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Demanding HDD Installation of Fusible 24-inch PVC Pipe Sets New Record

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Introduction and Project Background

The Standing Rock Reservation is home to the Standing Rock Sioux Tribe, and the reservation is located in north central South Dakota and south central North Dakota. The lack of a reliable municipal water source has plagued the reservation for several years. Recent federal funding has helped to alleviate this problem through the development of an area wide municipal water system, the Standing Rock Rural Water System.

The reservation wide engineering plan that was compiled by Bartlett and West, a full service engineering firm located in Bismarck, ND, was comprised of several elements. The core facilities project includes a caisson-style intake on the Lake Oahe reservoir, a 19,000 m^3/day (5 MGD) water treatment plant, a 19,000 m^3 (5 million gallon) primary storage reservoir and approximately 100 km (62 miles) of large diameter main line piping.

The initial stage of the Standing Rock Rural Water System included the design and construction of a raw water intake and treatment plant. Due to physical and political constraints, the intake and treatment plant were to be located approximately 19.3 km (12 miles) apart. A pipeline alignment connecting these two elements required the crossing of the Grand River with a raw water line at a point where its width approaches 1.5 km (approximately 1 mile). Due to environmental friendliness, ease of permitting, and relatively clean operation, horizontal directional drilling was chosen as the construction method for this stretch. Open excavation techniques were only preliminarily considered for this crossing.

The Grand River crossing portion of the raw water line involved design complications related to pipe material selection as well as installation. The portion of the raw water line, which was intended to pass under the Grand River would also be the portion where the highest static pressure would occur. In order to provide an adequate

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to pass under the Grand River, would also be the portion where the highest static pressure would occur. In order to provide an adequate factor of safety and the necessary restraint for large diameter pipe in this area, three alternate materials were selected: FPVCP Fusible C905 DR 18, HDPE DR 7.3, and Cross Linked HDPE DR 9, with the ultimate selection being made by the successful contractor. In order to minimize friction loss and ultimately meet the pipe interior diameter requirements for the project, FPVCP of 600 mm (24-inch) nominal diameter would be necessary and HDPE of 760 mm (30-inch) nominal diameter would be necessary. Ultimately FPVCP was chosen as the crossing material for a variety of reasons including the smaller outside diameter relative to inside diameter and the availability of material.

Crossing Lake Oahe

An HDD project of this length and size was going to be complicated enough, but this project had some additional aspects that made it an even greater challenge for both the driller and the product pipes that could be used.

The alignment required that a fairly significant body of water be crossed, as it was located on a portion of the damned up Grand River at the bottom end of an area known as Lake Oahe. When the project was designed, the average lake level was estimated at an elevation of 485 m (1,592 ft); this measurement being taken in the summer of 2008. This placed the deepest point of the proposed drill under about 12 m (40 feet) of water at this level.

There was also significant topography located on either side of the crossing, with steep banks rising out from the lake edges for another 15 to 24 m (50 to 80 feet), depending on which side of the crossing was evaluated. While this had limited effects on the drilling rig and related equipment placement and operations, it did have a large effect on the fusion and stringing of the product pipe for staging the pull and then performing the insertion operation.

Beginning the Work

The initial project scope seemed fairly daunting – but the events leading up to the actual construction provided even more challenges. A snowy winter, and then a rainy spring meant that when this work was to begin, the lake level that was estimated at 12 m (40 feet) at the deepest point went to 18 m (60 feet). Not only did the water get deeper, it also spread its horizontal reach up both banks of the crossing site, and in doing so placed the proposed location of the drilling, pipe fusion, and staging operation under water.

This brought about the largest change in the project, which was to switch the direction of the insertion and drilling processes and also to lengthen the bore so that it could be completed from the 'tops' of both banks, instead of as close to the water's edge as was originally possible. The bored crossing then went to approximately 1463 m (4,800 feet) as opposed to approximately 1280 m (approximately 4,200 feet) as originally designed. It also got relatively deeper, due to the new locations of the bore and insertion pits.

With the new direction of installation, the fusion process and pipe layout moved to the north side of the crossing, which presented several of its own challenges. The terrain of the north side of the crossing as well as the presence of several driveways required some creative solutions in order to assemble the entire length of 600 mm (24-inch) nominal diameter pipe into one single string.

Drilling Process

King Contracting, Inc (King) of Lincoln, Nebraska, won the project and was tasked with drilling this difficult crossing. King has performed many HDD installations ranging in difficulty over the years and specialize in all types of pipeline crossings including waterworks installations, like this project, and also oil and gasoline crossings more common to industrial work.

