FACTORS m,y,b

The problem of specifying acceptable gasket factors has been a long-standing concern of the ASME Boiler and Pressure Committees.

- m = factor needed to hold a seal under internal pressure, dimensionless.
- y = unit seating load, psi
- b = effective gasket width, in.

In 1941, Rossheim and Markl[20] reviewed values then in use, made changes, presented m and y tables for commonly used gasket materials, and suggested rules for finding b. It was known that m increased as the initial bolt load was given lower values — when the intitial pressure was zero m was very high. Therefore, the authors decided that y could be the m value required for a bolt load that would seal at zero internal pressure, and proposed the empirical formula $y = 180\ (2M - 1)^2$. Although Rossheim and Markl made no claim other than they hoped to stimulate research, their m and y values were adopted by the Code.

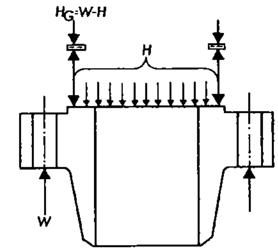

Fig. 4

Gasket tests show leakage usually happens well before the internal pressure has relieved the gasket reaction.

Suppose the ratio of the compressive stress of the gasket to the internal pressure of the fluid trying to escape is designated m' at the instant when leakage starts, then for a very poor gasket m' would be a large number. For good quality commercial gaskets it might range between 3 and 1.5. For a theoretically perfect case a leak would not start until the fluid pressure just exceeded the gasket pressure, with $m' = 1$. Assuming that reliable values of m' are available, the equilibrium conditions of Figure 4, can be expressed: bolt load = (fluid pressure) X (area subjected to fluid pressure) + m' (fluid pressure) X (area subjected to gasket pressure). In formula form this is $W_{m1} = \pi/4\, G^2 P + \pi\, 2b\, Gmp$ where W_{m1} is the bolt load (operating). The first term on the right side is the total hydrostatic pressure load acting on the effective gasket diameter G, and the second is the gasket reaction over an annular area $2b$ wide on the same G. Sealing theory requires that the load $2b\pi Gmp$ be resisted by the gasket when the internal pressure equals P. But the gasket also resists the total load, W_{m1}. When pressure P is applied, load $\pi/4\, G^2P$ is removed and $2b\pi GmP$ remains as the theoretical load required to hold a tight joint at P.

Factor m is derived from m' and has an added safety margin. Neither m or y values have theoretical standing and those now in use are based on practical experience and some formal experimentation. They have a direct effect on flange design and have been discussed for years without reaching fixed values that could be made mandatory. Many variables are involved, and much time is required to make a single test.[18]

At the present time, leakage criteria is getting a "hard look" and research programs are under study by the Pressure Vessel Research Committee to determine if m and y values can be set up in relation to specified leak rates. For example, a joint that held for one minute without the escape of one drop of water was considered "tight". This equals a leak rate of 10^{-3} cc. per second and would not be allowed in many industries. Possibly a leakage of 10^{-4} cc. per sec., corresponding to 6 drops per hour, would be acceptable for liquids, while 10^{-5} would be necessary for heavy gas and 10^{-7} for lethal substances. This concept may lead to multiple listings of gasket factors for a given material—with a different level of m and y values assigned to each leak rate and contained fluid.

Note: Code m, y and b values do *not* pertain to full face gaskets.

