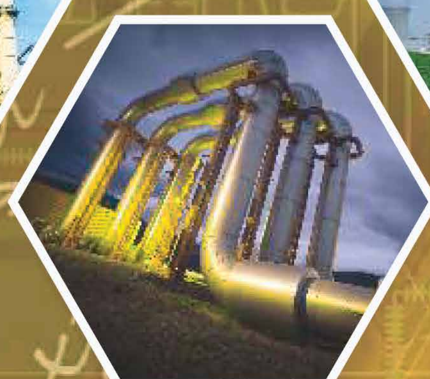
REPL
AUSTRALIA Pvt Ltd.

FCCU / RFCC Expansion Joints



Engineering Solutions

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REPL Australia Pty Ltd is a company specialised in design & manufacturer of Metallic & Non-Metallic Expansion Joints including critical FCCU – RFCC Bellows for refineries to meet global requirements. REPL incorporated under the companies ACT 2013, it has its manufacturing base in Indrad – Gujarat – INDIA. The company is promoted by the members of Sanghvi family the promoters of RATNAMANI Metals & Tubes Limited.

WORKSHOP AREA

OFFICE AREA

About FCCU (Fluidised Catalytic Cracking Unit)

Crude oil contains a wide variety of hydrocarbons of various lengths. Depending upon the length of the hydrocarbon, it can be used in a variety of ways.

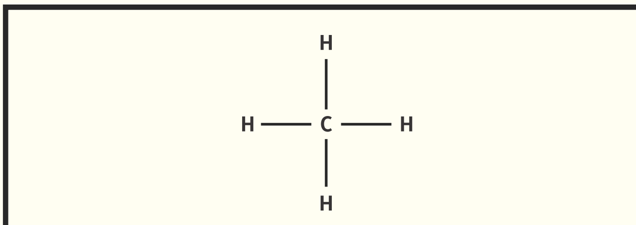
Example:
Cooking gas usually has 3 or 4 hydrocarbons (Propane – Butane), while gasoline for cars and diesel fuels have longer chains and lubricating oils and waxes even longer. The separation of these hydrocarbons is called distillation or fractionation, whereas the chemical reaction of breaking these hydrocarbons into smaller lengths is called cracking.

Fraction distilled from Crude Oil	Boiling Point Range°C	Carbon Chain Length	Hydrocarbon Present	Uses	Viscosity	Flammability
Refinery Gas	-160 to -5	1 to 4	Methane CH_4 Ethan C_2H_6 Propane C_3H_8 Butane C_4H_{10}	Home heating, Cooking' Camping Fuel	Low – easily flows (as gas orrunny liquid)	High (ignites & burns easily)
Gasoline (Petrol)	40 to 110	5 to 8	Octane C_8H_{18}	Car Fuel	Viscosity Increase	Flammability Decrees
Naphtha	110 to 180	8 to 10	Decane $C_{10}H_{22}$	Plastics		
Kerosene (paraffin)	180 to260	10 to 16	Dodecane $C_{12}H_{26}$	Jet Air Craft		
Diesel	260 to 320	16 to 20	Hexadacane $C_{16}H_{34}$	Fuel of Buses & Lorries		
Fuel Oil	320 to 400	20 to 50	Isosane $C_{20}H_{42}$	Industrial Heating System	High-does not flow easily (thick, sticky consistency)	Low (does not ignite & burns easily, burns with sooty flame)
Bitumen / Residue	400 to 600	> 50		Surfacing Roads		
Above values are for reference purpose only.						

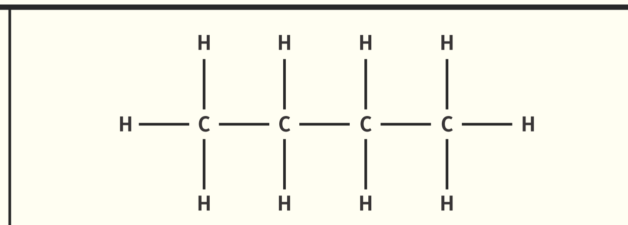
Crude oil will not contain the mixture of hydrocarbons to make the required range of products for the market and thus chemical or secondary processing will be required within a refinery. Normally the demand for lighter products such as Gasoline and Diesel is greater, so cracking of the long chain hydrocarbons is universally required within a refinery. A FCCU/RCCU is one of a number of cracking units.

