Proceedings of the ASME 2015 Pressure Vessels & Piping Conference
PVP2015
July 19-23, 2015, Boston, Massachusetts, USA

PVP2015-45196

FURTHER STUDIES ON PREDICTING LEAK RATES USING AN EMISSIONS CALCULATOR FOR BOLTED FLANGED CONNECTORS

Dale A Rice, P.E.
VSP Technologies, Inc.
Prince George, VA, USA

A. Fitzgerald Waterland, III (Jerry)
VSP Technologies, Inc.
Prince George, VA, USA

ABSTRACT

Work on the development of a practical tool, the "Fugitive Emissions Calculator" (FEC) has been previously reported. This tool, based in Microsoft® Excel® has been used to help predict anticipated fugitive emissions of various gasket materials with the proposed ASME / PVRC method for estimating leak rates using standard Room Temperature Testing (ROTT) data, the operating pressure, the pipe diameter, gasket stress, and other inputs. To further test the performance of the FEC, a sensitivity analysis has been conducted, focusing on several parameters, including system pressure, assembly efficiency, and gasket stress and their relative degree of significance on the predicted gasket tightness and leak rate. In addition, work has been conducted for developing a method for estimating the stress retention coefficient previously reported as a proposed modification to the PVRC leak rate method. The findings and conclusions of these studies are presented.

INTRODUCTION

Prior work documented the development of the FEC, a series of spreadsheets in Microsoft® Excel® that incorporate ROTT gasket constants in equations that are a function of certain operational variables [1]. These equations are the heart of an empirical model [2][3] that can be used to predict tightness and leak rates for specific gasket materials for which ROTT data have been collected. The ROTT method is a compression-decompression test with helium internal pressure and yields three constants, a, G_s, and G_b. (A case can be made for considering T_{pmax} as a 4th gasket constant as its value varies for each gasket material and depends on the maximum tightness parameter achieved either in the ROTT procedure or at the point of tightness hardening). This test uses a gas detector to measure leakage values (mg/s) for each gasket stress level from a standard 150 mm gasket. Then, a log-log plot of gasket stress versus tightness is made, and an analysis of the data is performed with this method to determine the three gasket constants.

ASME / PVRC have proposed essentially the following equation set wherein the gasket constants including T_{pmax} are needed to determine the predicted leak rate:

$$T_p = (\eta\, S_g/G_b)^{(1/a)} \le T_{pmax} \quad \text{(unitless)} \qquad \text{[Eq. 1]}$$
$$S_f = r\,(\eta\, S_g - P\,(A_i/A_c)) \quad \text{(psi)} \qquad \text{[Eq. 2]}$$
$$k_f = \log(\eta\, S_g/G_s) / \log T_p \quad \text{(unitless)} \qquad \text{[Eq. 3]}$$
$$T_f = (S_f/G_s)^{(1/k_f)} < T_{pmax} \quad \text{(unitless)} \qquad \text{[Eq. 4]}$$
$$L_r = [(P/14.7)(1/T_f)]^2 / 150 \quad \text{(mg / sec /mm)} \qquad \text{[Eq. 5]}$$
$$L_{tot} = L_r\, d\,(3600)(25.4)(1\text{x}10^{-6}) \quad \text{(kg/hr)} \qquad \text{[Eq. 6]}$$

Thus for any given gasket material, the equation set is a function of the following operational variables:

- System pressure, P
- Stress retention coefficient, r
- Gasket dimensions, d, A_i, and A_c
- Assembly efficiency, η
- Gasket stress at assembly, S_g

A discussion of the subjectively determined stress retention coefficient was included in the prior study [1]. Additional work is necessary to better understand the impact on the estimated leak rate when changing this variable. Initial gasket stress is a function of applied torque, the nut factor, number / diameter of bolts, and gasket to flange contact area. Assuming standard ASME B16.5 flanges, the variables for gasket stress at