flammable gas concentration.
Jumbo	Large rock drill used to create new tunnels.
Lower Explosive Limit (LEL)	The lower limit of flammability or explosivity of a gas or vapor at ordinary ambient temperatures expressed in percent of the gas or vapor in air by volume.
Potentially gassy	A hazardous classification that applies if either of the following conditions exists: <ul style="list-style-type: none"> • Air monitoring discloses 10% or more of the LEL for methane or other flammable gases measured at 12 inches from the roof, face, floor, or walls in any underground work area for more than a 24-hour period. • The history of the geographical area or geological formation indicates that 10% or more of the LEL for methane or other flammable gases is likely to be encountered.
Spalling	Breaking up large chunks of rocks into manageable lumps.

3. Responsibilities

The Contractor is fully responsible for the pre-planning, development of Method Statements, Job Hazard Analysis, overall safe work planning and implementation. The Contractor's Project Management is responsible for the assurance that all work is planned and conducted according to the pre-planning documents; Contractor and Lusail Health Safety & Environment (HSE) procedures and the Qatar Construction Specifications 2010. Should a conflict occur between procedures/standards or requirements the more stringent shall apply.

4. Project Underground Construction Plan (Plan)

The competent person in charge of the work develops and implements a project underground construction plan in accordance with applicable Qatar laws and this procedure.

Contractors should prepare their project underground construction plan in accordance with the Sample Underground Construction Plan template, included as (Attachment [LUS-HSE-FM4-446-065](#)).

The Project Manager and HSE Representative facilitate implementation and compliance with the Plan. The competent person is responsible for overseeing the Plan and monitors employees and subcontractors to ensure compliance with all Plan requirements..

At a minimum, the Project Underground Construction Plan must include the following information:

- Name of the person responsible for maintaining the program, and communicating program requirements to employees and other employers
- Name of competent person(s)
- JHAs and daily huddles
- Provisions for controlled access/egress and check-in/check-out
- Provisions for communication
- Provisions for inspections and testing
- Provisions for air monitoring, including substances to be monitored and frequency of monitoring
- Provisions for signs
- Provisions for training
- Emergency rescue plans
- Provisions for fire protection
- Provisions for ventilation
- Provisions to prevent flooding
- Provisions for compressed air work, including:
 - Requirements for a medical lock and its operation
 - Identification system for compressed air workers
 - Special compression and decompression requirements
 - Man lock and decompression chamber requirements
 - Requirements for compressor systems and air supply
 - Electrical power requirements
 - Sanitation considerations
 - Requirements for bulkheads and safety screens

5. General Requirements

- Supervisors ensure that all employees are instructed in the recognition and avoidance of hazards identified in Job Hazard Analysis (JHA).
- Inform oncoming shifts of any hazardous occurrences or conditions that have affected or might affect employee safety, including liberation of gas, equipment failures, earth or rock slides, cave-ins, flooding, fires, or explosions.
- In addition to minimum PPE requirements specified in [LUS-HSE-WG3-446-006](#), Personal Protective Equipment, personnel in wet underground areas must wear rubber boots and rain gear.

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- In accordance with [LUS-HSE-WG3-446-002](#), First Aid, Contractors shall provide first-aid stations at each portal or at distances requiring travel time less than 15 minutes, at a minimum.
 - Do not use internal combustion engines, except diesel-powered engines on mobile equipment.
 - Illuminate tunnels, shafts, and general underground work areas in accordance with [LUS-HSE-WG3-446-005](#), Field & Office Facilities.
 - A qualified electrician must perform and/or approve electrical work in accordance with [LUS-HSE-WG3-446-024](#), Electrical.
 - Trained welders must perform underground hot work in accordance with [LUS-HSE-WG3-446-028](#), Welding, Cutting, and Brazing.
 - Perform excavation work in accordance with [LUS-HSE-WG3-446-033](#), Excavations.
 - Ensure that caissons are equipped with required shields, stairs, platforms, ladders, shafts, man-locks, and gauges.
 - Perform work in compressed air environments in accordance with the requirements of 29 CFR 1926.803.
 - The project engineer determines any additional measures that may be required, such as ventilation shafts, sprinklers, target group lanes, and phased access.
 - Provide access and egress so that employees are protected from being struck by excavators, haulage machines, trains, and other mobile equipment.
 - Control access to all openings to prevent unauthorized entry underground, in accordance with [LUS-HSE-WG3-446-016](#), Signs, Barricades, and Traffic Control.

