

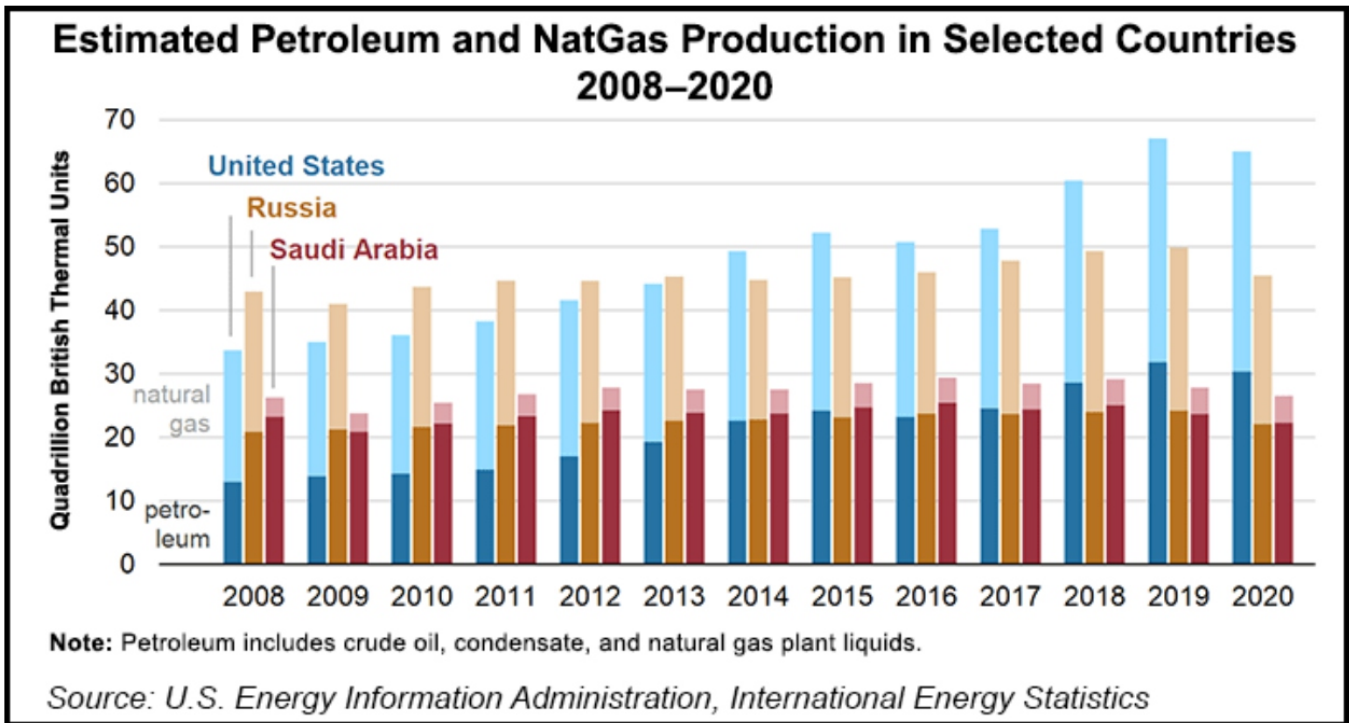


Improving Pipeline Emissions:  
**The Role of Flange Isolation Kits**

**GPT**<sup>®</sup>  
Industries

## Improving Pipeline Emissions: The Role of Flange Isolation Kits

The United States is the leading producer of oil and gas in the world, bringing with it economic benefits such as new jobs, improved trade balance, and greater competitiveness. Despite this, the industry faces numerous challenges in the coming years, not least among them the need to balance optimal oil and gas production with environmental stewardship. The balance between oil production and reducing greenhouse gas emissions is a difficult one to strike; fortunately new technologies can help reduce pipeline emissions in a way that helps oil and gas companies keep pipelines flowing. In this whitepaper, we examine the role of flange isolation kits in improving pipeline emissions.



