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Abstract

Insulation gasket kits are used to prevent electrochemical corrosion often observed in metal pipe system with dissimilar flanges materials or in buried pipelines. This insulation kit is typically used in refineries, pipelines, chemical plants and especially in offshore installations, such as oil platforms. The market offers a great range of materials to meet these applications, which are based in phenolic resin, epoxy, rubber, etc. However, end users, frequently, do not have a complete understanding of all the requirements to do a proper specification of the insulation kit to meet their needs. A correct selection of the insulation kit requires knowledge about its physical as well as its electrical features in order to avoid a potential failure in the field. Therefore, this paper proposes an overview of the main physical and electrical parameters for a reliable insulation kit, as well as alternative materials.

1. Introduction

A metallic pipeline or pipe installation that is buried underground, seabed or composed of dissimilar materials reacts similarly as a metal immersed in an electrolyte that creates anodic and cathodic regions. When this occurs, the pipeline metal in the anodic region will be corroded. However, corrosion may be prevented if the electrical connection between the cathode and anode is interrupted. Thus, an electrical insulation gasket kit is installed between two flanged joints within the metal pipeline to interrupt the cathode-anode-current flow. To be effective the kit must include an insulation gasket, insulation washers and full-length insulation sleeves, as shown in Figure 1 below:

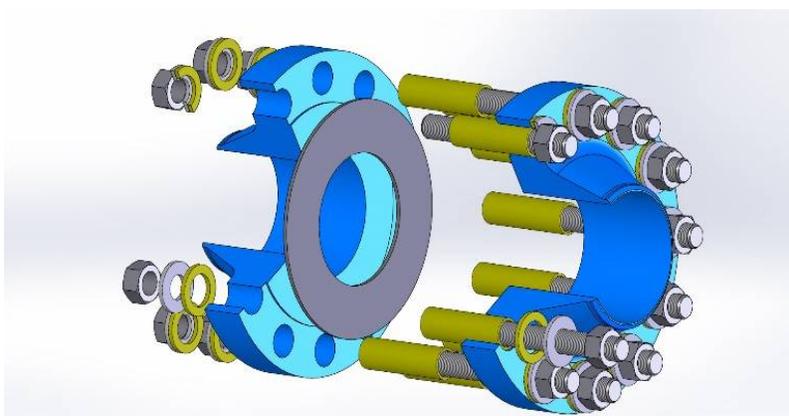


Figure 1– Insulation Kit

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Both metallic and non-metallic electrical insulation gaskets are used within a variety of industries, including those that process liquids, gases, and gaseous hydrocarbons, to seal flanged joints. While non-metallic gaskets adequately provide electrical insulation, they generally do not provide the mechanical strength necessary for high-pressure applications in pipeline typically found in offshore oil platforms. For these high-pressure applications, a metallic gasket is required to avoid a seal failure or even the blow out phenomenon.

There are many types of materials used for this application. In Brazil, the most used gasket type is made of phenolic resin for both RTJ and RF flanges. For RF flanges the gasket is additionally coated with CR rubber (Neoprene). These gaskets have been specified for all flanges classes. For lower class flanges, such as 150 and 300, usually there is no performance problem. On the other hand, for high pressure class there is a risk of damage on the gasket due to the higher seating stress required by these flanges.

Another potential problem in these insulation kits is the insulation washer excessive compression. If a washer fails, it can affect the overall reliability of the joint.

The electrical properties are not well defined by the industry. A major end user in Brazil defines the following electrical properties:

- Electrical insulation
Minimum 10 mega-ohm (MΩ) with 1000V DC
- Dielectric strength
Minimum 5 kilo-volts (kV) for 1 minute

However, these values seem to be excessive for an actual application in the field.

Thus, this paper will evaluate the physical characteristics of this insulation gasket in comparison with other materials and the electric tests required for the application.

It is important to mention that this study requires many different tests for a complete evaluation. Furthermore, even though this study is not complete, this paper is presented to draw attention that this important application is not well documented and does not have standard like other gasket types such as spiral wound gaskets and ring joints. Hence, the proposal of this paper is to call attention for an application that needs more regulation and normalization for a safe use in the field.