6. Communication

- The Construction Manager and HSE Representative establish and maintain direct communications to coordinate activities with other employers whose operations at the jobsite affect or may affect the safety of employees underground.
- Use effective natural voice communication and/or power-assisted voice communication to provide communication between the work force, the bottom of the shaft, and the surface.
- Provide hoist operators with a closed-circuit voice communication system to each landing station.

7. Emergency Provisions

7.1 Emergency Rescue Plan

- The HSE Representative develops and includes an emergency rescue plan in the project underground construction plan, in accordance with [LUS-HSE-WG3-446-011](#), Emergency Planning & Response.
- The HSE Representative periodically reviews the emergency rescue plan and conducts drills to ensure efficiency.
- Emergency equipment specified in the emergency plan is located within 15 minutes of each portal or shaft entry.
- Where conditions warrant, NIOSH-approved self-rescuers (escape respirators) shall be provided in accordance with [LUS-HSE-WG3-446-008](#), Respiratory Protection Program, and must be immediately available to all employees at workstations in underground areas where employees might be trapped by smoke or hazardous/toxic gases fumes, or vapors.
- A check-in/check-out procedure must be maintained to ensure an accurate count of the number of persons underground in an emergency. At least one designated person must on duty aboveground when any employee is working underground:
 - The designated person is responsible for securing immediate aid and keeping an accurate count of employees underground in case of emergency.
 - The designated person cannot have other responsibilities that overshadow the counting function.
 - The designated person shall remain at their post until verifying that all persons have exited the underground work area.

If a shaft is used as a means of egress, make advance arrangements for power-assisted hoisting capability to be readily available in an emergency, unless the regular hoisting means can continue to function during an electrical power failure at the jobsite. Such hoisting means must be designed so that the load hoist drum is powered in both directions of rotation and so that the brake is automatically applied upon power release or failure.

7.2 Rescue Team

- On jobsites where twenty five (25) or more employees work underground at one time, Contractors shall arrange for and provide a dedicated rescue service, either on the jobsite, or within ½ hour travel time, at a maximum.
- On jobsites where less than twenty five (25) employees work underground at one time, the Contractor shall station at least one (1) 5-person rescue team on the jobsite.
- Rescue team members must be trained and qualified annually in the rescue procedures, use and limits of breathing apparatus, and use of portable firefighting equipment.
- On jobsites where flammable or noxious gases may be encountered or anticipated in hazardous quantities, rescue team members must practice donning and using Self-Contained Breathing Apparatus (SCBA) on a monthly basis.
- The Contractor shall ensure that all rescue teams are familiar with conditions at the jobsite.

8. Ground Support

- To ensure stable ground, shore and/or fill in, or erect barricades and post warning signs as necessary to prevent entry. Scale adjacent areas or otherwise secure them to prevent loose soil, rock, or fractured materials from endangering the portal and access area.
- If employees enter a shaft or well over 1.5 meters (5') deep, it must supported by a steel casing, concrete pipe, timber, solid rock, or other suitable material.
- Install support sets so that the bottoms have sufficient anchorage to prevent ground pressures from dislodging the support base of the sets. Install lateral bracing between immediately adjacent sets to provide added stability.
- If a rock mass is separated from the main mass, secure it by a means designed by a qualified person.
- Provide anchored chain-link fabric for rock faces subject to spalling.
- Provide a protective shelter, as needed, to protect persons and equipment from the hazards of falling rock or other material.
- Promptly remove ice or snow buildup on rock faces or earth slopes that create a hazard.
- Do not allow anyone to work in unsupported sections of tunnels.
- To prevent further cave-ins, fill, block, brace, or treat all voids in back of ground supports.
- If tunnels are excavated by conventional methods, do not extend the excavation more than 24 inches (60.9 cm) ahead of ground supports; where continuous mining machines are used for tunnel excavation, do not extend the excavation more than 48 inches (121.9 cm) ahead of ground supports.
- Take measures to ensure that the underground area cannot be flooded by adjacent water sources.