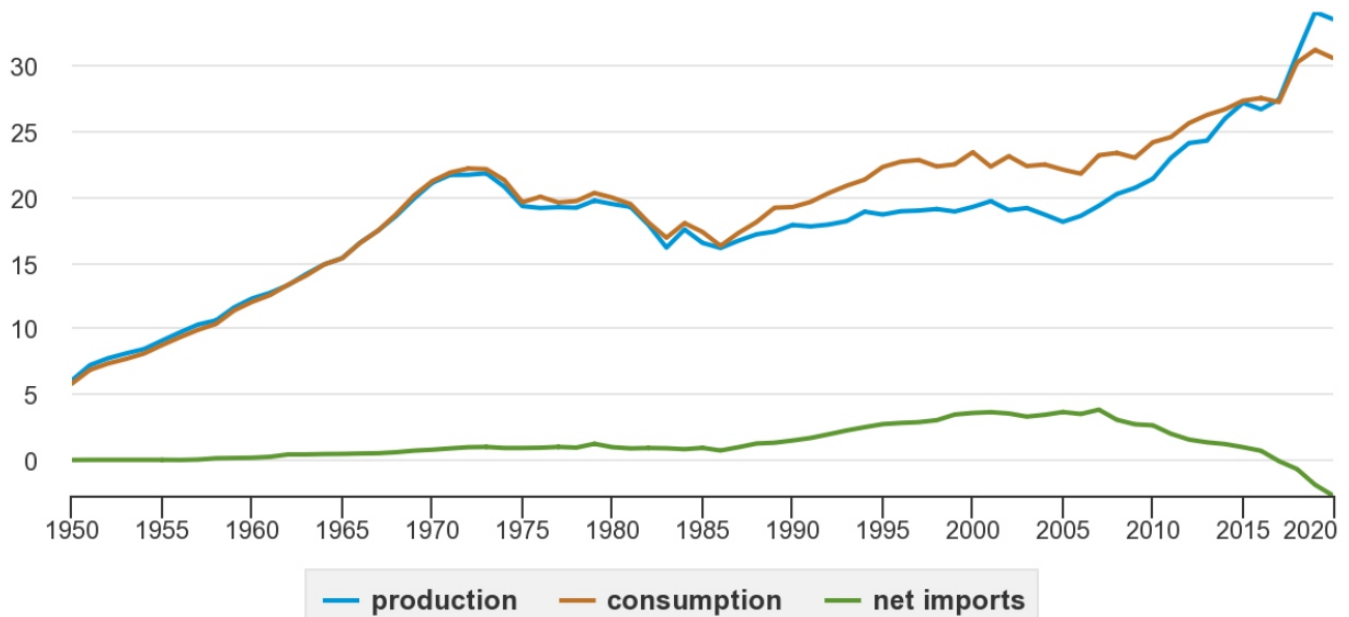
**Figure 1:** Estimated Petroleum and NatGas Production in Selected Countries 2008-2020, US Energy Information Administration  
Source: [eia.gov/todayinenergy/detail.php?id=40973](https://www.eia.gov/todayinenergy/detail.php?id=40973)

The U.S. has approximately **320,000 miles of natural gas pipelines**, and that’s excluding pipelines carrying crude oil and refined and petroleum products. Pipelines play a critical role in the movement of oil and gas over long distances to refineries, businesses and consumers. The growth of climate change awareness has led to a call to cut back on oil and gas production, and stop building pipelines to reduce greenhouse gas emissions (GHGs). However, the decision on how to address these challenges is more complicated than it might seem. Consider that discontinuing pipeline transport could:

- Increase U.S. imports of oil and gas without reducing consumption
- Cause the U.S. to lose its economic advantage - without actually reducing GHG emissions
- Increase global emissions, depending on **how replacement fuels are produced and emissions produced** in their transportation
- Reduce U.S. emissions but increase global emissions

## U.S. natural gas consumption, dry production, and net imports, 1950-2020

trillion cubic feet



Source: U.S. Energy Information Administration, *Natural Gas Annual*, September 2020, and *Natural Gas Monthly*, February 2021

**Figure 2:** U.S. natural gas consumption, dry production, and net imports, 1950-2020

Source: <https://www.eia.gov/energyexplained/natural-gas/where-our-natural-gas-comes-from.php>

## Pipeline Emissions and Their Causes

Pipelines are installed as segments and sealed at the joints to ensure there is no leakage. However, leakage can happen due to various reasons, resulting in the loss of product from the pipe around or through the sealing element. This release of the product is called an emission and the problem is **directly related to the sealability of a gasket or a sealing product**.



**Figure 3:** Natural Gas Compressor Station

Source: **Dreamstime**

Natural gas pipelines can emit GHGs from the burning of fossil fuels at compressor stations, and from methane released from small leaks during maintenance activities. Compressor stations with turbines and engines push the product through the pipeline over long distances, **emitting carbon dioxide and nitrous oxide**.

To curb this problem, oil and gas companies are upgrading equipment for better energy efficiency and reduced GHG emissions, including the diversion or capture of natural gas during maintenance.

The main causes of pipeline emissions include:

- Outdated compressor stations and engines
- Releasing gas into the atmosphere during maintenance
- Undetected leakages
- Irregular maintenance and damaged pipelines
- Outdated gaskets and sealing products
- Improper seal/gasket selection
- Poor gasket installation procedures
- Lack of proper vapor control and recovery system

## Emission Sources and GHGs

Carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) are the three main greenhouse gases relevant to the oil and gas industry. There are **two main types of emission sources**:

### Combustion-Related Emissions

This results from the use of fuel such as natural gas in equipment like engines, heaters, furnaces, etc. The main emission is CO<sub>2</sub> but combustion equipment is not 100% efficient and hence unburned hydrocarbons such as CH<sub>4</sub> are emitted as well. Nitrogen present in the air and fuel-bound nitrogen produce N<sub>2</sub>O.

