Global Products

Excavation Standard

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Version 1.1

Excavation

1.0 Introduction

Excavation (e.g. digging, cut & filling, micro-tunneling, pipe bursting, vibratory plowing, trenching, etc.) standards are designed to help prevent injuries to personnel, property damage and adverse environmental impact as a result of potential hazards associated with excavation work, including encountering underground utilities, potential overhead hazards, subsurface installations, hazardous atmospheres, falls, cave-ins and/or collapses.

An excavation is defined as any man-made cut, cavity, trench, or depression in an earth surface formed by earth removal.

This standard defines the Global Products requirements for Excavation.

The following sections provide minimum requirements for excavations as well as supporting guidance to clarify the intent of those requirements.

Requirements of this Standard shall be met.

2.0 Requirements

1. If excavations are exempt from the requirements of this standard, the reasons for the exemption shall be documented.

2. An Excavation Permit shall be required prior to breaking the surface, including but not limited to the following:
    a. Breaking the surface with power tools and/or heavy equipment (e.g. trencher, backhoe, pile driver, boring machine, jackhammer, or similar) regardless of depth.

        Note: Breaking the surface excludes scraping the ground (e.g. removal of weeds, small oil spills, hydro-excavation and hand tool use, etc.)

    b. Excavating 4 feet/1.2 m or deeper using hand tools.

3. An Excavation Permit shall be used in conjunction with a Permit to Work in accordance with the Global Products Work Authorization Standard.

4. Hazard Analysis shall be performed in accordance with the Products Hazard Analysis Standard when planning excavation activities.

5. A Job Safety (JSA) or equivalent shall be conducted at the work site prior to Excavation activities.
    a. Hazard Analysis shall include evaluation for potential exposure to hazardous vapors when the worker is required to crouch down to perform work in excavations between 3 feet/ 900 mm and 4 feet/1.2 m.

6. Revalidation, shift handover and work completion for excavation tasks must conform with Global Products Control of Work Standard

7. Stop Work Authority shall be exercised and immediate notifications (e.g., supervisor, emergency response personnel, utility company) shall be made upon discovery of damage (e.g., breaks, leaks, dents, gouges) to any subsurface installation.

8. Work must be stopped/suspended and the worksite made safe in the following circumstances:

    a. Protective systems (e.g. shoring, benching, etc.) are damaged and/or not in place when required
    b. Gas testing results exceed permissible levels.
    c. Utilities (e.g. underground power lines, water pipes, etc.) break, leak and/or are damaged.
    d. Excavation equipment does not maintain minimum distance from overhead obstructions or power lines as defined in the Global Products Electrical Safe Work Practice Standard.
    e. Unexpected odors (e.g., exhaust fumes, H2S odors, etc.).
    f. Unexpected subsurface structures (e.g., pipelines, drums, tanks, etc.).
    g. Unexpected leaks, releases, seeps or discharges of vapors or liquids (including water).
    h. After every rainstorm
    i. When fissures, tension cracks, sloughing, underground cutting, water seepage, bulging at the bottom, or other similar conditions occur.
    j. When there is a change in the size, location, or placement of the soil pile.
    k. When there is an indication of change or movement in adjacent structures.
    l. After any event that may damage protective equipment.
    m. After other events that could increase potential hazards (e.g., windstorm, earthquake, dramatic change in weather).

9. Potential hazards and/or surface encumbrances (e.g., trees, utility poles, rocks, proximity of structures, excavated material, vehicles/equipment) shall be removed or secured prior to beginning excavation work, including as applicable: (B)
    a. Underground utilities or subsurface installations (e.g., electric, fuel, water, compressed air, sewer and telecommunication lines) shall be identified.
    b. Notifications of planned excavations shall be made to the appropriate entities prior to beginning work.
    c. Arrangements shall be made with the appropriate utility company or agency for the protection, support, removal, shutdown, isolation or relocation of utilities or subsurface installations.
    d. Utilities left in place shall be protected (e.g., barricades, shoring, supports, or other means as necessary).

10. Underground conduits, electrical cables, and product lines or sewers within the limits of the excavation shall be isolated in accordance with the Global Products Isolation of Hazardous Energy Standard. Product lines or sewers within the limits of the excavation shall be isolated, where feasible and in accordance with risk as determined by the BU.

    a. Underground product lines and sewers within the limits of the excavation are only required to be isolated when the pre-job Hazard Analysis identifies the need for isolation.
    b. Underground conduits and electrical cables within the limits of the excavation that are not encased in concrete must always be isolated.
    c. Underground conduits and electrical cables within the limits of the excavation that are encased in concrete are required to be isolated:
        i. when demolishing the encasing concrete, or
        ii. when the pre-job Hazard Analysis identifies the need for isolation.

11. The exact position of utilities shall be located when excavating activities approach the estimated location by a safe and acceptable means (e.g., day-lighting by hand digging or probing with a blunt object, ground penetrating radar (GPR), pipe cable locators, etc.) when excavating approaches within 2 feet/600 mm of the estimated location of the utilities and lines.

    Note: Site drawings/plans may not accurately reflect the physical location of underground utilities and lines – they should be used for guidance only.

12. Required Marking lines:

    a. If conduits, cables, or piping are found on a drawing, their field location must be positively identified. Once positively identified, the centerline and depth must be marked or staked on the ground and added to the appropriate drawings.

    b. Mark lines using regulatory standard markings or if no regulations, use the guidance on the next slide. Utility locate marks should be in good condition and maintained. Marks deteriorate, re-mark the utility when necessary. Follow the universal color code.

    c. Colors to use when marking utilities (unless local regulations dictate otherwise)

White	Proposed Excavation
Pink	Temporary Survey Markings
Red	Electric Power Lines, Cables, Conduit, and Lighting Cables
Yellow	Gas, Oil, Steam, Petroleum, or Gaseous Materials
Orange	Communication, Alarm or Signal Lines, Cables, or Conduit
Blue	Potable Water
Purple	Reclaimed Water, Irrigation, and Slurry Lines
Green	Sewers and Drain Lines

13. Excavations in close proximity to buildings, roads, retaining walls, and other structures or deeper than 20 feet/6.1 m shall be reviewed and approved by a civil engineer or other qualified professional (e.g., Registered Professional Engineer).

14. The excavation area shall be isolated and barriers erected to prevent unauthorized access by vehicles and personnel not involved in the excavation work.

15. Personnel exposed to or directing vehicular traffic shall wear suitable garments made of reflective or high visibility material.

16. A warning system shall be used when mobile equipment is operated adjacent to the edge of an excavation and the operator does not have clear and direct view of the edge of the excavation. The warning system shall consist of barricades, hand or mechanical signals, or stop logs or equivalent.

17. Protection to the public shall be provided, including, as appropriate, barricades (e.g., guardrails, fences, covers), walkways, lighting, and posted signage.

18. Excavations with a depth greater than 4 feet/1.2 m shall be provided with safe means of access and egress (e.g., ladders, stairways, ramps), requiring no more than 25 feet/7.5 m of lateral travel. Ladders must extend beyond the lip of the excavation by 3 rungs and at least 3 feet/1 m.

a. Structural ramps used solely for worker access or egress, shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design.
    i. Structural members used for ramps or runways shall be of uniform in thickness and joined in a manner to prevent tripping or displacement.
    ii. Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner that prevents tripping.
    iii. Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.

19. Excavations classified as Confined Space (depths ≥ 4 feet/1.2 m) shall be in accordance with the Global Products Confined Space Entry Standard and Portable Gas Detection Standard.

20. A civil engineer, other qualified professional (e.g., Registered Professional Engineer) or competent person shall determine soil conditions and identify soil type in accordance with applicable legal requirements, as well as Chevron standards and/or accepted best practices to prevent cave-in or collapse.

21. Soils with the least stability shall be used to determine methods (underpinning, bracing, shoring, sloping, benching, and/or shield systems designed by a civil engineer or other qualified professional)to prevent cave-in or collapse, when multiple soil types are present.

22. While work is proceeding or an excavation is otherwise open, a competent person shall conduct and document inspections of the excavation, adjacent areas, and protective systems including, but not limited to:
    a. Daily, before the start of work each shift.
    b. As dictated by the work performed.
    c. After every rainstorm
    d. When fissures, tension cracks, sloughing, underground cutting, water seepage, bulging at the bottom, or other similar conditions occur.
    e. When there is a change in the size, location, or placement of the soil pile.
    f. When there is an indication of change or movement in adjacent structures.
    g. After any event that may damage protective equipment.
    h. After other events that could increase potential hazards (e.g., windstorm, earthquake, dramatic change in weather).

23. Personnel shall not enter an excavation while heavy equipment is in use or mechanical digging is in progress, and are not permitted underneath loads handled by excavation or lifting equipment.

24. Personnel shall not work on the faces of sloped or benched excavations at levels above other personnel without adequate protection for personnel at lower levels (e.g. safety net, fall protection, etc.).

25. Personnel shall be protected from loose rock, soil, excavated or other materials and/or equipment (including vehicles) that could enter the excavation including, but not limited to: (P)
    a. Scaling to remove loose material.
    b. Installation of protective barricades or retaining devices.
    c. Use of warning system (e.g., barricades, hand or mechanical signals, stop logs) to alert mobile equipment operators of an excavation edge.

d. Placing, storing and/or retaining materials and/or equipment no closer than 2 feet (0.61m) from the edge of the face unless otherwise designed and approved by a qualified engineer.

26. Steps shall be taken to protect workers from cave-ins for excavations including, but not limited to the following:
    a. When excavations are 4 feet/1.2 m or greater.
    b. When an inspection by a competent person in an excavation less than 4 feet/1.2 m m concludes that there is a potential for a cave-in.

27. Personnel entering excavations 4 feet/1.2 m or deeper (or when inspection by a competent person identifies the potential for cave-in for depths less than 4 feet/1.2 m) shall be protected by protective systems including support systems (e.g., underpinning, bracing, shoring), sloping, benching, and/or shield systems designed by a civil engineer or other qualified professional (e.g., Registered Professional Engineer):
    a. Materials and equipment used for protective systems are free from damage or defects and installed and maintained in a manner consistent with manufacturer recommendations.
    b. Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.
    c. Designs of protective systems shall meet applicable legal requirements, as well as Chevron standards and/or accepted best practices.

28. Personnel shall be protected from water accumulation in excavations including, but not limited to the following.
    a. Surface water and drainage shall be collected and discharged away from the working area through suitable means (e.g., cut-off drains, diversion ditches, berms, bunds, dikes).
    b. A competent person shall monitor surface water and drainage controlled or prevented by water removal equipment to ensure proper operation.

29. Procedures and requirements for the following circumstances shall be described including, but not limited to:
    a. Depending on the size of the excavation, type of soil, and local air requirements, dust suppression may be required during excavation.
    b. If the soil, groundwater or other material excavated appears contaminated, work shall be stopped and an environmental specialist's advice sought on the precautions and disposal requirements.
    c. Any excavation that cuts through a firewall or containment berm/bund requires an approved method of work that provides alternate means of containment while the job is progressing.
    d. Excavating in archeological sites requires special consideration and compliance with local legal requirements and shall be avoided wherever possible.
    e. Where dermal or airborne exposure to contaminants is anticipated, the hazard analysis must address the appropriate personal protective equipment.

30. An emergency rescue plan and equipment shall be available as determined by the Hazard Analysis. Trained personnel shall be on-site and available during excavation work as specified in the emergency rescue plan.

    a. Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous

atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

b. An emergency rescue plan and identified rescue equipment shall be available when an excavation meets the definition of a confined space

31. The reporting unit/business unit/facility shall maintain documentation of employees and contractors authorized to perform excavation activities.

32. The Excavation permitting process shall indicate roles, responsibilities, and protocols as described in the Global Products Control of Work Standard.

33. Personnel assigned responsibilities in excavation roles shall be trained and competent.

34. Training requirements and competency assessments for personnel authorized in Excavation activities shall be documented.

35. The Excavation Standard shall define the policy for record retention that meets applicable legal, corporate and operating company requirements (or at least 6 months, whichever is more).

3.0 Roles and Responsibilities

There must be clearly defined roles, and personnel must meet the training and competency requirements of this standard prior to starting work. Site or local regulations may specify additional training and competency requirements.