9. Drilling

- Employees are not allowed on a drill mast while the drill bit is in operation or the drill machine is being moved.
- Employees working below jumbo decks must be adequately warned when drilling is about to begin. Only employees assisting the operator are allowed to ride on jumbos.
- If jumbo decks are over 3 meters (10') high, stairs must be wide enough for two persons and must be set with guardrails on all open sides, excluding access openings of platforms, unless an adjacent surface provides equivalent fall protection.
- Walking and working surfaces of jumbo decks must be maintained and must will be designed to be slip-resistant and secured to prevent accidental displacement, in accordance with [LUS-HSE-WG3-446-018](#), Walking & Working Surfaces.

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- Conduct all blasting and handle explosives in accordance with [LUS-HSE-WG3-446-031](#), Blasting; and [LUS-HSE-WG3-446-017](#), Hazardous Materials Handling, Transportation and Storage.

10. Air Quality and Monitoring

The HSE Representative determines the identity of potentially hazardous/flammable/toxic substances and the required frequency of air monitoring, in accordance with [LUS-HSE-WG3-446-009](#), Exposure Identification & Controls and includes monitoring procedures in the Plan. The determination is based on the following criteria:

- Location of the jobsite and proximity to fuel tanks, sewers, gas lines, old landfills, coal deposits, and swamps
- Geology of the jobsite, particularly the soil types and their permeability
- History of air contaminants in nearby job sites or any changes in air quality monitored during a previous shift
- Work practices and jobsite conditions (e.g., use of diesel engines, explosives, or fuel gas, ventilation characteristics, visible atmospheric conditions, decompression of the atmosphere, welding, cutting, or hot work)

Conduct tests for oxygen (O₂) content before conducting tests for air contaminants. At normal atmospheric pressure, the atmosphere must contain 20.5% to 22% oxygen.

Ensure that the atmosphere in all underground work areas is quantitatively tested for carbon monoxide (CO), nitrogen dioxide (NO₂), hydrogen sulfide (H₂S), and other toxic gases, dusts, vapors, mists, and fumes as often as necessary to ensure that the applicable Workplace Exposure Limits (WELs) are not exceeded.

- If diesel or gasoline engine driven ventilation fans or compressors are used, test the inlet air of the fan or compressor daily, with the engines operating, to ensure that the air supply to the work area is not contaminated by engine exhaust containing CO.
- If air monitoring indicates the presence of ≥5 parts per million (ppm) of H₂S, test the affected area at the beginning and midpoint of each shift until the concentration of H₂S has been less than 5 ppm for three (3) consecutive days.
- Perform continuous monitoring when H₂S is present above 10 ppm. Notify employees when the concentration is above 10 ppm. At concentrations of 20 ppm, an alarm (visual and audible) must signal to indicate that respirator use, increased ventilation, or evacuation is necessary.

Test the atmosphere for methane and other flammable gases to determine whether the operation is to be classified as gassy or potentially gassy:

- When rapid excavation machines are used, operate a continuous flammable gas monitor at the face with the sensor(s) placed as high and close to the front of the machines' cutter head as practicable.
- When methane or other flammable gases are detected at ≥5% of the lower explosive limit (LEL) in any underground work area(s), or in the air return, increase the ventilation air volume or otherwise control the gas concentration.
- Conduct local gas tests before, and continuously during, any welding, cutting, or other hot work. When methane or other flammable gases are detected at ≥10% of the LEL where welding, cutting, or other hot work is being performed, suspend hot work until the concentration is reduced to less than 10% of the LEL.
- When methane or other flammable gases are detected at > 10% of the LEL, all employees (except those necessary to eliminate the hazard) must immediately withdraw to a safe location aboveground. Electrical power (except for pumping and ventilating equipment) must be cut off to the endangered area until the concentration is reduced to less than 10% of the LEL.
- In underground operations driven by drill-and-blast methods, test the air in the affected area for flammable gas before re-entry after blasting, and continuously when employees are working underground.

When ventilation systems have been shut down or have failed, conduct air monitoring after ventilation has been restored to determine the air contaminant levels. During this period of testing, employees are not permitted to remain in or enter the underground work area(s) affected.

11. Hazardous Classifications

When a competent person determines, on the basis of air monitoring results or other information, that air contaminants may be present in sufficient quantity to be immediately dangerous to life and health (IDLH), a notice will

be prominently posted at all entrances to the underground jobsite to inform all entrants of the hazardous condition. Take all necessary precautions to ensure employee safety in accordance with [LUS-HSE-WG3-446-009](#), Exposure Identification & Controls.

