

kompaflex ag
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**FCC Expansion Joints**  
for Fluid Catalytic Cracking

# About kompaflex

With over 40 years of experience kompaflex is a specialist in the design and manufacturing of custom-made metallic expansion joints for critical applications. We are a worldwide supplier for the Fluid Catalytic Cracking (FCC) market. These expansion joints are exposed to some of the most challenging conditions of any industry.

kompaflex-customized FCC expansion joints provide our customers with the latest technologies and solutions in the industry.

Established in 1981 in Switzerland, kompaflex is a family-owned and run company. With manufacturing facilities in Switzerland and the Czech Republic, as well as an established specialized representative and sales network, we meet the demand of our clients worldwide.



**kompaflex specializes in tailor-made expansion joints  
designed to meet customer needs**

**Manufacturing in  
Switzerland and  
Czech Republic**

# Design Codes for FCC Expansion Joints

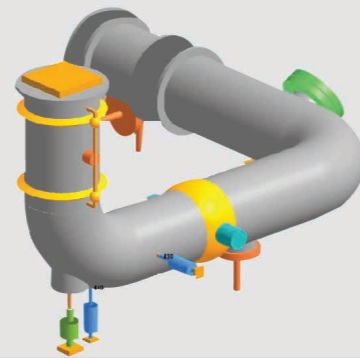
FCC expansion joints are exposed to high temperatures, high pressures, large thermal movements and very aggressive media. Due to these demanding service conditions, they are considered as highly engineered, critical components. kompaflex has a high degree of technical expertise to design these complex expansion joints.

Designed in accordance with associated design codes:

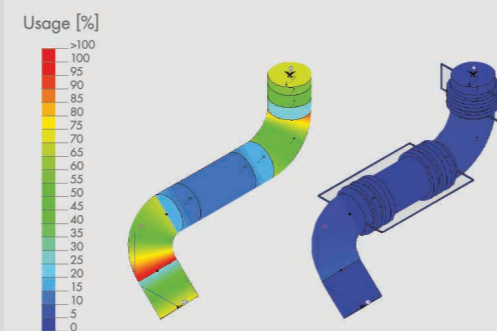
|                                                          |                                |
|----------------------------------------------------------|--------------------------------|
| ASME VIII Div. 1<br>Appendix 26                          | ASME B31.3                     |
| EJMA                                                     | EN 13445                       |
| EN 14917<br>(we are board member of<br>expert committee) | AD 2000                        |
| Project-specific<br>Technical Requisition                | Customer<br>Specifications (*) |

(\*) We are experienced in working with the specific design requirements of clients & licensors of the global refinery market, such as SHELL, Valero, UOP, Exxon Mobil, Marathon and many more. We advise on design enhancements in order to improve the originally specified design.

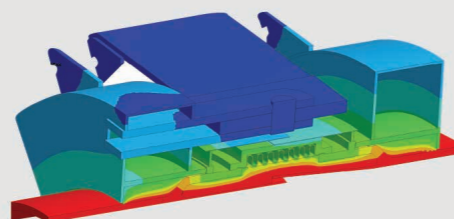
## Piping Stress Analysis



## Piping Stress Analysis



## Thermal Finite Element Analysis



**High degree of  
technical expertise**

# Engineering Services

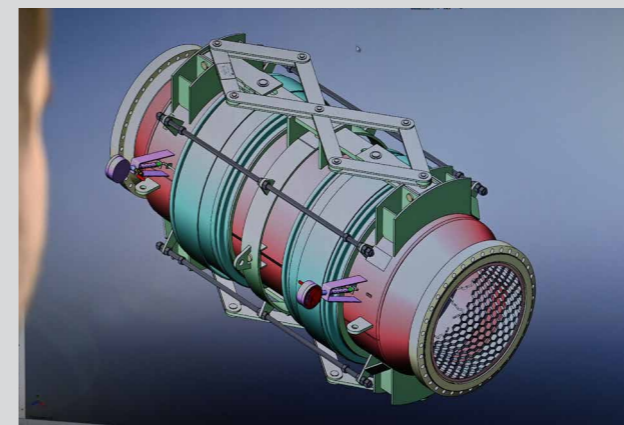


Our specialized engineering team designs and analyses FCC expansion joints in close collaboration with the client. We have extensive experience in working with complex specifications and requirements, preparing a highly advanced technical expansion joint solution.