Competent Personnel is a person who is capable of identifying potential hazards related to Excavation operations and has the authority to prompt corrective measures.

Table 1: Roles, Responsibilities & Competencies

Role	Responsibilities	Minimum Performance-Based Skills Required
Competent Person	• Identifies existing and potential hazards associated with work. • Knowledgeable of Excavation standard. • Mitigates hazards associated with Excavation work. • Understands when to stop work. • Provides technical support and regulatory advice for specific work-related topics.	• Global Products Excavation Standard
Environmental Specialist	• Provide evaluation and disposal consultation when soil, groundwater, etc. is suspected to be contaminated.	• Degreed and/or trained in environmental sciences. • Global Products Excavation Standard. • Knowledgeable about disposal regulations and requirements relevant to work.
Competent Gas Monitor (CGM)	• CGM may perform only continuous gas monitoring.	• Global Products Portable Gas Detection Standard. • Global Products Permit to Work/Hazard Analysis Std.

Role	Responsibilities	Minimum Performance-Based Skills Required
	• Knowledgeable about acceptable atmospheric working conditions and gas testing order. • Verifies and validates field calibration checks of gas testing equipment. • Understands when to stop work.	• Specific training in the use of relevant portable gas detection equipment. • Demonstrated competency in the use of portable gas detection equipment in the field. Training to recognize potential hazards for work requiring gas testing.
Qualified Gas Tester (QGT)	• QGT may perform initial gas testing for permit clearance. • Knowledgeable about acceptable atmospheric working conditions and gas testing order • Knowledgeable about gas testing techniques (e.g. vessel testing, stratified atmospheric testing, etc.) • Conducts and documents gas tests, *for work in progress.* • Allows work crew (authorized entrants, hot work crews, etc.) to witness gas testing if requested. • Determine the frequency of follow-up gas testing for tasks. • Verifies and validates field calibration checks of gas testing equipment • Calibration and response testing of portable gas testing equipment. • Understand the hazards inherent in hot work and confined space entry and the gases that may be present for relevant tasks where gas testing is required. • Understands when to stop work.	• Global Products Portable Gas Detection Standard. • Global Products Permit to Work/Hazard Analysis Std. • Global Products Confined Space Entry Std. • Global Products Hot Work Std. • Specific training in the use of relevant portable gas detection equipment • Demonstrated competency in the use of portable gas detection equipment in the field. • Training to recognize potential hazards for work requiring gas testing.

4.0 Training Requirements

4.1. Initial Training

Personnel must meet the competency requirements and be trained on the requirements of this standard, prior to starting work.

4.2 Refresher Training

Refresher training session shall be provided as follows:

- As required by local regulations or site policy.

- Whenever a person demonstrates insufficient knowledge of the Global Products Excavation Standard.
- When a serious incident related to excavation work occurred and the root cause identified the need to be retrained.
- Trained on the requirements of this standard, at least every three years

5.0 Records

5.1 Records requirements

- Copies of permits and associated documentation (including records of, soil studies or determination, inspection, maintenance, hazard analysis and training / competencies) shall be maintained in accordance with Global Products Managing Safe/CoW Work Prcess.

5.2 Retention requirements

Records shall be retained for the periods as specified below:

- All records mentioned above shall be retained by the facility for at least 1 year after the job has been completed.
- Training Records shall be maintained for 3 years or until re-training occurs.

6.0 Document Control Information

6.1 Documents Reference List

Title	Attachment
Excavation Inspection Checklist	Excavation Inspection Checklist

7.0 Document Control

Description	Corporate	DS&C	Global Products Specific
Approval Date			July 2021
Next Process Document Review			July 2026
Control Number			Version 1.0

7.1 Document Change History

Changes to this document are listed in the table below by change date.

