TECHNICAL BULLETIN

Thermal Cycling Capabilities of VSP PITA® Gasket

BACKGROUND:
Differential thermal expansion between PTFE gasket materials and metallic flange/bolt systems, combined with thermally influenced creep relaxation characteristics of all PTFE based gasket materials, creates limitations in the ability of some PTFE gasket materials to provide long term, reliable sealing performance in process or thermal cycling applications. ASTM F-36 gasket recovery data is sometimes used to assess a gasket's thermal cycling capabilities however it is a poor means of establishing suitability for cycling performance as it is a short duration, ambient temperature test that measures recovery, or springback, of the gasket after the compressive load has been completely released. In order to provide a direct qualification of thermal cycling performance and capabilities, the HOBT2-C (Hot Blowout Test) with cycles was developed under the guidance of the PVRC (Pressure Vessel Research Council) Bolted Flange Connection Committee as part of the 1995 PTFE Gasket Protocol[1 2]. The test procedure and data analysis methodology are currently being formatted as an ASTM F3 gasket testing standard.

ANALYSIS:
In the HOBT2-C test, gaskets are qualified for thermal cycling service for ASME class 150 and class 300 flange pressure ratings up to a maximum temperature in each respective flange class. The tested gasket is installed in a NPS 3 slip on flange and compressed to 5,000 psi gasket stress using a star pattern torquing sequence. Bolt load on all bolts is monitored with strain gauges.

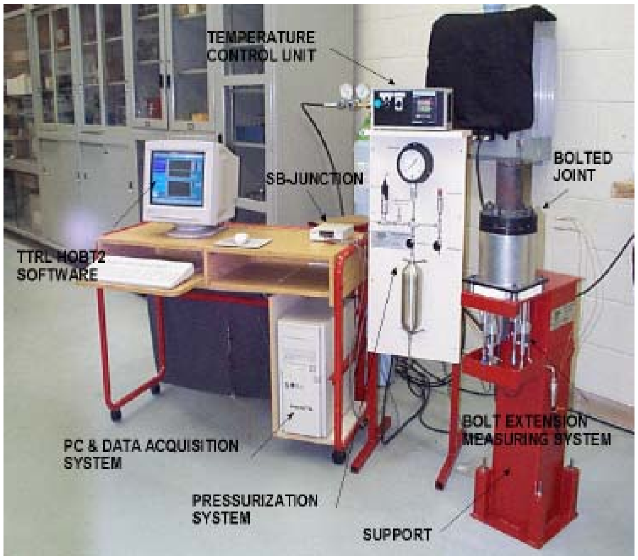

Figure 1: HOBT2-C Test Fixture

The first gasket/assembly is pressurized to the test qualification pressure (435 psig for class 150 flange qualification and 1,010 psig for class 300 flange qualification), and the flange is heated at a rate of 3°F/min until blow out occurs; Gasket temperature, gasket thickness, gasket stress, blow out pressure, and blow out temperature are all recorded. Analyzing the gasket creep rate and gasket stress, an estimate is made of the maximum test temperature that the gasket can thermally cycle to, and maintain at all times a stress higher than 1.5X test pressure (Tcd). The 1.5X pressure is an ASME section V111 based design criteria essentially setting the performance limit such that gasket stress remains at least 50% higher than the internal pressure.

Analysis Criteria:
Residual Gasket Stress (psi)/Test Pressure (psi) = 1.5

A second gasket/assembly is then assembled, pressurized, and heated up to the estimated cool down temperature (Tcd-identified from the first test) and then, rather than continuing to heat until blow out, the gasket/assembly is thermally cycled three times from ambient to this temperature. After the third thermal cycle the temperature is increased until blow out occurs. By comparing the blow out temperature of the first test (with no cycles) to the blow out temperature of this second test (with cycles), and evaluating the cool down gasket stress in-between cycles (gasket stress <1.5X test pressure), the accuracy of the estimated maximum cycling temperature is evaluated. A third gasket/assembly is then tested at a higher cycling temperature (Tcd) selected with the goal of bracketing the actual empirical maximum cycling temperature. This third test (the second cycling test) is conducted and the data and results of both cycling tests are analyzed. Providing that the cycling temperatures (Tcd) were accurately identified, the ambient temperature, residual gasket stresses from the two tests should bracket the 1.5X test pressure stress, thus allowing interpolation of the exact cycling temperature to produce an empirical maximum thermal cycling temperature for the gasket material, which is referred to as the Safe Reserve Temperature (Tr).

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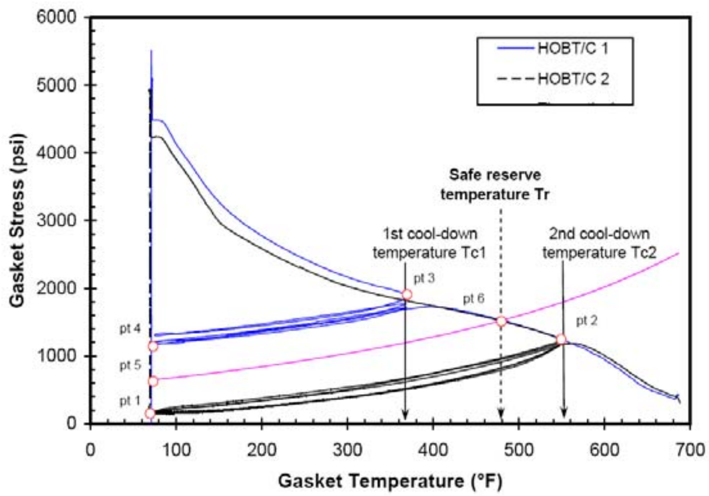

. **Figure 2: Identification of Safe Reserve Temperature (Tr)**

In addition to the determination of the Safe Reserve Temperature (Tr), analysis of a gasket material's HOBT2-C data and graphs yields further insight into the material's operating capabilities.

