ASME
SETTING THE STANDARD
1880 2005

2004

PVP-Vol. 478

ASME/JSME PRESSURE VESSELS AND PIPING CONFERENCE

ANALYSIS OF BOLTED JOINTS

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Test Procedure: The test procedure is based on the temperature limit after which the gasket material is no longer able to maintain a seal. Excessive temperature may cause physical damage to the gasket material and consequently an increase of leakage would be observed. The test parameters are as follows:

- Test pressure is according to the maximum temperature of flange material according to the ASMEB16.5 class 300 pressure-temperature rating [3]
- Sealed media: Nitrogen
- Gasket stress: 11600psi (80MPa)
- Temperature: The initial temperature test were defined as following: sample#1: 250°C (482°F); sample#2: 150°C (302°F); sample#3: 180°C (356°F) and sample#4: 150°C (302°F).
- Test duration: 120 hours for each temperature. The gasket specimen was replaced for new one after 120 hours testing

A summary of the procedure is as follow:

a) Installation of the gasket specimen with gasket seating stress of 80 MPa (11600psi) using bolting procedure designed to achieve a uniform gasket stress distribution in the flange: Ensure that the flange assembly has been cleaned and that the exposed surfaces of the flanges are free of all residues from previous tests. Clean and lubricate bolt threads, nuts and washers. Using a calibrated torque wrench, torque the bolts using cross pattern in three increments.

b) After 4 hours, re-torque the bolts to 80 MPa (11600psi).

c) Heat up the fixture until gasket test temperature is reached. After the temperature is stabilized, the fixture is pressurized with Nitrogen.

d) Record temperature and gasket leak rates using the according pressure decay method for 120 hours [4].

e) Repeat steps (a) to (d), using a new gasket specimen, for others test temperatures.

3. Results and Discussion

Average leak rates as a function of temperature for all samples are shown in Table 2 and Figures 2 through 5. According to these results, it could be verified that there is a temperature where an increase of leak rate was observed.

Table 2. Leak rate Results (mg/s.mm)

Sample #1				
T °C (°F)	Flange #1	Flange #2	Flange #3	Average
250 (482)	4E-06	4E-05		2E-05
280 (536)	1E-05	2E-05		2E-05
300 (572)	3E-03	1E-04		2E-03
320 (608)	1E-02	1E-02		1E-02
Sample #2				
T °C (°F)	Flange #1	Flange #2	Flange #3	Average
150 (302)	3E-06	2E-06	8E-06	4E-06
250 (482)	2E-06	1E-05	5E-05	2E-05
260 (500)	2E-06	8E-06	1E-05	7E-06
280 (536)	2E-04	3E-03	3E-04	1E-03
Sample #3				
T °C (°F)	Flange #1	Flange #2	Flange #3	Average
180 (356)	2E-06	6E-06	6E-06	5E-06
250 (482)	6E-07	2E-06	6E-07	1E-06
280 (536)	1E-05	4E-06	1E-05	8E-06
290 (554)	3E-05	1E-05	2E-04	8E-05
Sample #4				
T °C (°F)	Flange #1	Flange #2	Flange #3	Average
150 (302)	2E-06	1E-06	5E-07	1E-06
200 (392)	5E-06	2E-06	9E-07	3E-06
230 (446)	5E-05	2E-05	9E-06	3E-05
250 (482)	4E-04	2E-04	2E-04	3E-04

