

Flexible joint connections between PE and rigid pipe materials or structures

Scope

The document is applicable for the following:

- PE pipes connecting to other pipe materials such as DI or steel pipe at structures
- PE pipes connecting to or passing through rigid structures such as chambers
- Buried or exposed PE100 solid wall gravity or pressure pipes
- PE pipe of all SDR's and PN ratings
- Accommodating ground settlement between PE and rigid structures
- PE Burial designs in compliance with BS 9295, BSEN 1295, AS/NZS 2566-2

Summary

In pipeline designs using Polyethylene pipe, PE is often shown connecting to new or existing ductile iron or steel fittings that are cast into fixed structures, such as concrete chambers or manholes. In some cases, the connection method is simply shown on the drawing as “Flexible joint” or “Change coupler” without providing further detail of the materials or method. The fittings proposed in fig. 1 below (“Flexible Joint” & “Change Coupler”) simply don't exist, **there are no such products that enable the connections as shown in the designs below to be constructed.**

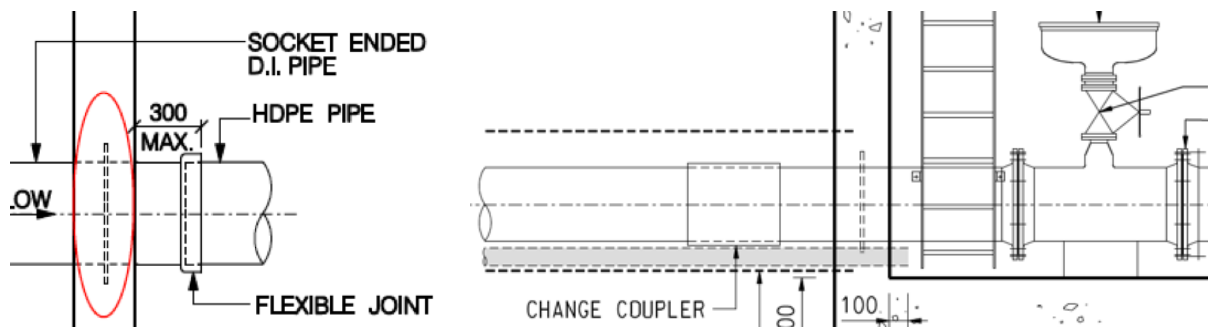


Fig. 1 - Examples of designs showing PE pipelines connecting to concrete chambers with Ductile Iron fittings

This confusion can lead to significant future operational issues for the pipeline owner. If the contractor makes their own decisions on how to make these connections (typically based on using the lowest cost option) it's highly likely these joints cannot perform for the design life, more typically they will fail relatively quickly.

Background

Ferrous materials (other than valves) are generally avoided in modern PE pipeline designs, especially in sewerage pipelines. The reason being that PE has a 100-year design life vs. ferrous materials with a 15 / 50 year design life (Sewerage / Potable water). Combining PE and Ferrous materials in a sewer system creates an unnecessary future maintenance demand on the ferrous components.

For example; in a 100 year design, you would need to schedule replacement of the DI fittings cast into the chambers (including demolition of chamber walls to replace DI puddle flanges) 5 x over the over the PE pipes design life (rehabilitate every 20 years). It makes little sense to create such a future maintenance demand.

PE equivalents of all standard DI fittings are available, such as: flanged bends, duck foot bends, puddle flanges, scour and drain tees, CCTV inspection hatches, air valve tees etc, refer Fig. 10. There is no technical reason that the entire system cannot be designed in PE, however they are often designed using a combination of PE and DI as shown in Fig. 1, because designers are simply more familiar with DI fittings.

Fig. 2 shows typical examples of connections using standard ex-factory PE assemblies incorporating puddle flanges and flanged or spigot ends for component connection.