In order to offer clients the best engineering solution, we provide the following services:

- ✓ Preliminary design study at FEED or Pre-FEED stage (\*)
- ✓ Custom design and calculation of critical expansion joints
- ✓ Dedicated project manager (single point of contact)
- ✓ Verification and, critically, optimization of bellows design
- ✓ 3D model including movement study
- ✓ Structural Finite Element Analysis
- ✓ Thermal Finite Element Analysis
- ✓ Pipe stress analysis

(\*) Industry advice: we advise to include the conceptual design for expansion joints in an early stage. This allows for consideration of required building length, spring rates and selection of the correct expansion joint type in the pipe stress analysis.



**We perform  
precision work**

# Expansion Joints for Fluid Catalytic Cracking

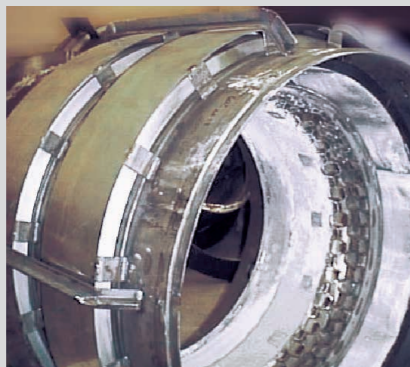
FCC expansion joint types include tied universal, gimbal, hinged and pressure balanced. All of these can be divided into 3 main categories:



## Cold wall

Cold wall FCC expansion joints utilize a high density internal vibracast refractory lining to considerably reduce the design temperature of the shell/piping below the temperature of the internal media.

Although the temperature of the catalyst or flue gas may be as high as 760 °C (1400 °F), the internal refractory lining and additional insulation material around the bellows reduce the shell temperature to below 343 °C (650 °F). As a result, ordinary carbon steel types are usually specified for the piping material of a cold wall expansion joint.



## Hot wall

Hot wall FCC expansion joints are usually fitted with abrasion-resistant lining consisting of hex-mesh and castable refractory materials. The purpose of the lining is to protect the piping from the abrasive catalyst fines flowing through in service but not to act as a thermal barrier. Thus, the shell/piping is typically manufactured from Chrome Moly alloys or stainless steel.



## Unlined

Unlined FCC expansion joints have no refractory lining installed as the media typically do not carry catalyst fines. These expansion joint types can still be exposed to very high temperatures and hence need to accept large thermal movements. They are generally used for inlet and outlet air and transferring gases from the reactor.





