

Design, Pipe Material Selection and Manufacture for the Lake Texoma Outfall Raw Water Pipeline: Genesis of a Fast-Paced Large Diameter Project

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ABSTRACT

The North Texas Municipal Water District (NTMWD) is responsible for supplying raw water to its thirteen member cities that ultimately benefits nearly 2 million people. Water from Lake Texoma, located on the Texas-Oklahoma border, accounts for approximately one quarter of NTMWD's supply. Restrictions were placed on pumping water out of the Lake due to an infestation of Zebra Mussels in 2009, and a major state-wide drought in 2010 and 2011 resulted in NTMWD facing severe shortages to its water supply. In 2011, an initiative was undertaken to have a new large diameter transmission pipeline built that would bring the Zebra Mussel infested water directly from Lake Texoma into a treatment facility in Wylie, Texas.

The resulting design was that of a 50-mile transmission pipeline ranging in diameter from 84-inch through 96-inch which needed to meet demands in Summer 2014. This line had to be built in just over two years, with an aggressive fast-paced design and construction schedule. Failure to successfully meet this schedule-driven project would result in severe impacts to over a million people. The Construction Manager at Risk (CMAR) delivery method for materials and construction procurement was used, along with other non-conventional methods such as direct communication with multiple pipe procurement during design, and releasing pipe manufacturer bid packages with only thirty percent design plans. This paper discusses in detail the means and methods utilized in delivering this large-scale project in the fastest and most efficient manner, design and specification of the pipeline, and pipe material selection from the CMAR Engineer's perspective. This is followed by details of the submittal and pipe-making processes from a Manufacturer's perspective on three of the five sections of the pipeline.

INTRODUCTION

The North Texas Municipal Water District (NTMWD), located in Wylie, Texas, was formed in 1951 and supplies water to a population of nearly 2 million, which includes 13 member cities and 46 other customers. The District also provides wastewater and solid waste services. Approximately 25% of the Agency's water comes from Lake Texoma. In 2009, restrictions were placed on pumping water out of the Lake due to the infestation of Zebra Mussels, an invasive species that has infested

PROJECT DELIVERY METHOD

The CMAR delivery method was chosen by NTMWD and the Engineer, Freese & Nichols, Inc., as the most feasible way to deliver a project of this magnitude and within the compressed time frame. Through a qualification based evaluation process, Garney Construction was selected and served as the Construction Manager (CMAR). This method brought a contractor into the project decisions and development prior to the completion of the 30 percent design phase. The CMAR also provided an avenue for the design team to develop bid packages early in the design phase and pre-purchase equipment and materials that could have an impact on the delivery schedule of the project. One of the major schedule impacts identified was the pipe manufacturing and delivery, and with the CMAR involved, the procurement and purchasing of the pipe could be implemented at a much earlier stage in the design process. The initial bid packages on the pipe began advertising at the 30 percent design stage.

PIPE MATERIAL AND MANUFACTURER SELECTION

The CMAR, NTMWD and Engineer went through multiple discussions and analyses on what pipe materials would be acceptable for this project. The size and pressure class of the pipe, as well as NTMWD’s preferred pipe materials limited the selection to AWWA C200 steel water pipe and AWWA C301 pre-stressed concrete cylinder pipe (PCCP). Both materials have been used extensively in NTMWD’s water transmission system and plants, and met the engineering and performance needs of this project.

Impact of Pipe Material Weight on Construction Equipment and Productivity: The CMAR had significant input on the installation methods of the two pipe materials and the impacts the installation of each could have on the schedule and availability of capable installation contractors. The CMAR was concerned about the slowed rate of installation the PCCP could possibly have to the schedule. With their experience, 96-inch PCCP would require a crane for installation due to the weight of the pipe sections, adding to the overall project cost for the contractor. They had concerns that the need for the crane installation rather than an excavator trench-and-lay method could also significantly impact the duration of construction, delaying the project delivery. But, the CMAR did determine it may be possible to install the 84-inch PCCP with a Komatsu 1200 excavator due to the decreased weight from the 96-inch pipe. They were confident, however, that both 84-inch and 96-inch steel pipe, with cement mortar lining and polyurethane coating, could be installed using an excavator, and would not require a crane. Also, since the steel pipe could be provided in 50-foot sections versus the 16-foot or 20-foot sections of PCCP, the installation productivity would be much higher. Table 1 summarizes the weight and length differentials for the two types of pipe materials.

