

**SECTION 608
HORIZONTAL DIRECTIONAL DRILLING**

608.1 DESCRIPTION:

This specification covers requirements for installation of underground infrastructure using the trenchless technology method known as Horizontal Directional Drilling (HDD). All installations shall be in accordance with the approved HDD Consortium's "Horizontal Directional Drilling Good Practices Guideline, third edition" and updates thereof.

The HDD method involves first drilling a pilot bore in the location(s) as indicated on the plans, next enlarging the drilled pilot bore to facilitate the installation of the required pipe line or bundle, herein referred to as the "product pipe." The pilot bore is enlarged approximately 1.5 times the size of the product pipe and then the product pipe is pulled into the enlarged borehole.

Installations are classified as small, medium or large which serves as a general indication of the level of equipment required for the installation. The size of bore is measured in inch-feet and is calculated by multiplying the nominal product pipe diameter in inches by the minimum allowable length of crossing in feet as indicated on the plans or as can reasonably be inferred from the locations of such bends, fittings, service connections, valves and any other equipment requiring excavation and/or connection to the pipe line at a specified location. The bore size refers to each individual bore, not the total footage of the permitted design.

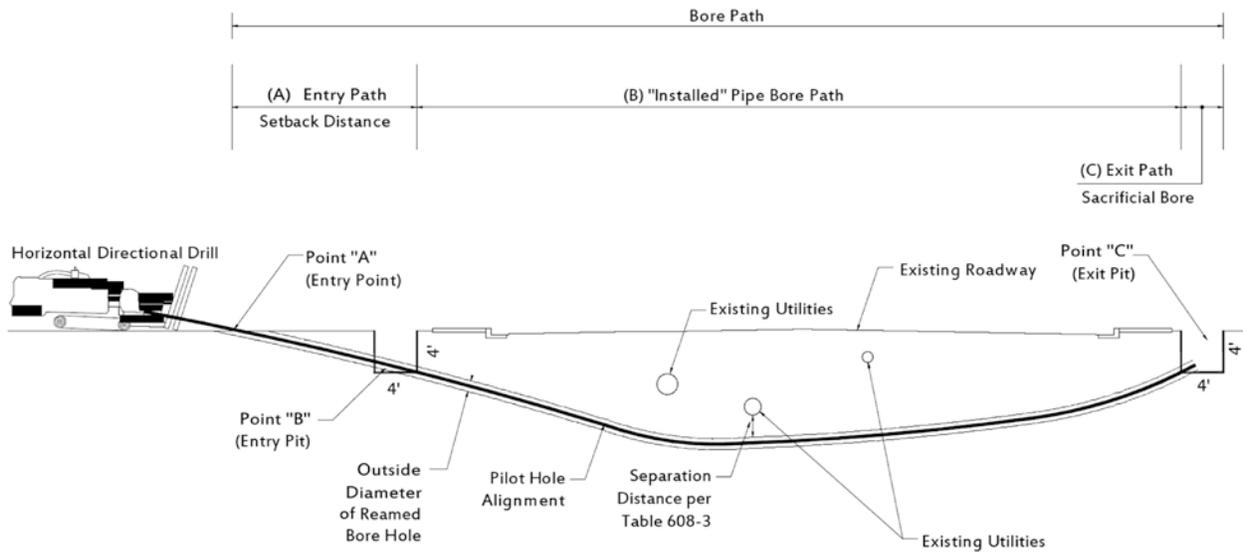
Bore size calculation: 200 foot installation of a 4 inch diameter pipe has a bore size of 800 in-ft.
(200 ft. × 4 in. = 800 in-ft)

TABLE 608-1	
CLASSIFICATION OF BORE SIZES	
Classification	Bore Size
Small	Up to 6,000 in-ft
Medium	6,001 in-ft to 15,000 in-ft
Large	Above 15,000 in-ft

608.2 HDD TERMS AND DEFINITIONS:

- a. Pilot Hole: The initial controlled drilled horizontal shaft used to guide the enlargement to design size and eventual installation of the product pipe.
- b. Reaming: The back reaming hole opener is attached to the drill pipe and rotated and pulled back through the pilot hole to enlarge the bore in one or more passes to the size needed for product pipe installation.
- c. Pullback: The pipe installation pulled back by a swivel/pulling head connected behind the reamer, which pulls the prepared product pipe into place.
- d. Drilling Fluids: Fluids consisting of water, bentonite, and any approved additives such as environmentally safe polymers, lubricants, and viscosifiers.
- e. Bore-tracking Equipment: Methods and systems generally defined as a walkover or non-walkover. To be specified by the Contractor and used to measure the actual accuracy of the bore to the specific line and grade. The bore path is monitored during the pilot bore by taking periodic readings of the inclination and azimuth of the probe located within the sonde housing.
- f. Bore-tracking Pit: An excavated area for entry, exit, slurry sump or any other excavation used to manage, control, and track the progress of the bore.
- g. Critical Structure: Any pipeline, utility, building, structure, bridge, pier, or similar construction partially or entirely located within a zone of active excavation.

