Expansion Joint design Case

In this design case is demonstrated how the use of Corpo™ optimal fibre reinforcement can increase the performance and reduce the material cost of a rubber expansion joint.

1. Conventional rubber expansion joint

Expansion joints are designed to provide stress relief in piping systems that are loaded by thermal movements and mechanical vibration. To deal with the various forces on the joint they require fibre reinforcement which guarantees both flexibility and strength. Conventional expansion joints are reinforced using prefabricated fibre plies. The use of these fabric plies makes it impossible to control the orientation of the fibres on complex shapes such as the bellow of an expansion joint. In both cases the inability to use the fibres in an optimal way leads to the following disadvantages:

High material cost

- More fibres needed than necessary
- More rubber needed than necessary
- Additional parts such as metal reinforcement rings necessary with multiple bellows

Lower Performance

- High rubber wall thickness and fibre pack make product less flexible
- Undesired radial and axial expansion under pressure

2. Redesign with Corpo™ technology

In this case we compare a conventional joint with a Corpo™ reinforced joint which will be designed according to the same general design specifications. The goal is to reduce the material cost and to improve the performance by using optimal fibre reinforcement technology.

General design Specifications for conventional expansion joint	
Materials	
Tube	Nitrile, 8mm wall thickness including reinforcement layers
Reinforcement	Nylon Cord Fabric,1400 dtex, approx. 100 gr.
Flange	Metal flanges
Size	
Bellow size (Nominal Bellow I.D.)	150 mm (6 inch)
Nominal flange to Flange	150 mm (6 inch)
Pressure	
Working pressure up to 50° (120°F)	16 bar (232 psi)
Movement	
Compression	25 mm (1inch)
Elongation	25 mm (1inch)
Angular deflection	20°

Table 1. General design specifications for a 6 inch I.D and 6 inch F-F spherical joint based on design specifications for this type of joint from various manufacturers. This is a combined result so individual numbers can vary from this average.

The type of materials, the size and the pressure will remain the same in the Corpo™ redesign. By using the fibre material more efficiently we expect to use less fibres and also less rubber. Besides a material cost reduction this will also make the joint more flexible and lightweight. Finally Corpo™ allows us to control the fibre orientation of the joint under pressure which prevents undesired radial expansion.

Redesign goals:

- Same type of Materials, Size and Pressure
- Less Material
- More flexibility (Movement)
- No shape changes under pressure
- Repeatability for constant quality

3. Corpo™ prototype development

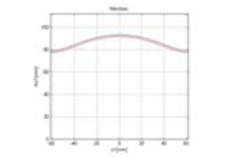	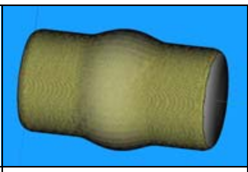	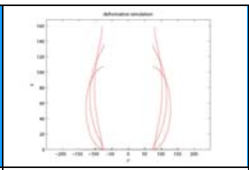	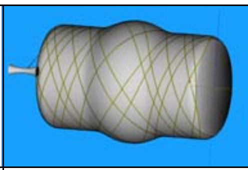	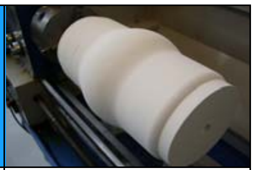
We use the nominal I.D and F- F as input for the Corpo™ bellow design.	Next, we calculate the required amount of fibres and the optimal fibre pattern for this application.	Using specially developed simulation and FEA software it is possible to predict the behaviour of the joint.	The next step is to simulate & check the automated production process for errors.	When al required mandrels and tooling are made we can start building the prototype.
				
The tube is build by wrapping rubber strips around the mandrel. (This is a picture from a multiple bellow expansion joint).	Next the fibres are accurately placed on the product using an automated winding process and the outer protective cover is applied.	The pull ply is also applied with robotic equipment using a predetermined pattern to ensure a constant and uniform pressure on the entire surface.	The final prototype is vulcanized and ready for testing.	The prototype is tested and evaluated on burst pressure, flexibility, expansion behaviour and amount of materials used.

Table 2. Development steps for the Corpo™ rubber expansion joint with 6 inch nominal I.D. and 6 inch F-F.

4. Results
The results from the prototype testing show that all design goals have already been achieved in this first prototyping phase.

- **30% less fibres**
- **20% less rubber**
- **More flexible; 200%(2 inch) in axial direction and approx. 175% (35°) angular deflection allowed**
- **Prediction & control over expansion behaviour under pressure**
- **All reinforcement steps can be CNC controlled leading to repetitive constant quality**

For the Corpo™ design a 4 mm abrasion resistant rubber liner was used whose strength was neglected and the required pressure resistance was already provided by the fibre structure only. Therefore, in future designs there can be used either less fibres or rubber material to obtain the required strength.

5. Conclusions
The results show that optimizing the fibre reinforcement of conventional expansion joints can lead to lower material costs and improved performance.
The amount of material saved is promising and can possibly be even increased with further development. Furthermore, the bellow is more flexible and allows greater movement in all three dimensions. For future designs this means that the flange to flange distance can be decreased.
Another advantage of using Corpo™ is that the design software and the accurate automated production equipment allows you to predict and control the behaviour of the expansion joint when it is pressurized and to make joints of continuous quality. This increases the safety of the joint and also makes it easier for an engineer to design with.
These conclusions are based on a 6 inch single bellow expansion joint. However, it can be assumed that these results also account for larger size customized bellows.

For more information about this case or to discuss the possibilities to apply Corpo™ in your product please contact Siebe Nooij at +3115 257 0754 or email at s.nooij@taniq.com.