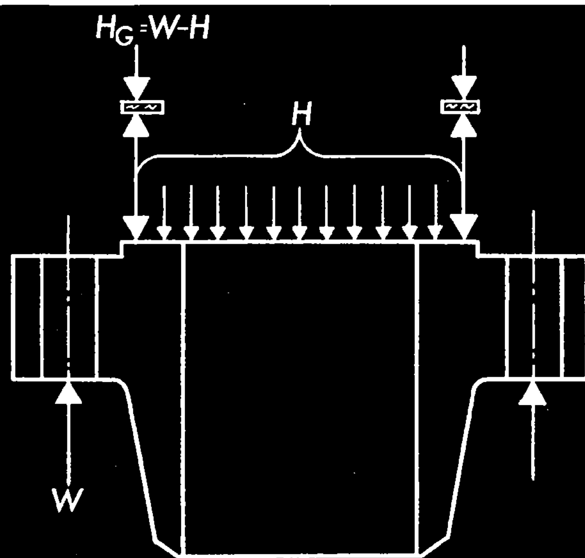

Fig. 4

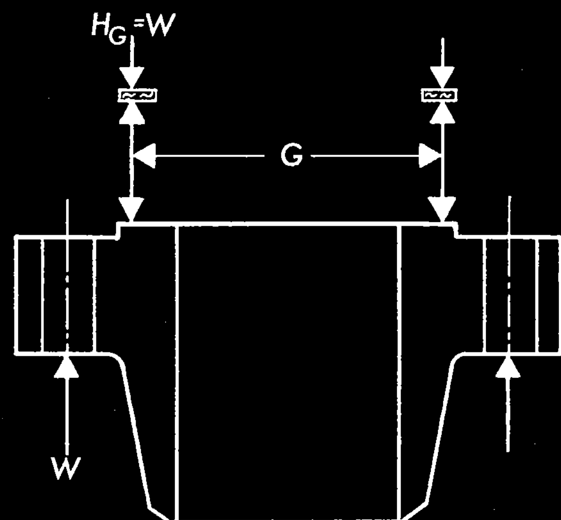

Fig. 5

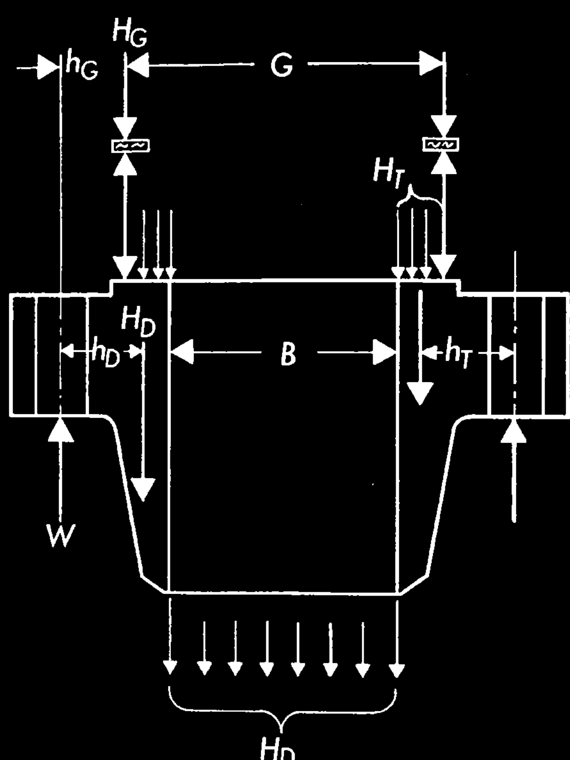

Fig. 6

The Code requires the analysis of two distinct load systems. The first is gasket seating — when there is no internal pressure. To achieve a seal, all facing surface irregularities must be filled with gasket material. This is done with direct force by bolting the flanges. The required seating load is represented by: $W_{m2} = b\pi Gy$ and is illustrated in Figure 5 where the bolt load (seating) is balanced by the gasket reaction.

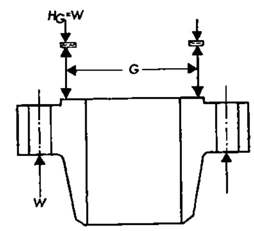

Fig. 5

The other load system relates to internal pressure and has four forces:

H_D — the hydrostatic end force
H_T — pressure force on the flange face
H_p — the total gasket load required to maintain seal
W — the bolt load

The first three forces work to separate the flange pair. They are balanced by the fourth, W, which holds the assembly together. This is illustrated in Figure 6.

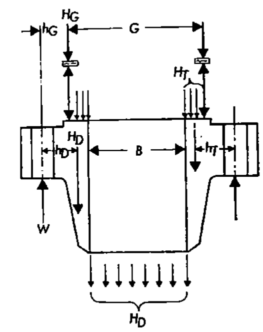

Fig. 6

The hydrostatic end force H_D comes to the flange from the closed end of the pipe system to which it is welded. The end force reaches the flange through the hub, and pulls on the ring portion of the flange mid-hub at its large end if it is a tapered hub.

The fluid pressure force H_T acts directly on the face of the flange where it is exposed. For a gasket covering the entire raised face in Figure 6, H_T would equal zero, but as a conservative allowance, leakage is assumed to be possible as far as G. The H_T force acts on a circle half-way between B & G.

The gasket load, $H_p = 2b\pi GmP$ where gasket factor m relates the required gasket stress *at* design pressure P *to* that design pressure. For example, an m factor of 3 means that the residual gasket stress at P must be at least $3P$ for the joint to be tight.

In order to calculate the moment acting on a flange, the forces are multiplied by the appropriate lever arms which are measured from the point of force application to the bolt circle. The forces and the lever arms indicated in Figure 6 are for an integral flange.

The gasket reaction load is generally assumed to decrease as internal pressure is applied. The actual change is affected by flange rotation, bolt stretch, and the gasket's ability to resist and recover from compression. Bolt loads frequently change too, for the same reason. They must be retightened, especially when gasket relaxation or creep occurs.

All of these variables may be explained by the following illustration. Let a pair of flanges be represented by two steel bars placed side by side as in Figure 7, page 20; they are separated by blocks, as shown, which represent the gasket, and forces W at the ends of the bars represent the bolt loads, which are balanced by opposite reactions at the blocks. Under the action of the "bolt loads" the bars are pulled together at their ends, the amount of deflection can be calculated by formulas in engineering handbooks. Consider now two cases: