American Gas Association

AGA White Paper:
Reducing Pipeline Damages from the Use of Horizontal Directional Drilling

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This document serves as a resource for natural gas utilities in reducing the risk of pipeline damage associated with horizontal directional drilling (HDD)[1], being performed by any entity in the vicinity of a natural gas pipeline. HDD is one example of a trenchless construction technique that has successfully been used by local distribution companies (LDC) for decades while installing natural gas pipelines. Trenchless construction includes various pipeline replacement and renewal methods with minimal surface excavation. Although this paper focuses on HDD, many strategies and practices that are identified would be applicable to protecting pipelines from other trenchless technologies, such as piercing tools and boring equipment, including pipe jacking.

Some advantages of HDD over conventional, open-cut methods may include:

1. Disturbances to the existing environment are minimized.
2. Densely populated areas feel minimal impact on business operations and traffic flows.
3. Spoil removal is significantly reduced. Roadway designs and surfaces are undisturbed.
4. Project planning flexibility is increased by eliminating the need to locate new underground routes. Route planning is often complex when designing pipe installation in heavily congested sub-surface areas.
5. Provides the opportunity to replace underground piping in essentially the same location.
6. Greenhouse gas emissions may be reduced up to 80%. The reduction can be attributed to less equipment, less trucking spoil removal, less dumping, and less replacement fill.
7. Enhanced employee safety due to reduced exposure to open excavations.

While the advantages of HDD are attractive to operators and their contractors, it is critical to utilize prudent HDD practices. Construction projects where low quality practices have been used can result in an incident, posing a significant threat to public safety. Unfortunately, serious pipeline incidents have recently occurred which potentially involved ineffective HDD practices:

- New Albany, Indiana – November 8, 2011
- Kansas City, Missouri – February 19, 2013
- Royal Oak, Michigan – February 27, 2013
- Ewing, New Jersey – March 4, 2014

Each incident has a unique set of circumstances and sequence of events and would be extremely difficult to develop a document that would cover every scenario where HDD is being used. Therefore, this paper is intended to offer general practices and principles that may help reduce the chances of an HDD incident from occurring. Most importantly, these methods require personnel who understand the technology and the risks associated with failing to account for the location of all underground utilities.

The intent of this paper is to provide guidelines that may go beyond the minimum standards of federal, state, and local regulations. This paper is written to provide general guidance to the natural gas industry. First party excavator is defined as a gas utility employee performing an excavation. Second party excavator is defined as a contractor working on behalf of the natural gas utility performing an excavation. Third party excavator includes all other excavators, including contractors working on behalf of other utility owners.

[1] Other resources that may be consulted include, federal, state and local laws and regulations, manufacturer instructions, and sources referenced herein.

Some industry references already exist that can reduce the risks of excavation damage and include:

- Common Ground Alliance Best Practices Version 11.0
- AGA's 2010 paper on Damage Prevention
- NASTT Good Practices Guidelines for various trenchless technologies available through the North American Society for Trenchless Technology (NASTT)

Several of the practices identified in this paper are applicable, regardless of who is performing the excavation. Some prevention strategies might vary depending on the affiliation of the excavator with respect to the natural gas utility and the local one call law.

The Key Elements of this guidance document include:

A. Planning and Design
B. Pipe Locating
C. Site Investigation
D. Contingency Planning
E. Inspection for Third (3rd) Party Excavations
F. Inspection for First (1st) party and Second (2nd) party excavations
G. Contracts between Utility and Its Own Contractor
H. Training /Qualification of Utility Crews and Inspectors

A. Planning and Design

Planning for a successful horizontal directional drilling project requires precision in gathering above grade and subsurface site information. Information that includes the location of other underground utilities is essential for quality design purposes. Good location accuracy can help to avoid property damage, injury and loss of life.

Site conditions will typically dictate the level of effort and expense required to determine the accurate location of existing underground utilities. The designer should verify site conditions by compiling all utility plans from owner records, including facility maps and as-builts.

All underground structures and utility lines in the proposed work must be identified and considered. Utilities within the designated project area may need to be located in the field and accurate digital/paper prints indicating the location of their facilities provided to the utility or contractor performing HDD. *If the proposed design crosses or is closely parallel to existing utilities, "potholes" or "test pits" may be required to determine the utility's exact location and depth.*

Space constraints can be a significant risk leading to HDD incidents. When reviewing existing structure locations, identify space constraints or tight fits that may block or add complexity to the pipe path. If space is limited, consider the feasibility of relocating the other utilities. If relocation of other utilities is not possible, a new pipe path may have to be considered.