Table 1: Steel Pipe (CML and Polyurethane Coated) and PCCP Weights and Lengths

Pipe Material	Wt. of Nominal 84-inch (lbs)	Length of 84-inch (ft)	Wt. of Nominal 96-inch (lbs)	Length of 96-inch (ft)
Steel Pipe (CML x Poly)	25,915	50	34,558	50
PCCP	38,500	20	42,200	16

CMAR and Pipe Manufacturers Cooperation: The project team also met with multiple pipe manufacturers to evaluate the specifications that would be used on the project. The manufacturers

were able to review the pipe and embedment specifications and provided input to the project team on material and manufacturing requirements. The meetings provided valuable information which changed or modified project details and specifications to provide a higher quality product and expedited delivery and installation of the pipeline. It allowed the manufacturers to discuss concerns and hear the reasoning of some of the more stringent requirements of the project specifications prior to submitting proposals. The input that was received from all pipe manufacturers also proved to be a valuable asset during the proposal and construction phases of the project.

From the project team analysis and discussion, it was determined that the C200 steel pipe would be acceptable on all pipeline sizes and sections, and PCCP would be accepted for the 84-inch sections only. The slower construction methods and requirement of the use of a crane for the 96-inch PCCP installation was a large determining factor in selecting acceptable pipe materials. With this decision, NTMWD and the project team advertised bid proposal packages reflecting these pipe material stipulations with 30 percent design plans and specifications.

Bid Proposal: The bid proposal packages were developed with five pipeline sections, A through E, with Section C being the only section with 84-inch diameter pipe; the remaining was 96-inch diameter. These packages were for the pipe only and were directed at pipe manufacturers, not contractors. With the five sections, pipe materials, and manufacturers options of proposing on single sections, multiple sections, or all sections, the rating and evaluation matrix grew to 23 possible scenarios. Also, these packages were submitted as competitive sealed proposals from the manufacturers, which allowed the project team to evaluate these proposals based on best value and project delivery deadlines rather than straight lowest cost analysis.

Pipe Supplier Selection: Three pipe manufacturers submitted proposals, each with multiple sections and combinations of sections, including cost reductions for delivering multiple pipe sections. After extensive evaluations and discussions, the project team awarded the steel pipe manufacturing to two companies; Northwest Pipe Company and Hanson Pipe & Precast, Inc. Hanson was awarded two steel pipe sections, A and B, and Northwest Pipe Company was awarded three steel pipe sections - C, D, and E.

Final Pipe Material Selection for the Project: The pipe material to be supplied for the entire project was AWWA C200 steel water pipe. The evaluations and final selection were based primarily on:

1. best value for NTMWD, and
2. pipe material delivery and manufacturing capabilities of the companies to meet the demanding schedule

PCCP would not be used in Section C as the material bid was higher in price than steel pipe and also because of the longer anticipated installation schedule for PCCP. With the aggressive pace and promise of delivering water for the summer of 2014, the project team felt the better value to NTMWD would be to not rely on only one pipe manufacturer for delivery, knowing the enormous task of manufacturing 47 miles of 96-inch and 84-inch pipe. As a contingency plan, this gave the CMAR an avenue to shift pipe supply from one manufacturer to the other if it became apparent that one of the manufacturers was not going to meet the tight schedule.

PIPE MATERIAL SPECIFICATIONS

Steel Water Pipe: The wall thickness for the 84-inch and 96-inch pipe was specified at a minimum of 0.365-inch and 0.417-inch, respectively, or a D/t ratio of 230, whichever was greater. In addition to direct buried pipe, there was also carrier pipe through casings. Buried pipe was specified at 50-ft lengths, while cased pipe had to be 20-ft in length. Lining for buried pipe was ½-inch thick cement mortar lining per AWWA C205, and 35-mil thick polyurethane coating per AWWA C222. For cased pipe, the carrier pipeline was specified with ½-inch thick cement mortar lining per AWWA C205, and polyurethane coating of 35-mil thickness per AWWA C222, with a 1-inch cement mortar overcoat, and two 1-inch thick by 2-ft wide brush coat bands per 20-ft section of pipe. Figure 2 shows steel pipe for cased application with brush coat bands.