Date (DD/MMM/YR)	Version Number	Description of Change
21 July 2021	*1.0*	*Global Products new standard*
1 *October 2024*	*1.1*	*Revised standard to align with Enterprise Standard changes made to define as Products standard Corrected typos on depth to uniformly reflect 4-ft/1.2m*

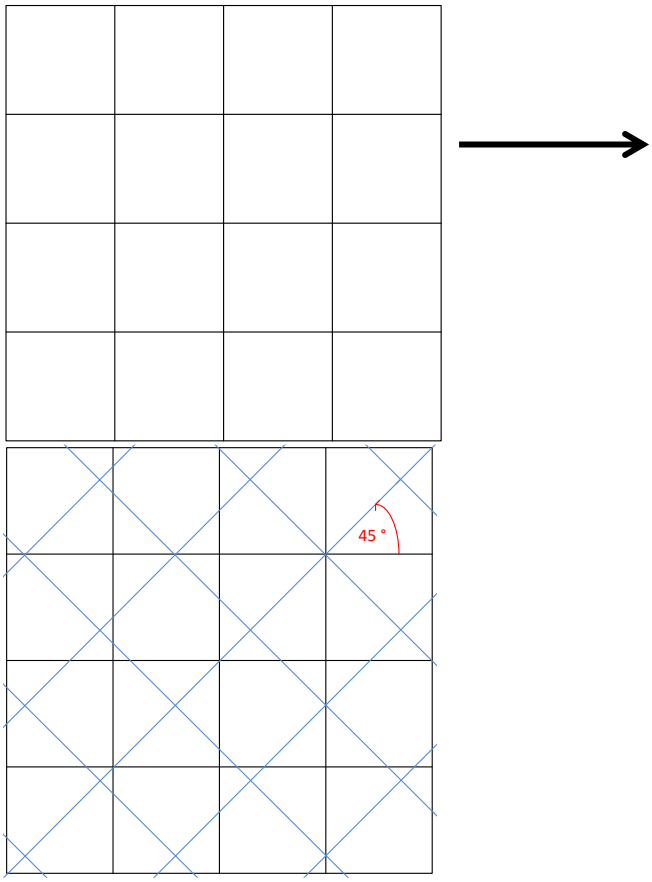
Appendix A: Line Locating Technologies Supplement

Additional Information to aid in understanding the different technologies available.

- # Line Locating Technologies

Contractors and Sub-contractors should locate utilities using a continuous survey method to sweep the area where work will occur. The electronic technologies for line locating require training, experience in operating, and a comprehensive level of data analysis to execute successful line locates. Verification of the equipment operator's training and competency should be completed before the line locate is initiated. Operators should be familiar with the equipment to be used, and should be capable of ensuring the equipment is within the proper mode and frequency, if applicable.

If there are no clear indications of where the utility is located in the target area, personnel should perform a "Blind Locate Sweep". A Blind Locate Sweep is the act of locating a utility with no direct connects to the utility or other subsurface encumbrance. When conducting a blind locate sweep it is important to transverse the site in a Cartesian grid, and then rotate 45 degrees and locate along another Cartesian grid. This ensures that the locate encompasses all subsurface linear angles.



The Line Locating Technologies Selection tool can be utilized to identify technology options suggested for each project site conditions.

NOTE: Check with equipment manufacturer for appropriate calibration and accuracy schedule. Equipment should be checked for accuracy (in relation to location and depth against a known underground facility) on a regular basis and recorded.

○ Electromagnetic (EM) (Radio Frequency Detection (RFD))

This instrument operates on the principle of radio frequency transmission and detection. The transmitter applies a known frequency to a utility and the receiver is able to detect this frequency along the length of the structure (Active mode). The success of EM in tracing underground utilities is based on the composition of the structure (metal or plastic) and the ability to accurately position the transmitter unit so that it can be attached to, or placed directly over the structure.

▪ Conductive Locating using Direct Connect Method

1. Conductive locating (direct connection to the utility) is a preferred method for locating subsurface utilities. Whenever possible, try and find a non-insulated appurtenance connected to the utility to enable a direct connection with the locating equipment.
2. Ensure the transmitter negative lead is properly grounded in the anticipated direction of the target utility and not placed over any known or potential conductors.
3. The positive lead should be directly connected to the targeted utility.
4. If no connection points for a direct connect are available, then conductive locating is not possible. See Induction Line Locating.

CAUTION: When direct connecting to a utility, confirm the test station is not damaged, and be aware of the potential for multiple lines bonded together.

