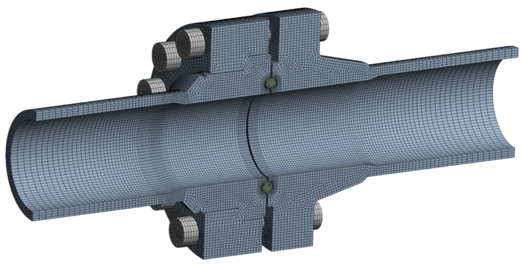
API FLANGE CAPABILITIES UNDER COMBINATIONS OF LOAD

API 6A (ISO 10423) 6BX flanges are used extensively in high pressure sub-sea oil and gas installations. The ability of these flanges to transmit bending moment and axial tension when correctly made up is given in the capacity charts provided in API 6AF for service temperatures up to 121°C, adequate for most services. When carrying out calculations to substantiate the design of these flanges FCL are often questioned as to why the predicted capabilities to transmit bending moment an axial tension are significantly less than expected based on the charts in API 6AF. This case study identifies the principal reasons for this reduction in capability, i.e. material selection, line pipe dimensions and cathodic protection of flanges in duplex stainless steels.

API defines the strength characteristics of materials employed in the flanges based on their tensile and yield strength at ambient temperature. Materials are grouped into four strength designations, 36K, 45K, 60K & 75K and API identifies the strength designation associated with different flange ratings. Thus for 5000, 10000 and 15000 psig rated flanges API requires that materials of strength designations 45K, 60K and 75K respectively are employed. Materials commonly used in sub-sea applications are carbon steels, A694 F52 and F65, as well as duplex and super duplex stainless steels A182 F51 and F55. These materials have strength designations of 36K, 45K, 60K and 75K respectively. Thus it can be seen that strictly only flanges in super duplex stainless steel are of sufficient strength to be used in 15000 psig rated flanges and that A694 F65 can only be used for flanges rated at 5000 psig. Use of a weaker material will obviously reduce flange capability.

API flanges are designed with bores which are equal to the nominal flange size and not to be matched with standard B36.10 pipe sizes which generally results in a flange with a reduced bore. Reducing the bore of the flange increases the bending moment developed in it and can leads to higher stresses and a reduction in capability.



Flanges in duplex and super duplex stainless steels installed sub-sea are susceptible to Hydrogen Induces Stress Cracking (HISC) if afforded cathodic protection. To minimise the risk of HISC reduced stress limits are imposed in DNV-RP-F112. These limits depend principally on the austenite spacing found in a micrograph of the material and the location under consideration with respect to the weld between the flange hub and line pipe. In general terms DNV-RP-F112 requires that the membrane plus bending stress is limited to approximately two thirds of the material yield strength at temperature. Following rules in ASME Section VIII Division 2 Section 4.16 the allowable longitudinal hub stress is equal to the yield strength of the material when API stress limits are adopted. The DNV recommended practice reduces the allowable stress by one third. It is also necessary to account for the additional bending stress at the hub to pipe weld as a result of misalignment, including that which is within the tolerance prescribed in the adopted piping code, which will reduce flange capability still further.

It can therefore be seen that these three factors play a significant part in reducing the capability of API flanges below that given in API 6AF, particularly for those in duplex and super duplex stainless steels when used sub-sea. While code calculations can be used the use of FE stress analysis is recommended to maximise flange capability particularly where stress limits prescribed in DNV-RP-F112, which are based on linearised stresses from such analyses, are to be satisfied.

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