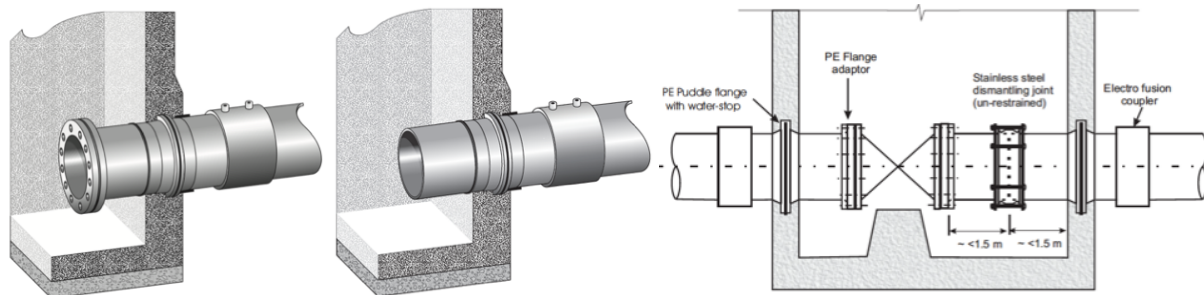


Fig.2: Examples of standard connections using PE fittings and puddle flanges through chamber walls to create a fixed flanged joint on the left hand side and a spigot end joint on the right side to connect a mechanical dismantling joint

This technical note focuses on connections where the designer has already designed a system using a PE pipeline with DI fittings in the chambers.

There are several things to consider when connecting PE to another pipe material or structure:

- Transfer of pressure thrust forces into the structure (pressurised systems only)
- Transfer of thermal and lineal stresses from the PE into the soil and structure.
- Transfer of settlement and / or ground movement forces between the pipe and structure
- Degree of expected movement (reclaimed land settlement, landslide potential... etc)
- Future maintenance such as having fixed or dismantlable joints inside the chambers.

Ductile Iron is a rigid pipe system joined by socket joints in the pipeline and flanged fittings in chambers. In DI pressure systems, the thrust forces on each unrestrained pipeline socket joint are transferred partially into the soil by surface friction and via anchor blocks at changes in direction. In flanged DI fittings, the forces are transferred via the bolted flange joints to a puddle flange cast into the structure.

Polyethylene is a flexible pipe material, it cannot be used with unrestrained socket joints like those used with DI pipe. The exception is when PE is used between two short fixed points. Each fixed point must be on the same axis (no direction changes inside the chamber) and best practice is to target ~1.5m or less of unrestrained PE pipe between each fixed point and the joint, refer Fig. 2. In this situation there is more than sufficient rigidity in the PE system to use an unrestrained joint on PE spigots, such as a Stainless steel dismantling joint. Mechanical couplers on PE should use a wide seal or lip seal gasket. (Avoid O-Ring type joint seals, O-Rings are too narrow to seal reliably).

Every PE joint type (Electrofusion, Butt-weld or Mechanical type 1) are designed to withstand the sum of all forces generated under the pipes maximum rated operational conditions. In a PE system the forces from pressure, ground movement and change in temperature are equalised along the length of the PE, between fixed points. Therefore, PE must be anchored (typically using a PE puddle flange or flanged joint) at any point where it enters or exists a structure or connects to another material. Otherwise movement of the PE could lead to leakage.

For connections made outside a structure, say between DI and PE (Refer Fig. 1), these should be made using a flanged connection. A flanged DI puddle flange end connects to a PE flange adaptor. This connection transfers 100% of the forces from the PE through the flange joint into the concrete structure via the DI puddle flange. The DI puddle must have an integral cast flanged end where it connects to the PE, as shown in Fig 4 & 7.

Note: Screwed DI flange ends are not recommended for tensile loads.

The proposed connection methods shown in Fig. 1 “Flexible joint” or “Change Couplers” cannot be made as shown. The outside diameters of PE and DI are not compatible and whilst there are forms of speciality mechanical transition fittings available for connecting PE to DI, the majority are not WIS (UK Water Industry Standard) 4-24-01 Type 1 approved joints. A Type 1 joint can transfer the full design thrust between the PE and the DI and this is required in the WSD Particular Appendix 22.09, Clause 5.9 for making PE connections.