Direct connection to gas service tracer wire

1 Source: New England Subsurface Imaging

▪ Induction Line Locating using transmitter placed on ground

An inductive search procedure is a reliable technique for locating unknown metallic lines. This type of search requires a transmitter and receiver.

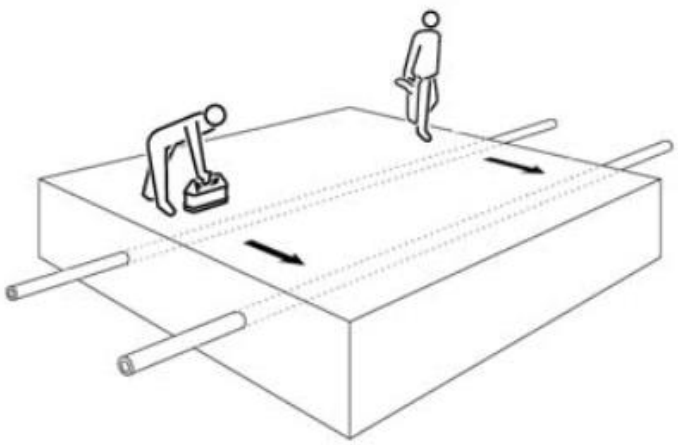
1. Ensure the direct connect leads are disconnected from the transmitter. An appropriate mode and frequency should be selected conducive with the location conditions. The transmitter induces a

signal into the ground at the intended utilities and detected with the receiver upstream or downstream of the transmitter.
2. Hold the transmitter with its length aligned with the assumed direction of any utility. The transmitter applies the strongest signal to the lines directly below it. Place the transmitter above an assumed location of utility.
3. Set the receiver sensitivity to a level conducive to the work environment to minimize interference from stray currents. Sweep the receiver side to side, keeping the receiver vertical, as they proceed in parallel with the transmitter.
4. Move the transmitter from side to side to verify the highest signal which indicates that the transmitter is also directly above the utility.
5. Mark the ground at the point of each peak signal detected with the receiver. Verify the peak signal against the null signal.
6. Repeat the search along any other possible paths of utilities.

The inductive method requires the transmitter will be placed on the ground inducing a current into the subsurface lines which will then be picked up by the receiver.

If personnel are going to induce current by placing a transmitter on the ground, proper frequencies should be used to minimize any “bleed off” that may occur from other facilities in the area.

Stray currents may interfere with the locating of the pipelines during this process and should be communicated to the excavator.



2 Induction Line locating (source: New England Subsurface Imaging)

▪ Inductive locating using ring clamp method

Personnel should ensure the clamp is properly attached fully closed and that the conductor is grounded at the near and far end.

1. Depending on brands and models, these locators range from single frequency to multi-frequency and can be used in conductive (direct-connect), inductive (transmitter placed on ground), and inductive (using ring clamp) modes.
2. They have visual and audible guiding system and instant depth readout.

NOTE: Check equipment manufacturer guidelines for appropriate calibration and accuracy schedule. Equipment should be checked for accuracy (in relation to location and depth against a known underground utility) on a regular basis and recorded.

3 Source: New England Subsurface Imaging

Cautions for Electromagnetic Locating

1. Further verification (e.g., probing, vacuum extraction, hand digging) may be required for abnormal conditions or area hazards that produce poor, inaccurate, or weak signals from the electronic line locator. Such conditions include, but are not limited to:
    a. Signal distortion caused by multiple pipelines or other adjacent utilities, conduits, etc.
    b. Foreign line crossings in the area
    c. Common bonded facilities
    d. Inconclusive electronic line locator readings
    e. Air coupling (transmitter interference) or other unwanted coupling
    f. Signal interference caused by overhead power lines
    g. Facility depth
    h. Ground water
    i. Technology limitations
    j. Sharp drop or complete loss in signal
    k. Ghost Signals
    l. Difference in size
    m. Inaccurate records
    n. Surface structures
    o. Short length facilities
    p. Any other condition that produces an inaccurate signal from the electronic line locator
2. If a condition exists that affects the accuracy of the electronic line locator or there is difficulty troubleshooting readings, then further verification of utility location should be pursued.