FCCU or fluidised catalytic cracking unit is a secondary processing unit found in many refineries. They have been used since the early 1940's. Typically the FCCU feedstock is heavy low value hydrocarbon from the bottom of the Crude Distillation Unit or Vacuum Distillation Unit. (page no 03)

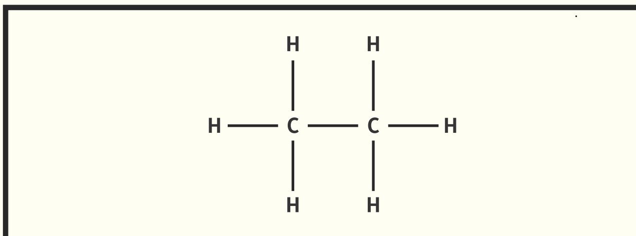
About FCCU (Fluidised Catalytic Cracking Unit)



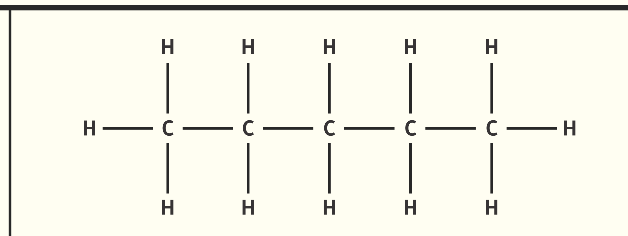
Methane



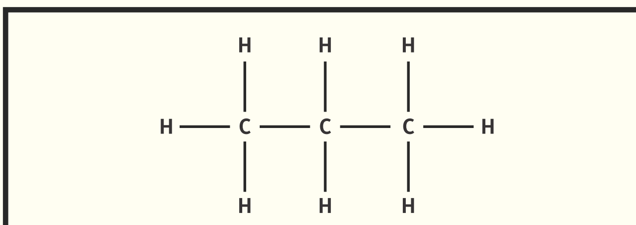
Butane



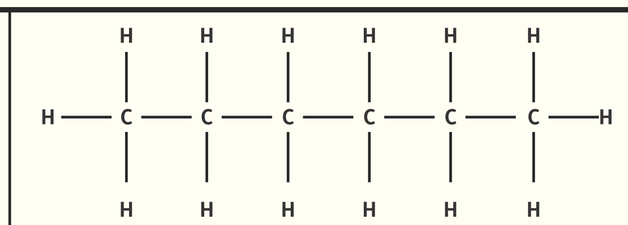
Ethane



Pentane



Propane



Hexane

Even heavier residues are sometimes used as feedstocks in which case the FCCU is often referred to as a RCCU (Residue Catalytic Cracker Unit). The purpose of the FCCU/RCCU is to break these longer chain high molecular weight hydrocarbons into shorter lighter molecular weight hydrocarbons of greater value. These lighter hydrocarbons can be used as components of Liquid Petroleum Gases (LPG), Gasoline, Diesel, or sometimes as feedstock for downstream petrochemical units.

The “heart” of a FCCU/RCCU is the reactor & regenerator section, normally referred to as the R&R. The R&R may be a combination of 2 or 3 interconnected pressure vessels. The third vessel often used within the R&R is a stripper vessel. In the reactor, the feedstock (long chain hydrocarbons) is with fine particulate catalysts at high temperatures (usually 490°C – 530°C). Catalysts are typically Zeolites and Alumina and therefore extremely abrasive.

About FCCU (Fluidised Catalytic Cracking Unit)

The feedstock is atomised and fed into the unit through a feed nozzle in the reactor riser, and catalytic breaking of the hydrocarbon chain is initiated. A by-product of this chemical reaction is carbon which is often referred to as coke. The reaction continues until the catalyst and hydrocarbons are separated within a series of cyclones at the top of the reactor. The hydrocarbons leave the top of the reactor to be separated into the various products within the fractionator column and other downstream columns.

The catalyst now covered with coke cannot perform the catalytic role and needs to be regenerated. If a stripper vessel is included in the R&R the coked or spent catalyst is stripped of any entrained hydrocarbons with steam.

