4.17 DESIGN RULES FOR CLAMPED CONNECTIONS

4.17.1 SCOPE

The rules in 4.17 apply specifically to the design of clamp connections for pressure vessels and vessel parts. These rules shall not be used for the determination of thickness of tubesheets integral with a hub nor for the determination of thickness of covers. These rules provide only for hydrostatic end loads, assembly, and gasket seating. Consideration shall be given to loads other than pressure, such as piping loads that may act upon the clamp connection (see 2.2.3.1).

4.17.2 DESIGN CONSIDERATIONS

4.17.2.1 The design of a clamp connection involves the selection of the gasket, bolting, hub, and clamp geometry. Connection dimensions shall be such that the calculated stresses in the clamp and the hub do not exceed the acceptability criteria of this paragraph.

4.17.2.2 In the design of a bolted flange connection, calculations shall be made for the following two design conditions, and the most severe condition shall govern the design of the flanged joint.

(a) Operating Conditions - The conditions required to resist the hydrostatic end force of the design pressure and any applied external forces and moments tending to part the joint, and to maintain on the gasket or joint-contact surface sufficient compression to assure a joint that meets the required tightness, all at the design temperature.

(b) Gasket Seating and Assembly Condition - The conditions existing when the gasket or joint-contact surface is seated by applying an initial load with the bolts when assembling the joint, at atmospheric temperature and pressure.

4.17.2.3 Calculations shall be performed using dimensions of the flange in the corroded condition and the uncorroded condition, and the more severe case shall control.

4.17.2.4 It is recommended that either a pressure energized and/or low seating load gasket be used to compensate for possible non-uniformity in the gasket seating force distribution. Hub faces shall be designed such as to have metal-to-metal contact outside the gasket seal diameter. This may be provided by recessing the hub faces or by use of a metal spacer (see Figure 4.17.1). The contact area shall be sufficient to prevent yielding of either the hub face or spacer under both operating and assembly loads.

4.17.2.5 It is recognized that there are clamp designs that do not utilize wedging action during assembly since clamping surfaces are parallel to the hub faces. Such designs are acceptable and shall satisfy the bolting and corresponding clamp and hub requirements of a clamp connection designed for a total included clamping angle of 10 degrees.

4.17.2.6 The design method used in this paragraph to calculate stresses, loads, and moments may also be used for designing clamp connections of shapes differing from those shown in Figures 4.17.1 and 4.17.2, and for clamps consisting of more than two circumferential segments. The design equations in this paragraph may be modified when designing clamp connections of shapes differing from those shown in Figures 4.17.1 and 4.17.2, provided that the basis for the modifications is in accordance with 1.1.1.2. The clamp connections designed in this manner shall be provided with a bolt retainer. The retainer shall be designed such that in case of failure of the primary bolting, the retainer shall hold the clamps together independently under the operating loads. Multiple bolting (two or more bolts per lug) is an acceptable alternative for meeting this redundancy requirement. See 4.8.3.2 for additional requirements for bolt retainers and redundant bolting. No credit shall be taken for clamp hub friction toward satisfying the redundancy requirement.

4.17.3 FLANGE MATERIALS

4.17.3.1 Materials used in the construction of clamp connections shall comply with the requirements given in Part 3.

4.17.3.2 Hubs made from ferritic steel and designed in accordance with the rules herein shall be given a normalizing or full-annealing heat treatment when the thickness of the hub neck section exceeds 76 mm (3 in.).

4.17.3.3 Cast steel hubs and clamps shall be examined and repaired, if required, in accordance with Part 3.

4.17.3.4 Hubs and clamps shall not be machined from plate.

4.17.3.5 Bolts, studs, nuts and washers shall comply with Part 3. The minimum bolt diameter shall be 13 mm (0.5 in.).

Change 13mm to 12mm

4.17.4 DESIGN BOLT LOADS

4.17.4.1 During assembly of the clamp connection, the design bolt load W is resolved into an effective clamp preload Wc, which is a function of the clamp-to-hub taper angle φ and the friction angle μ. An appropriate friction angle shall be established by the manufacturer, based on test results for both assembly and operating conditions.