Underground construction “gassy” operations may be de-classified to “potentially gassy” when air monitoring results indicates < 10% of the LEL for methane or other flammable gases for three (3) consecutive days.

All equipment used in gassy operations must be approved and maintained in suitable condition.

Each entrance to a gassy operation must be posted with signs notifying all entrants of the gassy classification.

Smoking and/or all personal sources of ignition, (e.g., matches and lighters) are prohibited in all gassy operations.

After an operation has been classified as gassy, discontinue all operations in the affected area until the operation is either in compliance with all gassy operation requirements or has been re-classified. Exceptions include:

- Operations related to the control of gas concentration
- Installation of aboveground controls for reversing the air flow

12. Ventilation

Supply fresh air to all underground work areas in sufficient quantities to prevent dangerous accumulation of dusts, fumes, mists, gases, or vapors, in accordance with [LUS-HSE-WG3-446-037](#), Ventilation.

When drilling rock or concrete, use appropriate dust control measures to maintain dust levels within safe limits, in accordance with [LUS-HSE-WG3-446-009](#), Exposure Identification & Controls..

13. Fire Prevention and Control

- Develop fire protection plans in accordance with [LUS-HSE-WG3-446-012](#), Fire Protection, and post them at the project site.
- Open flames and fires are prohibited in all underground construction operations except as permitted for welding, cutting, and other hot work operations. Post signs prohibiting smoking and open flames in areas with fire or explosive hazards.
- Do not store underground more than a 24-hour supply of diesel fuel for underground equipment. Do not carry, store, or use gasoline underground.
- Do not bring underground more than the number of fuel gas and oxygen cylinders necessary to perform welding, cutting, or other hot work during the next 24-hour period.
- Diesel fuel can be piped from the surface to an underground location only if all of the following conditions exist:
 - Diesel fuel is contained at the surface in a tank with a maximum capacity no greater than the amount of fuel required to supply for a 24-hour period the equipment serviced by the underground fueling station.
 - The surface tank is connected to the underground fueling station by an acceptable pipe or hose system that is controlled at the surface by a valve and at the shaft bottom by a hose nozzle.
 - The pipe is empty at all times except when transferring diesel fuel from the surface tank to a piece of equipment in use underground.
 - Hoisting operations in the shaft are suspended during refueling operations if the supply piping in the shaft is not protected from damage.
- Keep oil, grease, and diesel fuel stored underground in tightly sealed containers in fire-resistant areas at least 90 meters (300') from underground explosive magazines and at least 30 meters (100') from shaft stations and steeply inclined passageways. Position or dike the storage areas so that the contents of ruptured or overturned containers will not flow from the storage area. Immediately clean up leaks and spills of flammable or combustible fluids.
- Do not store flammable or combustible materials aboveground within 30 meters (100') of any access opening to any underground operation.

Use fire-resistant hydraulic fluids in hydraulically actuated underground machinery and equipment unless such equipment is protected by a fire suppression system or by multipurpose fire extinguisher(s) rated at sufficient capacity for the type and size of hydraulic equipment involved.

Provide and maintain fire extinguishers at the following locations:

- At each portal and shaft entry
- Within 30 meters (100') of the advancing face of each tunnel
- At locations containing combustible materials
- At the head pulley and at the tail pulley of underground belt conveyors

Any structure located underground or within 30 meters (100') of an opening to the underground must be constructed of material having a fire-resistance rating of at least 1 hour.

14. Hauling

Powered mobile haulage equipment must be designed, maintained, and operated in accordance with OSHA/ANSI specifications and [LUS-HSE-WG3-446-025](#), Motor Vehicles and Heavy Equipment.

Conveyors must be guarded. Employees are not permitted to ride power-driven chain, belt, or bucket conveyors unless specifically designed for transportation of persons. Endless belt-type manlifts are prohibited.

Vehicles not directly involved in work must be kept away from portals and construction activities.

If narrow-gage railroads are used for haulage, the tracks must be secured to prevent shifting. "Humping" of mine dump cars is not permitted.

