In order to establish the risk of malfunction of a VCF-joint, because of damage to the contact surface of a flange, the following analysis is presented.

(1) Introduction

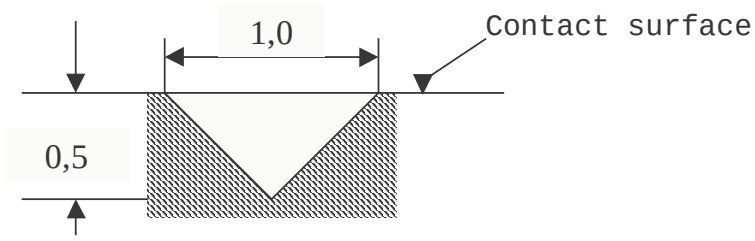
The aim is to estimate the probability and the consequences of damage to the contact surface of a VERAX flange. In case it has been dropped to the floor, a dent plus a bulge can have resulted. It follows, that the bulge may create a clearance between the surfaces, such that they don't seal. Such a case may be prevented by the inspection to make certain that surfaces are not damaged and the removal of bulge before assembly of the joint. The lighter the joint, the easier the handling, the smaller the probability of damage.

A scratch does present a second type of damage, if it has been formed across the contact surface, all the way from the inside and out. By applying the laws of hydrodynamics (by Daniel Bernoulli, 1700-1782, professor in Basel) to some specific case, it ought to be possible to reach a conclusion about the consequences of such a damage.

(2) Case

As a typical case the study is performed re: a non-gasketed, flanged pipe connection acc. to VERAX Standard VCF 105, rated at 1'500 lbf/in^2, i.e a DN 150, 6 inch joint for 168 mm pipe outside diameter. Flange O.D = 236 mm. Max working pressure 266 bar.

It is assumed, that a major scratch would be triangular, 0,5 mm deep, and 1,0 mm wide at its base, viz. at the flange surface. The cross-sectional area of such a scratch is 0,25 mm^2 and its equivalent diameter is 0,59 mm.



$$\text{Cross section area } A = \frac{0,5 * 1,0}{2} = 0,25 \text{ mm}^2$$

Equivalent diameter

$$d_e = \frac{4,0 * 0,25}{(1,0 + 2 * 0,5 * \sin 45^o)} = 0,59 \text{ mm}$$

(3) Calculations

In case there is a pin-hole of a diameter = 0,59 mm in the wall of a vessel where the pressure is = 266 bar, then the velocity of fluid flow through it will be = 230 m/s.

Flow velocity via pin-hole

$$v_0 = \sqrt{\frac{2 * 266 * 10^5}{1000}} = 230 \text{ m/s}$$

Assuming, that water at +20°C is the fluid, its kinematic viscocity = 1,01E-06 m^2/s then the Reynolds number R_e = 0,15 is arrived at.

$$\text{Reynolds number } R_e = \frac{230 * 0,59 * 10^{-3}}{1,01 * 10^{-6}} = 0,15$$

It is concluded, that the flow is laminar, as turbulent flow does appear only if the R_e number is above 2'320.

In such a case, 207 kg of water would escape in an hour.

Resulting flow q_0 = 2300 * 0,25 * 10^{-4} * 1000 =
= 58 g/s
= 207 kg/h

Now the assumed scratch, that does form the channel, is 40 mm long. Then the friction against flow does reduce the velocity of leakage, such that it becomes appr. = 1,8 m/s what means a flow = 0,46 g/s = 1,6 kg/h

Flow in the channel

$$V_1 = \left[\frac{266 * 10^5}{10^3 * g} * \frac{0,15}{64} * \frac{0,59}{40} * 2g \right]^{1/2} = 1,8 \text{ m/s}$$

Resulting flow q_1 = $18 * 0,25 * 10^{-4} * 1000$ =
= 0,45 g/s
= 1,6 kg/h

(4) Remedies

If a major scratch on a contact surface of a VERAX flange has been detected at assembly, there are simple means to correct it. The simplest is to fill it with a smear of Loctite 510 or similar, of a RTV Silicone compound or such.

(5) Recommendation

It is recommended, that an experiment be performed using a vessel with a VCF-joint, having a flange with a defined scratch across its contact surface, on purpose made to precise dimensions, such that its efflux can be studied under controlled conditions, in order to verify the above calculations.

In general we recommend, that the men working with the building of piping systems, be educated and trained for the assembly of VCF-joints, plus that precautions be taken to eliminate the kind of damage referred to.

(6) Conclusions

Although it is difficult to specify what consti-tutes a "major leak" -- considering that leaks of 1000 kg/hour have been reported -- it may be concluded, that even a major scratch will result in a minor leak.

The probability of damage to the contact surface of a VERAX flange is judged as reduced relative to that of conventional flanges. However,

it is concluded, that the occurrance of such can be significantly reduced by offering the men working with the installation of VCF-joints, thorough education and training.

(7) Epilogue

Any comment, objection, correction or such to the above, is invited and will be welcome.