2. Insulation kit materials

O Below the list of materials that will be evaluated in this paper:

Gaskets

- Phenolic resin coated with neoprene (CE + CR)
- Compressed fiber gasket NBR + aramid (CFG)
- Restructured PTFE + Hollow glass spheres (rPTFE)
- Serrated metal gasket faced on both sides with rPTFE (KAM)

Washers

- Cotton Fabric reinforced Phenolic resin (CE)
- Glass Fabric reinforced with epoxy (G-10)

Sleeves

- Glass Fabric reinforced epoxy (G-10)

2.1. Tests performed

Following good engineering practices, the non-metallic gaskets should be used up to flanges class 300. Higher pressure class flanges or aggressive service should use metallic gaskets. Therefore, the proposal of the tests is to evaluate CFG and rPTFE as alternative for CE + CR and KAM as an option for severe service applications replacing metallic gaskets faced both sides with epoxy laminates usually offered in the market.

Blow out

As metallic gaskets offer lower risk of blow out, this test was performed only with the non-metallic gaskets using standards ASME flanges:

Test details:

- Flanges 3 in class 150
- Torque: 108 N-m (80 lb.ft)
- Temperature rise rate: 100 C/h
- Max temperature: 360 C
- Pressure: 30 bar (435 psi)
- Media: Nitrogen

Test procedure: The gasket is assembled with the torque mentioned above at room temperature. Then, the system is pressurized and the flanges are heated up to gasket blow out. Figure 2 shows the test rig for blow out.



Figure 2 – Test rig for blow out

Sealability

Tests of sealability were performed based on DIN 3535-4. Below some details:

- Gasket dimensions: 50 x 90 mm
- Seating stress: 32 MPa
- Pressure: 40 bar
- Media: Nitrogen and helium
- Sealing target: $1,0 \times 10^{-1}$ mg/s.m (nitrogen)
- Sealing target: $1,0 \times 10^{-1}$ m.bar.l/s (helium)

Figure 3 shows the test rig used to evaluate sealability.



Figure 3 – Test rig 50T

Electrical insulation

To perform this test each gasket was inserted between two flanges with and without studs.
Test details:

- Equipment: Teraohmmeter
- Flanges: 2 in class 600 (without studs)
- Flanges 4 in class 300 (with studs)
- Electric tension: 1000 V DC

The electrical isolation evaluation is a pass/fail test. Figure 4 shows the equipment and test flanges:

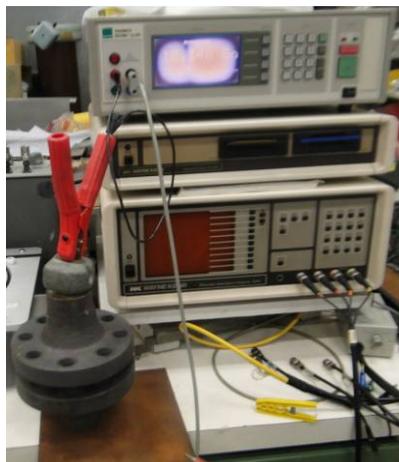


Figure 4 – Teraohmmeter

Dielectric strength

It was performed two types of dielectric strength tests.
The first test used a test rig of figure 5 following the parameters below:

- Standard: ASTM D-149
- Specimen dimensions: 190 x 190 mm
- Specimen thickness: 3.2 mm
- Voltage rate rise: 1 kV/s
- Sample environment: air or insulating oil



Figure 5 – Test rig for dielectric strength

Test procedure: The gasket is placed in the test rig in air or insulation oil environment. Then voltage is increased through two electrodes placed in contact with the specimen. The test is completed when there is a specimen breakdown. Because in some materials there is a flashover before breakdown, the test is performed with the sample immersed in insulation oil. This oil reduces the chances of flashover permitting a full comparison among the materials. Figure 6 below shows a sample with flashover:



Figure 6 – Example of flashover

The second test was performed in flanges in touch with and without studs as shown in Figures 7 and 8 respectively.



