Repair of 30-Inch HDPE Force Main

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Since the construction of the wastewater treatment facilities on Fleming Key, the City of Key West has been operating and maintaining the parallel, 30 inch diameter, HDPE force mains that conveyed untreated wastewater north from the Pump Station A on the south side of the island and treated effluent south from the treatment plant to the former outfall. Subsequent to the completion of the advanced waste treatment facilities and the deep injection well at the plant, the treated effluent main and outfall have been removed from service. Current plans call for adapting this main for use as an additional influent main to improve the hydraulic conditions in the wastewater transmission system and improve operational efficiency,

In the past, there have been multiple failures of these mains at the flanged connections that were made to connect the long fused sections of pipe at fittings along the pipeline route (see *Emergency Contingency Repair Plan for the 30-inch HDPE Force Mains,* CH2M HILL, May 2001). There is now a failure within one of the welded fittings north of the intersection of the White St. extension and Whiting St. where the mains cross into Key West Naval Air Station (KWNAS) property. The leak was discovered during pressure testing of the main during a related project. This failure appears to be at a weld (Figure 1) in the fabricated 90^0 fitting. These welds were performed under factory conditions prior to the fitting being shipped to the project site for installation.

Figure 1: Leak in Fitting Weld

The cause of the leak has not been determined. There is no obvious damage to the pipe however, long-term strain on the weld, could over time result in this type of failure. Induced strain on HDPE pipe is commonly caused by the temperature related shrinkage of the pipe during installation. The location of the leak is on the main previously used to convey treated wastewater from the plant, which at this location is the inside pipe as the main bends to the east (Figure 2).

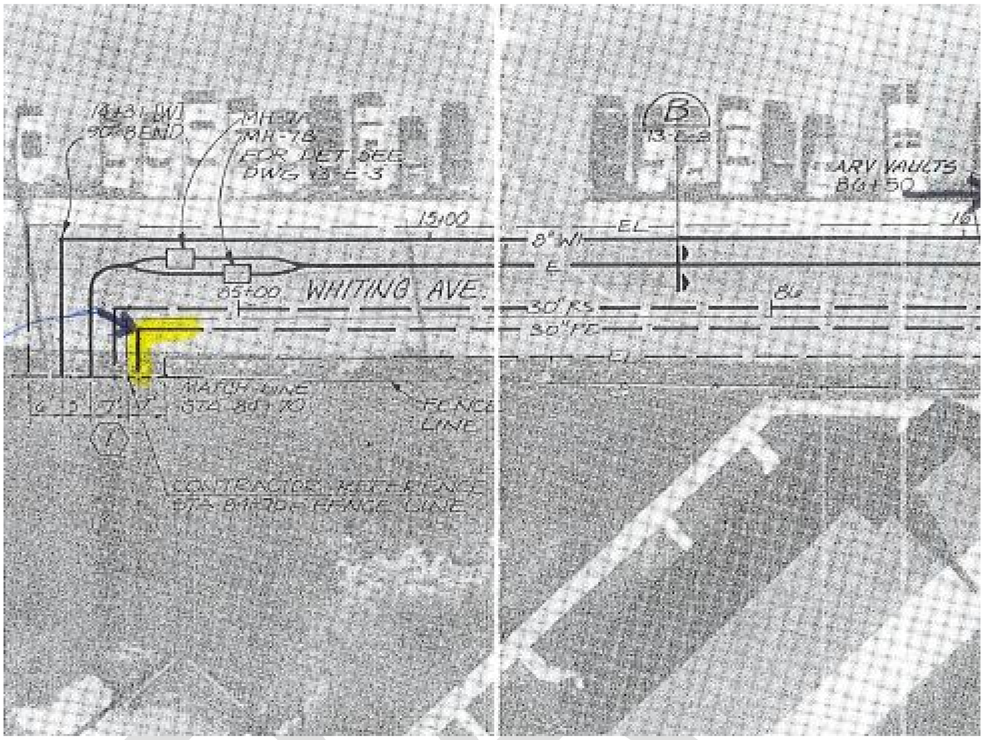

Figure 2: Location of Leak

As the pipes turn from the south to the east, as shown above, the separation between them changes. On the southern, housing side (Figure 3) the separation is 6-8”. On the northern, KWNAS side in Whiting Ave. (Figure 4), the separation is 12-14”. The south side of the fitting (where the pipes are closer together) is provided with a flanged joint, the other is a butt-welded joint. The flanged joint is a standard Class 125 bolted flanges with a 316-SS backing plate behind the welded (HDPE) flange on the HDPE side.

