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BUOYANCY CONTROL ON THE 56" CROSS ISLAND GAS PIPELINE PROJECT, TRINIDAD AND TOBAGO

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ABSTRACT

The Cross Island Pipeline (CIP) consists of approximately 76.5 kilometers of 56-inch natural gas pipeline from Beachfield to Point Fortin and originally designed with a total of 2.8 kilometers of continuous concrete weight coat for buoyancy control.

Alternate design and construction techniques were used to improve the efficiency of the pipeline construction methods used for the concrete coated sections. In areas where temporary work space was limited due to the crossing of foreign pipelines; or where induction bends were installed; or where the 56" pipeline closely paralleled existing pipelines, an alternate method of weighting had to be considered. Bechtel proposed alternative methods for buoyancy control such as installation of Concrete Strap-On Weights and the use of Geotextile Buoyancy Control Saddle Weights.

INTRODUCTION

The subject of this paper covers the buoyancy control techniques used to improve the efficiency of the Cross Island Pipeline construction methods. Buoyancy control for a 56" diameter pipeline has proved to be a real challenge, so three different methods were utilized, depending on specific conditions.

For long sections requiring buoyancy control, a standard reinforced continuous concrete coating with a minimum strength of 3000 psi and actual density of 210 lb/ft3 was applied. However, with each joint of pipe now weighing approximately 40 tons, standard methods of lowering each string into the trench had to be reconsidered.

Bechtel used the "dig-down" method for installation of this very heavy coated pipe. The pipe string was welded and concrete coated in place along the eventual ditch line. Once the concrete section was cured and all of the forms removed excavators started digging the trench on either side of the coated pipe to slowly lower the pipeline under its own weight to the proper depth of cover (minimum 1.2 meter). This resulted in a wide trench which not only increased the excavation and backfilling time but required additional temporary work space on the right-of-way to store the extra amount of spoil material.

In areas where temporary work space was limited due to the crossing of foreign pipelines; or where induction bends were installed; or where the 56" pipeline closely paralleled the existing pipelines, an alternate method of buoyancy control had to be considered. Bechtel proposed alternative methods for buoyancy control such as installation of Concrete Strap-On Weights and Geotextile Buoyancy Control Saddle Weights.

LOCATION

A location map is shown in Fig 1. The largest natural gas pipeline in the western hemisphere – the 56" Cross Island Pipeline for The National Gas Company of Trinidad and Tobago Limited (NGC) runs east to west from the Beachfield Facilities, and terminates at the Atlantic LNG Facilities in Point Fortin. The pipeline and facilities were to be installed largely during the dry season of January to May in each of the years 2004 and 2005, with minimal work activities planned during the intervening wet season.

Figure 1

DESIGN CONSIDERATIONS

A minimum strength of 3,000 psi and density of 190 lb/ft^3 with two layers of reinforced continuous coating was originally specified to increase the specific gravity of the pipe to 1.3 times the specific gravity of freshwater (1000kg/m^3) for buoyancy control; the concrete coating thickness for such minimum requirements were as follow:

Table 1

Pipe Wall Thickness (Inches / mm)	Concrete Coating Thickness (Inches / mm)
0.708 / 18.00	6.75 / 171
0.825 / 21.00	6.50 / 165
0.965 / 24.52	6.00 / 152

The two layers of reinforcement (100mm x 100mm x 10/10 WWM) were specified to be place equal distant from each other, maintaining a minimum thickness of ½” of concrete between the reinforcement and the outside surface of concrete.

To ensure adequate weight per meter was achieved, Bechtel recommended using iron ore as the aggregate. In using iron ore Bechtel was able to increase the concrete density to 210 lb/ft^3 and by increasing the concrete density Bechtel was also able to reduce the coating thickness by 1.0 inch. The use of iron ore also changed the requirement for the two layers of reinforcement to one layer, thus avoiding installation challenges of using two (2) layers.

The calculated concrete thickness with minimum strength of 3,000 psi and density of 210 lb/ft^3 with one layers of reinforced continuous coating are described in Table 2:

Table 2

Pipe Wall Thickness (Inches / mm)	Concrete Coating Thickness (Inches / mm)
0.708 / 18.00	5.75 / 146
0.825 / 21.00	5.50 / 140
0.965 / 24.52	5.00 / 127

CONSTRUCTION AND INSTALLATION

Reinforced Continuous Concrete Coating Method

The pipe was welded and concrete coated along the trench line. The reinforcement Concrete Strap-on Weights (Fig. 2) consisted of a single layer of 0.225 inch diameter non-galvanized welded wire fabric in a 4-inch X 4-inch grid. It was held in place by L-shaped concrete spacer blocks keeping the single layer mesh at a constant distance from the pipe and formwork. Three sizes of L-shaped spacers corresponding to the three thicknesses of concrete coating required were fabricated. At locations where a roll of mesh ends and another one begins the minimum overlap utilized was 2”.