FCC double gimbal expansion joint

# Refractory Installation for US based projects

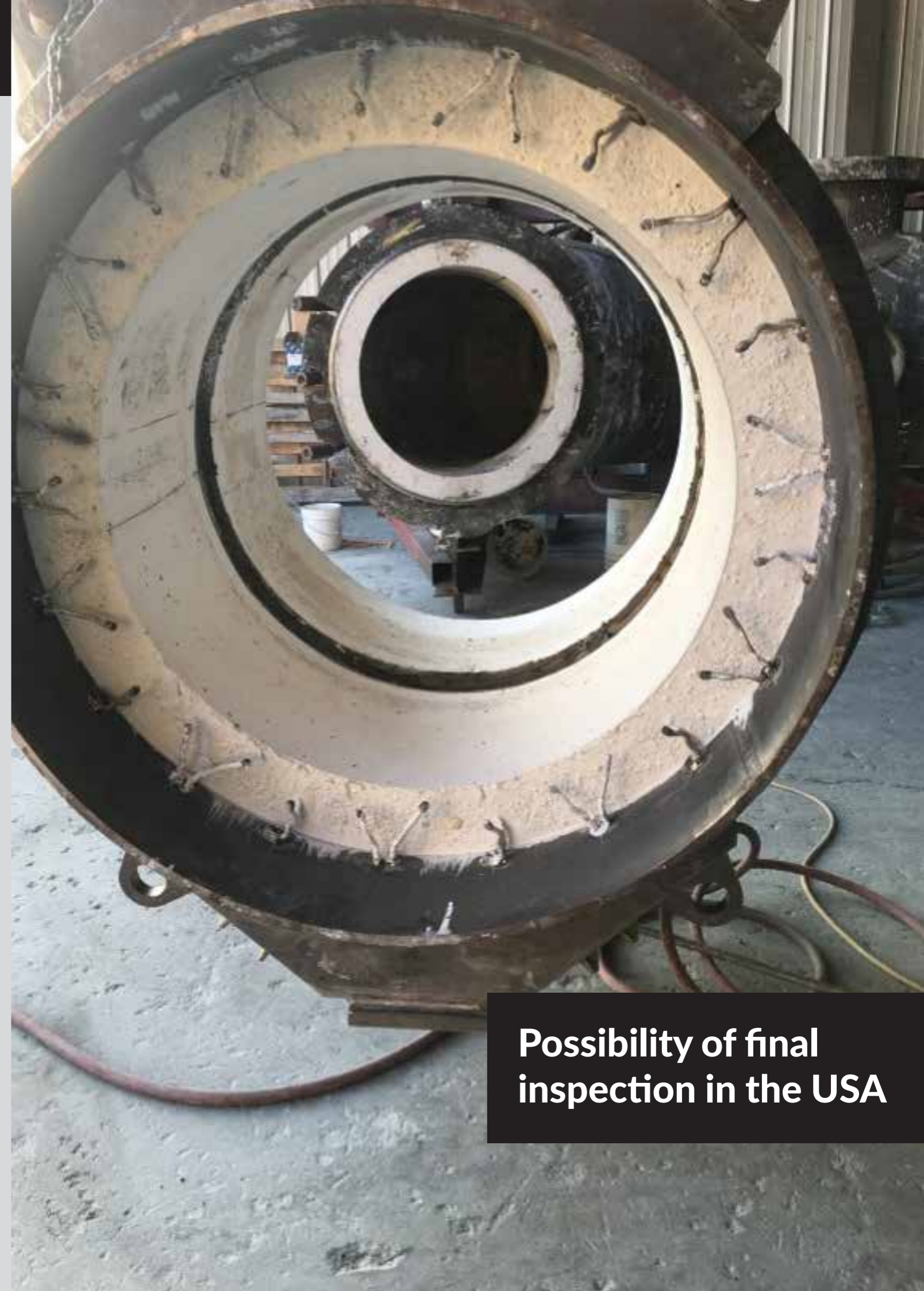
kompaflex and Heater Specialist HSI have an exclusive collaboration agreement for refractory-lined FCC expansion joints. FCC expansion joints for the US market are refractory lined by HSI in Tulsa, Oklahoma. This partnership gives the client the advantage of being able to inspect at the HSI facility in Tulsa, OK rather than having to travel to Switzerland.

The following shows a typical split of scope between HSI and kompaflex:

|   |                                                      |
|---|------------------------------------------------------|
| 1 | Request for quotation                                |
| 2 | Order placement, contracts                           |
| 3 | Overall responsibility, design, project management   |
| 4 | Fabrication of bellows and expansion joints hardware |
| 5 | Final assembly, anchors & hex-mesh                   |
| 6 | Refractory                                           |
| 7 | External coating                                     |
| 8 | Final pneumatic pressure                             |
| 9 | Inspection                                           |