Figure 3: North/South Housing Side

Figure 4: East/West KWNAS Side

The leak needs to be repaired to allow for future use of the former plant effluent main as a parallel raw sewage line to the plant. The purpose of this investigation was to determine the most practical, long-term, repair method and possible a methodology that could be used in the event of future pipe failures.

Repair Considerations

The conditions at the location of the leak are typical of the conditions encountered along the pipeline route. These issues need to be considered when evaluating potential repair options:

- The joints on both sides of the fitting need to be restrained against movement
- Relatively congested with traffic control considerations – this location is actually less problematic than most of the rest of the route and the traffic is primarily local and located within the KWNAS perimeter.
- Design working pressure of 65 psi – test pressure of 100 psi
- Most of the pipeline is located under paved streets
- Multiple jurisdictions – in this case City and KWNAS rights of way
- High groundwater conditions that require dewatering operations for construction
- The pipe is HDPE that has been buried since the late 80's. The nature of HDPE is that it deforms under load and may no longer be as "round" as it was when it was installed. The potential for the pipe being under an induced strain may also become a factor if the sections are separated.
- The two pipelines are close together and make it difficult to work on one pipe without impacting the other.
- The actual pipe specification used has not been verified. It is not known if the installed pipe is IPS or DIPS. In addition, specifications for subsequent, related projects suggest the pipe should be DR-11 whereas the repair report referenced above suggests that it may be DR-17. Other correspondence relating back to the original contract indicates that it may be SDR-21. The actual specification used determines what the actual inside diameter (ID) will be; the outside diameter (OD) will remain constant at 30" (IPS or DIPS). The actual shop drawings have not been located.

Repair Options

With the repair considerations in mind, a number of repair options were discussed in-house, with local contractors and industry experts, including:

- CP Chem/Performance Pipe engineering staff (leading HDPE pipe supplier)
- JCM engineering staff (leading custom coupling manufacturer)
- Plastic Pipe Institute engineering staff (industry trade group)

The following repair options were considered:

1. <u>New HDPE Fitting with Electro-Fusion (EF) Coupling(s)</u>

Fabricate a new HDPE bend section from the existing flange to a connection joined by an EF coupling or remove the flanged connection and use a new coupling on each side. EF couplings for pipe of this size are not common but are available (Strongbridge, Integrity Fusion – although these two companies appear to be related) in both DIPS and IPS. This option would provide a fully restrained joint with no metallic components. The couplings would be adaptable to other sections of the pipe if needed in the future (subject to verification of pipe material).

This methodology has the following advantages and considerations:

- The electro-fusion couplings can only be used on the thicker walled pipe with an SDR less than 17. We cannot verify that this pipe meets this standard.

- The pipe will have to be as round as the new couplings which may be very difficult to achieve in the field as the current ovality of the pipe has not been verified. Internal SS stiffeners may be able to restore the roundness of the pipe depending on the conditions observed.
- The entire fitting could be replaced using two couplings – any discrepancy in dimensions would need to be made up by the couplings. Leaving the flanged joint in place may make it difficult to align the other joint in the transverse direction.
- The excavation would need to be completely dewatered and dry for the duration of the replacement installation.

The EF couplings are external to the pipe being joined as shown in Figure 5 for a DIPS application. The ends of the existing pipe would have to be trimmed and made square enough to be accommodated by the insertion depth of the fitting. The budget level cost for a coupling similar to that shown below is $5700.

