Fire Integrity of Flanges

The main hazard of an onshore or offshore oil & gas installation is leakage of flammable and/or explosive substances. All installations are exposed to leakages – every year. Gas detection systems and Ex-rated equipment as well as strict routines relating to hot work reduce the risk of ignition to a level as low as possible.

Most leakages originate from flanges or fittings. The more severe the operating conditions are the more likely a leakage is.

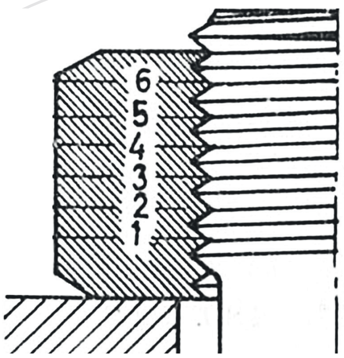

Figure 1 - Illustration of bolt/nut connection in flanges.

Flanges are not only a main concern regarding leakages. Flanges are also a major concern regarding escalation of a possible fire. Bolts are subject to pre-tension, and the load is carried by the threads. Bolts will easily lose their load-bearing capacity when exposed to heating. If the steel reaches its yielding temperature, a rupture and a leakage might occur. Figure 1 illustrates the bolt/nut connection, and Figure 2 presents the load distribution on the connecting threads.

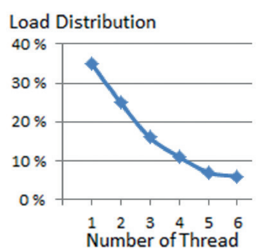

Figure 2 - Load Distribution on threads.

Petrell has for several years worked with modelling and simulation of flanges exposed to fire. In a project sponsored by Statoil, Petrell and SINTEF's fire laboratory (SINTEF NBL) both ASME flanges and compact flanges were tested in the laboratory followed by simulations.

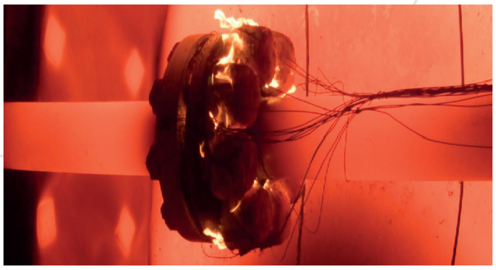

Figure 3 - Jet fire test of flange.

Figure 3 shows a compact flange exposed to jet fire. Tests were performed with and without fire protection of the nuts and bolts.

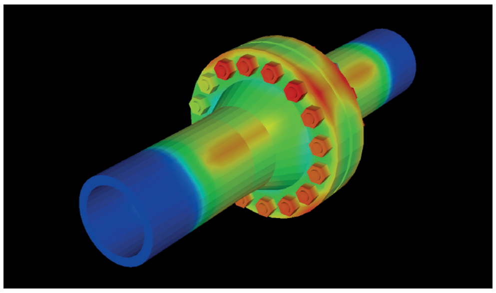

Figure 4 - An ASME weld-neck flange exposed to jet fire. Simulation performed with use of Brilliant.

Figure 4 shows a model without passive fire protection, and Figure 5 shows a model where all except one bolt/nut is fire protected.

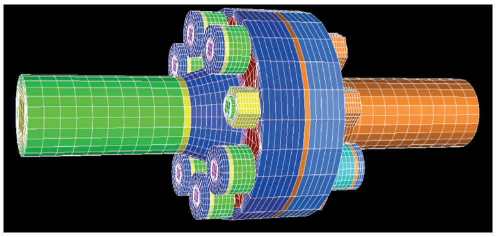

Figure 5 - A Compact weld-neck flange exposed to jet fire.

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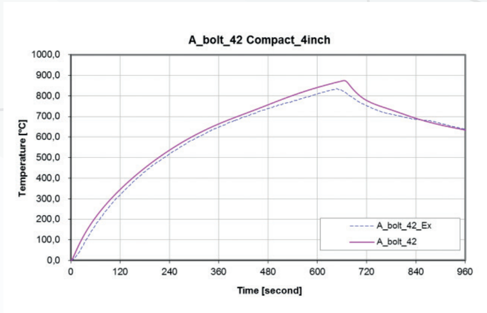

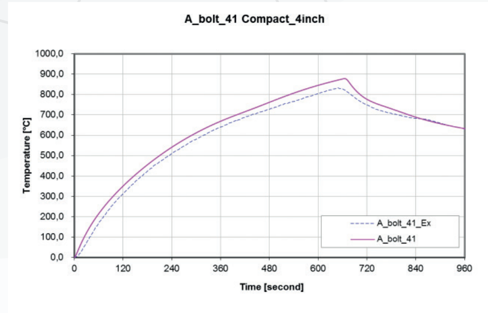

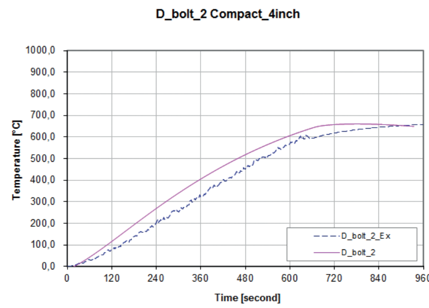

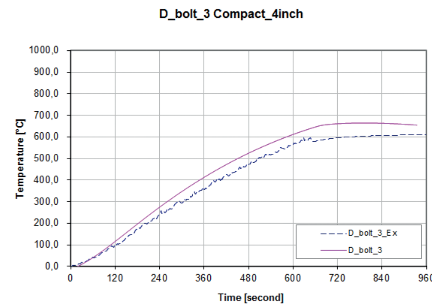

The figures above present temperature development in bolt/nut threads for a 4 inch compact flange. Simulated results from Brilliant are in pink and experimental results from fire testing are in dotted blue. Figure A_bolt_42 and A_bolt_41 presents temperature development without passive fire protection (PFP) and figure D_bolt_2 and D_bolt_3 presents results with PFP on the nuts. The heat load is about 200kW/m2. As the graphs show, there is good correlation between Brilliant and the fire test.