When rails serve as a return for a trolley circuit, both rails must be bonded at every joint and cross-bonded every 60 meters (200'). Bumper blocks or equivalent must be provided at all track dead ends.

Mine dump cars must be equipped with automatic safety couplings, and cradle cars must be equipped with a positive locking device to prevent accidental dumping.

15. Hoisting

All cranes and hoists must be installed, inspected, tested, and operated in accordance with the manufacturer's requirements and [LUS-HSE-WG3-446-026](#), Cranes, Hoists, and Lifts.

Materials, tools, and supplies being raised or lowered must be secured or stacked to prevent the load from shifting, snagging, or falling into the shaft.

A warning light, located to warn employees at the shaft bottom and subsurface shaft entrances, must flash when a load is above the shaft bottom or subsurface entrances, or when the load is being moved in the shaft (exception: fully enclosed hoistways).

If a hoistway is not fully enclosed and employees are at the shaft bottom, stop all conveyances or equipment at least 4.5 meters (15') above the bottom of the shaft and hold them there until the signalman at the bottom of the shaft directs the operator to continue. (Exception: The load need not stop if the load is in full view of the signalman who is in constant voice communication with the operator.)

Any connection between the hoisting rope and the cage or skip must be compatible with the type of wire rope used for hoisting. Maintain spin-type connections in a clean condition and protect them from foreign matter. Make cage, skip, and load connections to the hoist rope so that the force of the hoist pull, vibration, misalignment, release of lift force, or impact does not disengage the connection. Moused or latched open throat hooks do not meet this requirement.

16. Inspection and Testing

Supervisors and foremen notify the Project Manager of any non-routine jobs or tasks to be conducted during the 2-week look-ahead. The Project Manager adds the work to the schedule and initiates preparation of an AHA..

The designated competent person(s) conducts the following tests and inspections:

- Test communication systems upon initial entry of each shift to the underground, and as often as necessary at later times.
- Inspect haulage equipment in accordance with [LUS-HSE-WG3-446-025](#), Motor Vehicles and Equipment.

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- Inspect hoists in accordance with [LUS-HSE-WG3-446-026](#), Cranes, Hoists, and Lifts.
 - Inspect ground stability in hazardous subsidence areas.
 - Inspect the roof, face, and walls of all underground work areas at the start of each shift and as often as necessary to determine ground stability.
 - Test rock bolts for tightness. The Project Underground Construction Plan (Attachment [LUS-HSE-FM4-446-065](#)) determines the frequency of testing based on rock conditions and the distance from vibration sources.
 - Inspect ground conditions along underground haulways and accessways.
 - Inspect drilling, drilling areas, and associated equipment before drilling operations begin.
 - Test and label hydrostatic pressure in caisson shafts.
 - Inspect and test emergency equipment in accordance with [LUS-HSE-WG3-446-011](#), Emergency Planning & Response
 - Repair or replace damaged or dislodged ground supports.
 - Before any equipment is used, correct all defects that could affect safety and health.

17. Training

Contractors shall train their employees in the requirements to be followed during underground construction work.

The HSE Representative arranges employee training at the time of initial assignment. Supervisors are responsible for identifying additional employee training needs during risk mitigation planning (2-week look-ahead). Training can be organized and presented to groups or on a work area by work area basis, depending on the operation.

Rescue team members must be qualified and trained in conditions at the jobsite at least annually, in accordance with [LUS-HSE-WG3-446-011](#), Emergency Planning & Response.

Re-training is provided for employees when there is a change in job assignments or a change in equipment or processes that present a new hazard.

Additional re-training is conducted when there are deviations from or inadequacies in the employee's knowledge or use of proper procedures. The re-training re-establishes employee proficiency and introduces new or revised control methods and procedures, as necessary.

The HSE Representative maintains a record of all training or instruction given to employees, using an acceptable training form.

18. Documentation

The HSE Representative documents all instruction, training, and re-training records. Records verifying completion of training are kept in the individual employee's training files and archived a minimum retention time of 10 years from creation date.

In accordance with [LUS-HSE-WG3-446-009](#), Exposure Identification & Controls, the HSE Representative maintains a record of all air quality tests aboveground at the worksite until completion of the project.

19. Reference

Qatar Construction Specifications 2010

20. Attachments

[LUS-HSE-FM4-446-065](#)

Sample Underground Construction Plan