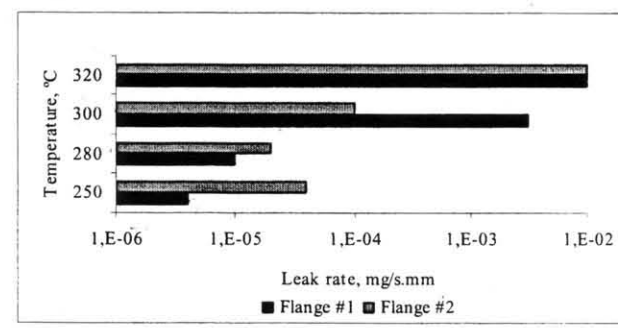

Figure 2. Average leak rate as a function of temperature of sample#1

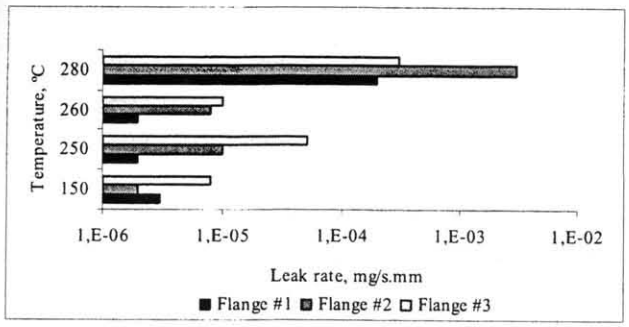

Figure 3. Average leak rate as a function of temperature of sample#2

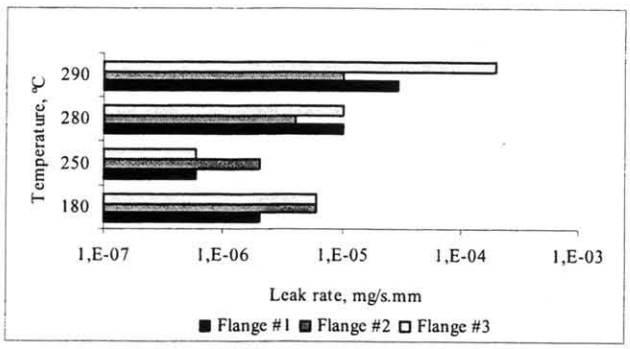

Figure 4. Average leak rate as a function of temperature of sample#3

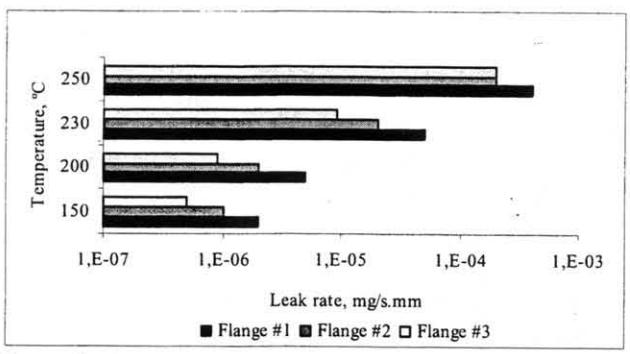

Figure 5. Average leak rate as a function of temperature of sample#4

From Figure 2, it was possible to verify that there is no major difference of average leak rate when the temperature was increased from 250°C (482°F) to 280°C (536°F) but when it was changed from 280°C (536°F) to 300°C (572°F) a significant increase of average leak rate was observed. According to this behavior, it could be verified that gasket performance degradation starts to occur when the test temperature was close to 300°C (572°F); therefore the critical temperature range of sample #1 could be 280 to 300°C (536 to 572°F).

Similar behavior was observed for other samples. Figures 3 and 4 show the charts of sample #2 and sample #3, respectively. It could be verified that the average leak rate increased 100 times when test temperature increased from the range critical temperature occurs 260°C (500°F) to 280°C (536°F) for the sample #2 and 10 times when temperature increased from 280°C (536°F) to 290°C (554°F) for the sample #3.

Figure 5 shows the charts of sample#4. It could be observed that the average leak rate at 230°C (446°F) is higher than respective values of 200°C (392°F) and 150°C (302°F).

Therefore, using the same criteria of sample #1, the critical temperature range of sample #2, #3 and #4 could be: 260 to 280°C (50 to 536°F); 280 to 290°C (536 to 554°F) and 200 to 230°C (302 to 446°F), respectively.

Since tests were performed in laboratory conditions, it would be expected that field conditions could affect results.

4. Conclusion

Test results clearly showed that it is possible to determine a critical temperature range for CNA sheets. All products tested showed that above a very well defined temperature level, the gasket sealability degraded, increasing the leak rate up to 100 times.

The critical temperature range for all samples could be established, as summarized bellow:

- Sample #1: 280 to 300°C (536 to 572°F)
- Sample #2: 260 to 280°C (500 to 536°F)
- Sample #3: 280 to 290°C (536 to 554°F)
- Sample #4: 200 to 230°C (302 to 446°F)

5. Reference

1. Veiga, J. C. C, 2003, "Industrial Gaskets", 4th Edition, Rio de Janeiro, RJ.
2. Naval Ship Technical Manual, Sept, 1998, "Gasket and Packing", vol. 2, Chapter 078.
3. ASME B16.5, 1998, "Piper Flanges and Flanged Fittings".
4. Derene, M. ; Payne, J.R. ; Bazegui, A. ; Marchand, L., 1998, "PVRC/MTI Technology for Characterizing Gasket Used in Bolted Flanged Connections", Part II, John H. Bickford – Marcel Derek, Inc, New York