○ Acoustic Pipe Locator

There are two common types of acoustic pipe locators: ultra sonic and and the “Thumper” acoustic tool.

Ultra-Sonic

Ultra-sonic utilizes modulated, ultra-high radio frequencies to find differences in subsurface densities. This offers the best method for locating subsurface objects that have a linear edge. The ultra sonic method does not need a direct connection to the line.

Figure: Ultra Sonic Line Locator (ULTRA-TRAC APL) (Source: Sensit Technologies)

Hand-held All Materials Locator (AML) is an example of an ultra sonic acoustic pipe locator. AML is user-friendly, ergonomic, and results are instantaneous. Accuracy is high for PVC, fiber optic, steel lines, and wires. Some disadvantages for the AML include: the device is guided by laser so can be difficult to see where you are locating if using during broad daylight, the device is sensitive so will need to be parallel to ground or slope.

Figure: All Materials Locator (AML) (Source: Brandon Miller, CPL)

"Thumper"

Acoustical pipe locators are used to mark out the location of non-metallic lines, such as Polyvinyl Chloride (PVC) water pipes, that are accessible from the surface. Common methods include sound/pressure wave transmitters, such as the RD500 or "Thumper", that transmit acoustical signals through fluid in the pipe, or the "Knocker" which attaches externally and transmits a signal along the

pipe. The buried portion of the pipe can then be traced and marked using a receiver that detects the signal at the surface. The “Thumper” method does require a direct connection to the line.

Figure: Acoustic Pipe locator. Knocker on left. Pressure pulser on right. (Source: RJM Equipment Sales, Inc.)

Cautions

The pipe must be exposed or daylighted at the surface to attach the transmitter to. Only then can the layout of the piping be traced. Irrigation systems often have a valve control box that can be accessed for this purpose. Sound/pressure wave transmitters require that the pipe be fluid filled.

○ Ground Penetrating Radar (GPR)

The GPR system transmits high frequency electromagnetic waves into the ground and detects the energy reflected back to the surface. The detection of subsurface structures located at the site depends on the electrical properties of the soil and the structure’s depth, diameter, and composition. GPR can find nonmetallic objects such as plastic pipe, voids, fiberglass tanks, as well as metal objects. The only requirement is that the material has different electrical properties than the host material. GPR is good in congested areas. Conductive soils (e.g., clay) severely limit penetration.

1. The GPR unit is pulled or pushed across the ground surface and should be done in a grid like pattern. Energy is reflected along boundaries that possess different electrical properties.
2. Reflections typically occur at lithologic contacts or where subsurface materials have high electrical contrasts, including metal objects such as underground storage tanks (USTs), drums, and utility pipes.
3. These reflections are detected by the antenna and are processed into an electrical signal that can be used to image the subsurface feature.
4. GPR data should be reviewed in the field to assist in the delineation of potential piping or other subsurface structures.
5. GPR can also be used to identify subsurface features such as sinkholes that would create an unsafe situation to drill, excavate, or move heavy equipment over.

Figure: Ground penetrating radar (Sensors & Software LMX100) (Source: Sensors & Softwares)

CAUTIONS for GPR:

1. The GPR response may be attenuated by saturated soils or soils with high clay content, and potential interference issues may include rebar-reinforced concrete at the surface.
2. GPR can be run using different frequency antenna, with higher frequency antenna (500 mHz) providing better resolution, but less depth penetration. If utilities are expected at depths greater than 6 to 8 feet, a lower-frequency antenna (250 mHz) should also be used.
3. GPR is limited when attempting to locate small-diameter pipes with depth. Generally, a pipe must increase in diameter by one 1 inch for each foot in depth to be seen using GPR.
4. Plastic piping is more difficult to detect than metal piping using GPR, and caution should be used if plastic utility lines are suspected. Consider complimentary technologies to supplement GPR and provide multiple lines of evidence.
    a. Technologies may include radio frequency, magnetic and/or electromagnetic surveys. Smaller version GPR units are available to identify rebar patterns in concrete.
    b.