## Equipment Leaks and Vented Emissions

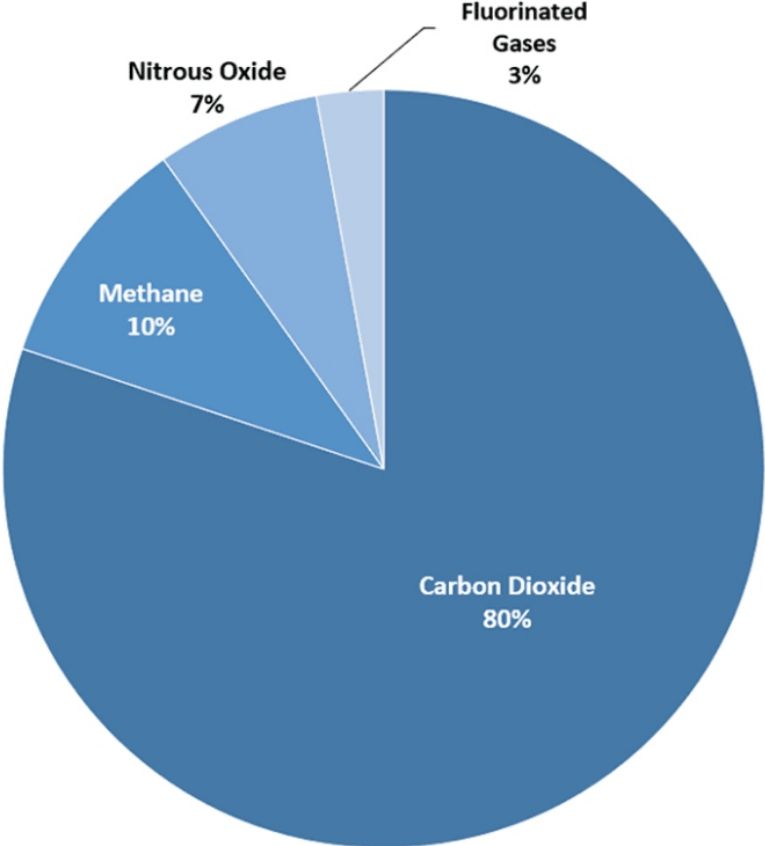
Equipment leaks happen when emissions are unable to pass through a vent, chimney, or equivalent opening. These unintentional emissions are a result of wear and tear, as well as equipment damage. These include worn out valves, pipelines damaged during maintenance operations, or **corrosion of pipelines**. Vented emissions are intentional emissions designed into the equipment or system, such as the clearance provided between the packing and the compressor rod for the free movement of the rod resulting in emissions, and vent sacks in petroleum and natural gas production, processing, and refining facilities.

## Scrutiny by Environmental Agencies

There is increased surveillance to monitor the GHG emissions of companies in the oil and gas sector to satisfy the requirements of the Environmental Protection Agency (EPA). The EPA has strict standards to reduce emissions of hazardous air pollutants (HAP) and volatile organic compounds (VOCs) from production, transmission and storage facilities.

According to the **EPA's annual GHG inventory**, in 2019, U.S. greenhouse gas emissions totaled 6,558 million metric tons of carbon dioxide equivalents. Emissions decreased by 1.7% from 2018 to 2019, driven largely by a decrease in total energy use and a shift from coal to natural gas and renewable energy in the electric power sector.

## Overview of U.S. Greenhouse Gas Emissions in 2019



U.S. Environmental Protection Agency (2021). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019

### Measuring Pipeline Emissions

According to the Interstate Natural Gas Association of America (INGAA), fugitive emissions are the biggest source of methane emission in the transmission sector. Fugitive emissions are **unintentional losses from equipment leaks** due to normal wear and tear, improper or incomplete assembly of components, manufacturing defects and corrosion. Methane is considered a far more potent gas than Co2.

Referring to INGAA guidelines, two tiers are used to estimate pipeline emissions. The Tier 1 method only requires the length of the pipeline while Tier 2 requires the pipeline length and number of compressor and meter/regulator stations. The following tables summarize the emission factors for fugitive emissions based on Tier 1 and 2 methods. The GHG emissions are derived by multiplying the activity data by the emission factor. The fugitive emission for methane is then converted using the Global Warming Potential (GWP) of gas to get the CO<sub>2</sub> equivalent.

### Fugitive Emissions of Tier 1:

Activity Data	GHG	Emission Factor	Emission Factor Units
Pipeline length	CH <sub>4</sub>	7923	lb CH <sub>4</sub> /mile-year
Pipeline length	CO <sub>2</sub> (1) (from CH <sub>4</sub> oxidation)	7.59	lb CO <sub>2</sub> /mile-year
Pipeline length	CO <sub>2</sub> (2) (from pipeline leaks)	466.7	lb CO <sub>2</sub> /mile-year

Source:

[https://www.researchgate.net/publication/303499223\\_Estimating\\_Greenhouse\\_Gas\\_Emissions\\_Level\\_of\\_A\\_Natural\\_Gas\\_Pipeline\\_-\\_Case\\_Study\\_from\\_A\\_to\\_B\\_Point\\_in\\_West\\_Java-Indonesia](https://www.researchgate.net/publication/303499223_Estimating_Greenhouse_Gas_Emissions_Level_of_A_Natural_Gas_Pipeline_-_Case_Study_from_A_to_B_Point_in_West_Java-Indonesia)



## Fugitive Emissions of Tier 2:

Activity Data	GHG	Emission Factor	Emission Factor Units
Pipeline length	CH <sub>4</sub>	7923	lb CH <sub>4</sub> /mile-year
Pipeline length	CO <sub>2</sub> (1) (from CH <sub>4</sub> oxidation)	7.59	lb CO <sub>2</sub> /mile-year
Pipeline length	CO <sub>2</sub> (2) (from pipeline leaks)	466.7	lb CO <sub>2</sub> /mile-year
No. of compressor stations	CH <sub>4</sub>	1259400	lb CH <sub>4</sub> /station-year
No. of compressor stations	CO <sub>2</sub>	72747	lb CO <sub>2</sub> /station-year
No. of meter/regulator stations	CH <sub>4</sub>	2533	lb CH <sub>4</sub> /station-year
No. of meter/regulator stations	CO <sub>2</sub>	146.34	lb CO <sub>2</sub> /station-year

Source:

[https://www.researchgate.net/publication/303499223\\_Estimating\\_Greenhouse\\_Gas\\_Emissions\\_Level\\_of\\_A\\_Natural\\_Gas\\_Pipeline\\_-\\_Case\\_Study\\_from\\_A\\_to\\_B\\_Point\\_in\\_West\\_Java-Indonesia](https://www.researchgate.net/publication/303499223_Estimating_Greenhouse_Gas_Emissions_Level_of_A_Natural_Gas_Pipeline_-_Case_Study_from_A_to_B_Point_in_West_Java-Indonesia)

Other methods to measure GHG emissions include:

- Flame Ionization Detector (FID)
- **Fourier-transform Infrared (FTIR) Spectroscopy**
- Non-dispersive Infrared (NDIR)
- Airplane Light Detection and Ranging (LIDAR)
- Optical Gas ImagingAerostat Aloft Platforms
- Radial Plume Mapping
- Eddy Covariance Methods

The EPA also has a GHG inventory tool for estimating carbon dioxide and methane emissions from natural gas and oil systems. The user guide can be downloaded [here](#).

## How Pipeline Emissions Contribute to GHG Emissions

With natural gas, distribution lines are supplied from transmission pipelines at “city gate” stations, where the pressure is reduced and regulated, and the gas is distributed through underground mains and service lines to end-users. The GHG emissions here take place at **regulating stations, vaults and customer/residential meters** (Figure 5).



**Figure 5:** Natural gas meters and old rusty pipes  
Source: [iStock](#)

In the oil and gas industry, a study found that oil and gas pipelines are the biggest source of emissions; most come from pipeline transport, and **nine of the top 10 carbon polluters were oil and gas pipelines.**

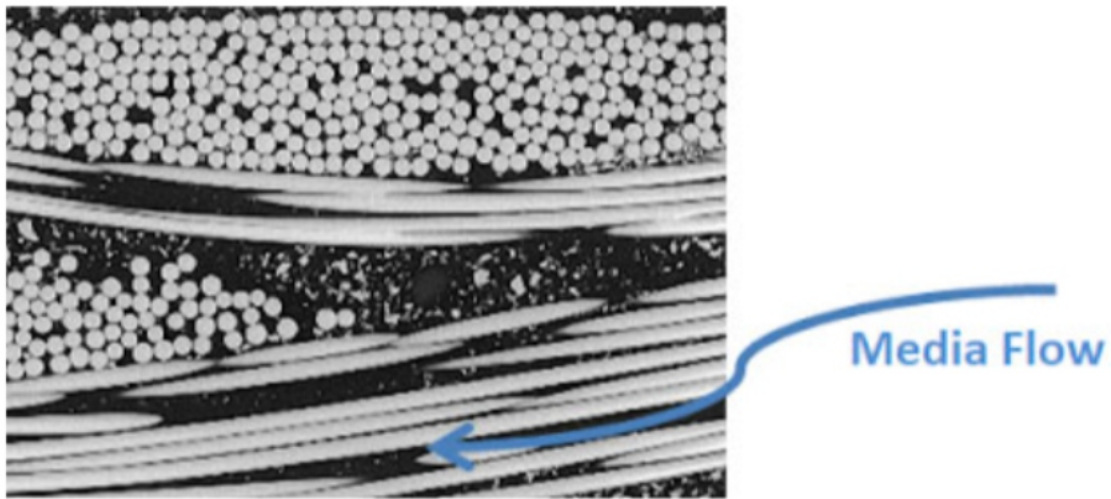
In a newer method, known as the **bottleneck method**, carbon tallies are done using all emissions that a facility enables, including extraction, transport and end use. This provides a more accurate picture of total emissions.

## Poor Sealability and the Role of Gaskets in Emissions

Pipelines of any kind work best when they are sealed well. A poorly sealed pipeline will leak and eventually fail to keep the product within the pipeline system. The most important product that helps confine the product within the pipeline is an **isolation or insulating gasket**. Most isolation gaskets are made of glass-reinforced epoxy (GRE). The glass in the epoxy matrix is arranged as straight rods, similar to straws (Fig. 6). This allows gas to follow the straight path and escape into the atmosphere.

GRE typically has a dielectric value higher than 500 volts per mil when dry. When immersed in water, and if no external pressure is acting on it, it absorbs very little water. However, during hydrotesting, the pressure can drive water into the GRE, significantly reducing its isolation capabilities. Since external moisture is usually not under pressure, it has little to no effect on its isolation properties.