**kompaflex ag**  


***HSI***  
 Heater Specialists, LLC.

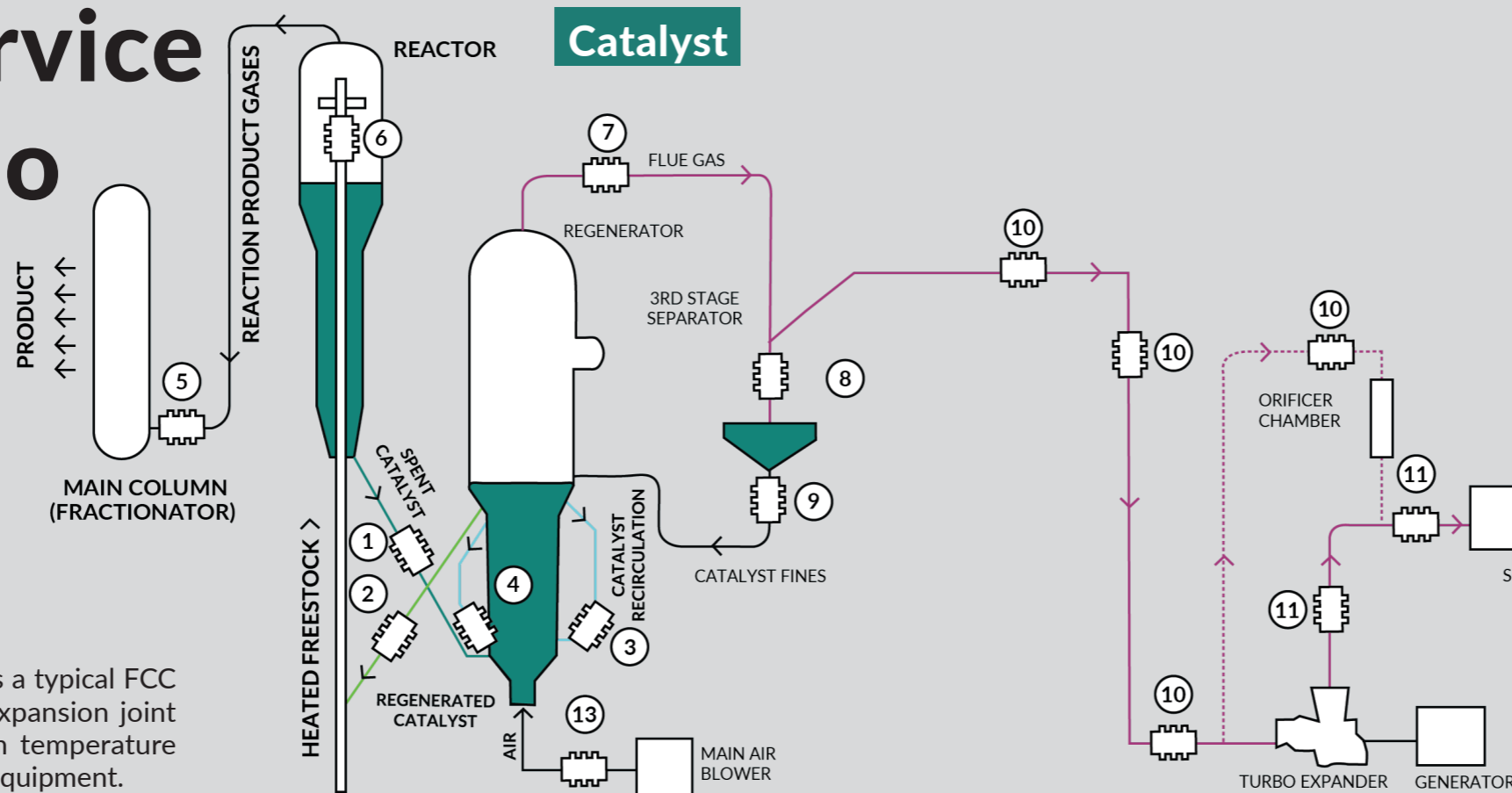


**Possibility of final  
inspection in the USA**

# FCC Service Portfolio

The high temperatures involved in FCC processes require the use of several types of expansion joints.

The process diagram shows a typical FCC process and the type of expansion joint typically found in the high temperature piping between vessels or equipment.