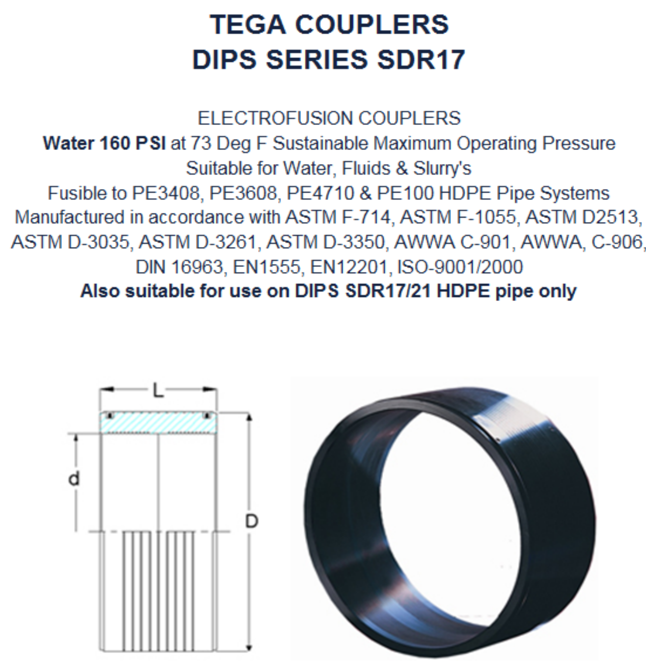

Figure 5: Electrofusion Coupling (Strongbridge/Integrity Fusion)

The advantage of this repair method would be a fully welded (essentially no joints) and restrained, non-metallic joint, if it could be constructed. The components of this type of repair would include a fabricated 90° HDPE bend with extensions on each side as necessary to fit and an EF coupling. The repair could be made with one flanged coupling matched to the existing flange or two EF couplings.

2. New Ductile Iron (DI) Fitting

Make up a DI replacement section to replace the existing fitting and provide a connection back to the pipe on each side. There is a reason non-metallic pipe was used for this main and those reasons still exist. The other concern with this method of repair is the difficulty of providing thrust restraint.

- The pipe will be in brackish groundwater – if DI is used, it needs to be ceramic epoxy coated in and out.
- The DI pieces need to be restrained (either manufacturers restraints - more expensive and longer lead time) or mechanical restraints (meg-a-lug or equal). Mechanical restraints also need to be coated and

touched up after installation. Consideration should be given to cathodic protection of the DI components which will add cost and long-term operational considerations.

- It will be difficult to work with the mechanical restraints around the pipe given the proximity of the adjacent pipe and groundwater conditions.
- This option will result in two joints for each leg of the fitting
- There will need to be a restrained adaptor coupling on each side to transition from the HDPE to DI. An example of this type of coupling is shown in Figure 6.

This repair will require that the fitting be restrained by some external means since it will not be possible to attach a bead section to the ends of the existing HDPE pipe sections. Possibilities for providing external restraint are shown in Figure 7 and demonstrate the potential difficulties with such and installation.

