Horizontal Directional Drilling - Pullback Support Design for Various Pipe Materials

Ensuring Successful HDD Installations

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Stress measurements conducted on Horizontal Directional Drills (HDDs) have shown that the highest stress imposed on the product pipe during installation in many cases occurs during the lifting of the pipe above ground. HDD pullback lift support design is therefore a critical key component of the overall engineering and design of HDD installations. Lack of detailed lift designs can have severe impacts on the success of the HDD installation, including overstressing of product pipe, pipe damage, schedule delays due to lack of necessary lift equipment on site, high pullback forces and coating damage due to misalignment of the pipe at the exit point, and/or un-safe lifts where lifting equipment may be in danger of overloading and failure. Key to a suitable lift design is a good understanding of the characteristics of different product pipe materials, and the impact the pipe material has on the various considerations that go into it.

The four types of product that could typically be installed by HDD are Carbon Steel, High Density Polyethylene (HDPE), Fusible Polyvinyl Chloride (FPVC), and Ductile Iron pipe. Steel and HDPE pipe are very commonly installed via HDD. FPVC is becoming increasingly prevalent in HDDs in recent years, and ductile iron pipe is relatively uncommon but is sometimes installed via HDD. Steel is primarily used in the Oil & Gas industry with higher operating pressure applications, while FPVC and HDPE are commonly used in both water/sewer and electrical or fibre-optic cable conduit applications, and ductile iron is typically utilized in only water/sewer jobs. Steel pipe joints are welded together while HDPE and FPVC pipes are fused together utilizing heat and pressure to join two joints together with a fusion machine. Ductile iron pipe differs from the others in that it is usually installed in single joint increments, each joint connecting to the previous with a bell and spigot quick-connection before it is pulled downhole. Where steel, HDPE and FPVC pipe elastically bend to adhere to downhole curves, ductile iron pipe does not bend and relies on the deflection at these specially designed bell/spigot joints in order to adhere to any curves. Because of these flexible connections, long strings of ductile iron pipe typically aren't laid out in pre-fabricated strings which are lifted to align with the exit point, as it would be more akin to trying to lift a chain than lift a single solid member. However, if each joint of pipe is supported adequately, long strings of pre-fabricated ductile iron pipe can be utilized.

> ***Pullback design is key to ensuring the validity, feasibility, efficiency, and safety of HDD Construction***

The type of material being installed by HDD will affect many considerations within the pullback and lift design. One of the first major differences in pipe materials is weight. Steel pipe and ductile iron pipe of similar OD may have relatively similar weights, depending on wall thickness. An HDPE pipe of a similar OD may be lighter by 40 percent or more in comparison to these pipes, and an FPVC pipe of the same OD would be even lighter since FPVC typically has lower wall thicknesses than similarly sized HDPE. The differences in weights could equate to differences in required lift support spacing in order to ensure the lifting equipment is not overloaded.

Workspace limitations are one of the primary concerns that pullback lift plans have to deal with. Preferably, any HDD would have a section of straight open space past the exit point, at least as long as the HDD, so that a single straight pipe section can be prepared for pullback. This would allow the contractor to install the product in one continuous pull, without having to stop for completion of an intermediate weld or fusion. Depending on the size of pipe, a weld, coating and inspection of a steel pipe could add up to a full day of stoppage on the pullback operations, which in many cases could add unacceptable risk of the product pipe becoming stuck and resulting in an unsuccessful pullback. For an intermediate fusion on PVC and HDPE pipes, the stoppage time can be significantly less than steel, but still can cause undue delays that add unwanted risk. Additionally, there are other impacts such as internal de-beading of the fuses that can be difficult or impossible when fusing two long

Figure 1. Steel, HDPE and FPVC pipe all elastically bend to adhere to above-ground curvture

sections of plastic pipe together. Proper quality control during the welding, fusion, and coating (where applicable) processes are key, as cutting out a bad fusion or recoating pipe during pullback is not tolerable from a risk standpoint.

Having straight open workspace to accommodate a single pull section is, unfortunately, not always the case. In fact, in densely populated areas it is almost never possible. Sometimes the designer may need to get creative in trying to utilize available workspace and minimize intermediate welds and fuses while also minimizing impact to the public and ensuring worker safety. In general, steel pipe can afford the least amount of horizontal bending or "roping" in order to go around obstacles or stay within available open workspace, whereas PVC and especially HDPE can be curved at much tighter radii which can allow single pullback sections in some relatively tight locations. On average, FPVC pipe can be bent to approximately 50 percent of the radius steel pipe can, while HDPE can be bent down to approximately 10 percent of the radius that similarly sized steel pipe can be bent to due to their relative flexibilities. An analysis should be completed to determine that the pipe will not be overstressed when roping around obstacles and that the equipment intended to support the pipe through these changes in direction above ground are properly sized to ensure they can safely support it.

Where the limiting workspace constraint for a straight pullback is a road, rail, or watercourse, there may be ways to accommodate crossing these obstacles with the pull section without significantly impacting them or blocking them off. For roads and rails, support of the pull-section above the road/railway such that traffic can continue below the pipe section can be completed. If this is to be

Figure 2. HDPE can turn a much tighter corner than other pipe materials

Figure 3. If a road can't be closed, why not go under it? Having straight open workspace to accommodate a single pull section is increasingly rare

done, careful planning, permitting, and engineering design of redundant supports above the lane of travel are key to achieving this successfully and safely. Another alternative may be the completion of a pre-installed large diameter casing or culvert below the road/railway. This can allow threading the pipe pull section through the casing/culvert under the obstacle, therefore avoiding any impact to flow of travel.

One of the major differences in pipe materials is weight

Where watercourses intersect a pullback alignment, sometimes if it is small enough the contractor may be able to provide lifting supports on either side in order to span the pipe across the water without causing overstressing of the pipe. Where a wider watercourse is crossed, it may be worthwhile constructing temporary bridging above the watercourse to allow for pipe and support equipment travel above it.

Buoyancy Control is another consideration that can impact many HDD pullback lifting plans. Buoyancy control entails filling the product pipe up with water as it is pulled below surface to reduce the buoyant weight of the pipe and reducing overall pull force. Buoyancy control is typically recommended for steel pipe installations of 24-inch OD or larger and would be considered necessary for most sizes of plastic pipe. The pullback alignment and laydown area should be selected with consideration of the buoyancy control plan, as the ballasting of the pipe will require a considerable amount of water, pumps, as well as ballast

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lines. Additionally, the ballast line and water flowing through it within the pipe being installed will add weight to supports holding the pipe in place which should be accounted for when sizing the equipment.

CONCLUSION:

Different product pipe/conduit materials have differing physical properties and each needs to be treated accordingly. Industry guidelines and codes, as well as manufacturer specifications need to be referenced when developing pullback designs, and detailed calculations on allowable bending, equipment loading and required lift heights should be completed, whether these be hand calculation models, software-based analysis models, or a combination of both. Additional impacts of horizontal curves, buoyancy control, sloped grades, and roller friction force contribution to vertical support loading all need to be considered within these calculations. Completing such analysis is a critical key in ensuring the validity, feasibility, efficiency, and safety of a full HDD design.

Figure 4. Pullback towering over a road