The weather encountered leading up to the project created challenges for the drilling as well as the overall plan of attack for the bore as previously described. One major complication that arose during the drilling process that was affected by the water level increase was the ability to track the pilot bore using a guidance system. King used a wireline system and steering company in Centerline Directional Guidance Systems (Centerline), but they ran into trouble placing the coils required in the lake. Divers were used to attempt to place the coil wire on the bottom of the lake, but the extra 6 m (20 feet) of depth due to the rainy spring and strong crosswinds

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and currents meant that accurate survey from the bottom of the lake was nearly impossible. Centerline laid their wireline system as far as they could operate it effectively, and then drilled the pilot bore 'blind' under the water, using only the steering corrections made to estimate where the pilot bore was at any given time for the bulk of the crossing. Even given these circumstances, they were able to hold the bore within 1.5 m (5 feet) of the proposed alignment when they reached the other side of the water and were able to locate the pilot equipment. Figure 1 shows the drilling rig and operational setup.

A Vermeer 200x300 drill rig was used to install the pilot bore at a diameter of 250 mm (9 and 7/8 inches). This was the first indication that the soils present for the bore were going to provide a challenge. The pilot bore took approximately 10 days to complete, while dealing with the differing soils present and struggling to keep down-hole tooling matched to the conditions present at any given time in the bore. Soil conditions along the alignment varied from clay to shale to silty sand. King used the same Vermeer drill rig for the first reaming pass, but ultimately used a larger American Augers AA625 for the second 38-inch ream and then pipe pullback.

Fusible PVC™ for the Crossing

FPVCP was bid as an option for the crossing and was selected for the crossing by King. The tensile properties of PVC lend themselves very well to a crossing of this type, as long as they can be effectively utilized by the joining methodology of the pipe. The ability to fuse PVC pipe has created this ability for long strings of pipe, such as the one required for this project. Additionally, the tensile capacity of the plastic allows a higher pressure class to be attained with a thinner wall compared to other fusible thermoplastic systems. This ultimately means a larger flow area for a given outer diameter, which results in reduced construction costs in a smaller total bore hole size required – reducing reaming passes, drilling fluids, and the time required to complete a crossing – all saving construction dollars and perhaps more importantly, time on site.

Underground Solutions, Inc. (UGSI) provided the 600 mm (24-inch) DR18 Fusible C-905 pipe for the crossing and also performed the fusion services to assemble

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the pipe on site. As mentioned previously, the new direction and length of the installation required that 1463 m (4,800 feet) of pipe be strung along an existing roadway, complete with driveways and a difficult topography. To handle the required topography and to facilitate easier movement of the pipe string, the pipe was placed on appropriately sized and spaced rollers as shown in the figure to the right.

The driveways were handled by replacing existing drainage piping with oversized, 915 mm (36-inch) CMP culverts and then stringing the pipe through those culverts with a roller at either side. The driveway was excavated, the culvert placed at the approximate location, FPVCP pipe was then threaded through, and the alignment of the composite section was adjusted. Finally, the crossing was backfilled and then plated to allow access while the rest of the staging continued. This assured the pipe would be out of the way for the staging process and then again during installation, while access via the driveway was maintained as shown in the figure on the next page. The culverts were then left in place after the work was completed to function as a drainage crossing.

Pipe Insertion and HDD Completion

Once the borehole was completed and the alignment was set up for insertion, the pipe was prepared for pullback and final placement. Insertion began on August 19,

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2009, at around 8 AM. The pullback process began around 10 PM, August 20, 2009. A total length of 1463 m (4,800 feet) was installed.

During the insertion process, a waterline was installed in the pipe that stretched the length of the staged pipe and down into the insertion pit. This line was then used to pump water into the PVC as it was installed, thus filling it with ballasting agent (clean water) that reduced the buoyancy effect of the pipe on the top of the borehole. This provides several benefits, the greatest of which is the reduction of pull forces required that act on the drill rig and the pipe itself during the installation process. The average pull force for the drill in total was about 160,000 lbs. Towards the end of the installation, over the last 152 m (500 feet) or so, when pull forces are expected to be the greatest, the required calculated force at the drill rig was recorded at approximately 200,000 lbs. The 600 mm (24-inch) nominal Fusible C-905, DR 18 pipe has a safe allowable pull force recommendation of 305,000 lbs. This value includes a 2.5 safety factor on the tensile capacity of the pipe and joints.

The alignment was flushed with 1,360 m^3 (360,000 gallons) of water on August 31 and September 1, 2009 to ensure that all the air was removed from the alignment prior to pressure testing. The alignment passed pressure test on September 1, 2009, holding required pressure for 4 hours with no loss, at which time it was accepted as a complete crossing.

Conclusions

Horizontal directional drilling played a major role in allowing construction of a raw water delivery system project for the Standing Rock Sioux Tribe in South and North Dakota. A record setting 1,463 m (4,800 LF) bore under Oahe Lake of 600 mm (24-inch) Fusible C-905 pipe has defined an early success on the project. The crossing presented a number of unique challenges for King Contracting, Inc., the driller that installed the crossing, including the remoteness of the drilling site, water level issues in the lake, adjustments to the overall layout of the drill and fusion, varying ground conditions, and wireline system challenges.

After the drill and fusion of the pipe were completed, 1,463 m (4,800 LF) of pipe was installed for this record setting bore. With 90 of 100 km (56 of 62 miles) of the new transmission pipeline yet to be installed, arguably the most challenging portion of the 10 year pipeline construction process has already been installed and tested. ■