WorldCargo news

# New design of pipe end connection

## Liftech Consultants Inc. has developed a new structural detail for connecting a pipe member to the crane structure*

Pipe-to-gusset plate connections in pipes that experience significant fatigue, such as upper diagonals, have frequently experienced fatigue cracking on ship-to-shore cranes. The cracking at fracture-critical pipes has led to several catastrophic failures. There are several common design approaches to this connection, and all are susceptible to fatigue failure.

Liftech introduces a new approach that significantly increases reliability by eliminating the centre gusset plate altogether by using two side gusset plates. The key element to this new approach is two gusset plates, one welded to each side of the pipe, to transfer the load from the pipe to the crane structure. This also improves access to the connection for inspection and repair.

*Figure 2: Side gusset plate design*

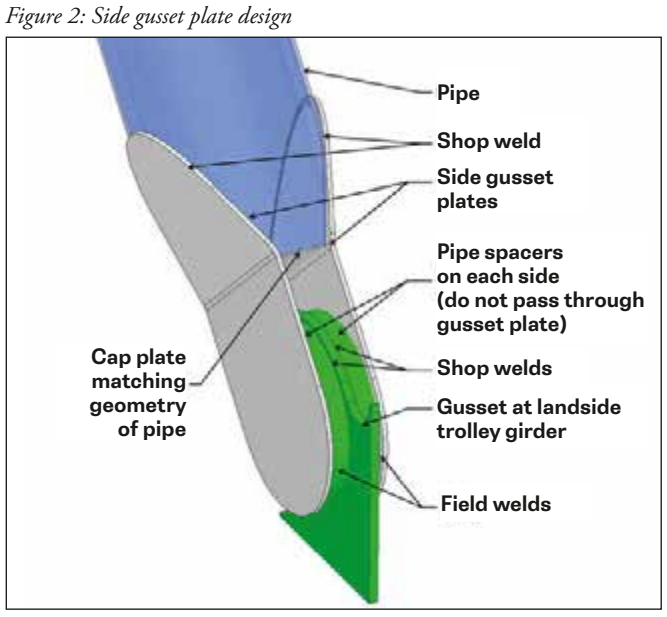
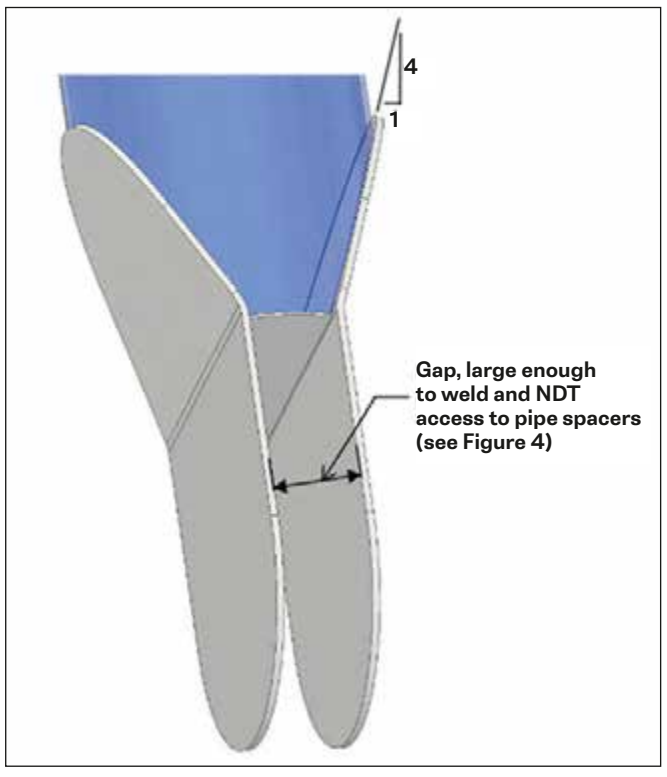



*Figure 3: Shop abricated portion*




## Background

The pipe-to-gusset plate connection, 'end connection', is one of the most common ways to connect a pipe member to the crane structure. Figure 1 shows two end connections – with and without a seal plate at the end of the gusset plate.

Both types are susceptible to cracking at the end connection, especially for the upper diagonal, as fluctuating fatigue stresses are large.

## New design

If the centre gusset plate can be eliminated, the end connection and associated cracking can also be eliminated. To achieve this, Liftech has developed a concept using two side gusset plates rather than a centre gusset plate (see Figure 2).

The two side gussets serve as closure plates of typical conventional pipe end connections. However, in this new design, instead of terminating at the centre gusset plate, each side gusset plate is bent parallel to the gusset plate of the adjoining structure with a gap between them to provide sufficient space for welding and periodic MT and UT examination and repair, if necessary.

The side gusset plates at the connection to the diagonals are sloped 1:4 to reduce stress concentration and provide a gradual transition. The side gusset plates are connected to the single gusset plate on the crane structure with two pipe spacers. The portion shown in Figure 3 will be shop fabricated.