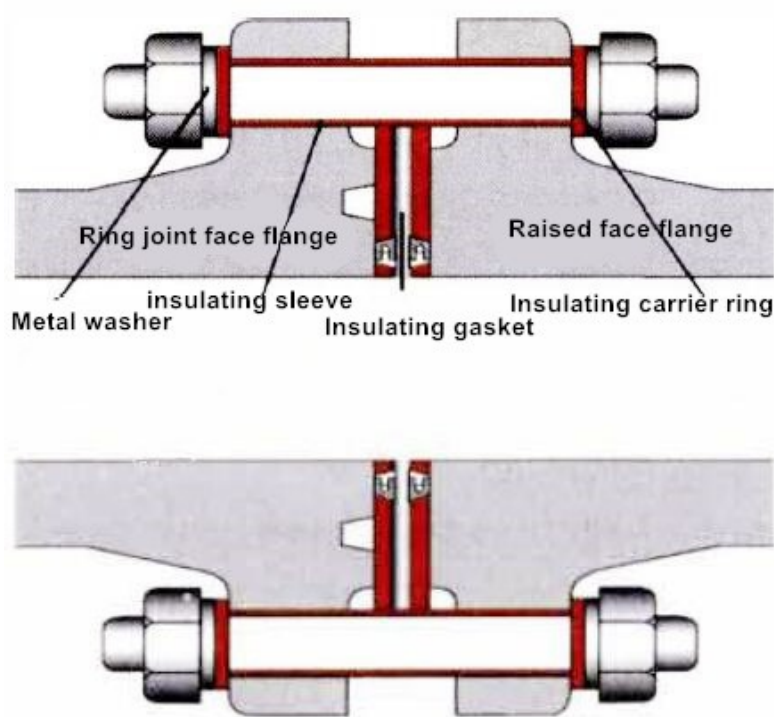
Another issue faced in GRE gaskets is that **the epoxy used is not chemically suitable for many chemicals**, including common pipeline products such as H<sub>2</sub>S or steam. Hence, care has to be taken when installing GRE isolation gaskets in pipelines containing any of these mediums.



**Figure 6**  
Source: GPT Industries

## What are Isolation Gaskets?

Isolation gaskets isolate flanges from the flow of electrical current through the pipeline. In other words, they separate dissimilar metals such as stainless steel to aluminum, or cast iron to carbon steel. They are made of a non-conductive material that provides electrical insulation between cathode and anode. Galvanic corrosion occurs when an anode, a cathode, an electrolyte and a current path are present; isolation gaskets help prevent this contact. They are commonly used in the oil and gas and petrochemical industries, as well as in offshore applications dealing with high chloride content.



**Figure 7:** Insulating gasket assembly

Source:

<https://www.metallicsteel.com/discussion-on-galvanic-corrosion-control-measures-for-dissimilar-metal-flange-connection-of-offshore-oil-and-gas-platform-pipeline.html>

Once **galvanic corrosion** begins, it can lead to rapid metal loss, resulting in leaks or, if unchecked, catastrophic failures. Primary assets are protected using **cathodic protection** (CP), which works by converting the anodic sites on the pipeline to cathodic sites. This is done by supplying electric current from an alternate source and equalizing the potential on the surface of the metal structure. Isolation gaskets,

- Protect areas beyond the CP system where the metal is unprotected
- Reduce or eliminate stray currents generated by AC or DC sources
- Eliminate or drastically reduces flange face corrosion
- Seal at low stress, making them ideal for low-torque requirements

## Improving Pipeline Emissions by Proper Sealing

There are two primary factors that determine the sealing capability of a gasket:

1. **Gasket Permeability:** Since gaseous mediums are mostly invisible, it is difficult to determine whether a gasket is leaking unless it is seen or heard. Sophisticated methods are now available to assess leakage, such as infrared technology to detect temperature changes, gas analyzers and chromatographs.

2. **Gasket Load:** Gaskets typically have a psi (pounds per square inch) or a kPa minimum requirement and a maximum allowable limit (note the maximum can change if the gasket is exposed to a liquid).

Suppose that a gasket has a minimum gasket load (or stress) of 3,000 psi, or 20,684 kPa, and a maximum gasket load (or stress) of 15,000 psi, or 103,421 kPa. This means the gasket will start to create an acceptable seal at the minimum stress and can begin to break down at the maximum stress.

A “good” load on this gasket might be around 10,000 psi, or 68,948 kPa. This allows for some bolt stress relaxation and gasket relaxation to occur before leakage or gasket failure. To achieve the proper gasket stress, the bolts should be torqued to the proper level. The proper gasket stress depends on many variables:

- Reused nuts/bolts, rusty nuts/bolts
- Calibrated torque wrench
- Proper flange face RMS (root mean square)
- Finish (should be concentric or spiral grooves)
- Type of lubricant used
- Type and number of washers used (should be two washers)

## Flange Isolation Kit (FIK) Products

GPT has two patented solutions for improving pipeline emissions with the following FIK products:

- The Pikotek VCS-ID Isolating Gasket/Kits
- EVOLUTION Isolation Gasket

### The Pikotek VCS-ID Isolating Gasket/Kits

The **Pikotek VCS-ID** (Inside Diameter) Seal introduces an internal, machined polytetrafluoroethylene (PTFE) seal at the bore of the existing VCS design platform. The patented interlocking mechanism is designed to be approximately 0.100" larger than the pipe ID. Its use ensures an extremely tight seal and resistance to the effects of internal pressure or aggressive media.



**Figure 8:** /wp-content/uploads/2020/09/20200902083900\_54623.jpg  
Source: GPT Industries

As the inside diameter of the inner PTFE seal is the same as the pipe bore, the formation of an electric bridge caused by conductive sediment buildup between the gasket steel core and the flange face is eliminated. During installation, the inner PTFE seal compresses to a final state that matches the pipe ID.