Figure 7 – Flanges with studs



Figure 8 – Flanges without studs

Test details:

- Equipment: Ferranti
- Flanges: 2 in class 600 (without studs)
- Flanges 4 in class 300 (with studs)
- Voltage rate rise: 1 kV/s
- Environment: air

Both electrical tests, dielectric strength and electrical insulation, with studs were performed in order to evaluate the complete insulation kit, i.e., the insulation gasket, insulation washers and insulation sleeves. The tests without studs were performed in order to evaluate only the insulation gasket inserted between flanges.

2.2. Tests results

Below the results per type of test:

Blow out

Table 1 shows the results:

Table 1 - Blow out tests

Material	Max Temperature (C)	Blow out (C)
CFG	360	No
rPTFE	360	260
CE + CR	150	No

Test performed with CE + CR was interrupted at 150 C, the limit of the rubber. The material did not blow out up to 150 C, but its rubber cover was released from the phenolic core as shown in Figure 9.



Figure 9 – Sample of CE + CR after test

The rPTFE achieved limit recommended for PTFE material (260 C). This value can be considered satisfactory since the service conditions for insulation gaskets is usually less than 180 C.

Sealability

Table 2 shows the results:

Table 2 – Sealability

Material	Media	Leakage
CFG	Helium	$1,37 \times 10^{-3}$ m.bar.l/s
rPTFE	Helium	$4,11 \times 10^{-5}$ m.bar.l/s
CE + CR	Nitrogen	$3,36 \times 10^{-3}$ mg/s.m
KAM	Helium	$1,37 \times 10^{-3}$ m.bar.l/s

Helium is a more permeable gas and, hence, more difficult to seal. Anyway, all materials achieved results much better than the proposed target.

Electrical insulation

Table 3 shows the results:

Table 3 – Electrical insulation

Material	Stud	Insulation (M Ω)
CFG	No	324
rPTFE	No	7.043
CE + CR	No	2.722
KAM	No	1.455.000
CFG	Yes	61
KAM	Yes	10.719

The materials rPTFE and CE + CR were not tested in flanges with studs. But based in the tests of CFG with and without studs and also considering that this evaluation is not so critical, we can suppose that these materials would pass in the test with studs without difficulty.

Dielectric strength

Table 4 shows the results of the tests performed with a sample of each material according to standard ASTM D-149:

Table 4 – Dielectric strength in the test rig

Material	Environment	Dielectric strength (kV)
CFG	Air	18,1
rPTFE	Air	29,3
CE + CR	Air	Flashover
CFG	Oil	36,2
rPTFE	Oil	32,5
CE + CR	Oil	14,7

Theses testes were only performed in non-metallic materials since the test rig requires a square plate sample. Table 5 shows the results of the test performed in flanges with and without studs:

Table 5 – Dielectric strength in the flange

Material	Stud	Dielectric strength (kV)
CFG	No	5,8
rPTFE	No	6,5
CE + CR	No	5,1
KAM	No	6,6
CFG	Yes	4,3
KAM	Yes	5,0

In this test was observed that the breakdown occurred in the insulation sleeve or insulation washer. Figure 10 shows a test with breakdown in the insulation sleeve.

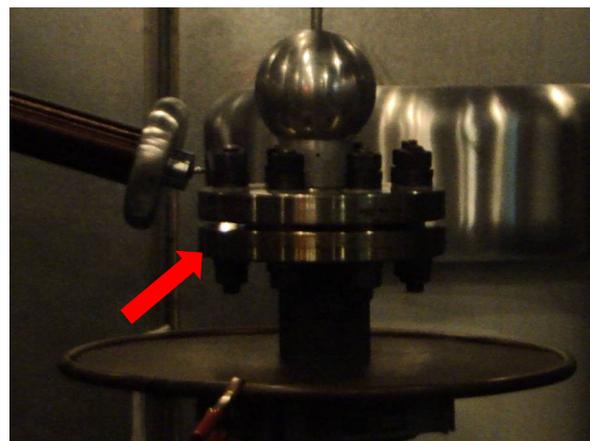


Figure 10 – Breakdown in the insulation sleeve

3. Discussion

One of the main problems reported in the field about insulation kits is the limit of seating stress of the insulation gasket. But it is also important to notice the limit of stress of the insulation washer. In the tests in flanges it was observed that some washers broke during the assembly of the flanges. Figure 11 shows an example of this type of failure.