Figure 2

The concrete coating forms were originally installed around weld joint area (Fig. 3) after ultrasonic inspection, field FBE coating of weld joints and jeeping took place. The forms covered a 3 meter section of pipe with the field-welded joint located in the center of the 3 meters section of formwork. By placing the center of the forms around the weld joint area it allowed installation of three (3) additional forms in the remaining section of the pipe joint.

Figure 3

The formwork (Fig. 4) of mild steel was rested on top of the concrete spacer keeping it a constant distance from the pipe. The formwork was held in place by steel bands placed around the outside of the form.

Figure 4

The concrete was introduced via concrete pump through an opening at the top of the formwork (Fig. 5). The formworks were not removed until the concrete met the curing requirements. Depending on the test batches this was expected to be around 12 hours.

Figure 5

After the concrete had sufficiently cured, the pipe was lifted via the uncoated portion and wooden skids and mats were moved from the uncoated sections and placed under the concrete coated section to support the pipeline (Fig. 6). The remaining section of pipe was then formed up and coated as above. This process continued along the pipe until the required length of concrete coating was achieved.

Figure 6

As the concrete coating application method was applied in muddy or wet soil due to high water table in the area, it was necessary to build the roadway with mats for personnel, material, and mixer trucks to carry the pre-mixed concrete batches.

After sufficient concrete curing time had elapsed the dig-down method of ditching commenced. This method involved a minimum of two backhoes working on either side of the pipe by removing spoil material from around the base of the pipe. Reference Fig. 7, Fig. 8, and Fig. 9. The mass of the continuous concrete weight coated pipe caused the unsupported earth to be displaced into the excavated voids. This was repeated along the pipe until the final and correct depth had been reached.

Figure 7

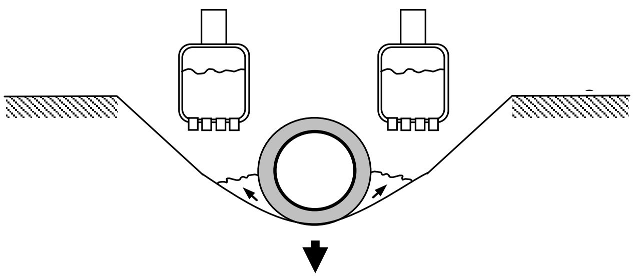

Figure 8

The resulting trench was wide because of several factors such as the soil conditions, the method of installation, and the size of the pipe. This not only increased the excavation and backfilling time but also required additional temporary work space on the right-of-way to store the extra amount of spoil material.

Figure 9

As part of the Bechtel Management process it was necessary to review the existing buoyancy control design and propose alternate construction techniques to improve upon the efficiency of the pipeline construction methods and project schedule. Alternative methods for buoyancy control such as installation of Concrete Strap-On Weights and Geotextile Buoyancy Control Saddle Weights were proposed and selected.

Concrete Strap-On Weights. The strap-on concrete weights (Fig. 10 and Fig. 11) were designed to improve the constructability of the pipeline. The strap-on concrete weights were originally approved for installation in river crossings that required 9, 18, or 24 meters of equivalent length of concrete coating. The Concrete Strap-On Weights are of a semi-circular design and are 3 meters in length. They were held in place by nine large stainless steel bands and buckles rated for coastal and underwater application.

Using the 210lb/ft3 density concrete the required concrete thickness for each of the weights in relation to the pipeline class location was standardized for the 0.708” pipe wall thickness as described in Table 2.

The strap-on concrete river weights of 5.75” of concrete thickness were pre-cast in two halves in the yard using specially designed forms. The weights were cast in advance, allowing enough time for the concrete to cure to a project acceptable condition.

Figure 10

The concrete weights were transported to the work site for installation as required.

Figure 11

To prevent the concrete weights from damaging the FBE coating, the pipe was protected by the use of Tapecoat closed cell polyethylene foam rock shield. The rock shield covered any section of pipe that may be in contact with the concrete weights.