Design Considerations

When establishing the location of the bore path, planning for adequate clearances between the proposed and existing facilities is critical. *Remember to consider your state utility commission's requirements for clearance when crossing or running parallel to other utility infrastructure*. Clearances should be calculated with the shortest or most conservative distances to nearby

structures. Calculation should include the distance from the outside edge of existing structures to the nearest edge of the largest diameter back reamer used.

In addition to pathway planning, design a bore path that will minimize secondary damage sometimes produced by directional boring fluid (e.g. road heaving). Proper depth for the size of the bore hole, soil type, and existing soil conditions should be considered.

The decision to bore all or part of a project should be based upon many factors and is generally project-specific. It may be safer and more cost-effective to use open cut installation techniques when taking into account all necessary HDD design and safety considerations.

B. Pipe Locating

One-Call Centers

All states require excavators to contact "Call before you dig" one-call centers prior to excavation. Considerations for individual state one-call center requirements should be made when submitting a locate ticket request. These centers notify underground facility owners, who will either contract out or perform locating services within a mandated timeframe. In some cases, where facility owners do not support the one-call system, additional actions must be taken by the natural gas utility to locate these facilities using its site assessment tools and procedures. It is strongly recommended that natural gas utilities use their partnerships with trade organizations and local regulatory agencies to help persuade all underground facility owners to participate in the one-call system. In addition, call centers should be encouraged to include HDD as an excavation type when generating a ticket. *In addition to following the State One Call Law, natural gas utility operators can benefit from a close review of one-call tickets involving higher risk or critical facilities, such as high pressure and large diameter pipelines.*

Locators

Locators use existing drawings showing the location of underground utilities and a surface geophysical or electromagnetic locating method (or methods) such as pipe and cable locators, ground penetrating radar (GPR), and/or metal detectors to interpret the presence of a subsurface utility, and mark its approximate horizontal position on the ground surface in the work area in accordance with applicable state one call laws.

Unlike actual exposure of the subsurface utility by vacuum excavation (potholing or test-pitting) by which the utility's precise horizontal and vertical position can be visually determined, conventional locating methods are only an electronic proxy that *infers* the location of the underground facility and as a result, the paint line or so called "location mark", may not be exactly where the underground facility is located.

These surface markings, which include labeled stakes, flags, and/or highly visible paint marks at regular intervals on the surface of the ground, generally indicate the approximate horizontal location of the utility within a tolerance zone (see below), typically specified by state damage prevention laws. If known, the size of the pipe should be specified to indicate any additional tolerance that should be considered when excavating within the limits of underground structures and/or within the defined area of the proposed excavation.

Electromagnetic locating of utilities has been actively used since 1910. Technologies and practices have advanced rapidly since then, but the basics and theory of electromagnetic locating has not

fundamentally changed. It is a proven method of locating a conductive (or ferrous) facility and, while the equipment has evolved, little of the actual function of that equipment has changed.

There is often a misunderstanding among excavators and those not familiar with locating technology regarding how accurately those flags or paint marks reflect the actual location of the underground facility. Depending on the field conditions surrounding the pipe and its own characteristics or even the expertise of the individual using the locate equipment, the markings may not be entirely accurate.

Because there can be distortion in the electromagnetic field caused by changing density of the earth, the composition of the earth, the proximity of other underground facilities, the moisture content of the earth, and other factors such as the depth and size of the utility and because the level and direction of the distortion is unknown and might be unseen, the location of the underground facility may not be exactly where the strongest electromagnetic field is located from above ground. *This can cause the facility mark not to be exactly above the underground facility.*

Cable locators are designed to find electromagnetic fields. Almost all locating equipment consists of two parts: the receiver (the piece of equipment in the locator's hands) and the transmitter. Both work together to help find the approximate location of underground facilities.

The transmitter is used to induce a radio frequency in the land mass near where underground pipes or cables are located. The receiver looks for the electromagnetic fields that find and surround the cable or pipe from the transmitter. The locate technician sweeps the receiver across the ground and measures the level of the electromagnetic field.

The location of the strongest electromagnetic field above ground, by inference, is where the cable or pipe is 'located'. That is also the case if the transmitter is connected to the cable or pipe above ground or the pipe is equipped with tracer wire that can be electrified, in which case the horizontal location of the underground infrastructure can be determined. However, this is not always the case.

As a result, an excavator should *always* assume that the underground facility could be anywhere within the Tolerance Zone (see below) on either side of the temporary mark. When digging within the Tolerance Zone of a facility mark, extra care should be taken. Prudent excavation techniques –digging by hand or using soft excavation techniques such as vacuum excavation – should be employed until the location of the facility is exposed and known.

