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Pipeline Material Selection - aCase for Ductile Iron Pipe

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The start of a new year is always a good time to reflect and measure broad and long-term trends in the Pipeline Industry. One of the growing trends is the use of Ductile Iron Pipe in water and wastewater projects. The rise of the use this material can best be understood in the current context of the market.

The Pipeline Industry and the process of providing safe and affordable water and reliable wastewater systems are full of challenges, surprises, frustrations and complexities. In a water stressed and developing country such as South Africa, the need for ever expanding infrastructure is compounded by the distances, conditions and pressure ratings that pipelines have to traverse and be operated under.

South African challenges extend to escalating costs of services, greater demand for new service delivery, and a shrinking skilled/experienced labour workforce.

Added to this is the need to stay current with technological advances and alternatives. This is specifically true for design engineers and end users when it comes to the selection of pipe materials.

Ductile iron Pipe is one of those materials that is versatile and simplifies the engineers' choice through its ease of availability and the variety of features and benefits the material possesses.

The Sustainability Challenge

Pipeline material selection is a complicated process, dependant on many factors including; the availability, cost, and suitability for purpose and local constraints. Materials must be durable, resistant to corrosion internally and externally, provide smooth internal surfaces which does not deteriorate with time, and must be capable of withstanding stresses imposed on them by internal fluid pressures and external loading. In addition, they must be easy to handle cut and lay and have reliable jointing systems.

Further, although less obviously, they must be able to cope with some abuse during transport to site, installation, and subsequently to service. And finally, they must be economical to purchase, construct and maintain.

Decision making amongst engineers are split with some more receptive to new materials and others more resistant until a material has achieved a proven track record.

A trend amongst some specifiers is to specify more than one pipe material type and base the final decision only on capital costs, thereby neglecting the total life cycle costs of the pipeline and possibly compromising the pipeline's sustainability.

Sustainability is an issue to be addressed at the very beginning of a pipeline design and if sustainability is not assured there is little point in spending the money.

A simple definition for sustainability is whether or not something continues to work over time. For a water service, this would mean that water continues to be available for the period for which it was designed in the same quantity and at the same quality as it was designed.

Pipeline material selection is an optimising process and the material selected must be chosen

for the sum of its properties. Material selected may not rank first in each category but must be the best overall choice. Sustainability can only be assured when water supply is not seen as a series of projects where the capital costs and the aspect of construction are the elements which enjoy most of the attention, rather than the provision of a service over the lifespan of the pipeline.

Ductile Iron Pipe's reputation as a sustainable and viable long-term material has been gained through its high ranking when subjected to an optimising process with other materials and its low Life Cycle Costs.

Ductile Iron Pipe

Ductile Iron Pipe is a natural outgrowth of grey cast iron pipe and has been utilised in South Africa since the 1950's. It was re-introduced to South Africa in the late 1990's.

Ductile Iron Pipe has a long lineage, tracking its history through the production in cast iron which dates back centuries. Continuous improvements in the jointing and protective coating methodologies which include bell and spigot jointing, cement mortar lining internally and zinc spray externally, supplemented by polyethylene sleeving, has increased the reliability of ductile iron pipe.

The benefits of this pipe begin in the method of production. Quality can never be inspected into a product but is rather intentionally built into the product through its method of production. Ductile Iron Pipe possesses a natural high degree of corrosion resistance due to its high carbon content and ductility through the addition of a small amount of magnesium to the molten metal before casting which turns the carbon flakes in the material into nodules.

The pipe is manufactured in a centrifugal casting process which produces a seamless high-density pipe with an integral joint.

The internal diameter of Ductile Iron Pipe is larger than that of any other pipe material, for a given pipeline diameter. This coupled with the smooth mortar lining implies that Ductile Iron pipe provides the least resistance to flow ensuring a lower cost in power consumption across the life cycle of the system for equivalent flow when compared to other pipe materials.

Power saving has become a major factor in pipe material selection. Recent comparison between Ductile Iron Pipe and other materials have shown a savings, dependant on pipe diameters being compared, of between four percent and twenty three percent per annum.

Surge and Water-hammer is an unavoidable phenomenon on pipelines. Pipe classes for Ductile Iron Pipe is based on the wall thickness vs the diameter of the pipe. The standard pipe class for water applications is Class 40 which can be utilised for working pressures up to 40 bar. In addition, Ductile iron has an inherent damping capacity and a high resistance to cyclic failure. The pipe is also designed with a high safety factor; in excess of three times the pipe's operating pressure to allow for abnormal surge pressures.

Most pipe materials have a limited safety factor of between 1.25 and 1.6 times the pipe's operating pressure. Ductile Iron Pipe therefore provides peace of mind against excessive surge pressures and boosting capacity should the system pressure increase in future.

Ductile Iron is impermeable; contaminated soil can therefore not penetrate the pipe wall as is common with some pipe materials. This coupled with the pipe design's reliable sealing system ensures years of reliable operation under all pipeline pressure extremes.

As a ferrous material, the aspect of corrosion and corrosion protection is often raised in the application of Ductile Iron Pipe. Ductile Iron Pipe, because of its sealing system, ensures that every pipe length is insulated from the next with no continuity of current flow. This fact coupled with the pipe's standard coating and the material's natural resistance to corrosion, ensures decades of maintenance free operation without the need for cathodic protection in most applications. In addition,

a wide selection of coatings and linings is available to suit virtually every application.

The performance of a pipeline can only be guaranteed by the strength of its joint. Ductile Iron Pipe makes use of a reliable spigot and socket joint with a dynamic sealing system which increases the integrity of the seal as the pressure increases. Further, the jointing allows for angular deflection and excellent resistance to negative pressure conditions.

The spigot and socket seal arrangement coupled with the robustness of the material, makes Ductile Iron Pipe easy and quick to lay and in many applications, the pipe can be laid as fast as plastic pipe. One of the most critical aspects of pipe material selection is the understanding of the intimate relationship between the soil and the pipeline. The more rigid the pipe, the less reliant on pipe embedment and the more flexible the pipe the higher the reliance on the pipe embedment for support the pipe material will be.

Ductile Iron Pipe is considered a semi rigid material with sufficient strength and stiffness to make it less reliant upon pipe embedment for support. This factor minimises the need for imported bedding and surround and makes the laying of pipe more economical in comparison to flexible pipe materials. An additional advantage of semi rigid pipe is its high resistance to vacuum conditions. Flexible pipe is highly susceptible to pipe collapse under certain vacuum conditions.

Ductile Iron has exhibited tremendous impact-resistance. The material's toughness makes it much less vulnerable to damage from improper handling or abnormal service conditions. In addition, it has proven its integrity in heavy traffic conditions with unstable soil environments, where other materials might fail due to the stresses caused by unusual superimposed external loading.

Sustainability through life Cycle Costing

Pipeline sustainability is not ensured by close attention to the initial purchase price only. Neither is it guaranteed by the successful construction of the pipeline. Rather, it is achieved through the careful evaluation of several pipe materials in an optimising process taking every aspect of the pipeline's life cycle into account and choosing the most appropriate material which may not necessarily be the lowest in initial capital costs.

Ductile Iron Pipe, because of low installation cost, maintenance free operation, high flow capacities, resistance to cathodic corrosion and a relatively low initial purchasing price, provides the lowest cost of ownership in comparison to all alternative pipe materials.

A trend to monitor in future therefore is the continued growth of Ductile Iron Pipe as a material of choice for both water and wastewater applications.

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