Lifting of the Strap-On Weight segments was done using suitably rated slings and shackles. The slings were attached to the shackles, which were fixed on the pre installed eyelets embedded in the semi cylindrical weight segment. The bottom segments were lifted and placed in alignment to receive the pipe. This operation continued until the desired length of concrete segments had been placed.

The pipe protected by the rock shield was then placed into the semi cylindrical bottom sections using the relevant pipeline construction equipment. After the pipe was positioned into the bottom semi cylindrical segment, the top sections then were lowered down onto the pipe, completing the encirclement.

The two segments of the reinforcement Strap-On Weights were held permanently in place by nine (9) stainless steel bands, 1-1/4” wide, clamped by stainless steel buckles, tensioning of the bands was performed using a banding tensioner tool. The above operation was repeated until the required length of coated pipe has been encircled and banded (Fig. 12).

The weighted pipe strings were prepared along the ROW, then lowered into the trench.

Figure 12

Geotextile Buoyancy Control Saddle Weights. Similar to the strap-on concrete river weights, the geotextile buoyancy control saddle weights were designed to improve the constructability of the Cross Island Pipeline. Geotextile buoyancy control saddle weights were considered for installation in areas where temporary work space was limited due to the presence of crossing pipelines; or where induction bends were installed; or where the 56” pipeline closely paralleled existing pipelines

The installation of geotextile buoyancy control saddle weights helped improve the schedule by reducing installation time. Prior to selecting geotextile saddle weights as a pipeline buoyancy control system, Bechtel worked together with the manufacturer of the saddle weights for resolution of technical requirements such as soil pH range and local geotechnical conditions; sun exposures, expected loss in strength of the material during construction, longitudinal forces, overall service life, and saddle weight minimum separation.

The geotextile saddle weights selected had a total volume of 74 cu ft with a design weight of 14,250 lbs (6,464 Kg) and are split in 6 compartments (3 per side) and were 2 meter long and 1.2 meter tall with 0.6 meter thick legs and had two integrated lifting loops allowing the geotextile saddle weights to be installed with a single hook.

Figure 13

The spacing requirement was based on the criteria of the iron ore specific gravity of 4.65 (density of 292.57 lb/ft3). The following table (table No. 3) lists the required separation for each of the weights in relation to the pipeline class location.

Table 3

Class Location	1	2	3
Pipe Wall Thickness (inch)	0.708	0.825	0.965
Pipe Saks Minimum Separation	3.18 m	3.47 m	3.82 m

Installation of Geotextile Buoyancy Control Saddle Weights

Geotextile Buoyancy Control Saddle Weights were filled with iron ore using a specially designed quick fill and release hopper system at the storage yard (Fig. 14).

Figure 14

The saddle weights were lifted and positioned over the pipeline by the lifting loops using a side-boom or crane (Fig. 15). The saddle weights were lowered onto the pipeline and the lifting loops released. This operation continued until the required design separation and length of saddle weights were placed along the pipeline section.

Figure 15

Additional Considerations During Installation

To prevent the saddle weights from damaging the FBE coating, the pipe was protected by the use of Tapecoat TC2025-1 3/8” closed cell polyethylene foam rock shield. The rock shield covered the section of pipe in contact with the saddle weights (Fig.15).

The Installation of saddle weights was conducted under normal trench conditions. Where water was present at the locations at the time of installation, water diversion or pumping of water was adopted to obtain the required installation conditions. Standing water up to approximately 2 feet deep did not interfere with the installation of the saddle weights. In areas such as stream crossings and foreign pipelines, concrete slabs were provided for mechanical protection; competent fill material was placed and compacted around and over the pipeline up to the base of the concrete slab.

CONCLUSIONS

Alternate design and construction techniques were developed to improve the efficiency of conventional pipeline concrete construction methods and advance project schedule. In areas where temporary work space was limited due to crossing of foreign pipelines; or where installation induction bends were required; or where the 56" pipeline closely paralleled existing pipelines, the installation of alternate methods of buoyancy control was successfully completed. Bechtel used Concrete Strap-On Weights and the use of Geotextile Buoyancy Control Saddle Weights as alternative methods for buoyancy control.

There were a number of benefits to using the alternate buoyancy control methods. It helped improve the schedule in approximately 45 – 60 days as it took less time to prepare and install. Trench depth and workspace limits were reduced as compared with the installation of continuous concrete weight coating operations that require additional temporary work space on the right-of-way to store the extra amount of spoil material when performing the dig-down method.

REFERENCES

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