Figure 608-1



The setback distance is dependent upon elevation difference from A (surface) to B (desired grade), entry angle of rig, and bending radius of drill rods.

608.3 MATERIALS:

All product pipe material shall be of the size, type, and class as shown on the plans.

Sectional pipe is pipe that requires assembly of the joints, such as a bell and spigot pipe. Sectional pipe shall be specifically designed for installation by HDD.

Non-sectional pipe is pipe that requires joining together by a fusion or welding process. It is assembled prior to pulling the product pipe into the bore hole.

Non-sectional pipe that requires fusion of the joints, such as HDPE or Fusible-PVC, shall be fused by a skilled operator. The Contractor is responsible for using qualified personnel to ensure the fusion process follows the pipe manufacturer's recommended procedures. The Contractor shall submit certification from the pipe manufacturer or an accredited training agency documenting personnel qualifications. Untrained personnel shall not be permitted to perform fusion of any pipe on the project. The Contractor shall use a data-logger or manually record the following information for each fused joint in the product pipe line, unless the product pipe is used as a sleeve, pulled through a sleeve, or used for dry utilities.

- Date and time of joint
- Temperature
- Fusion pressure applied to joint
- Joining/fusion time
- Cooling time

Solid tracer wire AWG #14 or larger shall be pulled with the product pipe to ensure compliance with ARS 40-360.22, paragraph M.

608.4 RECORD DOCUMENTS AND SUBMITTAL REQUIREMENTS:

Submittal requirements are based on the bore size classification as shown in Table 608-2. The required items contained in items 1 through 10 shall be submitted prior to the authorization to commence field construction. Copies of all documents shall be maintained at the construction site and be available for inspection.

TABLE 608-2			
SUBMITTAL REQUIREMENTS			
Required Record Document	Bore Size Classification		
	Small	Medium	Large
1. Agency Approved Plans	•	•	•
2. Personnel Qualifications	•	•	•
3. Surface Survey		•	•
4. Bore Plan/Profile		•	•
5. Drilling Fluid Management Plan		•	•
6. Equipment & Site Setup			•
7. Drilling Fluid Pressure Calculations			•
8. Pipe Stress and Pullback Calculations			•
9. Bore Data	•	•	•
10. As-Built	•	•	•

608.4.1 Agency Approved Plans: The facility owner shall submit plans for approval to the Agency in whose right-of-way the facility owner is proposing to install the new utility. Any changes from the approved plans will require a re-submittal of plans and re-approval. Plans are to identify the location of all property lines, right-of-way, and easements within the project construction limits. No work is to take place outside of the construction limits as shown on the agency approved plans.

608.4.2 Personnel Qualifications: The Contractor shall provide a competent and experienced individual familiar with the equipment and the type of HDD operations to be performed. The individual shall be present onsite while HDD operations are being performed and be in direct charge and control of the HDD operations. Documentation of experience and appropriate training evidenced by a certificate of attendance from a training program shall be provided upon request.

608.4.3 Surface Survey: A surface survey is not required for small bores unless specified by contract or permit documents. A surface survey requires the contractor prior to starting the drilling operation to submit to the Engineer a surface survey of elevations along the planned bore alignment, the maximum interval between elevations shall be ten feet (10'). Upon completion of the installation of the product pipe, the Contractor shall have a second survey performed and shall have the elevations compared with the pre-bore survey elevations. The second survey and the comparative results shall be submitted to the Engineer. Any change in elevation of a paved surface greater than 1/2" shall be considered excessive and shall be repaired at the Contractor's expense. Any elevation deviation of a paved flow line that is greater than 1/4" shall be considered excessive and shall be repaired at the Contractor's expense.

608.4.4 Bore Plan/Profile: A scaled plan and profile drawing of the proposed pilot bore shall be submitted by the Contractor. The bore plan/profile shall show existing surface features and grade, the proposed pilot bore size and path, and all existing utilities with dimensioned vertical and horizontal clearances.

608.4.5 Drilling Fluid Management Plan: Indicate the type and amount of the drilling fluid planned to be used on the project. Include safety data sheets for the identified drilling fluid components and additives. The drilling fluid plan is developed based upon the anticipated soil conditions, and a sufficient supply of fluid is to be available to enable successful completion of the bore. Indicate the intended method of disposal of spent drilling fluids and

include approvals from off-site disposal sources. The Drilling Fluid Management Plan shall identify contingency measures to be employed in case of inadvertent returns. The contingency plan may include containment with sediment control devices, removal with vacuum equipment or other such contingency measures as appropriate. In all cases, the plan shall indicate that if primary control measures fail and inadvertent returns cannot be controlled, work will be suspended until such a time as the plan can be revised and effective control measures can be implemented.