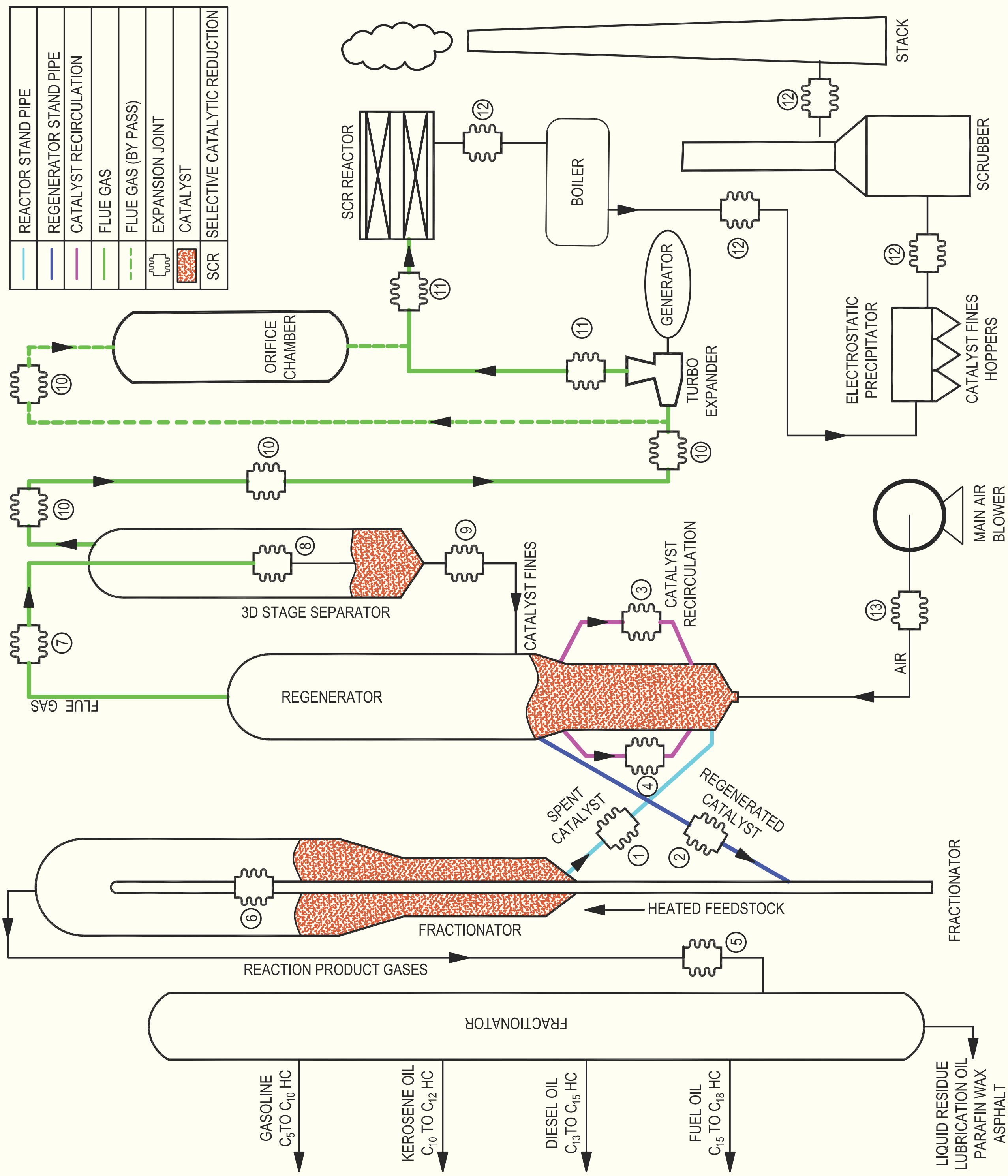
These hydrocarbons and steam are returned to the reactor.

The spent catalyst is fed into a regenerator vessel where the coke is burnt off the catalyst. This combustion process provides the thermal energy for the whole FCCU/RCCU process. Air is fed into the regenerator through an air grid. There are several different types of air grid used, but all have the function of distributing air into the fluidized bed of catalyst where the coke is burned off. This reaction takes place at very high temperatures (650°C -750°C). The catalyst is now white again, that is it has been regenerated. The catalyst and the flue gases are separated in a series of cyclones at the top of the regenerator. The flue gases still contain a lot of heat and depending on how the regenerator is operated contain CO. This CO is combusted downstream in a CO boiler and the heat from the gases recovered in producing steam.

The hot regenerated catalyst then is returned to the reactor to be again contacted with the hydrocarbon feedstock.

