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Practical Application of Fastener Preload Guidance Research

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ABSTRACT

Bolted flanged connections (BFC) in North America and throughout the world are designed, fabricated and constructed according to several design codes and component standards including the ASME Boiler and Pressure Vessel Code[1] and ASME B31 Piping Codes. Despite the considerable engineering controls in place to ensure proper equipment design, bolted flange connections are all too often the source of leaks, fugitive emissions and process shutdowns in the process industries[2]. A significant contributing cause of flange leaks is the limited understanding, of and improper selection and application of optimum assembly preloads on flange fasteners. Currently there are several "rule of thumb" approaches for identifying assembly bolt preload; each of these has limitations and short-comings that practitioners of these approaches need to be aware of. A new approach providing guidance to the selection of assembly preload bolt stresses is detailed.

INTRODUCTION

ASME pressure vessel design rules do not determine assembly bolt loads. ASME Section V111, Division 1 Appendix 2 calculations establish "design" bolt loads that are then used to establish flange thickness and total bolt area[3]. While there is limited guidance provided in Appendix S for using bolt loads higher than design values during assembly of the flanged connections[4], this Appendix alone does not provide sufficient guidance for one to determine an "optimum" assembly bolt load with full consideration for each of the components within a flange system. There is currently no standard procedure, method or approach for use in establishing the optimum assembly bolt load for ASME code designed pressure vessels or standard ASME pipe flanges.

When torque, or load control, is employed during flange assembly, engineers or flange assemblers currently utilize one of several different approaches or "rules of thumb" to establish the "assembly torque value". Neglecting the fact that the bolted, flanged connection is a device that includes three primary components (flange, bolts and gasket), these approaches instead typically focus on the optimum assembly bolt load for just one of the specific components; without fully considering the effect of the bolt load on the other components.

The selection of assembly bolt preload (assembly torque) as a percentage of the fastener yield strength is one common approach. Practitioners of this approach often incorrectly assume that the flange and all system components have been designed for this level of assembly bolt load. Table 1 of ASME PCC-1 "Guidelines For Pressure Boundary Bolted Flanged Joint Assembly" provides target torque values for low alloy steel bolting. While Chapter 10 of this document details the basis of these target torques as 50 ksi bolt stress and Chapter 12 provides guidance to "Individually select the Target Prestress for each joint, considering each joint element that will affected by the prestress", it further states that the 50 ksi prestress level is "generally considered suitable for joint systems designed using SA193-B7 low-alloy steel bolts, except for joint systems using ring joint gaskets"[5]. ASME B16.5 flanges were not designed following Appendix 2 design criteria and thus users should exercise caution when using the PCC-1 Table 1 torque values when assembling these flanges. As can be seen from Figure 1 below, for ASME Class 150 flanges used in conjunction with common sheet type gaskets, precision application of 50 ksi bolt assembly stress only develops optimum gasket stress for NPS 1 through NPS 1.5 flanges. Below NPS 1 the gasket stress developed exceeds the compressive limit of many sheet type gasket materials, while above NPS 1.5 the gasket stress developed barely exceeds the minimum stress required for sheet type materials[6].

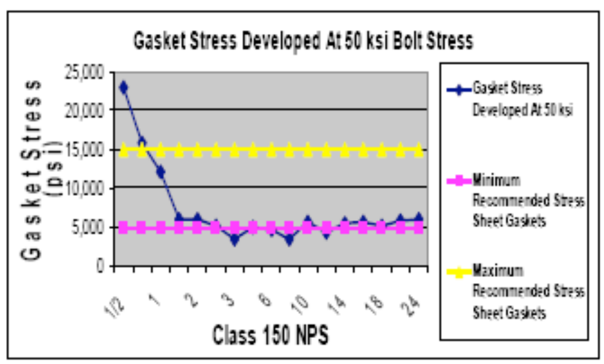

Figure 1: SHEET GASKET STRESS DEVELOPED AT 50 KSI BOLT STRESS