- Do the thermal cycles have a negative impact on the pressure resistance of the gasket in service and cause a reduction in the blow out temperature compared to the test without cycles?
- Does the gasket experience additional compression during the heat-up/cool down cycles and create additional bolt load loss?
- Does the gasket blow out in any of the tests?

<u>CONCLUSIONS:</u>

1) ASME class 150 and class 300 HOBT2-C testing was performed on 1/8" thick PITA® gaskets. Following the ASTM protocol for establishing the Safe Reserve Temperature, the following maximum cycling temperatures have been defined:

ASME Class 150 services (Pmax = 435 psig)
Tr = 454 °F

ASME Class 300 services (Pmax = 1,010 psig)
Tr = 444 °F

2) The PITA® gasket's Safe Reserve Temperature is considerably higher than for other high performance PTFE based materials. For example:

1/8" Barium Sulfate Filled PTFE:
Class 150 Tr = 356 °F – 374 °F

3) Unlike other PTFE based gaskets, the thermal cycles appear to have no impact on the pressure resistance of the PITA® gasket. Referring to Figure 3, the temperature-gasket stress plots for all three HOBT tests are nearly identical. There was minimal "ratcheting" of the gasket during the thermal cycles, and the temperature-gasket stress curves converge to the same point at the conclusion of the test. In all three class 150 tests, the PITA® gasket was tested up to the thermal limits of the test fixture itself, and did not blow out.

Test #1 (no cycles): Blow-out temp. >738 °F
Test #2 (cycles at 425 °F): Blow-out temp. >738 °F
Test #3 (cycles at 500 °F): Blow-out temp. >738 °F

(NOTE: Upper limit of HOBT2-C test fixture = 738 °F)

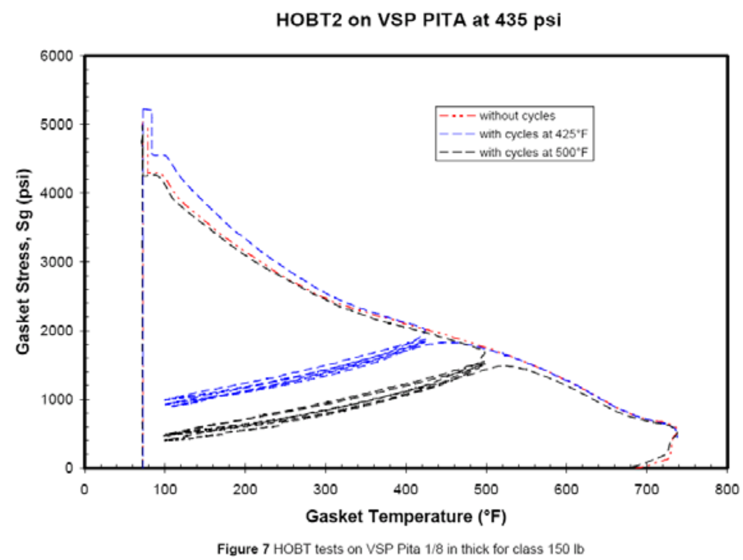

Figure 3: Master Plot Of All Three HOBT2-C Temperature-Gasket Stress Curves

5) The 1.5X operating pressure appears to overly conservative as the minimum gasket stress/pressure ratio in the determination of the Safe Reserve Temperature for the PITA® gasket. In the class 150 tests (435 psig), the actual ratio was 1.15 and for the class 300 tests (1,010 psig) the actual ratio was 0.89.

<u>APPLICATION:</u>

HOBT2-C testing conducted by Cetim Laboratory[3] and ETS[4] confirm the PITA® gasket to provide effective pressure resistance in both ASME class 150 and class 300 flange systems in extreme thermal cycling services. Following forthcoming ASTM data analysis protocol, a very conservative temperature limit of 454 °F is established for less rigid flange systems operating at pressures up to 435 psig, and a conservative limit of 444 °F is established for more rigid flange systems operating at pressures up to 1,010 psig.

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[1] "PTFE Gasket Qualification Project", Final Report, Tightness Testing & Research Laboratory (TTRL), Ecole Polytechnique of Montreal, October 1995
[2] Derenne M., Marchand L., and Payne J.R., "PTFE Gasket Qualification", WRC Bulletin #442, June 1999
[3] "HOBT Tests on VSP PITA 3" x 150 Gasket", Final Report, Cetim Laboratory, February 23, 2005
[4] "HOBT Testing Of VSP PITA 1/8" Thick Gasket Style, Final Report, Static & Dynamic Sealing Laboratory, Ecole de Technologie Superieure, Montreal, May 1, 2008

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