## Features & Benefits:

- Reduces **cavitation** in the piping
- Reduces flange erosion
- Helps prevent **microbiologically induced corrosion** (MIC)
- Does not affect line pigging operations
- Creates a longer effective isolating distance than the standard platform
- PTFE is hygroscopic, i.e. does not absorb water, and best for electrical isolation
- Dual locking feature creates a positive lock in the vertical and radial direction, providing a secure seal which will not dislodge during handling, transportation or installation
- Same torque required as standard VCS or VCFS, making installation simple

## Applications:

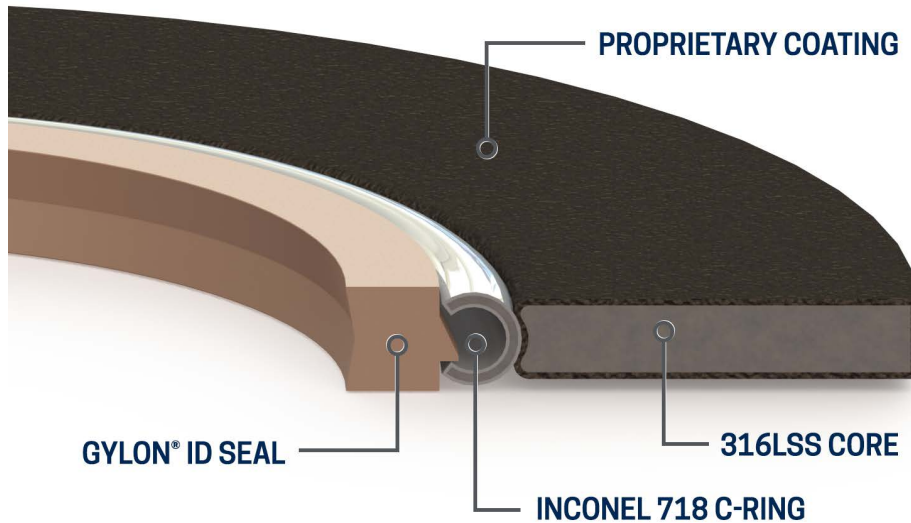
- Flange insulation in conjunction with cathodic protection
- Insulation between dissimilar metals to prevent galvanic corrosion
- Wellhead isolation from interconnected flow lines
- Valve, Christmas tree, pump, compressor connections
- Mating mismatched ring-joint to raised-face flanges
- Eliminates fluid trap where the potential of **stress corrosion cracking** exists with corrosive media

Detailed specifications are available in the [VCS-ID Data Sheet](#).

## EVOLUTION Isolation Gasket

The **EVOLUTION** Isolation Gasket is a fully encapsulated isolating gasket with a thin 1/8" design that minimizes installation issues encountered in thicker gaskets. The gasket is coated with an abrasion resistant, impact resistant, and chemical resistant GPT proprietary material that's especially suited for the oil and gas industry.





**Figure 9:** Cross-section of Evolution Isolation Gasket  
Source: GPT Industries

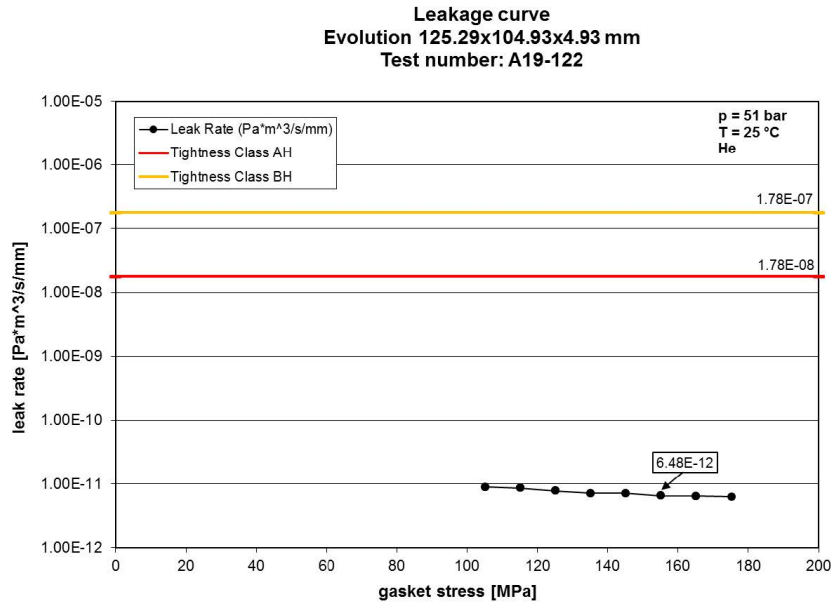
### Features & Benefits:

- Thinner profile of 1/8" or 3 mm makes installation easier and accurate
- GPT proprietary coating with high dielectric strength
- Fully encapsulated coating eliminates expensive cores
- Rated from -300F/-184C to 500°F or 260°C
- Inconel 718 C-Ring which is fire safe and passed the API 6FB, 3rd Edition Fire Test in multiple sizes/classes
- High pressure to extremely high pressure capability
- The PTFE ID seal makes it resistant to oil and gas chemical like H<sub>2</sub>S, CO, and Co<sub>2</sub>
- The encapsulated coating eliminates need to replace gaskets after hydrotesting
- Once installed, the gasket inner seal matches the pipe bore

## EVOLUTION® Emissions Testing Reports

GPT's Evolution gasket has undergone several industry leakage and emissions testing, to quantify the emission reductions that this can provide. Below are results from the testing that took place.

