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Using HDPE 4710 for Water Main Replacement Projects

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ABSTRACT: This paper discusses the adoption of HDPE 4710 material for a water main replacement project by the City of Palo Alto and covers development of the specifications, standards, and construction procedures and methods (heat fusion joining, mechanical connection of dissimilar materials, and horizontal directional boring).

City of Palo Alto Utilities

The City of Palo Alto owns natural gas distribution, water distribution, sewer collection, electric distribution, dark fiber optics loops, and storm drain collection systems. The City of Palo Alto Utilities is responsible for providing services to approximately 60,000 residents.

The water distribution system is comprised of 219 miles of water mains of various materials including polyvinyl chloride (PVC), ductile iron (DI), concrete cylinder pipe (CCP), cast iron (CI), and asbestos concrete (AC). Copper is used for service lines 2" and smaller.

In order to provide reliable and cost effective service, in 1991 the City began accelerated replacement of aging water, gas, and wastewater infrastructure. Water mains that begin to show signs of extensive corrosion, become subject to increased maintenance and recurring breaks or inadequately sized were indentified by staff and selected for replacement.

Water Main Replacement Project (WMR) 21/22

WMR Project 21/22 includes replacement of approximately 33,515 linear feet of the existing water mains, predominately AC, 51 fire hydrants, 13 existing fire services, and reconnection of 669 existing customer copper services at various locations within City of Palo Alto.

High Density Polyethylene (HDPE) 4710, SDR 11 potable water pipe conforming to the ANSI/NSF Standard 61[1] and ASTM D3350[2] with a cell classification of PE 445574C and molded HDPE 4710, class 200 fittings were specified for the WMR 21/22 project.

The superior performance of polyethylene material in the City gas system (82 miles installed), ability of heat fusion joining that produces self restrained joints as strong as or even stronger than original pipe[3, 4, 5], ability to install water mains by horizontal directional methods (HDD), and familiarity of staff with the polyethylene material and fusion equipment/procedures were contributing factors for transition from PVC to HDPE material in water distribution system.

Since PVC has been the primary material used for water main replacement, the City specifications, standards, and installation procedures required major revision to incorporate polyethylene. One of the most important modifications was selection and specification of fittings that can be used to join new HDPE water pipes to the existing water distribution system containing mains of various materials. This work required extensive research and design.

A number of fittings[6, 7] were considered for integrating new HDPE piping into the existing water distribution system. The following fitting were selected:

Mechanical Joint Adapters (MJ) for joining HDPE to DI and PVC piping. The MJ adapter connection is fully self-restrained.

PE Flange Adapters for joining HDPE to existing flanged valves.

Mechanical coupling Smith-Blair 441 series were selected for joining HDPE and ACP pipes.

Mechanical coupling Smith-Blair EZ-W series were specified for joining HDPE and CIP pipes.

The advantage of the HDPE system is that pipes and fittings can be connected by heat fusion and form joints that are restrained against pullout[8]. The butt fusion method, which creates permanent leak free joints, was specified for connecting straight lengths of HDPE pipe, and fittings such as valves, tees, ells, and reducers.

In order to minimize the number of mechanical joints that may leak, staff specified American AVK[6] resilient seated gate valves with polyethylene pipe ends. These valves can be joined by butt fusion with other components in the HDPE water system.

Figure 1. American AVK valve with HDPE pipe ends.

Electro fusible Frialen VA service saddles manufactured by Friatec Gas Water Inc. (Friatec)[6] and transition saddles manufactured by George Fisher Central Plastics (Central)[7] were selected as tapping hardware for reconnecting existing copper services. For proper installation of tapping hardware, the specifications require use of top loading clamp for 8" and larger saddles.

Electrofusion couplings by Friatec and Central were specified for HDPE connection at locations where butt fusion is not feasible.

Figure 2. Flex Restraint Installation

The City also had to consider the possibility of HDPE pipe pullout due the Poisson shortening effect[8] that occurs when the pipe is pressurized. The worst case for this condition is in long strings of PE pipe where unrestrained connections transition to existing pipe material. Allowance for this effect must include compensation for both pressure testing and surge events where the related undesirable pullout is possible. Electrofusible HDPE pipe flex restraint devices[6], encased in concrete and attached to HDPE near transition connection, where selected as in-line anchors to prevent pullout.

Another issue for potential movement is due to the thermal expansion/contraction associated with temperature changes. According to the PPI Handbook of Polyethylene Pipe[13], Chapter 6, "fused PE pipe joints are fully restrained. The pipe and the fused joints can easily accommodate the stress induces by changes in temperature". Also, a "buried pipe is generally well restrained by soils loads and will experience very little lateral movement. However, longitudinal end loads may result that need to be addressed".

One of the challenges was to design a fully fusible fire hydrant assembly. The DuraFuse Duck Foot Bends by GPS PE Pipe Systems[9] were considered for fire hydrant bury. This fitting completely eliminates the need for mechanical joints and is supplied as a full kit including base, tee, full faced stub flange assembly and reducer. The base is designed to be joined to HDPE pipe by an electrofusion coupling. Unfortunately, the DuraFuse Duck Foot Bends were designed for use with metric (SI) sized pipes and could not be used on this project. Instead, a conventional DI burry was connected to HDPE pipe with PE flange adapter. The flange adapter is designed for butt fusion connection to HDPE pipe at one end and for connection to a burry flange with serrated sealing surface and backup ring at the other end. The backup ring provides thrust resistance and seal. The fire hydrant assembly also incorporates an AVK valve with HDPE ends joined to HDPE pipe by two electrofusion couplings.