Figure 2: Steel Pipe for Cased Application, 20-ft Sections with Two Brush Bands per Section

Specified joints for the pipeline included single lap welds with allowance for the Weld-after-Backfill process for exterior field joint coating. The selected Modulus of Soil Reaction, E' , was 1500 psi for granular embedment, and 3000 psi for flowable fill. Table 2 summarizes the specifications to which the steel pipe was manufactured.

Table 2: Steel Pipe Specification Summary

Nominal Diameters	84-inch and 96-inch
Steel Yield Strength	42,000 psi minimum
Allowable Stress	50% of yield for working pressure
Wall Thickness	84 inch 0.365-inch min. or $D/t = 230$, whichever greater. 96 inch 0.417-inch, or $D/t=230$
D/t Ratio	230 maximum
Pipe Section Lengths	50-ft direct bury pipe, cased pipe was 20-ft
Lining Type	Cement Mortar Lining per AWWA C205
Lining Thickness	1/2-inch
Coating Type	Polyurethane per AWWA C222
Coating Thickness	35 mils min.
Joints	Single Lap-Welded w/ Weld-after-Backfill

PCCP: The Prestressed Concrete Cylinder Pipe, though ultimately not used on this project, was permissible for use in Section C, with a diameter of 84-inch. The PCCP specification required that the pipe be minimum Class 150, with Trench loading design. External load for pipe wall design was bury depth+4-ft of cover for future loading AND bury depth+4-ft for live load, totaling an additional 8-ft of cover over actual bury depth. Fittings were required to be 2.5D radius and were required to be encased in flowable fill. Specified joints were Carnegie-type with O-Ring, and restrained joints were required to be welded. Where adjacent pipe cylinder thickness exceeded 0.188-inch, trimmed spigots were required for welded joints.

PIPE DELIVERY AND COORDINATION

With the manufacturers selected and the design progressing, the manufacturers immediately began producing pipe. Included in the proposal requirements was the need for each pipe manufacturer to have a certain amount of pipe completed and stored on their site ready for shipment. This was planned so that when the pipe installation contractors were given their notice to proceed, pipe would immediately be ready for shipping and there would be no delay in laying pipe. Pipe making began with 60 percent design plans, with the Engineer approving submittals for standard sections of pipe (straight pipe). The final design plans were completed approximately 3 months after the pipe manufacturers submitted their proposals. Therefore, as the plans progressed, they were sent to the manufacturers for updated lay schedules. The manufacturers' lay drawings were approved in segments throughout the design.

Embedment and Clearing Bid Packages: Once the pipe materials were known, the CMAR could begin bidding out the embedment material packages to potential suppliers. Also, the clearing bid packages could be sent out as well. Each step of the pipe installation was bid separately to minimize any delay to the actual installation of the pipe. Before the pipe installation packages were even advertised, work had begun along the route and the project was progressing smoothly. Embedment material was being delivered along the route, clearing was steadily progressing for each pipeline section, valves and appurtenances were being ordered and delivered, and tunnels were being installed and completed all along the 47 mile route.

Installation Contractors: To avoid communication problems, multiple handlings, and field coordination issues, pipe was held at the manufacturers' facilities until installation contractors were selected and were able to proceed. Sections A and B was awarded to John D. Stephens, Inc., Section C was awarded to Bar Construction, Section D was installed by Garney Construction, and Oscar Renda Contracting, Inc., installed section E. Figures 3a, b, and c show various field installation pictures.



Figures 3a, b, c: Trenching, Pipe Laying, Butterfly Valve Installation in Section C, STA 2404+15

By holding pipe at the respective manufacturer’s facility, each installation contractor had control of their pipe sections for handling, stringing, and delivery condition assessment. The CMAR wanted each installation crew to be responsible and accountable for receiving and handling of their own pipe throughout the process. By using this method, any issues or problems with the pipe quality was the direct responsibility of the installation contractor, and they could deal directly with their pipe supplier.

A MANUFACTURER’S PERSPECTIVE

Sections C, D and E Specifics: Pipeline Sections C, D, and E, which made up the latter section of the Lake Texoma Outfall to the Wylie water treatment plant raw water line, was supplied by Northwest Pipe Company. Headquartered in Vancouver, Washington, this manufacturer has plants strategically located throughout the United States to facilitate product delivery to all parts of the country as well as Canada. The three sections of pipeline included a total of 159,550 lf, or 30.2 miles of pipe; 113,600 lf, or 21.5 miles of this was 96-inch in diameter, while 45, 950 lf, or 8.7 miles of it was 84-inch diameter. Pressure classes ranged from 150 psi to 200 psi. Table 3 summarizes details.