NOTE: GPR is ONLY reliable for the following conditions:

a. **Dry, non-conductive sandy soils**

b. **Target utility is large diameter, metallic piping**

c. **Shallow penetration depths**

d. **No proximity to electromagnetic generating apparatuses (e.g. vehicles, overhead powerlines, heavy equipment, etc.)**

e. **Locating is conducted by a highly trained operator (e.g. geophysicist)**

▪ High Resolution GPR Concrete Scanning Tool

Applicable uses include clearing small sections of concrete. For example where concrete needs to be cored for drilling or to replace a section of concrete. This technology can locate the rebar and other anomalies.

This technology utilizes the same technology as described above for the GPR, using high frequency electromagnetic waves to detect subsurface anomalies. Using the higher end of the GPR frequencies enables users to be able to map out even the rebar lattice work underneath a concrete surface.

Limitations are that it is only good for concrete scanning and only to a depth of 20-24 inches.

Figure: High Resolution Concrete Scanning (Source: Pennhaul Technologies)

○ Magnetic

This technology detects the magnetic field of iron and steel objects and energized power lines. It provides audio detection signal that peaks in frequency when the tip of the locator is held directly over the target. Fundamentally, magnetic detection (magnetometer) is a metal detector and cannot determine depth.

1. Used to conduct blind searches, ground surveys, or to locate underground metal masses
2. A good locator for initial locating and on a greenfield site

Figure: Magnetometer (MAGGIE™ Magnetic Locator) (Source: Pipe Tools)

Cautions

Magnetic is best applied in large open areas with minimal interference issues (such as rebar reinforced concrete, metallic fences, nearby operating motors/generators, overhead powerlines, etc.)

○ Sonde

In general, pipe and cable locators work well for metallic utilities or utilities that can accept a metallic conductor or transmitter (sonde) inserted into them (e.g., empty conduits, storm or sanitary sewers with access, empty and accessible pipes, etc.). A small sonde or "beacon transmitter" is pushed through the pipe.

A wide range of available frequencies is necessary to search for utilities. In general, frequencies from 50 Hz to 480 kHz can be successful. It is usually prudent to have this complete range available during a utility search.

For example, a relatively shallow cast iron pipe with rubber or other nonmetallic jointing material might only be found using the high 480-kHz frequency, whereas a deep steel pipeline may need the 8-kHz frequency to find it and the 1-kHz frequency to trace it for any length of distance.

Figure: Sonde Locator (Schonstedt XT) (Source : MegaDepot)

Notes:

1. Some manufacturers combine several of these frequency capabilities into one instrument, although this sometimes compromises antenna efficiency.
2. In the sonde mode the transmitter is not used at all. This mode is used to trace non-metallic pipes, or metallic pipes where the other modes are inapplicable or inefficient.
3. The receiver searches for the signal emitted by the sonde. Since the signal being traced by the receiver is produced by the sonde, and not travelling along the pipes, there are some differences in the way the receiver is used. As the receiver gets closer to the sonde, the signal strength increases to a maximum when directly over the sonde, if the plane of the sensors is parallel to the axis of the sonde (approaching from a direction that is perpendicular to the direction of the pipe).
4. Due to the nature and strength of the sonde signal, it is necessary to have some idea of where the sonde is along the utility, to narrow the search area to a circle of several feet radius centered at the sonde. This should be controlled by the work crew that is “guiding” the sonde.
5. Once in the surroundings of the sonde, it is important to differentiate whether you are positioned along the axis of the sonde (the direction of the pipe) or off to either side.
6. In the sonde mode the arrows are not functional, so the signal strength is the only indication available, and it will be "null" (very close to zero) if the receiver is placed on the axis of the sonde with the plane of the sensors perpendicular to it. A rotation of 90 degrees from this position should produce a null.
7. Move away from the axis and follow the direction that results in increasing signal strength.
8. Rotate the receiver back and forth and move in the direction that produces the maximum signal.
9. To measure depth, simply place the tip of the receiver unit on the ground and press the DEPTH button when the signal strength is at a maximum. The achievable depth depends on a number of factors, but it is typically possible to read depth up to 5 to 8 feet (1.5 to 2.4 m).

Cautions for Sonde:

Nonmetallic utilities without access for sondes or wires cannot be located with this method.