Heat fusion is a very effective joining method; however, in order to ensure integrity of joints, it is essential that the fusion procedures are performed by the experienced and qualified personnel following the manufacturers recommended procedures[5]. The Project specifications require that all persons performing fusion are qualified and certified by the City. The certification process involves testing the contractor's personnel in the actual field conditions on the equipment the contractor plans to use, including all fusion equipment and generators. This process insures that the related equipment is in good working order and that the contractor has all of the required equipment. The City also has a full time polyethylene fusion certified Inspector at the job site.

Integrity of fusion joints and flexibility of polyethylene material made practicable installation of large diameter water mains (6" through 12") by horizontal directional drilling (HDD) techniques. In order to prevent forces exceeding the safe pull strength of the material[10], the City specifies commercially available weak links that limit pull force for specific pipe diameters and wall thicknesses.

Figure 3. McElroy Fusion Machine.

The City specifications also stipulate a set of techniques that must be employed by the Contractor to ensure protection of the existing underground infrastructure including potholing and verifying actual location and depth of every utility crossing the proposed bore paths. The Contractor is not allowed to push compaction/reaming devices through existing borehole or leave the pilot hole open. Instead, either product pipe shall be pulled back or, if expansion of the pilot hole is required, rods shall be ferried between the launch or receiving pits.

Leak testing of new water system is specified in accordance with ASTM F2164[11]. In fused polyethylene water piping system no leakage shall be observed. The new pipeline is slowly filled with potable water and all trapped air is bled off. The main is pressurized to 150 psi. The pressure shall be maintained constant for 4-hour period by adding makeup water. After 4-hour period, the pressure shall remain steady within 5% (7.5 psi) of a target 150 psi test for one hour. The total test time should not exceed 8 hours[8]. If the pipeline has to be retested, the specifications require the Contractor to depressurize pipe and allow it to "relax" for 8 hours before the next testing sequence.

Disinfection and bacteriological testing of new water system is performed in accordance with ANSI/AWWA C651[12]. These procedures are similar to disinfection/testing of non-polyethylene water mains. However, the Project specifications limit the concentration of disinfecting solution – it should not contain more than 12% of active chlorine to avoid possible damaged to the inside surface of polyethylene pipe[8, 12].

Other project innovations are: installation of cathodically protected tracer wire along the new water mains, installation of marker balls above all fittings, taps, and changes in main alignments, and GPS survey of the installed piping system. These efforts will significantly facilitate location of the installed facilities in the future.

WMR Project 21/22 construction began in October 2009. Bid prices revealed approximately 10% savings for HDD construction versus the open trench method. Currently (on 12/31/09), the Contractor has installed approximately 2100' of 12", 600' of 10" and 2300' of 8" HDPE water main by the open trench method and 4500' of 8" main by HDD, which represents 30% of the Project. The contract allocates 300 calendar days for completion of this Work.

The Project specifications allow installation by the open trench at locations where the horizontal directional drilling is not feasible due to location of existing underground infrastructure or soil conditions. It is expected that approximately 50% of all mains will be installed by HDD in WMR 21/22.

Figure 4. Installation of 12" HDPE by Open Cut

Future Water Main Replacement Projects

The City's goal is installation of fully fused high density polyethylene water system including individual water services. In the future, the City plans to begin replacement of existing copper services with HDPE using pre-manufactured fittings that allow transition from HDPE to copper below grade. The HDPE/copper transition fitting looks similar to anode service riser used in the gas industry. The City is currently working on design of a new water service connection standard that will allow utilization of HDPE/copper transitions. Fully fusible fire hydrant assemblies are

another objective. The current standard will be modified if a fitting similar to the DuraFuse Duck Foot Bends becomes available effectively eliminating mechanical joints in the assembly.

The City also plans to specify HDD as the primary method of installation for future water mains and services.

Figure 5. HDD – A borehead in the launch pit.

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References:

1. NSF/ANSI 61, Drinking Water System Components-Health Effects
2. ASTM D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
3. ANSI/AWWA C906-07, Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) Through 63 In. (1,600 mm), for Water Distribution and Transmission
4. PPI TN-41, High Performance PE Materials for Water Piping Applications
5. PPI TN-42, Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects (2009)
6. ISCO HDPE Product Catalog, www.isco-pipe.com
7. Central 2007 Connector and Equipment Catalog, www.centralplastics.com
8. AWWA M55, Manual of Water Supply Practices, PE Pipe-Design and Installation
9. GPS PE Pipe Systems Catalog, www.gpsuk.com
10. ASTM F1804, Standard Practice for Determining Allowable Tensile Load for Polyethylene (PE) Gas Pipe During Pull-in Installation.
11. ASTM F2164, Standard Practice for Field Leak Testing of Polyethylene (PE) Piping Systems Using Hydrostatic Pressure.
12. ANSI/AWWA C651, Standard for Disinfecting Water Mains
13. Plastics Pipe Institute, Handbook of Polyethylene Pipe, 2nd edition, 2008, www.plasticpipe.org