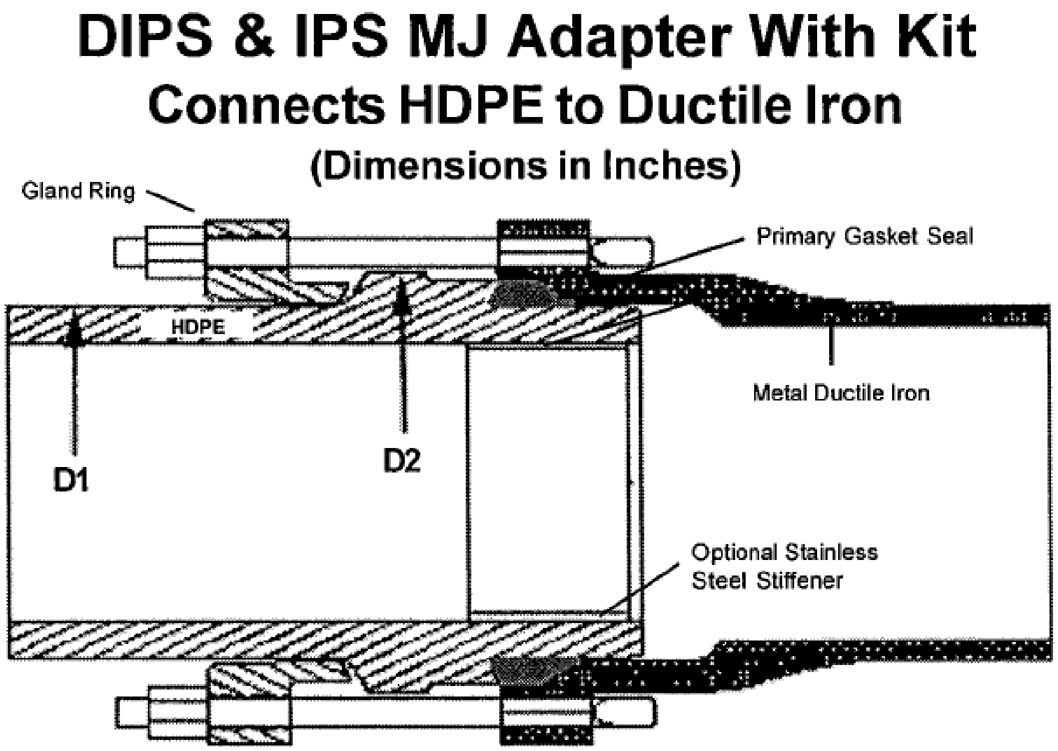

Figure 6: DI to HDPE Coupling

The components of this type of repair would include a RJ 90° DI bend with RJ spool piece extensions on each side as necessary to fit, a DI/HDPE adaptor coupling for connection, an internal SS stiffener for each coupling (total of two if the flanged connection is replaced) and whatever form of thrust restraint can be accommodated.