## Energy Recovery and Cleaning

| No. | Expansion Joint (FCC Process Diagram)                        | Single or Universal Bellows | Pressure Thrust Restraining Hardware |
|-----|--------------------------------------------------------------|-----------------------------|--------------------------------------|
| 01  | Spent Catalyst Standpipe Expansion Joint                     | Universal                   | Unrestrained                         |
| 02  | Regenerated Catalyst Standpipe Expansion Joint               | Universal                   | Unrestrained                         |
| 03  | Recirculation Catalyst Standpipe Expansion Joint             | Universal                   | Unrestrained                         |
| 04  | Cooled Catalyst Standpipe Expansion Joint                    | Universal                   | Unrestrained                         |
| 05  | Reactor to Main Column Expansion Joint                       | Universal                   | The Rods, Hinge, or Gimbal           |
| 06  | Reactor Riser Expansion Joint                                | Single                      | Unrestrained                         |
| 07  | Regenerator Outlet Expansion Joint(s)                        | Single or Universal         | The Rods, Hinge, or Gimbal           |
| 08  | 3rd Stage Separator Expansion Joint                          | Single                      | Unrestrained                         |
| 09  | Catalyst Fines Expansion Joint                               | Universal                   | The Rods, Hinge, or Gimbal           |
| 10  | Expander Inlet or Orifice Chamber Inlet Expansion Joint(s)   | Single or Universal         | The Rods, Hinge, or Gimbal           |
| 11  | Expander Outlet or Orifice Chamber Outlet Expansion Joint(s) | Single or Universal         | The Rods, Hinge, or Gimbal           |
| 12  | Flue Gas Expansion Joints                                    | Single                      | Unrestrained                         |
| 13  | Main Air Blower Expansion Joint                              | Single or Universal         | The Rods, Hinge, or Gimbal           |

| Cold Wall or Hot Wall Configuration | Abrasion Resistant Refractory Lining in Hex Mesh | Abrasion Resistant Insulating Refractory Lining |
|-------------------------------------|--------------------------------------------------|-------------------------------------------------|
| Hot Wall                            | Yes                                              | Not Common                                      |
| Cold Wall                           | Not Common                                       | Yes                                             |
| Cold Wall                           | Not Common                                       | Yes                                             |
| Cold Wall                           | Not Common                                       | Yes                                             |
| Hot Wall                            | Not Common                                       | No                                              |
| Hot Wall                            | Yes                                              | No                                              |
| Hot Wall or Cold Wall               | Yes                                              | Yes                                             |
| Hot Wall                            | Yes                                              | No                                              |
| Cold Wall                           | Not Common                                       | Yes                                             |
| Hot Wall                            | Not Common                                       | No                                              |
| Hot Wall                            | Not Common                                       | No                                              |
| Hot Wall                            | Not Common                                       | No                                              |
| Hot Wall                            | Not Common                                       | No                                              |

# FCC Specific Features

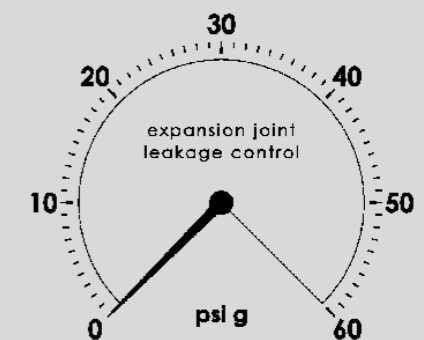
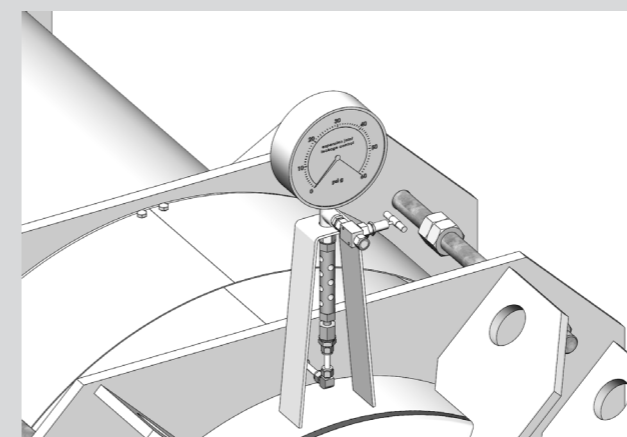
## 2-Ply Bellows

FCC expansion joints are widely fitted with 2-ply (also called redundant ply) bellows. Each ply is designed for full design conditions individually. Should, during operation, the inner ply fail (leakage due to corrosion, stress crack) the outer ply will be to take to full load and operate until the next planned shutdown.