Tolerance Zone

In recognition of the proxy nature of the location marks and to account for discrepancies caused by distortion, most jurisdictions recognize a Tolerance Zone that surrounds the mark and caution excavators that the paint line on the ground or other surface marking should only be considered to be an approximate indication of the location of the buried utility somewhere within that zone.

The size of the Tolerance Zone varies by state from 18" to 30" on either side of the center line of the locate marked on the surface. Within this zone, the excavator is required to dig with caution using hand digging, soft digging, vacuum excavation or other similar prudent excavation techniques.

The Tolerance Zone requires hand or safe digging or drilling practices. The zone is important because the location of underground facilities is *indirectly* determined with locating equipment.

Locating Methods

Pipe and cable locators are the most common method used to locate metallic lines or the tracer wire installed on non-metallic pipes.

Plastic pipes can also be located by inserting a sonde through an access point to the underground utility under live conditions or with an acoustic pipe tracer that operates utilizing elastic wave theory. The advantage of using the sonde technique is that it can be accompanied by a closed-circuit television (CCTV) camera that also provides internal features of the pipe, like service tees, in-line tees, stand pipes, etc.

Ground Penetrating Radar (GPR) is currently the third most common method for locating. The major advantage of GPR is that it can image different types of materials buried underground. The drawbacks of using this equipment include limited applicability to highly conductive soils (clay and saturated soils), practical limitation of imaging objects located 2 meters below the surface, notable subjectivity of the interpretation, and likely higher operating costs compared to pipe and cable locators.

While GPR may be a good *addition* to a locating practice, the results do not indicate a higher success rate with this technology than with electromagnetic efforts. Experience has shown that gas pipelines located with an electromagnetic locator are not always found with the GPR method, and accuracy is the key to quality locating services. Soil conditions and moisture significantly impact attenuation of the signal, making it difficult to interpret by the operator. In addition, underground objects like tree roots, boulders, abandoned facilities, etc. cannot be differentiated from the pipeline.

Locator Training

The changes in technology affect the training that a locate technician receives. To become a proficient locator, effective training and periodic refresher courses are key to acquiring and maintaining the necessary skills. It may be helpful for potential technicians to receive instruction in the theory of electromagnetic locating. Without this basic theory, effectively using the equipment (no matter how advanced) and employing sound troubleshooting techniques becomes challenging. If locating technicians understand the premise of completing a circuit, have an understanding of proper metallic conductors, size of frequency fields, and a strong knowledge of utilities and utility construction, success usually follows.

To assure better quality and success, an LDC can consider the use of a formal certification program for its locating personnel. This can also be an approach for companies that outsource their locating work to third parties.

C. Site Investigation

After locates are completed and/or prints are received from other utilities, perform a site investigation. Review the area for facilities that were not located, such as sewer lines. Look for clear evidence of sub-surface facilities such as cleanouts, manholes, septic systems, re-paved trench lines, and any others. It may be useful to talk to property owners or local municipalities to learn of additional customer-owned facilities that may not have been marked.

If sewer lines exist and are not located, find the cleanouts and/or manholes to determine the physical location of a sewer line. Access to cleanouts and manholes can allow locating by

electronic means (e.g., the insertion of metallic fish tape) prior to the physical spotting of the sewer. A video camera may also be inserted through the sewer main to help locate sewer and drain connections. Of particular importance is the use of a camera capable of extending through a sewer lateral to pinpoint the location of the lateral in the drill path. It may be necessary to obtain a homeowner's approval and the local sewer municipality in order to perform some of these actions. Ideally, state one-call laws would require new sewer lines to be locatable by having tracer wire installed.

Communications with local municipalities may also provide information regarding locations of sewer mains and/or laterals and could include targeted public awareness communications on sewer blockages which could potentially be caused by a cross bore. Cross bores occur when trenchless technology inadvertently punctures and intersects sewer laterals. Cross bores with sewer lines have resulted in catastrophic incidents throughout North America. Therefore, identifying sewer lines and their precise locations is critical for safe HDD operations. HDD should not be used if any known underground facility location and depth crossing the proposed bore path cannot be determined.

Some Additional Precautions

Because "seeing is believing," vacuum excavation ("Potholing" or "Test Pitting") can be a great extra step in damage prevention *after* utilities have been initially located and marked. In circumstances where there is any uncertainty of the precise location of facilities that may conflict with the proposed drill path, vacuum excavation allows for verification of locates, particularly in congested utility areas.