608.4.6 Equipment & Site Setup: Specifications on directional drilling equipment shall be used to ensure that the equipment will be adequate to complete the project. Equipment list is to include, but not be limited to: drilling rig, mud system, mud motors (if applicable), down-hole tools, guidance system, and rig safety systems. Include calibration records for guidance equipment. Identify the site setup dimensions and where the equipment shall be located. Equipment shown on the site layout is to include but not be limited to: drilling rig, mud system, drill rod stock pile and mud return pit. Identify the pipe staging and assembly areas.

608.4.7 Drilling Fluid Pressure Calculations: Provide documentation sealed by an Arizona registered professional engineer for the calculations of minimum required and maximum allowable drilling fluid pressures anticipated throughout the bore to maintain drilling fluid circulation and minimize the occurrence of inadvertent returns. Indicate how such pressures shall be monitored and recorded throughout the progression of the bore. Provide manufacturer's specifications for the down hole fluid pressure monitoring system(s) and properly calibrate such system(s) prior to commencing the installation.

608.4.8 Pipe Stress and Pullback Calculations: Submit documentation indicating the product pipe manufacturer's specified maximum allowable bending radius and maximum allowable pulling force for the pipe being installed. Provide calculations sealed by an Arizona registered professional engineer that show the anticipated bending radii for each segment of the pipe and the total anticipated pulling force required to complete the installation and that the maximum radius and the maximum allowable pulling forces for the pipe are within tolerable limits. The drill rig to be employed shall be capable of exerting a pullback force of at least two times that of the total anticipated pulling force required to complete the installation of the pipe specified. Furnish documentation indicating how the pulling forces introduced to the pipe will be monitored and indicate the methods that will be employed to record such data and ensure that the force exerted on the pipe does not exceed the pipe's maximum allowable pulling force.

608.4.9 Bore Data: Identify the installed location of the bore by writing down each rod and indicating the depth and pitch. Submit a copy of this information when requested.

- Rod/joint number
- Depth and pitch of locate reading

608.4.10 As-Built: Identify the installed location of the bore on a scaled drawing referencing any benchmark information provided on the original construction drawings. Also indicate the location of all existing utilities as provided on the original construction drawings and verified in the field, as well as any undisclosed utilities as discovered in the field throughout the prosecution of this work. Also submit copies of any drilling fluid logs, pipe fusion logs, and any other such information as it pertains to the work undertaken pursuant to this specification.

608.5 CONSTRUCTION:

608.5.1 Horizontal Directional Drilling Equipment: The HDD equipment is to have an electronic "walkover" tracking system or a Magnetic Guidance System (MGS) to accurately guide boring operations; a system to monitor maximum pullback pressure during pull-back operations; a system to detect electrical current from the drill string shall be in place with an audible alarm that automatically sounds when an electrical current is detected; a vacuum unit of sufficient capacity to handle the drilling fluid volume; and trained and competent personnel to operate the systems. All equipment shall be in good, safe condition with sufficient supplies, materials, and spare parts on hand to maintain the system in good working order for the duration of the project.

608.5.2 Guidance System: An electronic "walkover" tracking system, or a MGS probe or proven (non-experimental) gyroscopic probe, and interface for continuous and accurate determination of the location of the drill head shall be used during the drilling operation. The locating system shall be capable of determining the in ground

position of the drill head and shall be accurate to $\pm 2\%$ of the distance from the transmitter to the receiver. It shall enable the driller to guide the drill head by providing information on the pitch; roll and clock face orientation of the drill head. The locating system shall be capable of determining the depth of the drill head from the transmitter to the surface at any location along the path of the bore. The locating system shall be calibrated per the manufacturer's specifications prior to commencing the bore.

608.5.3 Drilling Fluid (Mud) System: A self-contained, closed, drilling fluid mixing system of sufficient size to mix and deliver drilling fluid composed of bentonite clay, uncontaminated water, and appropriate additives shall be used. The mixing system shall be able to molecularly shear individual bentonite particles from the dry powder to avoid clumping and ensure thorough mixing. The drilling fluid reservoir tank shall be of sufficient capacity to supply an amount of drilling fluid that is equal to the maximum rated output of the drilling fluid pump over at least a fifteen minute duration. Ensure the drilling fluid is mixed per drilling fluid manufacturer's recommendations and continually agitate the drilling fluid during drilling operations.