The 2-ply bellows design improves operational safety and reliability of the whole system. It avoids exposing operators of increased risk or the need for an unscheduled shutdown. It allows for easy inspection of the bellows tightness.

2-ply bellows design including inter-ply monitoring via a pressure gauge.

- ✓ inner ply failure – the gauge will show the system design pressure

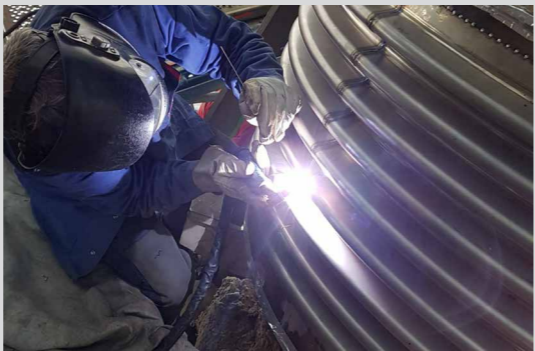


**Automatic Column and Boom Welding Machine for large equipment**

Clamshell Design

In the event of a bellows leak through both bellows plies an oversize clamshell bellows is installed over the existing bellows while the unit is on line. They are a temporary repair solution avoiding cutting or opening the pipe of an existing expansion joint.

The bellows is supplied in 180 degree segments that are field welded 2 places along the longitudinal seam during installation. The bellows has a weld end that allows attachment to existing end plates.



Packed Bellows

In order to protect the bellows from high media temperatures, FCC expansion joints are typically fitted internally and externally with ceramic fibre blankets. The ideal design temperature of the bellows ranges between 200 °C and 500 °C. The lower limit avoids dew point corrosion and the upper limit prevents embrittlement of the Inconel 625 bellows material.

kompaflex offers thermal Finite Element Analysis to verify the correct design temperature of the bellows.



External Hardware



| No. | Type           | Description                                                                           |
|-----|----------------|---------------------------------------------------------------------------------------|
| 01  | Control Rods   | Limit movements of bellows                                                            |
| 02  | Pantograph     | Distribute movement evenly and support centre pipe weight                             |
| 03  | Slotted Hinges | Distribute movement evenly and support centre pipe weight (if installed horizontally) |
| 04  | Tie Rods       | Allow lateral movement and restrain                                                   |
| 05  | Hinge          | Allow angular movement in one plane and restrain pressure thrust force                |
| 06  | Gimbal         | Allow angular movement in all planes                                                  |

# Field Service

FCC expansion joints expansion joints are a critical component of the refinery and require high level of expertise during installation and operation.

We support our clients by offering a variety of field services:

|   |                                                             |
|---|-------------------------------------------------------------|
| 1 | Technical support with practical solution-oriented approach |
| 2 | On-site inspection by our technical field advisor           |
| 3 | On-site installation                                        |
| 4 | Immediate response to end user in emergency                 |
| 5 | Express Clamshell design, manufacturing and installation    |



kompaflex offers support to clients throughout the expansion joint's life cycle. Our highest priority is to ensure that the refining process is not disrupted, guaranteeing reliable operation and avoiding failures and unscheduled shutdowns. Our qualified welders, on-site field supervisors and engineers are fully committed to achieving this goal, working hand in hand with customers, contractors and end-users.

**Immediate support to end user in emergency**

# Quality and Testing

Together with the client kompaflex establish a detailed inspection test plan to ensure the highest quality and reliability of the product. kompaflex expansion joints are manufactured according to the most stringent international standards. We are certified to:

## Standards

- ✓ ISO 3834-2
- ✓ ISO 9001
- ✓ DIN EN 13445
- ✓ DIN EN 13480
- ✓ DIN EN 14917
- ✓ AD 2000
- ✓ European Pressure Equipment Directive (PED) 2014/68/EU
- ✓ PED Module H/H1 certified
- ✓ ASME codes
- ✓ EJMA



We provide detailed design review and supporting calculations. Quality assurance during fabrication and full traceability of materials form part of our documentation, ensuring the high-quality standards of our production.