Table 3: Pipelines C through E Specifics

Pipeline Section	Diameter	Footage (lf)	Footage (miles)	Pressure Class
Section C	84-inch	45,950 lf	8.70 mi	150 psi and 200 psi
Section D	96-inch	65,600 lf	12.42 mi	150 psi and 200 psi
Section E	96-inch	48,000 lf	9.09 mi	150 psi and 200 psi

Manufacturing Challenges: The uniqueness of this project, in that it was a CMAR delivery method project, and was fast-track, with established pipe delivery milestones for the pipe manufacturer and installation milestones for installation contractors, presented some unusual challenges for the pipe manufacturer when compared to a “traditional” Design-Bid-Build project. The number of installation contractors added to these complexities. Another unusual challenge was that when the project bid, the engineer had only 30% design plans; at awarded time, design plans were at 60%, and pipe manufacture had to commence immediately. Drawings were changing regularly, which meant pressure classes were also changing, i.e. changing pipe wall thicknesses. There were also some alignment changes between 60% design to 100% design. Given the magnitude of this project, ordering steel coils of the correct wall thickness was crucial to ensure that there was sufficient coil available at any given time to make the required amount of pipe needed in each diameter as well as each pressure class.

To facilitate the manufacturing timeline and delivery commitments to the project, pipe was made in three different facilities of the company, presenting some formidable logistical challenges for the manufacturer. With the Saginaw, TX Facility serving as the main project management center, pipe was simultaneously manufactured in Saginaw, at the Denver, CO Facility, as well as at the Parkersburg, WV Facility.

Additional challenges to the manufacturer included ensuring strict and efficient coordination of design and drawings submittal-and-approval process with the CMAR and the Engineer, providing an expedited Front End Package and Drawings Package, gaining approval for both in a timely manner, with plans changing from 60% to 100% design. Finally, the expedited delivery requirements and the necessary coordination were critical to the success of the project.

MANUFACTURER PROJECT MANAGEMENT PROCESS

Following selection for the manufacture of Sections C, D, and E, a purchase order was provided by the CMAR for the 30 miles of pipe to the pipe manufacturer, Northwest Pipe Company. The Sales Team then handed over the project to the Engineering/Project Management Team. After the Engineering/Project Management Team reviewed the contract plans, project specifications and project requirements, the Sales and Engineering Teams set up meetings to discuss project details with the customer, the CMAR. Once delivery dates and schedules were established for the whole project through these partnering meetings, the Operations Team of the pipe manufacturer determined that it would be most prudent to make pipe in 3 different facilities simultaneously to meet the customer's required delivery requirements. Coils were then appropriately ordered to make pipe at each of the three plants; Saginaw, TX, Denver, CO, and Parkersburg, WV.

To meet the expedited pipe delivery requirements, the manufacturer quickly submitted the Front End Package for approval, which included 1) design calculations, 2) straight pipe drawings with specified joint lengths, 3) Lining and Coating system specifics, 4) pipe joint end-detail with lining and coating holdbacks specifics, 5) stulling details, and 6) QA-QC package

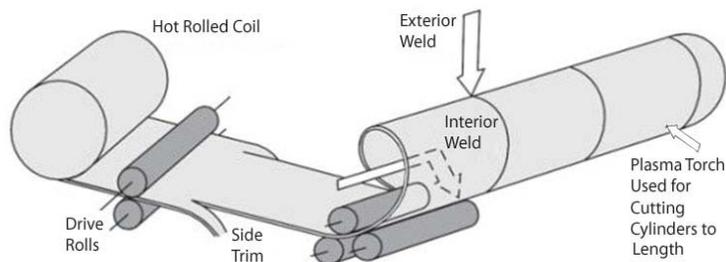
As discussed earlier, the pipeline design was still very much in progress when the project was won and awarded, delivery schedules established, approvals given on the Front End Package, and steel coils were ordered. Therefore it was critical to keep the lines of communication open between the manufacturer and the CMAR on a weekly basis, with a keen eye on any changing pipe classes (pipe wall thicknesses), until 100% design drawings were completed by the CMAR Engineer. Appropriate changes to coil orders were made as required as drawings progressed from 30% to 100%. As the engineer and contractor reviewed the Front End Package, the manufacturer worked on detailed project plan and profile layouts, along with each fittings/specials detail drawing submittals. To keep schedules on track, the CMAR team expedited review of the Front End Package drawings as well as all drawing package submittals. Following approval of the Front End Package submittal, manufacture of straight cylinder pipe joints was begun.