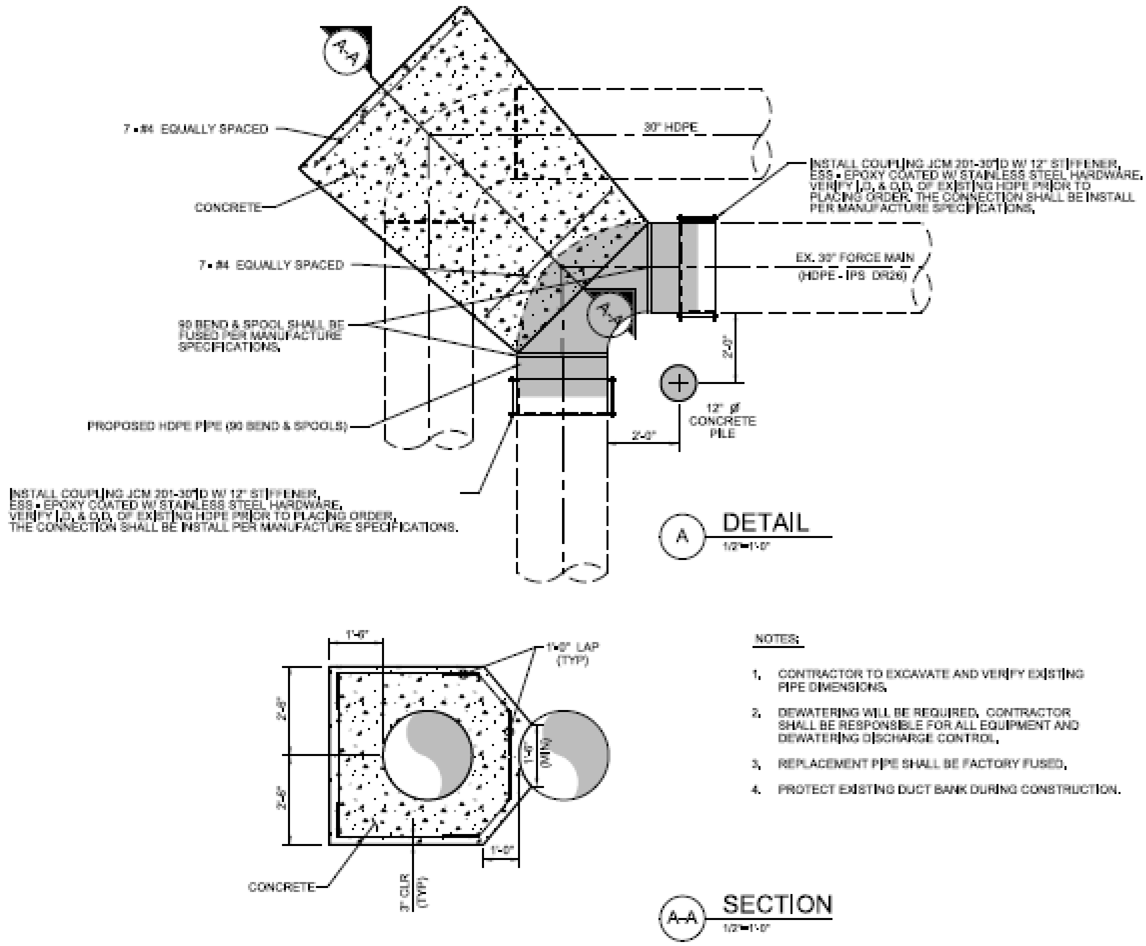

Figure 7: Thrust Restraint Options

3. New HDPE Fitting – Mechanically Coupled Connection(s)

Fabricate a new HDPE section from the existing flange to a connection joined by a coupling or remove the flanged connection and use a new coupling on each side. The advantage of leaving the flanged connection in place is that restraint would only need to be provided in one direction which due to the limited space may be easier to deal with. The disadvantage is that it may be difficult to align the other leg of the fitting.

This methodology has the following advantages and considerations:

- Slight differences in pipe ovality can be accommodated by the couplings, but the dimensions will need to be field verified prior to ordering.
- The entire fitting could be replaced using two couplings – any discrepancy in dimensions would need to be made up by the couplings. Leaving the flanged joint in place may make it difficult to align the other joint in the transverse direction. Each side of the fitting would have a single joint.
- The couplings could be duplicated and kept on hand in case of the need for future repairs (once the pipe thickness has been verified)
- The couplings proposed by JCM are fully restrained and do not require external piles or thrust blocks which would be difficult to install in the confined location and problematic in predicted performance given the disturbed soil conditions.
- Pipe thickness (SDR) would have to be determined to size the required, internal stiffeners. The stiffeners also assist in restoring pipe roundness when they are installed.

The situation was discussed with JCM and they developed a coupling based on their standard components for use on the HDPE pipe and the conditions described above. The proposed coupling is shown in Figure 8. The HDPE pipe manufacturers are comfortable with the restraining JCM couplings and work closely with them on applications. They consider JCM to be in the forefront of HDPE coupling technology. The dimensions of the restraining "ears" will fit in the space between the pipes; however the excavation will have to allow the installation crew to work around the full circumference of the pipe, as would any of the options considered.

1. The restraint ears extend 5" from the restrainer body plate. The plate thickness of the restrainer is .5" (total O.D. = 41")
2. The lower left hand side of the drawing rev shows the serrated I.D. surface that grips the pipe and provides the restraint
3. The components of this type of repair would include a fabricated 90° HDPE bend with extensions on each side as necessary to fit, two (2) 201-3000 ESS -R couplings for connection, two (2) 610-3000 ESS for restraining (as shown in Figure 8) and two (2) 6231-2769 stiffeners for each coupling (total of four if the flanged connection is replaced).
4. All metallic components to be 316 SS
5. The budget level cost for a coupling similar to that shown below is $