Figure 11 – Broken washer

This problem is more frequent in flanges that use studs with higher nominal diameter. A reason for that is the tensile rate between stud root area and effective washer area. As shown in Chart 1 below, depending on the stud diameter the same force can generate a higher tensile on the washer

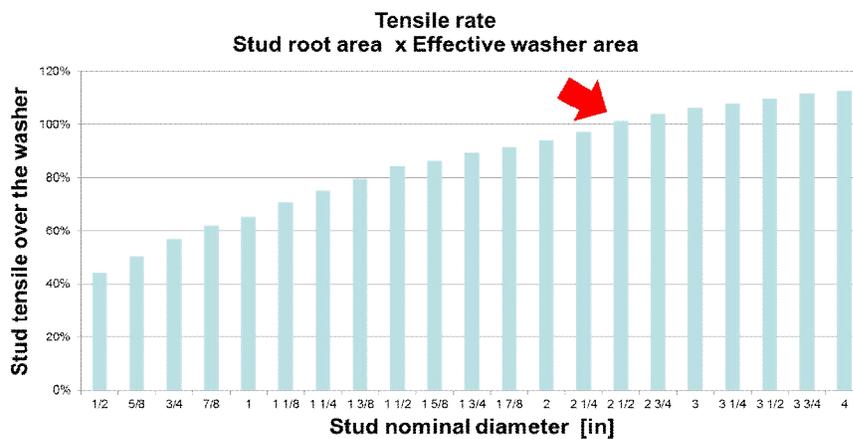


Chart 1 – Tensile over the washer

In order to avoid this problem, many tests were performed. The washer integrity was preserved using two hardened metallic washer above the insulation washer as shown in figure 12 below:



Figure 12 – Assembly with two hardened washers

4. Conclusions

In this paper we showed tests to assure a good performance of Insulation Gaskets Kits. In addition to usual gasket properties like sealability all gaskets tested showed satisfactory electrical properties.

It has been found that the weaknesses of the Insulation Kits are the sleeves and the washers. During dielectric strength tests it could be observed that a breakdown can occur on the insulation sleeve or insulation washer that highlights the attention for their dimension and material selection. Also, this test could demonstrate that the dielectric strength result reduces when the test is performed with studs. It recommended that the electrical tests be performed with the complete kit assembled to its flange and studs torqued.

The mechanical properties of the insulation washers are also a matter of concern. It was verified that the insulation washer installed on flanges that use studs with higher nominal diameter are more intended to break than insulation washer assembled on flanges that use studs with lower nominal diameter. The torque value for larger bolts is critical to avoid washer failure.

It is usual to require a breakdown voltage of 5 kV for Insulation Kits that seems to be above the requirement for a typical application. This value can cause a breakdown in the sleeve or insulation washer.

In the blow out test, it was shown that the CE + CR gasket has a limitation of its maximum service temperature of 150 C since its rubber does not support temperatures above this value.

There are few standards and references for specification, testing and installation of Insulation Gasket Kits, which causes many field failures in especially in offshore services. The exploratory findings of this paper will be used in future studies and authors plan to propose a test protocol for these products in a future paper.

4. References

NEMA LI 1-1998 (R2011), "Industrial Laminating Thermosetting Products", National Electrical Manufacturers Association, Virginia, USA

ASTM D-149 – 97a, "Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies", American Society For Testing and Materials, Pennsylvania, USA

ASME Boiler and Pressure Vessel Code, 2004, section VIII, Division 1, Appendix 2, "Rules for Bolted Flanged Connections with Ring Type Gaskets", NY, USA

ASME PCC-1 2013, "Guidelines for pressure Boundary Bolted Flange Joint Assembly", American Society of Mechanical Engineers, NY, USA.

ASME B16.5 2013, "Pipe Flanges and Flanged Fittings", American Society of Mechanical Engineers, NY, USA.

ASME B16.20 2012, "Metallic Gaskets for Pipe Flanges", American Society of Mechanical Engineers, NY, USA.