European Sealing Association e.V.

Tightness in Gasketed Flanged Unions

PART 1: The Background and the Challenges

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1- Background

Industrial fluid handling systems are equipped with flanged connections to assemble and interconnect their reactors, vessels and piping lines. Traditionally their design, calculation and execution have focused on assuring their mechanical stability and integrity, without consideration to the degree of tightness and leakage. The gasket selection process was made by its capacity to withstand the pressure and temperature conditions and chemical compatibility to the media being handled, ignoring any quantification of its sealing capacity.

Three developments have brought a change in the approach to these issues:

- New materials replacing asbestos.
- Growing concern about fugitive emissions to the environment.
- New standards approved for the design, calculation, operation and maintenance of pressure equipment in industrial processes.

2.- Traditional calculation methods

The most extensive is the ASME Boiler and Pressure Vessel Code, Section VIII, based on previous work done by the Taylor Forge Company. Most of the European national codes are based on this, including Chapter 11 (Flanges) of the present European Standard EN 13445-3 for unfired pressure equipment design, which contains in Annex G, an option to new calculation methods. However the ASME Code, Section VIII method is only concerned with the flange and bolt stresses, without regard to external loads from the flanged connection such as pipe bending stresses. This method requires two gasket factors for calculation of the bolt stresses:

Factor **y** Stress required to close gasket porosity and ensure conformity with the flange face. (This is not the required assembly stress which will be defined by the new standards).

Factor **m** Gasket factor or tightening factor. Multiplier to be applied to the internal fluid pressure to obtain the necessary working gasket surface seating pressure.

The code itself contains Table 2-5.1 with **m** and **y** values for different types of gasket materials, many based on asbestos fibres. Factors **m** and **y** were taken from Rossheim & Markl paper, "Gasket Loading Constants", published in the September 1943 issue of Mechanical Engineering. The ASME Code makes clear that the gasket stresses (surface pressures) obtained from the **m** and **y** values are only valid for the flanges and bolts mechanical calculation and do not ensure sealing. In fact the calculation is made without reference to a tightness level, as if a gasket could have only two possible solutions, leak or no-leak.

Factors **m** and **y** take an important place in design calculations. In 1979 an ASTM F586 standard was introduced to give experimental support to these factors. However, it was too late. The need for a complete change of theoretical system and the PVRC moves in that direction stood in the way. ASTM F 586 was subsequently withdrawn in 1998.

3.- Traditional materials

From the introduction of the **m** and **y** factors in 1943 until the 70/80s, depending on the country, the types of gasket materials available could be classified in three general groups:

a) Metallic gaskets

From soft metal sheets to oval and octagonal section rings (RTJ) of mild steel,

stainless steel and other alloys.
b) Semi-metallic gaskets
Spiral-wound gaskets, metal-clad gaskets
c) Non-metallic gaskets (Soft gaskets)
They range from rubber and cellulose based materials to compressed asbestos fibre (CAF) made by calendaring a mix of asbestos fibre and elastomeric binder.

4.- New materials: Graphite, PTFE and others

In the early 70s two new materials were introduced, expanded mineral graphite and PTFE. Their particular properties offered distinct advantages and the subsequent restrictions on the use of asbestos encouraged their use. The development of a new generation of asbestos-free compressed materials followed, based on aramid, carbon and mineral fibres. More recently mica-based sheet materials are being used in high temperature applications. Their properties are very different from those of CAF, a "universal" material which could accommodate a wide range of service conditions. In contrast, the new materials, even if they could exceed asbestos performances in specific applications, require very restricted and precise fitting and service conditions. Asbestos has been replaced by a range of products, not by a single "universal" one. The new materials brought a complete change in soft gasket technology and made a small but important impact on the semi-metallic gaskets. Not surprisingly the **m** and **y** factors in the ASME code table, based to a large extent on asbestos materials, were seriously questioned, leading to a new approach in the design and calculation of non-asbestos gasketed flanged connections.

5.- Emissions and fugitive emissions

The importance of environmental protection in present and future industrial activity is self evident. Specific European Legislation is presently in force. Besides extreme cases covered by the Seveso II (96/82/CE) and Seveso III (2003/105/ CE) Directives the central piece of legislation is Directive 2010/75/EU dated 24 November 2010 on Industrial Emissions, which re-defines seven earlier Directives related to industrial emissions, into a single clear and coherent legislative instrument. This includes the IPPC

(integrated pollution prevention and control) Directive, the Large Combustion Plants Directive, the Waste Incineration Directive, the Solvents Emissions Directive and 3 Directives on Titanium Dioxide and contains provisions covering the inspection of industrial installations, the review of permits, reporting on compliance and protection of soil.
A definition for fugitive emissions was given on the 1995 ESA Conference on the Control of Fugitive Emissions: "A fugitive emission is any chemical (or mixture of chemicals), in any physical form, which represents an unanticipated or spurious leak from anywhere on an industrial site". At that Conference, the estimate for all the USA of "equipment leaks" from pumps, valves and flanges amounted to 300.000 tonnes per annum or 1/3 of the total emissions of organic compounds in the oil and chemical industries. European estimates point to fugitive emissions as responsible for up to 50 % of all VOCs (Volatile Organic Compounds) emissions from oil refining[1].

[1] Definition of a "Fugitive Emission", Dr. Brian S Ellis, European Conference on Controlling Fugitive Emissions, Antwerp, 1995

The main process industries, with large and critical populations of pumps, valves and flanges on diverse equipment, face the challenge of fugitive emission control using as their main tool the LDAR (Leak Detection and Repair) programmes.
The Oil and Gas Refineries BREF (Best available technique REFerence document) Note states: "the only real option is the implementation of a permanent (LDAR) programme." The LVOC (Large Volume Organic Chemicals) BREF Note coincides in recommending LDAR programmes with specific suggestions on maintenance and improvements of sealing elements.
LDAR programmes started in the USA after the 1990 Clean Air Act Amendments and based on the EPA 21 "sniffing" method for detection of excessive leakage. This method is not aimed at a quantitative determination but to identify excessive concentrations near equipment units.
LDAR programmes are being established and growing in Europe to comply with the IPPC Directive and BREF Notes requirements. Progress varies across its member states. The German requirements of TA-Luft, and guidance given by VDI 2200, 2440 and 2290 rely more on type approvals, adoption of specific sealing materials and proper calculation according EN 1591-1.
The European Sealing Association members are active in this field. One important result of their joint work is the ESA BAT (Best Available Technique) Guidance Note, in itself a draft for a possible Horizontal BREF on Sealing.

6.- New pressure equipment calculation standards and new gasket testing methods

These will be the subject of two future articles that will be published on these pages.

The European Sealing Association (ESA) has produced this article as a guide towards Best Available Techniques for sealing systems and devices. These articles are published on a regular basis, as part of their commitment to users, contractors and OEM's, to help to find the best solutions for sealing challenges and to achieve maximum, safe performance during the lifetime of the seal. The ESA is the voice of the fluid sealing industry in Europe, collaborating closely with the Fluid Sealing Association (FSA) of the USA. Together, they form a key source of technical information on sealing technology, which is the basis for these articles. For more information, please visit www.europeansealing.com