European Sealing Association e.V.

Valve packing characterisation and design

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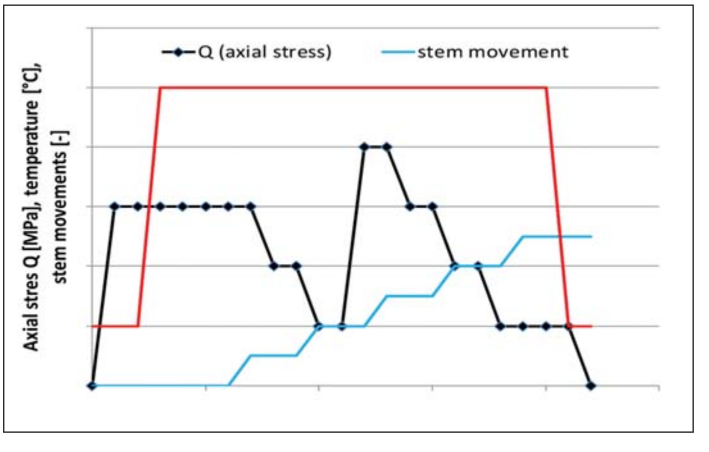
There is an increasing demand from valve end users for low emission sealing systems, but it remains important that the valve continues to move smoothly and efficiently. Since the frictional load of the stem packing has a contrary effect on these two requirements, valve and valve packing manufacturers are challenged with respect to the prediction and improvement of packing behaviour in a valve.
This is the reason that the European Sealing Association (ESA), in collaboration with the Fluid Sealing Association (FSA) and the Fluid Equipment Committee of French research house CETIM (a working group composed of French valve and sealing product manufacturers who initiated this program) are developing a tool to predict the initial packing tightening force that is required to reach certain characteristics in relation to friction and sealing performance.
A European Standard is already in place for flanges that allows end users and engineering firms to engineer a bolted flange connection in such a way that the minimum leak rate is being achieved at minimal cost. Calculation method EN1591-1 has been developed to predict flange behaviour through mechanical calculations. The parameters on which this method feeds are being generated by EN13555 gasket parameters tests. However, unlike this situation for flange gaskets there is no current standardized method that characterizes valve stem packing parameters, such as mechanical behaviour, friction, sealing performance versus packing load, in a similar way.
Several emission standards have been developed in the last 2 decades that test either the valve or valve packing for their fugitive emissions tightness. The German VDI2440, the American Petroleum Institute's API622 and API624 and the international ISO15848-1 are all standards that measure valve or valve packing leakage under a certain set of given conditions such as temperature, pressure and mechanical cycles. These standards however, do not model packing behaviour. On the other hand, calculation methods have been developed to model the behaviour of mechanical packing, but these have never been linked to actual leakage and mechanical behaviour of the packing in a real stuffing box.
This is why the initiative has been taken to develop this new calculation tool for valve packing. The development project for this new tool consists of a calculation part and a parameter testing part.

Calculation Method

The calculation method that predicts the behaviour of packing in the stuffing box is simplified in a realistic way to assure the practicality of the method.
Each ring is characterized individually and the possible interaction between rings is not taken into account. Gland deformations and gland misalignment are not taken into account; packing and Live Loading Systems are considered to have deformation but the other valve components are considered to have an infinite rigidity. Pressure end thrust is considered in two ways to ensure integrity of the system under all circumstances. First of all it is considered that the pressure acts on the gland bottom directly and secondly it is considered that the pressure acts on the bottom of the packing set. Packing creep is evaluated to simulate volume loss of the packing set and also the thermal expansion and contraction of the different elements of the system are considered including their effects on the mechanical behaviour of the components.

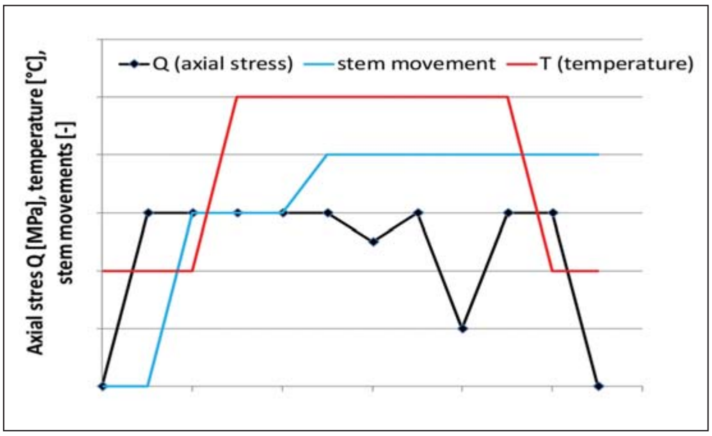
The principle of the calculation can be summarized in 2 major steps:

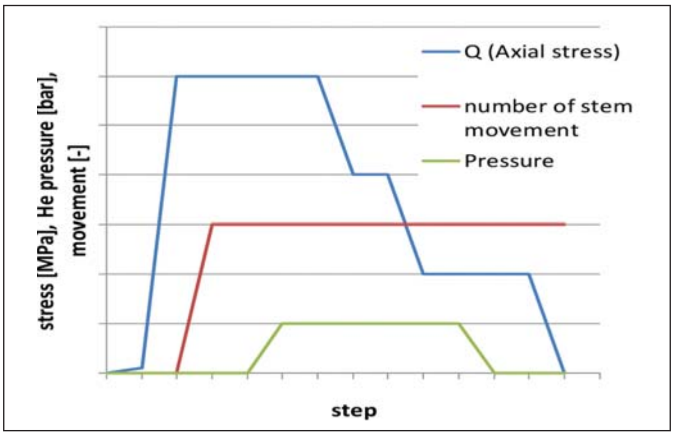
- The calculation of the required initial bolt load to fulfil the tightness criteria in all situations (assembly and operations) and definition of the accuracy of the tightening method that is used.
- The verification of the mechanical integrity of the bolts and the gland flange and a check on the level of packing friction for an initial bolt force corresponding to the upper limit of the tightening range.



Testing procedure

The second part of the project is the development of a testing procedure that determines the packing ring characteristics needed for the calculation method. The mechanical tests are planned to be carried out on individual rings, but the test rigs have been developed to be able to test full packing sets up to 6 rings.
The application of a gland stress Q_A, applying stem movements, heating the stuffing box assembly to the test temperature and then repeatedly reducing the stress while applying stem movements and measuring the friction will generate the ring thickness as a function of applied stress e_p, the dynamic coefficient of friction and the axial force to radial force coefficient of transmission K.
Further testing will generate the ring modulus of elasticity E_R, the relaxation coefficient of the packing ring R_X, the deflection variation over time of the packing ring due to creep Δe_P and the coefficient of thermal expansion of the packing ring α_R.
The last part of the test determines the sealing performance of the packing.
After application of stress on the packing and actuating the stem several times, the leakage is measured by helium mass





spectrometry. Then the stress on the packing is reduced a number of times after which the leakage is measured at the lower stress level. This procedure is repeated several times to determine a reliable relational curve between packing stress and leakage.

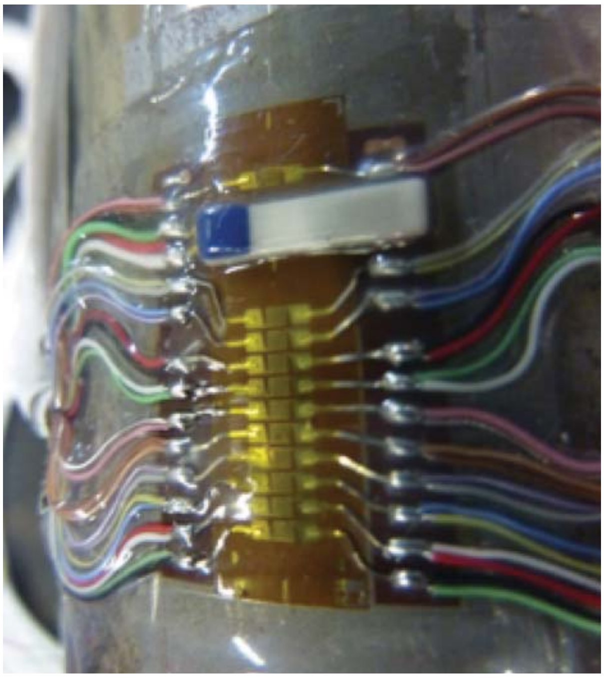
Test bench

The test bench consists of a hydraulic cylinder to actuate the stem, a stem movement transmission section with load or torque sensor and press to apply the gland load and a test cell containing a stuffing box with up to 6 packing rings. The test cell can be interchanged depending on whether leakage or mechanical behaviour is to be measured. The stuffing box is dimensioned and toleranced as defined in API622. The sealing test cell is able to measure the leakage rate of 1″ stem diameter packing for internal Helium pressures up to 8 MPa.
The mechanical test cell allows the testing of a variable number of packing rings. The test cell is equipped with 3 strain gauge chains (positioned at 120° angles), each made of 10 strain gauges to measure the stuffing box external diameter deformation. This enables

determination of the value of the axial to radial contact pressure transfer coefficient (K). The test cell is also equipped with a load sensor to measure the transferred axial load to the bottom of the packing, and 3 displacement transducers positioned at 120° angles to measure the packing deflection.

What does this all mean in the real world?

This testing and calculation method can be used for any type of packing. A valve designer will now be able to use the results of these procedures to predict leakage and friction behaviour of a packing in a valve. This will enable more effective design of the valve and prediction of the packing behaviour. It will predict all the forces that are required to make the packing seal well and optimize design of the valve and in particular the stuffing box, the gland bolts and the gland itself. This will result in savings in material and design costs and avoid potential re-work expense. It will also enable generation of exact installation instructions for that specific valve which will increase the quality of the installation procedure and in the end the performance of the valve in operation.



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