The Contractor shall be responsible to monitor drilling fluid properties and return fluid properties and shall modify the drilling fluid mix as appropriate for the soil conditions encountered. Contractor shall continually monitor and record any necessary drilling fluid properties such as viscosity as determined by a marsh funnel standard test method (ASTM D6910). The drill fluid pumping system shall be capable of delivering drilling fluid at a sufficient output rate and at minimum pressures as necessary to enable successful completion of the bore. Furnish pumping equipment and/or vacuum truck(s) of sufficient size to convey drilling fluid from containment areas, to storage and recycling facilities or disposal.

608.5.4 Directional Drilling Operation: Prior to drilling the pilot hole, "Walk" the bore path with the locating system, as per the manufacturer's specifications, attempting to identify any areas of potential interference and record the results of such inspections. Verify that all known utilities have been located and there is no conflict with the proposed work. Ensure all utilities that run parallel within 2' of the proposed work are exposed at intervals sufficient to determine there will be no conflict with the proposed work. Comply with surface survey requirements.

Determine the depth of the drill head every 10' or every rod length, whichever distance is greater. Record location information for the entirety of the bore, either manually in a driller's log or automatically via the locating system. Make all recorded readings, and plan and profile information available at all times. Do not allow the deflection radius of the drill pipe exceed the deflection limits of the product pipe at any time throughout the crossing. Use white paint and mark the depth of the pilot bore on the ground at an interval not exceeding 10'.

Stabilize the open bore hole by means of bentonite drilling slurry pumped through the drill rod and through openings in the drill head or reamer. The drilling slurry shall be in a homogenous/flowable state serving as an agent to carry the loose cuttings to the surface through the annulus of the borehole. Calculate the volume of drilling fluid required for each reamer pass based upon hole size and soil conditions. The driller shall not be permitted to "outrun his mud" which is the condition occurring when the drilling penetration or retrieval rate is generating cuttings at a rate faster than the drill fluid pumping system can suspend and convey the cuttings out of the bore hole.

Contain all drilling fluids in pits or holding tanks for recycling or disposal. Monitor drill fluid circulation throughout the duration of the bore activity and immediately take corrective actions to restore fluid circulation should circulation be lost.

Upon completion of the pilot bore, ream the bore hole up to a large enough diameter to accommodate the pullback of the product pipe. The final reamed hole opening shall be 1.5 times the outside diameter of the product pipe for pipe lines 24" or less, or no larger than 12" plus the outside diameter of the product pipe for pipe lines greater than 24".

Maintain a one foot (1') minimum separation between the outside of the pilot bore hole and the outside of the utility when no reaming is required to install the product pipe.

When the pilot bore hole is to be reamed, maintain a minimum separation between the outside of the pilot bore hole and the outside of existing utility equal to one foot greater than the largest required reamer diameter.

Minimum separation between the bore and any existing underground utility shall conform to Table 608-3.

TABLE 608-3	
MINIMUM SEPARATION FROM EXISTING UNDERGROUND UTILITIES	
Minimum Separation	Type of Underground Utility
2' vertical	Outside of bore to outside of wet utility (wastewater, storm, flood irrigation, water, etc.)
1' vertical	Outside of bore to outside of dry utility
6' horizontal	Running line to outside of wet utility

608.5.5 Handling Product Pipe: Care shall be taken during transportation of the product pipe to prevent it from being cut, kinked, or damaged. Use ropes, fabrics, or rubber protected slings and straps when handling pipes. Do not use chains, cables, or hooks inserted into the pipe ends. Use slings spread apart for lifting each length of pipe. Do not drop pipe or fittings onto rocky or unprepared ground.

Store pipe on level ground that is free of sharp objects that could damage the pipe. Limit the stacking of pipes to a height that will not cause excessive deformation of the bottom layers of pipe under anticipated temperature conditions. Where necessary due to ground conditions store the pipe on wooden sleepers, spaced suitably and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

Handle assembled pipe in a manner that avoids damage to the pipe. The pipe is not to be dragged over sharp objects. Position slings to prevent stress on pipe joints. Product pipe that has cuts, gouges, or excessive deformation shall be removed and replaced.

608.6 MEASUREMENT:

Measurement of product pipe installed by HDD shall be by the lineal foot of pipe installed. Measurement shall be along the centerline of the product pipe, through all valves, fittings and manholes, from centerline to centerline of valves, fittings or structures or to the end of pipe.

608.7 PAYMENT:

Payment will be made at the contract unit price for each type and size of product pipe installed and accepted. Payment shall be compensation in full for the product pipe and furnishing all labor, material, tools, and equipment required for the horizontal directional drilled installation of product pipe, complete in place, including all related excavation, shoring and bracing, backfill, and compaction. When specified payment shall also include, testing, disinfecting, restoration, and connections to existing lines or works.

- End of Section -