FCCU/RCCU bellows are used in some areas within the R&R to compensate for the different thermal expansion of the vessels and piping. There are normally bellows with the reactor/ regenerator (and stripper) standpipes as well as several in the flue gas system from the generator to the CO boiler. These have to be designed not only to account for the movements involved but also for the high process temperatures, the corrosive environments and erosion from the catalyst. These are thus specialised FCCU items.

FCCU/RFCC Expansion Bellows are vulnerable component of the complete system. In this application the design requirements for expansion bellows usually influenced by high temperature, pressure and large thermal movements in combination with aggressive flowing media.



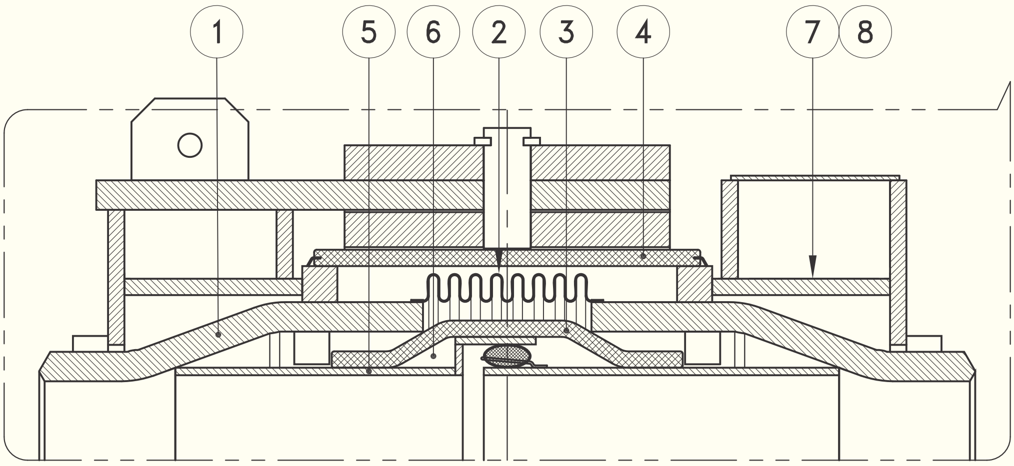
Sr. No.	Expansion Joint Location	Flowing Media	Media Temp. °C	Design Pressure kPa (g)	Expansion Joint Type	Accessories	Material Pipe / Duct	Construction	Abrasion Resistant Lining In Hex Mesh	Insulating Refractory	Redundant Ply	Slotted Hinges, Pantograph, Gimbal	Limit Rods	Floating Hardware
1	Spent Catalyst Standpipe	Catalyst	537 to 760	207 to 690	Universal Circular Metallic	Unrestrained	Cr-Mo or SS304H	Hot Wall	✓	–	✓	✓	✓	✓
2	Regenerated Catalyst Standpipe						CS	Cold Wall	–	✓	✓	✓	✓	✗
3	Recirculation Catalyst Standpipe						CS	Cold Wall	–	✓	✓	✓	✓	✗
4	Cooled Catalyst Standpipe						CS	Cold Wall	–	✓	✓	✓	✓	✗
6	Reactor Riser			21 to 69	Single Circular Metallic		Cr-Mo	Hot Wall	✓	✗	✗	✗	✗	✗
8	Third Stage Seprator	Flue Gas & Catalyst Fines		6.9 to 103			SS	Hot Wall	✓	✗	✗	✗	✗	✗
12	Flue Gas	Flue Gas	149 to 399	< 34	Single Circular Metallic & Non Metallic		CS or SS	Hot Wall	✗	✗	✓	✗	✓	✗
5	Reactor to Main Column	Product	426 to 648	207 to 690	Universal Circular Metallic	Tie Rods, Hinge, or Gimbal	Cr-Mo	Hot Wall	✗	✗	✓	✗	✓	✓
7	Regenartor Outlet	Flue Gas & Catalyst Fines	537 to 760		Single or Universal Circular Metallic		CS or SS	Hot Wall or Cold Wall	✓	✓	✓	✗	✓	✓
9	Catalyst Fines	Catalyst			Universal Circular Metallic		CS	Cold Wall	✗	✓	✓	✗	✓	✗
10	Expander Inlet or Orifice Chamber Inlet	Flue Gas			Single or Universal Circular Metallic		SS	Hot Wall	✗	✗	✓	✗	✓	✓
11	Expander Inlet or Orifice Chamber Outlet			34	Single or Universal Circular Metallic		SS	Hot Wall	✗	✗	✓	✗	✓	✓
13	Main Air Blower	Air	343	0 to 690	Single or Universal Circular Metallic		CS	Hot Wall	✗	✗	✓	✗	✓	✗

Typically hot walled expansion joints are located (installed) in the flue gas duct of an FCC unit. It is supplied with hexmesh and castable material (example: abrasion resistance refractory RESCOBOND AA-22S). The refractory lining requires dry out after installation.