The second consideration is ground movement. It is common that chambers and pipelines settle at different rates to each other, significantly more so when installing pipes in reclaimed land with piled structures for example. In DI pipelines this movement is generally accommodated using “rocker joints” these are a pressure rated DI joint with ball sockets, that can articulate the changes in level, refer Fig. 3 for an example.



Fig 3: Example of a flanged Ductile Iron rocker joint, these do not need to be used with PE pipe connections.
Image credit: Yung Yu Special joint Co.

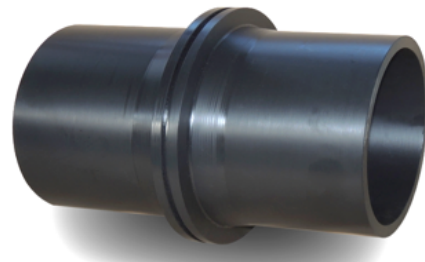


Fig 4: Example of PE puddle flange

Such joints should not be used with PE pipes. PE has a far higher degree of flexibility compared to a rocker joint, therefore if a rocker joint is used, the PE bends before the joint articulates, rendering the joint unnecessary. British Standard 9295: 2010 *Guide to the structural design of buried pipelines*, makes the following comments regarding rocker joints:

BS 9295:2010 Clause A13.3:

“Pipe materials with a high degree of longitudinal continuity and flexibility, such as welded polyethylene and welded steel, do not typically require rocker pipes at structures but other engineering solutions might be required where settlements are large”

PE can accommodate significant ground settlement as typically found in reclaimed land situations where a piled fixed structure connects to a buried PE pipe that is subject to settlement. The PE simply stretches and curves to accommodate the change in levels over time. For more information on the performance of PE in reclaimed land, see our Technical Note on ***Differential ground settlement using PE pipes.***

What's the solution?

For pressure pipe joints

The preferred solution for a new pipeline design using a PE puddle flange is given in Fig. 2. For existing designs that have a DI puddle flange with an integral cast flange (Fig. 4) this connects to a standard PE flange adaptor as shown in Fig. 7. This PE joint can accommodate significant ground movement and transfers 100% of the thrust, thermal and settlement forces into the structure via the DI flanged joint.

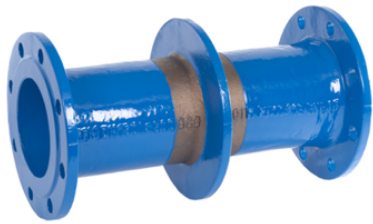


Fig. 4: Integral cast DI puddle flange
Image Credit: Technimex International BV



Fig. 5: Spigot end puddle flange
Image Credit: www.bimex.lu

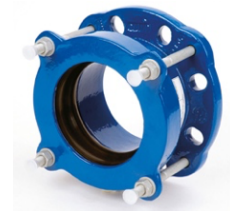
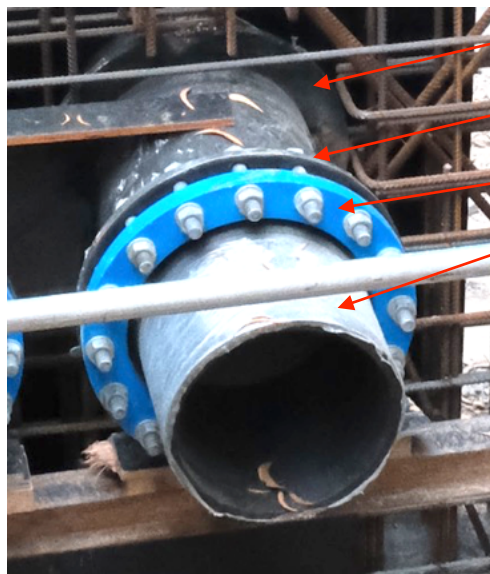


