The question has been brought up to us: "What is your attitude regarding a joint project to study the structural integrity of non-gasketed pipe joints built according to the VCF-System?"

Although we ourselves are satisfied, that the load carrying capacities listed in our standards specifications are valid and true -- as they are based on the following experiments -- we are ready and willing to participate in further research.

(1)

In the report ASEA TM 10183, dated 1964-10-08, results regarding an early type of non-gasketed joint, was presented. A pulsating pressure from zero to proof test pressure was applied. After 1,8 million cycles, it was concluded, that the dynamic forces felt by the bolts were small enough for the bolts to endure them.

A joint for pipe OD = 57 mm having a wall thickness = 2 mm, was exposed to bending, while at max. operating fluid pressure. It began to leak at a bending moment = 2,4 kNm what meant 370 N/mm^2 in the pipe wall, equivalent to a stress 40% above its (min. guaranteed) yield limit.

(2)

Wirsbo Bruk performed a study dated 1966-03-17 regarding the effect of reduced flange outside diameter. In the experiment three sizes of an early type of non-gasketed joint were tested both for strength against fluid pressure and for resistance against bending. It was concluded, that the flange outside diameter could be reduced somewhat and that the pipe buckled before the joint opened.

(3)

In 1980 a Functional Test of a Vessel with Compact Flanges in Metal-to-Metal Contact was performed in co-operation with the ASME and under the supervision of Det norske Veritas in OSLO. A VERAX joint for 20 inch pipe with 2 inch wall thickness, rated at 1'500#, was studied regarding the integrity of its 24 bolts M42.

In the experiment it was demonstrated, that the desired bolt preload readily could be achieved by using hydraulic stud tensioners. The forces felt by the bolts actually went down by 3% on an average as

the pressure went up to above max. working pressure.

A special device, which was used, indicated that at 400 bar the flanges separated 0,0006 mm at their inside edges. The results have been published in the Welding Research Bulletin 262, October 1980. Copies from the full report are available from the DnV Library under project nr: 755603.

(4)

In the doctorial dissertation LiTH 130, the results from appr. five years of research are available. A Finite Element Analysis demonstrated, that in the flanges in a non-gasketed joint, there are no tensile stresses as high as in the pipe proper. This simple fact has been explained also by means of a theoretical experiment published in Proceedings of the IMechE, 1989, Vol. 203, nr E2, pages 135-138, LONDON, UK.

By actual measurements using bolts equipped with strain-gauges, it was shown, that the influence on bolt integrity from external loads in a properly built non-gasketed joint, is 2% or less.

In this study one experimental vessel was exposed to excessive pressure and one to bending. In both cases the pipes failed, but not the joints.

(5)

In the years 1985-1988 six vessels built to the same drawings as above, were tested by some research insti-tutions in an effort to verify the results reported in the dissertation LiTH 130.

- University of Witwatersrand, professor D Marcus, JOHANNESBURG, Union of S Africa
- Raymond Engineering, John Bickford, MIDDLETOWN, CT, USA
- Ruhr-Universität Bochum, professor F Jarchow, BOCHUM, Germany
- University of Illinois, professor G E O Widera, CHICAGO, ILL, USA
- University of Strathclyde, professor T G F Gray, GLASGOW, Scotland
- Teknologisk Institutt, Josef Olsen / Jan Chris-tiansen, OSLO, Norway.

Their reports all confirm the results from the main experiment in the LiTH 130.

(6)

The force felt by one bolt equipped with strain-gauges, in a VCF-joint was measured and recorded, date 1993-12-15. It clearly did show, that in a properly built VCF-joint a perfectly static mode does rule. It was concluded, that as there is no gasket to blow or wear and as bolts are exposed to pure static load, the joint is prefectly safe and sound. Providing that it was properly made and assembled, then it can not possibly fail.

(7)

In 1993 a small vessel with a 2'500# VCF-joint in the middle was built from pipe 60,3*11. It was tested for leakage by using a mass spektrometer and Helium. The result showed, that at least 500 years would pass before 1 gram of He would have escaped. Such low leakage was achieved by having flange surfaces coated with a thin layer of pure gold.

The same vessel then was tested for strength. At 1'683 bar, the pipe OD had yielded 1 mm, while the test rig could go no higher. The VCF-joint stayed intact.

(8)

In October 1995 a few vessels having VCF-joints in the middle, were taken to the BOFORS proving grounds, charged with rocket propellant and blown up. In all tests the VCF-joints stayed intact although the pipes yielded / burst. A copy of a video-recording of the events is available upon request.

(9)

At this moment, an independent evaluation of modern, flanged pipe joints is under way at the University of Strathclyde in GLASGOW. After an extensive FEM study, a final part to verify the results by experiments, now is under way. Various measurements of displacements resulting from fluid pressure, axial load and bending have been be made. Possibly the results will be made public.

(10)

In case the results from the research listed above are considered inadequate, VERAX is ready and willing to engage in any study of the structural integrity of VCF-joints. In such a case we presume, that we may supply the VCF-joints to be tested and that the total cost of such a study will be shared by the parties sponsoring it.

Any comment is welcome.

Jan Webjörn