### Shell MESOC SPE 85/300 TAT Testing:



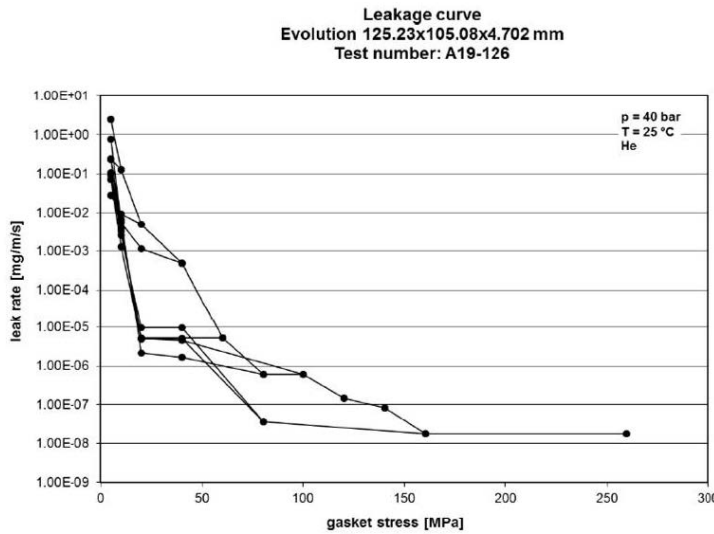
### Shell Leakage Test (RT)

At room temperature, Evolution had an average leak rate of  $6.48 \times 10^{-12}$  Pa\*m<sup>3</sup>/s/mm. The test medium that is used for this is Helium. This falls well within Shell Tightness Class AH, the only gasket to do so that GPT has ever tested. To help quantify this number, Shell provides leak rate equivalents shown below:

Leak Rate Equivalents					
cc / sec	mbar - liter / sec	Torr - liter / sec	Pa - m <sup>3</sup> / sec	Approximate Equivalent	Approximate 1mm <sup>3</sup> Bubble Equivalent
1	1.01	7.6x10 <sup>-1</sup>	1.01x10 <sup>-1</sup>	2x10 <sup>-2</sup> SCFM	Steady Stream
1x10 <sup>-1</sup>	.01x10 <sup>-1</sup>	7.6x10 <sup>-2</sup>	1.01x10 <sup>-2</sup>	1 cc every 10 seconds	Steady Stream
1x10 <sup>-2</sup>	.01x10 <sup>-2</sup>	7.6x10 <sup>-3</sup>	1.01x10 <sup>-3</sup>	1 cc every 100 seconds	10 per second
1x10 <sup>-3</sup>	.01x10 <sup>-3</sup>	7.6x10 <sup>-4</sup>	1.01x10 <sup>-4</sup>	3 cc per hour	1 per second
1x10 <sup>-4</sup>	.01x10 <sup>-4</sup>	7.6x10 <sup>-5</sup>	1.01x10 <sup>-5</sup>	1 cc every 3 hours	1 every 10 seconds
1x10 <sup>-5</sup>	.01x10 <sup>-5</sup>	7.6x10 <sup>-6</sup>	1.01x10 <sup>-6</sup>	1 cc every 24 hours	1 every 100 seconds
1x10 <sup>-6</sup>	.01x10 <sup>-6</sup>	7.6x10 <sup>-7</sup>	1.01x10 <sup>-7</sup>	1 cc every 2 weeks	3 per hour
1x10 <sup>-7</sup>	.01x10 <sup>-7</sup>	7.6x10 <sup>-8</sup>	1.01x10 <sup>-8</sup>	3 cc per year	Bubbles too infrequent to observe
1x10 <sup>-8</sup>	.01x10 <sup>-8</sup>	7.6x10 <sup>-9</sup>	1.01x10 <sup>-9</sup>	1 cc every 3 years	
1x10 <sup>-9</sup>	.01x10 <sup>-9</sup>	7.6x10 <sup>-10</sup>	1.01x10 <sup>-10</sup>	1 cc every 30 years	
1x10 <sup>-10</sup>	.01x10 <sup>-10</sup>	7.6x10 <sup>-11</sup>	1.01x10 <sup>-11</sup>	1 cc every 300 years	
1x10 <sup>-11</sup>	.01x10 <sup>-11</sup>	7.6x10 <sup>-12</sup>	1.01x10 <sup>-12</sup>	1 cc every 3000 years	

This states that utilizing an Evolution gasket, with a leak rate to 10-12 will provide an equivalent of 1 cc of helium leaked every 3000 years, with bubbles too infrequent to observe.

**EN 13555 – MESC 85/300 3.3.4**



**3.3.4 Leakage Test according EN 13555**

Again, at room temperature, Evolution had a standard leak rate of approximately  $1.00 \times 10^{-8}$  mg/m/s at a typical gasket stress, and still provides tight sealing capabilities at low gasket stresses. This leakage is approximately 10,000 times less than any other gasket GPT has tested in the EN 13555 test.

**Chevron Fugitive Emission Test (CFET)**

<i>Thermal Cycle Number</i>	<i>Leakage Readings (PPMv)</i>				<i>Flange Temperatures</i>	
	<i>Ambient Temp.</i>		<i>500 deg F Temp.</i>		<i>Heated</i>	<i>Other</i>
	<i>Avg.</i>	<i>Max.</i>	<i>Avg.</i>	<i>Max.</i>	<i>(deg F)</i>	<i>(deg F)</i>
Start	0	1	19	27	501	340
1	3	3	38	38	501	332
2	0	1	19	20	501	322
3	0	1	18	25	500	343
4	1	2	28	29	501	344
5	0	1	End of Test- 5 Thermal Cycles Complete			
<b>Averages -&gt;</b>	<b>1</b>	<b>2</b>	<b>24</b>	<b>28</b>	<b>501</b>	<b>336</b>
<b>Maximums -&gt;</b>	<b>3</b>	<b>3</b>	<b>38</b>	<b>38</b>	<b>501</b>	<b>344</b>

During the Chevron Fugitive Emissions Test, the gasket is sent through cycling testing, at both ambient temperatures, and the max design temperature of 500 F. The test medium for this is methane. For ambient temperatures, Evolution had an average leakage of 1 PPMv. For elevated temperatures, Evolution had an average leakage of 24 PPMv. The standard criteria that are used for considering a gasket to pass at ambient temperatures would be 100 PPMv leakage.