## In-house Non-Destructive Testing

- ✓ **RT-D**  
Digital Radiography (X-ray)
- ✓ **UT**  
Ultrasonic Testing
- ✓ **PT**  
Penetrant Testing
- ✓ **MT**  
Magnetic Particle Testing
- ✓ **LT**  
Bubble Leak Testing  
Helium Leak Testing  
Hydrostatic Pressure Testing  
Pneumatic Pressure Testing
- ✓ **PMI**  
Positive Material Identification
- ✓ **VT**  
Visual Testing
- ✓ **Further**  
Spring Rate Testing  
Pressure Thrust Force Testing

## Destructive Testing

- ✓ Mechanical Fatigue and Life Cycle Testing
- ✓ Squirm Testing
- ✓ Burst Testing
- ✓ Movement test outside geometrical limits

# References

## OMV, Austria

### Refinery Schwechat, Delivery 2023

#### Specification

Replacement of 4 2-ply FCCU Expansion Joints according to UOP specification

#### Design

- ✓ Refractory lined Reactor expansion joint DN 800
- ✓ Refractory lined Regenerator expansion joint DN 800
- ✓ Refractory lined Hot flue gas expansion joint DN 1000
- ✓ Cold flue gas expansion joint DN 1000



## Essar Oil, UK

### Refinery Stanlow, Delivery 2022

#### Specification

4 multi-ply expander load expansion joints DN 631. The expansion joints had to match-in-line pressure and compensate this force. This could be achieved as kompaflex versatile bellows manufacturing allows to manufacture to the exact diameter required.

#### Design

- ✓ Designed acc. ASME B31.3, EJMA 10th Ed. & ASME VIII Div. 1 - App 26
- ✓ CE marking (CE0036)
- ✓ Testing & welding acc. PED 2014/68/EU Kat. IV Module G



## Valero Energy Ltd, UK

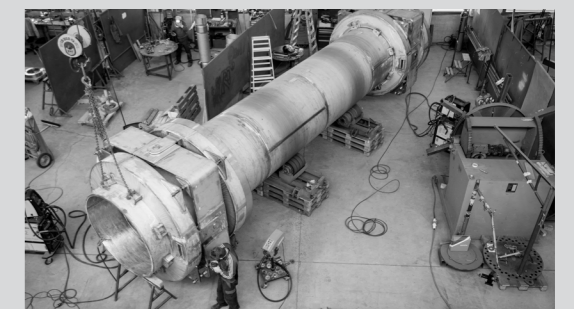
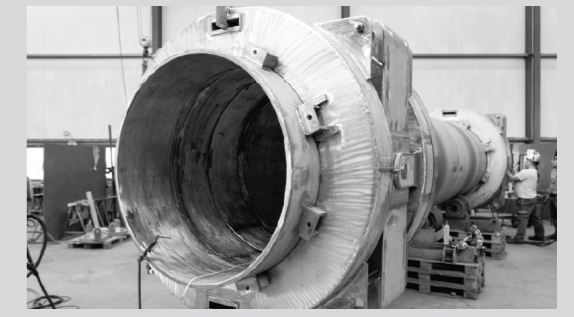
### Refinery Pembroke, Delivery 2020

#### Specification

FCC double gimbal expansion joints incl. the large connecting intermediate pipe. This like-for-like replacement is 10 m long and weighs 18.5 t. With our advise and consult approach to the project, the end user was able to choose the very latest advanced design and production engineering available to the market.

#### Design

- ✓ 2-ply Inconel 625 LCF bellows incl. leakage control
- ✓ Thermal FEA to ensure optimal bellows design temperature
- ✓ High Temperature of 750°C for design
- ✓ Full stainless steel body in 304H
- ✓ Floating gimbal rings including ceramic insulation pillows



## Holly Frontier El Dorado, USA

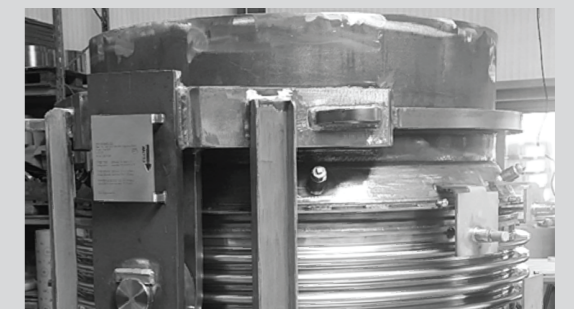
### Refinery LLC, Delivery 2019

#### Specification

Revamp of two angular FCC expansion joints including the connecting mitered J-Bend. kompaflex proposed a redesign of the internal liner design. Collaboration with Heater Specialist performing the refractory installation and final pneumatic testing of the assembly in Tulsa, Oklahoma.