The lining is designed to withstand the abrasion from the catalyst flowing through the unit during operation. However, it is not intended to be used as a thermal barrier. Thus shell temperature of the expansion joint rises above the allowable temperature limit of normal carbon steels.

The expansion joint weld, ends or center spools are normally fabricated from various Chrome Moly alloys and stainless steel

The turbo expander inlet and outlet expansion joints are unlined (without refractory) to avoid the loose pieces of abrasion resistance refractory entry into the turbo expander.



1. Flared Weld Ends or Fabricated Cone: The flared weld ends reduces the thermal stresses caused by the differential radial thermal growth between the duct operating at the full temperature and the insulated bellows element operating at a lower temperature.

2. Redundant Ply: Redundant ply bellows are specified for critical expansion joint applications. The multiplies redundant bellows design allows constant monitoring of the gap between the inner and outer plies.

Each ply is designed to withstand the full operating/design condition in the event the integrity of the inner ply is breached.

The Features of a Hot Wall Expansion Joint

3. Internal Insulation Pillow: The internal insulation pillow is provided to reduce the operating temperature of bellows element below the material creep range.

4. External Insulation Pillow: The external insulation pillow is provided to maintain the bellows operating temperature above the dew point condensation temperature. This minimizes the risk of corrosion on the inner layer of the bellows element. The arrangement of external insulation pillow is such that for inspection purpose it can be temporarily removed.

5. Internal Telescoping Liners: The internal telescoping liners are provided in such a way that there do not reduce the inner diameter of flue gas flowing through expansion joint without pressure drop. The unique construction of internal telescoping liners provides a cavity/gap to accommodate internal insulation pillow. It is a critical component to reduce the operating temperature of bellows element below the material creep range.

6. Opening/Gap: The opening/gap between the internal telescoping liners is provided at the center of the bellows to reduce the radial gap needed for the expansion joint movements. Depending on the service condition the opening / gap can be filled with seal rope as a barrier for dust particle to enter into the cavity.

7. Floating Hardware: Hot wall design is externally insulated, so the expansion joint weld ends (pipe/shell) operate at the media temperature. The expansion joint hardware is outside of the insulation. Therefore, it is relatively cool, but it must be connected to the extremely hot shell. The differential growth of the shell and rings results in a significant stress problem.

The solution is floating hardware attached to the shell and designed so that there is no constriction on the shell that could result in unacceptably high stress.