The Engineer discussed all questions they had on submitted drawings as well as any other changes on contract plans with pipe manufacturer and expedited approval, with *approved as noted* comments. This approval was also very important for the pipe manufacturer because it allowed for the fittings and specials fabrication to begin. Detail drawings were released to the Production Team following approval to make all pipe and fittings with required mark numbers and pipe ends. Once drawings were released to Production, the department scheduled delivery with the CMAR. As stated earlier, each installation contractor was responsible for the receiving and handling of their own pipe throughout the process. This way, any issues or problems with the pipe quality was the direct responsibility of the installation contractor, and they could deal directly with the pipe supplier.

MANUFACTURING STEEL PIPE

The spiral welded steel pipe making process begins with the manufacture of the cylinder from steel coils. On this project, coils were ordered to the project-specific wall thicknesses, with an accuracy of 1/1000th of an inch, Figure 4a. Cylinders were then fabricated on a spiral pipe mill from

these steel coils which were helically wound and welded internally and externally at the seams, resulting in a full penetration submerged arc butt weld, Figure 4b.



Figures 4a, b: Steel Coils, Schematic of Spirally Welded Steel Cylinder Manufacture

Submerged arc welding of the cylinders is shown in Figure 5a. A plasma torch was then utilized to cut cylinders to their specified 50-ft lengths, and when needed, to 20-ft lengths for cased pipes, Figure 5b. Once the cylinders were made and end preparations completed, hydraulic expanders were used to form the weld-bell on one end of each cylinder, Figure 5c.



Figures 5a, b, c: Submerged Arc Welding, Plasma Cutter, Forming of Weld Bells

This was followed by performing a hydrostatic test on every 84-inch and 96-inch cylinder by pressuring them to 75% of the yield strength of the steel, Figure 6a. Each hydrostatically tested cylinder was then internally lined with a 1/2-inch thick cement mortar lining, Figure 6b, and was externally coated with a 35-mil thickness polyurethane coating, Figure 6c. In addition to the hydrostatic testing of every cylinder, numerous other quality control tests were performed at every step of the manufacturing process, per C200 and any additional requirements of the project specifications. The welds underwent bend testing, tensile pull testing and the coil was required to undergo V-notch Charpy testing. Shop welds on fittings were tested using non-destructive tests (NDTs) such as magnetic particle testing. The cement mortar lining underwent compression strength testing per AWWA C205, and the polyurethane coating was required to be tested for adhesion and all other tested required by AWWA C222 and project specifications.



Figures 6a, b, c: Hydrostatic Testing, Cement Mortar Lining, Polyurethane Coating

CONCLUSION

At the time of the writing of this paper, the transmission pipeline had been completed, and all field hydrotesting performed. Plant connections were being made, with plants 3 & 4 to be completed by the end of May, 2014, and plants 1 & 2 to be completed in June 2014. The Lake Texoma Pipeline is planned to be in operation by the end of May 2014. This project is a testament of how a large diameter, critical water transmission pipeline can be designed, manufactured and constructed on a fast-track in the most efficient manner.

Utilizing a CMAR on a project of this magnitude with such an aggressive schedule proved to be greatly beneficial to the Engineer, NTMWD, and the contractors involved. While the project was challenging in many ways for pipe manufacturers, a good line of communication with the CMAR team ensured a successful project, even though bidding was done when the pipeline was at only 30% design, pipe-making started at 60% design, and design changes continued from 60% to 100% design. The CMAR provided a single point of management for the entire procurement and installation process. It relieved the Owner and Engineer of the daunting task of managing and inspecting a \$300 Million project that was compacted into a 2.5 year schedule. It allowed the longer lead-time items to be pre-purchased very early in the project to eliminate normal delays generally seen with these types of items. The benefit of securing the pipe and starting manufacturing prior to having completed design plans substantially expedited the process. The benefit of having a contractor on the project team at such an early stage and throughout the project also provided great input and valuable information that the Engineer and NTMWD rarely get in a typical design project. This also benefited the pipe manufacturers and other suppliers by working directly for a contractor rather than multiple contractors that this project required.

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