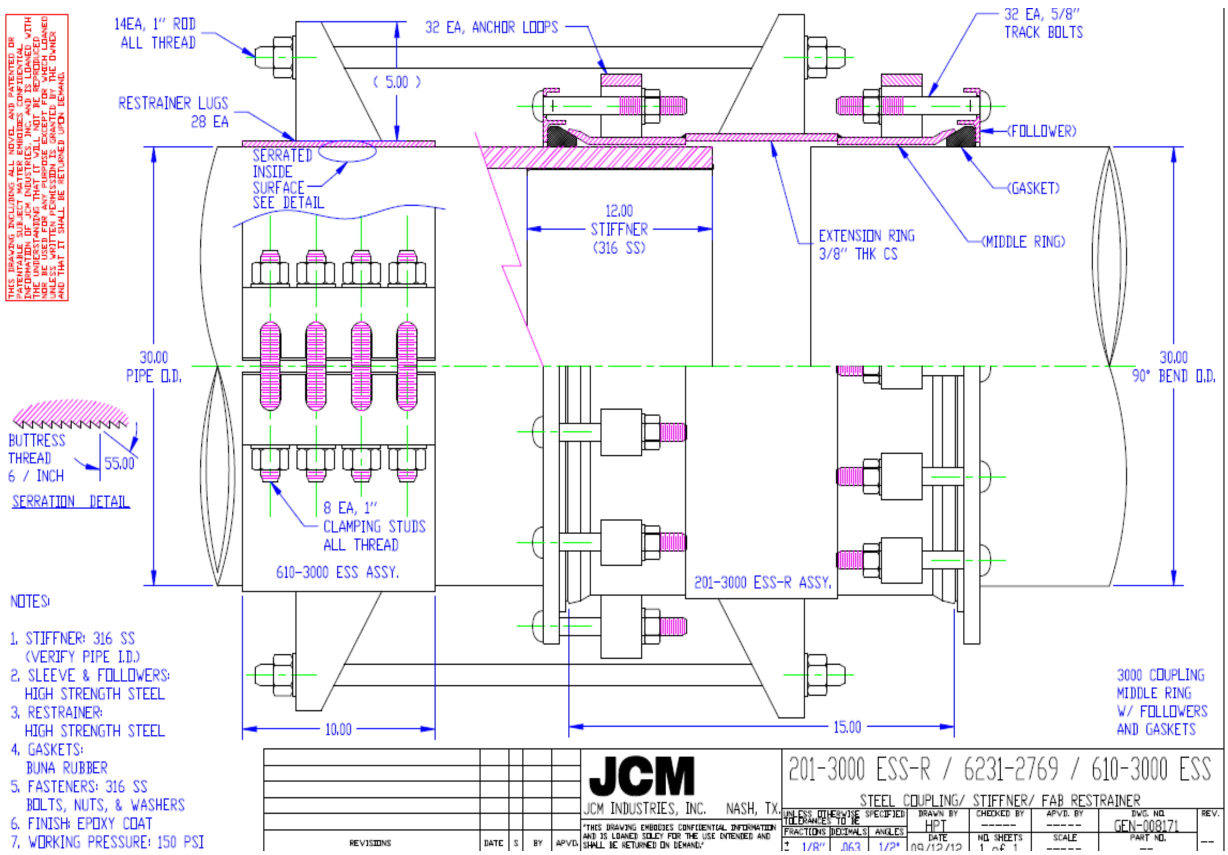

Figure 8: Restraining Coupling (JCM)

Recommendations

The recommended methodology for repairing the leak will likely depend on what is actually available and what is constructible considering the site restraints. Given the above discussion, Option 3, with the mechanical coupling may be the only feasible alternative although Option 1 should provide the most reliable, long-term solution. It would also be advantageous from a cost basis if the existing flanged joint could be used for the new fitting if the installation can be successfully completed in this manner. Both types of couplings could be provided in extra quantities and kept on hand for future repair needs. The capabilities and experience of the selected contractor may also determine the selected option.

No matter which option is selected, the repair will be a 2 step process that will require exposing the pipe section twice.

Step One

1. Open, stabilize and dewater trench from beyond the existing pipe joints on both sides of the fitting.
2. Disassemble the flanged joint on the south side of the fitting. Observe the flange and weld and determine if the flange has adequate remaining service life and has not been compromised.
3. Cut the pipe on pipe side of the butt-welded joint east of the fitting
4. Square and trim the end of the cut pipe and determine pipe dimensions. Record ambient temperature inside trench.
5. Determine if the existing flanged joint will be used for the new fitting (if not, repeat 3 and 4 for the south side of the fitting). Observe any movement of the pipe once the sections are separated and determine if the alignment will be acceptable
6. Provide detailed measurements for fabrication of the new fitting, spool pieces and couplings, including ovality and SDR. Fitting supplier will need the observed temperature during measurement and the expected temperature during installation.
7. Temporarily plug pipe ends and cover trench as acceptable to the KWNAS.
8. Decisions:
    a. Determine if the flanged fitting will be reused
    b. Determine if Option 1 is feasible
    c. Select either Option 1 or 3 and order components to be fabricated
9. Order materials

Step Two

1. Open, stabilize and dewater trench around the repair area.
2. Expose full pipe diameter on each end and provide adequate room/depth for the new fitting
3. Clean pipe exterior within the area of the couplings.
4. Install stiffeners and re-round pipe
5. Install fitting with selected joint/couplings and pressure test
6. Restore trench and surface