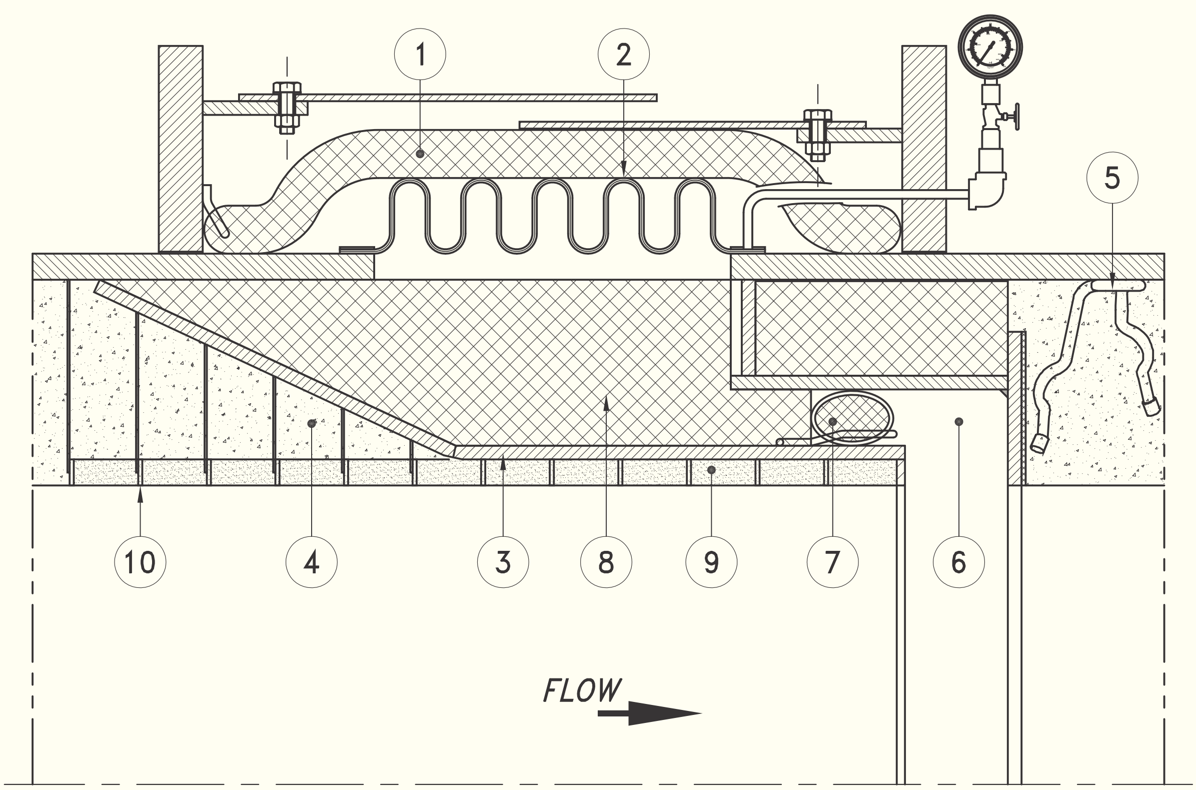
8. Floating Ring: The floating ring is designed to restrain the pressure thrust force along with any external design forces. The floating ring construction allows for differential thermal growth between the weld ends operating at the full temperature and the insulated floating ring.

Due to insulation used between the weld ends and the inside of the floating ring, the floating ring operates at a lower temperature compared to the weld ends. In some cases, the floating ring may be carbon steel even though the flue gas temperature may be as high as 786° C. The floating ring is not welded directly to the weld ends.

The cold wall expansion joints are refractory lined to ensure the temperature of weld ends or center spool does not exceed 343°C, although the temperature of the catalyst or flue gas may be as high as 760°C. The cold walled design utilizes refractory along the duct wall, and hand packed abrasion resistance refractory in hexmesh on the liner.

Therefore, weld ends, or center spool is typically fabricated from various low alloy or carbon steel materials. The refractory lining is consisting of stainless steel anchors and high-density vibrocast refractory material. The thickness of lining varies from 100 mm to 200 mm depending on service condition. The lining requires dry out after installation.

The cold wall design provides several advantages because the duct is insulated and it operates at lower temperature than, the actual temperature of catalyst or flue gas. The number of convolutions and required thickness of bellows element can be reduced due to lower design temperature.



The Features of a Cold Wall Expansion Joint

1. External Insulation Pillow: The external insulation pillow is provided to maintain the bellows operating temperature above the dew point condensation temperature. This minimizes the risk of pitting corrosion on the inner layer of the bellows element.

2. Redundant Ply:A redundant ply bellow is specified for critical expansion joint applications. The multiplies redundant bellows design allows constant monitoring of the gap between the inner and outer plies.

Each ply is designed to withstand the full operating/design condition in the event the integrity of the inner ply is breached. A woven mesh is provided by good manufacturers to ensure independence and to provide a smooth flow of entrapped gas during manufacturing.

3. Internal Flow – Liner: The internal flow liner is fabricated from SA 240 Gr. 304H or SA 240 Gr. 321H material. The upstream end of the flow liner has a conical section and the downstream end of flow liner has a cylindrical section. The downstream end of the flow liner operates at a higher temperature compared to the upstream end.

4. Refractory: The high density vibracast refractory lining insulates the inside of the duct. It reduces operating temperature for expansion joint shell (weld ends / center spool).

5. Refractory Anchors: The stainless steel 304H material, wavy vee anchors, are used to anchoring the high density vibracast refractory lining to the carbon steel shell.

6. Opening / Gaps: The longitudinal and radial gaps at the open downstream end of the liner are designed for thermal movements of the expansion joint. These gaps are minimized as much as possible to minimize the amount of catalyst that can enter the liner cavity.