The end to the landside trolley girder support beam or the apex beam will have two pipe sections welded to it and will offer adjustability when the diagonal is installed onto the crane. If air tightness testing is required, then a hole can be made in the gusset plate to allow one test for both sides of the spacer.

## FEA analysis

Liftech performed finite element analysis (FEA) for both the conventional pipe connection design and the new pipe connection design using the same load, pipe size, and modelling approach. We found that the weight of the new design is comparable with the conventional design. For the new design, we found the maximum first principal stresses are at locations that are either without welds or are inspectable. In contrast, the maximum first principal stresses of a conventional pipe connection are at the end connection, which is often concealed by a seal plate. Also, we found the maximum first principal stress of the new design is a little more than half of that of the maximum first principal stress of the conventional design. Fatigue life, or the time that fatigue cracking may appear, is related to stress cubed. We expect that the fatigue life of the new design will be nearly seven times that of the conventional design.

One concern with the design is that the transverse plate at the bend line may be inadvertently mislocated and will create an offset. Liftech performed another FEA to determine the stresses with a 10mm offset of the transverse plate. The results were similar to the connection results without the 10mm offset.

The FEA showed that the maximum first principal stresses do not increase significantly, so the fatigue life is only reduced slightly as well.

For the table of results shown in Table 1 the load applied is a 300t axial load.

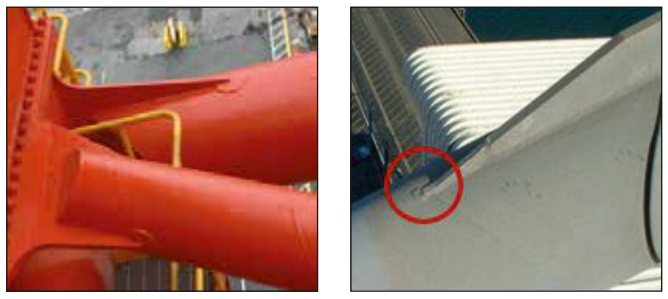


*Figure 1: Pipe-to-gusset plate connection, with seal plate (left) and without seal plate (right)*

## Conclusion

The conventional pipe-to-gusset plate connections of the upper diagonal (as shown in Figure 4) have frequently experienced fatigue cracking on ship-to-shore cranes.

The new approach of eliminating the centre gusset plate altogether and using two side gusset plates has the following advantages over the conventional pipe-to-gusset plate connection:

- The high fatigue stress locations are inspectable and repairable.
- The fatigue life is expected to be six to seven times that of the conventional connection.
- The weight is comparable.
- The longitudinal deflection is comparably small.

Based on the promising investigation, the next steps would be as follows:

- Discuss with a manufacturer how to best fabricate and weld the connection.
- Build a prototype or mock-up.

**This article is written by Kenton Lee, principal, senior structural engineer at Liftech Consultants. The views expressed are not necessarily shared by WorldCargo News.*

*Figure 4: Conventional pipe connection*

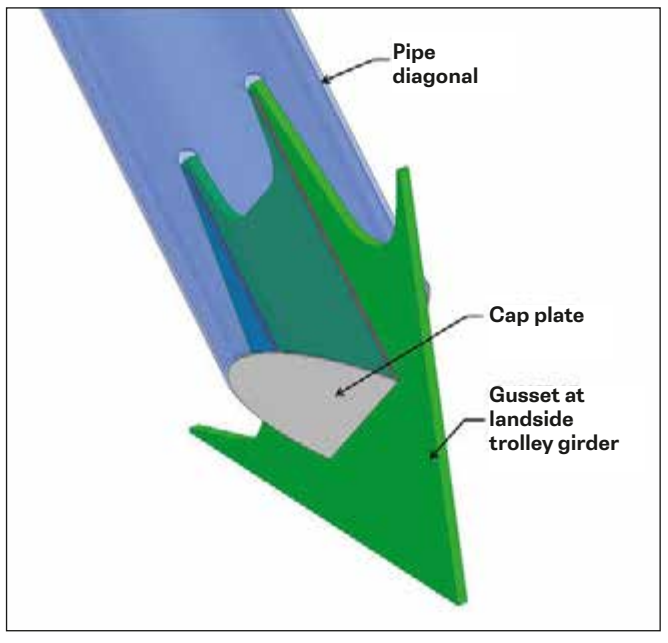



**Table 1: FEA analysis results with 300t applied axial load**

| | Conventional Design | New Design | |
|---|---|---|---|
| **Maximum Stress Location** | End connection of gusset plate | No offset of transverse plate at bend line<br>Bend line of transverse plate | 10mm offset of transverse plate at bend line<br>Same as 'no offset' |
| **First Principal Stress, MPa** | 235 | 124 | 126 |
| **Fatigue Life Comparison** | 1.0 | 6.8 | 6.5 |
| **Longitudinal Deflection, mm** | 1.15 | 1.65 | 1.62 |

*Source: Liftech Consultants Inc.*