#### Design

- ✓ 5° angular design movement
- ✓ 4" refractory lining Vesuvius AR 400VC
- ✓ 2-ply Inconel 625 LCF bellows incl. leakage control
- ✓ Final Inspection by Sentinel at HSI



# References

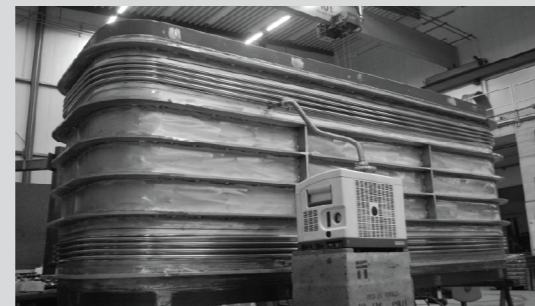
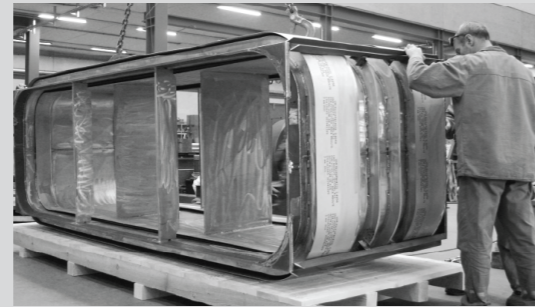
## Shell FLNG Prelude, Australia

### Technip Samsung Consortium, Delivery 2014 Specification

Design and manufacturing of two large rectangular multi-ply expansion joints for steam duct between turbine and condenser. Design conditions of full vacuum and large lateral movements at 122 million cycles only achievable with a multi-ply bellows. Express Delivery in 5 weeks over Christmas.

#### Design

- ✓ Multi-ply rectangular bellows
- ✓ DN 3640x1140 mm
- ✓ Bellows in Inconel 625
- ✓ Intermediate pipe in Inconel 825
- ✓ Permanent leakage control
- ✓ Including Lloyds approval



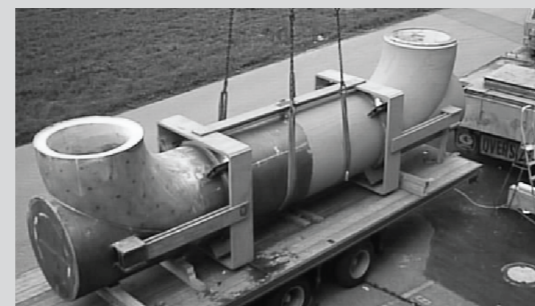
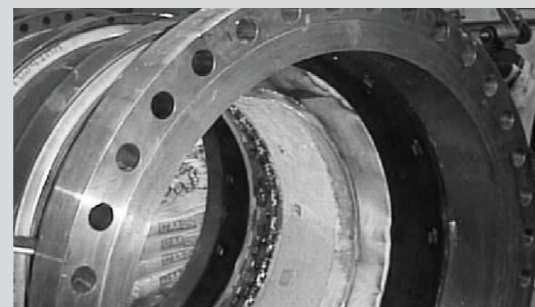
## Esso / Exxon, Germany

### Refinery Ingolstadt, Delivery 2000 Situation

Lurgi-Envirotherm was working with Exxon-Mobil USA and Germany's Esso AG to develop an innovative procedure for converting or recycling refinery residues. A first commercial plant has been built for this purpose in the Esso refinery in Ingolstadt.

#### Task

Delivery of over 40 custom-made FCC hot wall and cold wall expansion joints different sizes (largest piece 16 tons weight). Hex-mesh inner construction and protected bellows by special sealing sleeves.





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