**Figure 10:** Evolution Isolation Gasket  
Source: GPT Industries

**Applications:**

- Preventing galvanic corrosion where dissimilar metals are used
- Where fire-safe flange insulation is required along with cathodic protection
- Wellhead isolation from inter-connected flow lines
- Valve, Christmas tree, pump and compressor connections
- Mating mismatched ring-joint (RTJ) to raised-face flanges
- Eliminating fluid trap corrosion between ring-joint flanges where high concentrations of aggressive hydrocarbon media like H<sub>2</sub>S and CO<sub>2</sub> are present
- Eliminating turbulence and flow-induced erosion between ring-joint RTJ flanges
- Sealing between flanges subjected to vibration or cavitation such as in compressor stations
- Emissions critical applications - Hydrogen, Carbon Capture, CO<sub>2</sub>
- Detailed specifications are available [here](#).

## Flange Isolation Kit (FIK) Installation

The following steps should be followed to install a GPT Isolation Gasket properly. For complete details, see [GPT Isolation Gasket Installation Instruction](#).

1. Clean and inspect the flange face and ensure flange face finish is in accordance with American Society of Mechanical Engineers, Post Construction Committee-1 ([ASME PCC-1](#)) guidelines



**Figure 11:** Gasket Installation

Source: GPT Industries

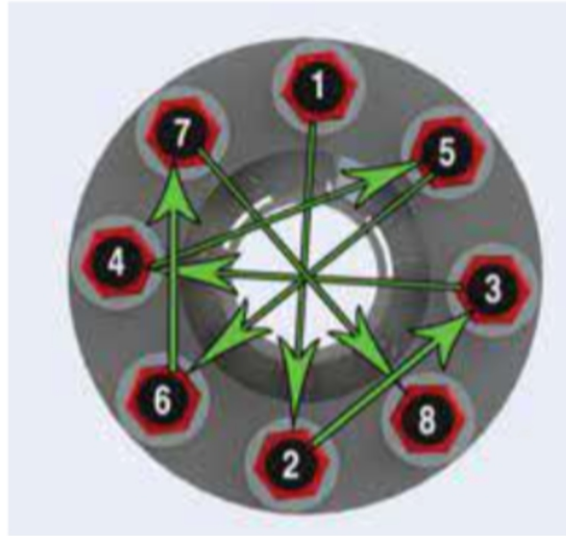
2. Ensure wide enough flange gap is created before installing the gasket. Gasket should be installed only after aligning flanges.

3. Apply PIKO-LUBE to bolts. METALLIC BASED LUBRICANTS SHOULD NOT BE USED. First insert steel washers, then install G10 washer against flange face, then install sleeve on bolt. Use two washers per side for HCS coated washers. Always use new bolts, never re-use washers, sleeves or gaskets once installed.

4. Install sleeves and washers on the bottom half of the flange assembly for easy alignment of type-F gaskets.

5. DO NOT DAMAGE THE SEAL. It is suggested to use the cardboard included in the packaging during installation to help protect the seals and isolating materials from damage.

7. Torque in in a legacy star pattern  
Snug each stud to 10-20 (ft-lb) (14-17 Nm)  
Tighten to 30% of target torque  
Tighten to 70% of target torque  
Tighten to 100% of target torque  
Final torque to 100% in circular pattern as shown in figure below



**Figure 12:** Legacy Star Pattern  
Source: GPT Industries

GPT also offers a [GFIT \(GPT Flange Isolation Training\) program](#) that teaches engineers how to properly install and test flanges. The workshop offers participants an in-depth, virtual 1-½ hour session on proper FIK installation techniques for field installers and engineers.

### **Previous FIKs vs GPT EVOLUTION**

The [EVOLUTION](#) gasket eliminates GRE totally from the design as well as benefiting from the addition of the PTFE inside diameter (ID). This results in an unparalleled sealing tightness performance, ideal for emission reduction in pipeline connections. That makes it a superior choice for controlling emissions of GHGs such as methane, ethane, carbon dioxide, carbon monoxide and hydrogen, as well as many other chemicals that need to be contained in piping systems.

Although GHGs will continue to be an area of concern when it comes to pipelines, proper gaskets are part of the solution and help ensure that unnecessary emissions are avoided.

## Resources:

<https://www.gptindustries.com/en/pillar-page/emissions>

<https://eos.org/articles/the-surprising-source-of-greenhouse-gas-emissions>

<https://www.nationalcarboncapturecenter.com/research/>

<https://www.epa.gov/air-emissions-inventories/what-definition-voc>

<https://www.epa.gov/stationary-sources-air-pollution/natural-gas-transmission-and-storage-facilities-national-emission>

<https://www.brookings.edu/policy2020/bigideas/the-united-states-can-take-climate-change-seriously-while-leading-the-world-in-oil-and-gas-production/>

<https://www.sciencedirect.com/topics/engineering/fugitive-emission>

<https://submar.com/ways-pipelines-actually-curb-greenhouse-gas-emissions/>

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