Fig. 6: Typical Flange adaptor
Image Credit: Saint-Gobain PAM UK



- DI Puddle cast into Chamber wall*
- DI cast Flange end*
- Steel PE backing ring*
- PE Flange adaptor spigot for connection by electrofusion coupler to the PE pipeline*

Fig. 7: Ductile Iron puddle flange to PE pipe in a pressure connection for transition from DI to PE in Hong Kong

If the DI fitting extending from the structure has a spigot or pipe end (as shown in Fig. 1 and below in Fig. 8), this needs to connect via a ductile iron flange adaptor or socket / flange (Fig. 7) which is bolted to a standard PE flange adaptor. The DI flange adaptor connecting to the DI spigot is an un-restrained joint, therefore the PE must be anchored to prevent it pulling the DI flange adaptor off the DI spigot, as shown in Fig. 8. This connection is more complicated than the connection design shown in Fig. 2.

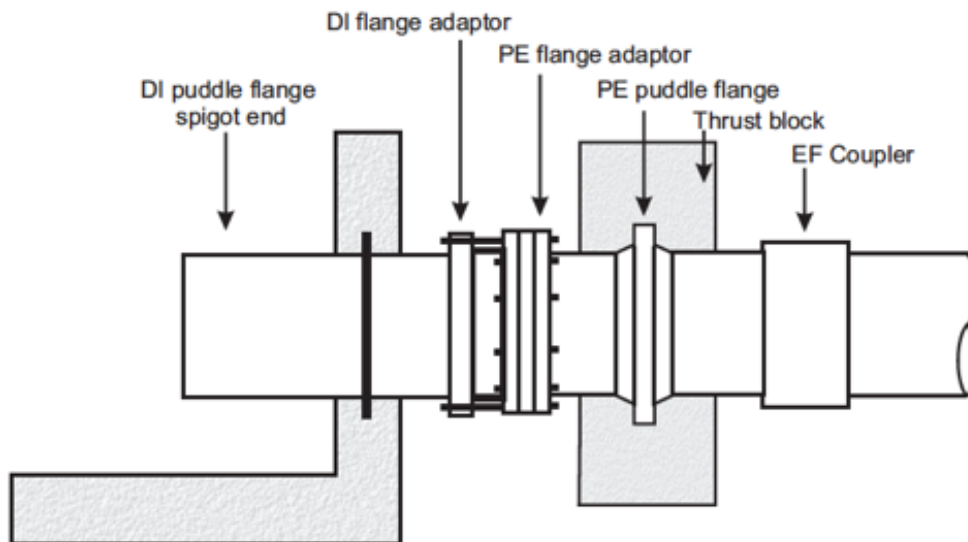


Fig. 8: Restraining a PE pipeline when connecting to a non-restrained DI spigot

For non-pressure pipe joints (Gravity pipes)

The thrust forces are less because there is no thrust exerted by the pressure. The forces come from thermal change, as the PE changes length due to temperature or from ground movement. Anchoring of PE is always required when connecting to other materials or structures.

A PE Transition fitting is used to connect to an existing DI spigot, they have a rubber ring joint socket end (Fig. 9) or spigot end for coupler connection. They also have an integral puddle flange for casting into a corbel against the existing structure to anchor it. These are standard fittings, available ex stock in Hong Kong.



Fig 9: Example of a PE socket transition fitting. After connection to the PE pipe, the transition fitting is encased in concrete anchoring the transition fitting via the puddle flange to the DI pipe and the chamber wall

References

1. British Standard 9295: 2010 Guide to the structural design of buried pipelines
2. BS EN 1295-1: 1997 Structural design of buried pipelines under various...
3. AS/NZS 2566.2:2002 Buried flexible pipelines, Part 2: Installation.

Typical Standard PE pressure fittings



Fig. 10: Typical examples of PE pressure fittings



Fig 11: Example of a Sewerage rising main chamber with puddle flanges each end, knife gate isolation valve, Pressure drainage tees, dismantling joint and CCTV access point. All manufactured in PE except for the blank flange and the knife gate valve

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