Some LDCs take additional precautions where drilling is likely to occur in close proximity to transmission lines or other high profile utilities. In these circumstances, some LDCs require all excavators, including directional drillers, to vacuum excavate and expose the pipeline at or near the proposed crossing before any other excavation takes place. In addition to clarifying the location, this procedure allows the excavator to verify the actual pipe size, material, and condition that will confirm its identity and ensure proper clearance during directional boring activities which cross or run parallel to the pipeline. Ensuring proper locates and then educating the contractors on safe digging practices provides an extra level of damage protection for high-profile lines.

Before construction, a final check for signs of underground utilities which may have been overlooked should be completed. Checking for facilities that have not been located should be completed in the immediate planned bore path and nearby area as well. Potential areas of facilities without locates can be found at patched trenches in the paving or infrastructure with underground utilities such as power poles and boxes, fire hydrants, etc. Any additional facilities (or lack thereof) should be confirmed prior to construction. If an unmarked facility is suspected, operators should re-notify the one-call center.

It is a best practice to create a final bore plan once all underground facilities have been located and all locates cleared for routine work. Geo-technical investigation involving soil corings may be appropriate for larger projects. Not only does the bore plan lay out a path which avoids conflicts, but also may indicate existing conditions where the number of or placement of conflicting utilities makes another construction method preferable.

Operators may consider requiring test holes remain open for both the initial drill and pull-back, to help verify proper separation and that no damage has occurred.

D. Contingency Planning

There are multiple points in a construction lifecycle where things may not go according to plan, causing immediate consequences or setting the stage for future incidents. It is important that there be an established understanding of these points and a contingency plan or process in place to ensure safety.

Contingency plans for the construction phase, especially for strikes (gas & electric) should be in place and discussed at the morning tailgate meetings. Electric strikes should be identified by the machine's alarm system, at which point the operator must remain on the machine and no other personnel are to touch the energized equipment. If contact with the underground wire cannot be broken, the operator must remain on the equipment until the facility owner arrives on site to de-energize it.

In the event of a pipeline damage, the section of damaged gas line will need to be isolated by the gas utility to shut off the flow. If the natural gas utility is using HDD, it might consider identifying critical valves or isolation points prior to the start of the project, in the event damage actually occurs. If a pipeline damage occurs, the excavator should immediately call 911 and the local utility so the utility operator can follow appropriate procedures to isolate the line. The area should be secured from the public and bystanders for safety reasons.

E. Inspection for Third Party Excavations

Third party excavation continues to be the leading cause of incidents to natural gas distribution pipelines. The lack of consistent and effective enforcement for third party excavators who damage natural gas pipelines continues to be a challenge for the natural gas industry. Without complete One Call participation by all facility owners and rigorous enforcement of state One Call laws, natural gas utilities typically have more difficulty influencing the actions of 3rd party excavators, including those using HDD in the vicinity of natural gas pipelines. Additionally, coordination of work plans and schedules will help ensure that adequate inspection by the natural gas utility and oversight of third party work is performed. For information on state damage prevention laws and the enforcement that exists in each state, visit PHMSA's Pipeline Safety Stakeholder Communications page that contains the link to each state:

http://primis.phmsa.dot.gov/comm/states.htm?nocache=605

Other Actions

When natural gas utilities are aware of HDD projects being performed by 3rd party excavators in the vicinity of their pipelines, actions might include:

- Educating the excavator on safety practices when using HDD.
- Enhanced communications with the excavator and sharing of information, including contact information for company personnel.
- Confirming location of pipeline, exposing it, and requiring structural support, as needed.
- Monitoring of higher profile pipelines (e.g., high pressure, larger diameter) to ensure no damage occurs to the pipeline or its coating.
- Periodic site inspections for accurate and visible locate markings, ticket scope for daily work and validity of one call tickets.
- Periodic inspection when excavating within tolerance zones.

In addition to identifying upcoming bores through one-call tickets, it is in the utility's best interest to provide outreach and education to those who perform excavations. In the case of drilling, this is typically a contractor familiar with local laws and requirements. In instances where a contractor has repeatedly damaged facilities, the utility may suggest enrollment in a damage prevention workshop to educate the contractor, or take steps with the government to seek enforcement of state laws and the imposition of civil fines or penalties, e.g., revocation of a license.

F. Inspection for 1st Party and 2nd Party Excavations

Frequent construction inspections should be planned during HDD projects. Examples of tasks to be reviewed include:

- Daily review of sonde calibration records (note: located in the drill head, the sonde collects data such as location and depth so that bore path can be adjusted)
- Frequent inspections of drill head locations.
- Periodic confirmation of drill head depth by test-pitting and visual identification.
- Maintaining sufficient clearance from other utilities during back-reaming operations.
- Monitoring of higher profile facilities
- Verification the crews are working with a current and valid one-call ticket
- Review personnel DOT Operator Qualifications for tasks to be performed, where applicable.