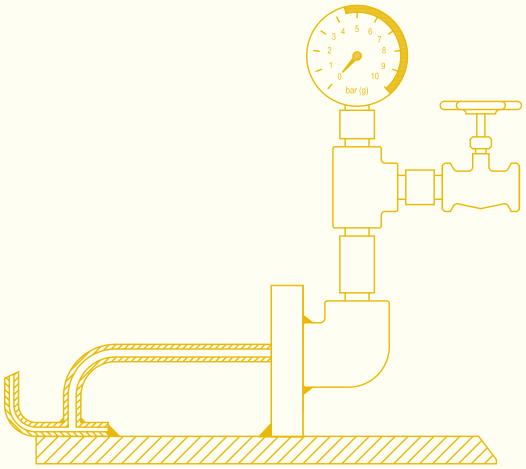
7. Rope Seal: The Rope seal minimizes the amount of catalyst entering the cavity between internal flow liner and the bellows.

8. Internal Insulation: The internal insulation pillow is provided to reduce the operating temperature of bellows element below the material creep range.

9. Abrasion Lining: The downstream of internal flow liner has a cylindrical section, the cylindrical portion of the internal flow liner is packed with an abrasion resistant lining. Hex Meh reinforce it.

10. Hex Mesh: The inside of the internal flow liner contains a hex mesh lining. Hex mesh is used to anchor the abrasion lining and the refractory in the conical section of the flow liner.

Redundant – Testable Ply, Expansion Joint Assembly:



Most expansion joints in oil refineries, especially FCC units use two-ply bellows, but they are also ideal for regenerated catalyst standpipe, spent catalyst standpipe, recirculation cooled catalyst flue gas piping and hot gas expanded piping. Regardless of your application, downtime costs money. A two-ply testable bellows element is designed to provide you with the comfort of predictability.

In a two-ply testable bellows, each ply is designed to retain the full line pressure and temperature, providing a safety barrier in the event a leak is formed in the inner ply. Furthermore, by attaching a monitoring system to the outer ply, one can evaluate the status of the inner ply. If the monitoring system shows full pressure on the pressure gauge, it indicates a leak in the inner ply. This is a tell tale sign to schedule maintenance in lieu of an unannounced shutdown

1. Each ply is designed to withstand the full line pressure and temperature. In the event of an inner layer ply, the outer ply is still capable of sustaining the system operating conditions.

2. Each two-ply testable bellows element contains stainless steel tube test ports with a coupling for accessory attachment. When combined with a pressure gauge, one can quickly monitor whether the inner ply is retaining the pressure or if a leak has occurred. It is also common for the test port to be attached to an electronic monitoring system wired directly into plant control room.

3. Each test port is held in place with a steel brace which ensures torque loading is not induced into the bellows neck during installation of accessories.

4. Two-ply bellows also make it possible to pressure test and inspect for leaks during field inspections and in some cases if conditions permit, the expansion joint can be tested while in service. Sometimes a wire mesh is used between the bellows to ensure flow equalization between the plies of the bellows.

Testing and Quality Assurance

REPL is a dedicated to providing quality products and services backed with a complete guarantee. With one of the most comprehensive quality assurance programs in the industry, our products are inspected and evaluated extensively through each stage of production. REPL is capable of performing all types of non-destructive testing : such as Radiography, Ultrasound, Mass Spectrometer, Magnetic Particle, Hydrostatic and Liquid Penetrant.

REPL can also provide cycle testing, meridional yield – rupture, spring rate testing, hardness testing, impact testing, ferrite count, pneumatic testing, helium leak detection and positive material identification (PMI) as part of our program. Our group inspectors are certified to ASNT-TC-1A with multiple Level II and III inspectors in house.

On-site installation services

As a growing company in the Expansion Joint industry, REPL can also provide on-site services comparable to American or European vendors. Our service group consists of highly qualified technicians and engineers specialised in solving Expansion Joint installation and application problems.

Plant Surveys and Emergency Breakdown Prevention:

Preventing breakdown before if occurs is one of our specialties. Our engineers are dedicated to identify, prevent, and solve problems on-site. Our site people undertake inspection of existing Expansion Joints. and identify tell-tale signs. We provide the Inspection reports with comments on the actual condition of units together with any recommendations for improvements, repairs or remedial actions including planning for replacement.

REPL can assist you to avoid an unplanned emergency breakdown due to Expansion Joints.

CLAMSHELL Technology

Installation of Metallic Expansion Joints and in particular "CLAMSHELL" repair bellows requires skilled and experienced installation staff. Often clients prefer that the manufacturer carries out such installation work to avoid errors and focus responsibility on a single source vendor. Our site team of skilled welders can carry out such work. The team is experienced and familiar with site work including working confined spaces by complying with site safety procedures.

Refurbish &Repair Existing Expansion Joints

REPL can offer customers to bring existing expansion joints back to an "as-new" condition by removing the existing bellows elements and replacing with new.

This practice allows the cost of manufacturing new pipe work components and any restraining structure to be avoided.

It is often used as a fast solution to get the plant back online quickly when a bellows element in an expansion joint has reached the end of its life.

BEFORE

AFTER

We have dedicated team for Refinery Services, FCCU (Fluid Catalytic Cracking Unit) & RFCC (Residue Fluid Catalytic Cracking)

Our team comprises of the following overseas experts.

Our first expert with 30 years of vast experience in critical refinery application and troubleshooting. He is familiar with all cracking processes from various licensor such as UOP, KBR, SHELL, EXXOON, Technip - Stone & Webster.

Our second expert with 35 years of vast experience in FCCU bellows fabrication, installation of CLAMSHELL Bellows in FCC / RFCC in HOT (online) or COLD condition. We also provide services in plant survey, analysis on probable reasons for bellows failure, recommendation and comments, setting up a monitoring program and maintenance policy, installation and replacement of metallic braid (rope seal) etc.

Our third expert with 13 years of experience and specialises in design and application of all types of Metallic Expansion Joint including FCCU (Hot Walled & Cold Walled), Floating & Semi Floating Hardware, Refractory & Anchor Selection and solving corrosion issues.

Our fourth expert is a Doctorate in Mechanical Engineering with 16 years of experience and specialising in FEA (Finite Element Analysis), CFD (Computational Fluid Dynamics) and mechanical/structural engineering design. He assists the design development, modification and verification processes through application of stress, heat transfer and fluid flow analysis capabilities.

During Turnaround or Plant Shutdown The Onsite Inspection

Our engineers are dedicated to identifying, preventing, and solving problems on-site. They undertake inspection of existing expansion joints (bellows) and submit inspection reports with recommendations.

Decoking & Coke Formation

Our engineers are dedicated to identifying, preventing, and solving problems on-site. They undertake inspection of existing expansion joints (bellows) and submit inspection reports with recommendations.

Coke formation in the transfer lines is largely due to liquid condensation on the inside surface of the line. The condensed liquid remains in the line where it undergoes thermal cracking reactions which produce coke deposits. These deposits are usually quite hard and can be difficult to remove from the line.

Polythionic Acid Stress Corrosion Cracking

The most common fluid causing intergranular corrosion in hydrocarbon plants is polythionic acid. The polythionic acid is formed in the presence of sulfur, moisture and oxygen. Sulfur can come from feed stock, additives or fuels.

Inspection Practice of FCCU Expansion Joints

The usual practice for inspection of metallic FCCU expansion joint, other than visual inspection are: PT (liquid dye penetrant) investigation to look for cracking, Routine check for the metallurgical condition, in-situ metallography / replication could reveal microstructure changes as polythionic acid attack or sigma phase embrittlement, and thermograph to detect high temperature hot spots.

Periodic In-service Inspection

1. Immediately after placing the system in operation, a visual inspection should be conducted to insure that the expansion joints in the manner for which they were designed are absorbing the thermal expansion.

2. The bellows should be inspected for evidence of unanticipated vibration.

3. A program of periodic inspection should be planned and conducted throughout the operating life of the system. The frequency of these inspections should be determined by the service and environmental conditions involved. Such inspections can pinpoint the more obvious potential problems such as external corrosion, loosening of threaded fasteners, and deterioration of anchors, guides, and other hardware. It must be understood that this inspection programme, without any other backup information cannot give evidence of damage due to fatigue, stress Corrosion or general internal corrosion. These can be the cause of sudden failures and occur without any visual or audible warning.

4. When any inspection reveals evidence of malfunction, damage or deterioration, this should be reviewed by competent design authority for resolution. Additionally, any changes in the system operating conditions such as pressure, temperature, movement, flow, velocity, etc. that may adversely affect the expansion joint should be reported to, and evaluated by, a competent design authority.

NOTE

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