It is critical that the location of the drill head be known at all times. Locations must be known in relation to the locations of other underground facilities. Using a calibrated sonde tool can help assure the bore path is being followed, as planned. All pipe crossings should be exposed, at least to the installation depth of the proposed pipeline (considering back-reaming operations). Critical facilities may benefit from additional safeguard when excavation is occurring. These facilities can be placed on a monitoring and standby schedule during construction.

G. Contracts Between Utility and Its Own Contractor

Prior to contracting a 2nd party for work involving HDD, a thorough vetting of the potential contractor should be completed by the utility. Areas of examination may include, but are not limited to detailed review of the both the contractor's and natural gas utility's operating procedures. The following are of particular interest:

- Contractor-written processes that require the contractor personnel to pothole at all crossings.
- Contractor-written requirement that establishes a minimum separation from existing pipe.
- Contractor-written requirement for daily calibration of sondes enabling accurate location of drill head at all times.
- Utility understanding of contractor's training, qualification and documentation of such records.
- Verification that contractor personnel have completed training on all required operator qualification tasks.
- Utility ensure that the contractor has access to the utility's construction procedures.

Contracts between utility and its contractor are a critical element to assure that safety is not being compromised at any time. For instance, the utility is encouraged to contemplate how its contract should be structured to facilitate potholing (or test-pitting) and taking additional time to verify the location of all underground lines in the scope of the project.

H. Training /Qualification of Utility Crews and Inspectors

Training is a critical element for performing HDD and inspecting HDD operations being performed by utility crews. A clear understanding of fundamental information and techniques for performing HDD installation is useful for both crews performing this activity and inspectors observing work performed by others.

The North American Society for Trenchless Technology (NASTT) is a prime resource for publications and training in this area. NASTT's publication, *Horizontal Directional Drilling Good Practices Guidelines*, was developed to provide contractors, engineers and owners with a comprehensive resource. The guidelines offer successful HDD practices in training operators and supervisory personnel. This training augments operation instructions typically included in Operator's Manuals provided by the drill rig manufacturer, while presenting a clear understanding of the process and applications.

Summary

Use of HDD and other trenchless technologies has continued to grow. Trenchless technologies have environmental advantages that minimize ground disturbance, spoil removal, pavement restoration costs and the production of greenhouse gases. They are, in many circumstances, safer and can reduce public inconvenience. The technology also reduces the impact of pipeline construction in densely populated areas. Business operations can continue to operate and traffic disruption and delay is minimized.

Nevertheless, with all their advantages, there are other factors that need to be considered before employing trenchless methods.

Every user of HDD should be aware of these risks and the need to adopt safe and prudent methods. These include thorough planning of the project and the bore plan, detailed location of all of the potential conflicts within the work area, a comprehensive facility compilation, employment of trained and competent personnel, execution and enforcement of safety-focused business agreements, and constant awareness of drill head locations.

Project planning and design for HDD improves with a full detailed knowledge of the nature and location of all underground infrastructure within the proposed work area. This includes coordination among all facility owners, one-call centers, locate personnel, and project team members to ensure the most comprehensive approach to the construction site activity.

All personnel must be well-trained and competent to perform their duties. Locate personnel should understand the operational theory and the limitations of their equipment. Both construction and locate personnel should be aware of the extent and meaning of the state's tolerance zone. Within this zone the excavator is required to use appropriate "dig with caution" options, such as hand digging, soft digging, vacuum excavation or other similar safe excavation techniques, unless otherwise allowed by the facility owner or applicable regulations.

The project planner should consider the location of all existing underground utilities when calculating the bore path. Calculations should be the most conservative and should include the outside edge of existing structures to the nearest edge of the largest diameter back reamer. Any intersection within the tolerance zone shall require the "dig with caution" options, unless otherwise allowed by the facility owner or applicable regulations.

LDCs should inspect and provide oversight to their own construction contractors. Prior to the creation of construction agreements between the LDC and 2nd party excavators, a thorough vetting of 2nd party capabilities, expertise, written processes, and operator qualification programs should be reviewed. Ideally, contracts would promote safe boring processes through fair and equitable compensation agreements.

All utility crews should be properly trained and become proficient in materials provided in NASTT's publication, *Horizontal Directional Drilling Good Practices Guidelines*. Project management should ensure all crew personnel are properly qualified.

The actions needed for successful HDD are not limited to this document. Users should review current federal and state requirements and become well-versed in existing industry references.

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