Flange Leakage Analysis

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Abstract— With the current market scenario, all the projects that we do are highly Schedule driven. And to help us meet this crucial deadline, we are utilizing various technologies and high-end software's. But seldom we do a backhand check, if the result delivered by these software's are accurate and if it takes care of all the requirements as mentioned in the code. In this paper, we are discussing about two different topics concerned to Flange leakage analysis done using Autopipe Stress Analysis Software. The first part is, if this software performs flange leakage calculation as per the code requirement that all calculations shall be made on dimensions in the corroded condition. And the second part is, if the software takes the Allowable for Austetic stainless steel and Nickel alloys pipe flanges as per the code requirement.

Index Terms— Flange Leakage Calculations, Flange Analysis, Rules for Bolted Flange Connections, Flange Corroded condition, Allowable for Austentic Stainless steel and Nickel Alloys, Autopipe, Piping Stress Analysis.

1 Introduction

FLANGE leakage calculation is a mandatory code requirement for all critical systems in a plant. In spite of tight bolted connection between flanges, these flange joints will experience bending moment as a result of thermal growth of the piping and / or excessive deflection, which will try to open up the flange joint. Whether the given flange is capable of absorbing the external forces and moments along with the internal pressure due to the fluid, is calculated by stress engineers to ensure safety of the plant.

The flange leakage calculation can be performed in many ways, the most common are Equivalent pressure method, ASME Sec VIII Div 1 or 2 and ASME Sec III NB or NC method. This paper deals about Flange leakage calculation done using ASME Sec VIII method in Autopipe software.

2 Flange Leakage in Corroded Condition

2.1 Code Requirement for Analysis

As per ASME Sec VIII Div 1, Flange leakage calculations are presented in Mandatory Appendix 2 (reules for Bolted Flange connections with Ring type gaskets). As per Clause 2.1 of this appendix, "All calculation shall be made on dimension in the corroded condition". And the same requirement is specified in clause 4.16.2.3 of ASME Sec VIII Div 2. Hence as per ASME code, we have to consider the corroded condition for Flange leakage calculations i.e. reduced thickness and increased inside diameter of the Flanges.

2.2 Autopipe Analysis

While performing flange leakage calculation as per ASME code in Autopipe, it does not consider the internal diameter of the flanges after deducting the corrosion allowance. And users too do not have an option to change it manually. Even after defining the flanges as a non standard flange, users are allowed to change all the other flange properties except the flange inner diameter, which is taken automatically from the pipe data that we have provided. And this un-corroded inner diameter of the flanges is used for the further calculations.

2.3 Interpretation

It is advisable to do the flange leakage calculation using CII or manually using an excel sheet as per ASME formulas' for Flange leakage calculations. As a minimum, the flanges which are qualified marginally, or (say) above 90% as per Autopipe calculation are to be re-verified, so that the results that we deliver are according to the code requirements.

3 Allowables For Flange Leakage Calculation

3.1 Code Requirement for Analysis

As per code ASME B31.3, Note 4a, to Appendix A tables, states that the stress values printed in italics exceed two-thirds of the yield strength at temperature and values printed in boldface are equal to 90% of yield strength at temperature.

Further, Paras 302.3.2(d)(3) and 302.3.2(e), for Autentic stainless steels and nickel alloys, the allowable provided in Table A-1 of code, is the lowest of the two-thirds of S_Y and 90% of the yield strength at that temperature. But application of these stress values is not recommended by code for the flange joints in which slight deformation can cause flange leakage or malfunction. Please refer Fig 1 for snap shots of the applicable paras from ASME B31.3 code.

Hence as per the code, if the allowables are printed in italics or bold face, code recommends to use either 75% of the stress value printed in Table A-1 (or) two-thirds of the yield strength at temperature listed in the BPV code, section II, Part D, Table Y-1.

The above mentioend statements are applicable as per ASME Sec VIII Div 1 and Div 2 also.

Para 302.3.2 (e), Application Limits :

(e) Application Limits. Application of stress values determined in accordance with para. 302.3.2(d)(3) is not recommended for flanged joints and other components in which slight deformation can cause leakage or malfunction.

(1) These values are shown in italics or boldface in Table A-1, as explained in Note (4a) to Appendix A Tables. Instead, either 75% of the stress value in Table A-1 or two-thirds of the yield strength at temperature listed in the BPV Code, Section II, Part D, Table Y-1 should be used.

Para 302.3.2(d)(3) :

(d) Other Materials. Basic allowable stress values at temperature for materials other than bolting materials, gray iron, and malleable iron shall not exceed the lowest of the following:

(1) the lower of one-third of S_T and one-third of tensile strength at temperature

(2) except as provided in (3) below, the lower of two-thirds of S_Y and two-thirds of yield strength at temperature

(3) for austenitic stainless steels and nickel alloys having similar stress–strain behavior, the lower of two-thirds of S_Y and 90% of yield strength at temperature [see (e) below]

Fig. 1 – Snap from B31.3 code

3.2 Autopipe Analysis as per B31.3

While selecting the flange material library as B313-12 in Autopipe Flange leakage program, as shown in Fig. 2 below. Allowables are directly fetched from Table A-1 of B31.3. Software doesnot check if the allowable values printed are in Italics or Boldface. Hence for Austentic stainless steel flanges and Nickel alloy flanges, the allowables needs to be checked manually from code and fed into Autopipe.

Attachment	Joint Efficiency Factor	Lap Contact OD mm	Ring Type	Reverse	Flange Material Library	
Integral			None	☐	ASME Section VIII Div. 1	NS
Integral			None	☐	ASME Section VIII Div. 1	A106-I
Integral			None	☐	ASME Section VIII Div. 2	A106-I
Integral			None	☐	B313-12	A106-I
Integral			None	☐	B313-12	A106-I
Integral			None	☐	B313-12	A106-I

Fig. 2 – Snap from Autopipe flange leackge program

3.3 Autopipe Analysis as per ASME Sec VIII

While selecting the Flange material library as ASME Sec Div 1 or Div 2 in Autopipe Flange leakage problem as shown in Fig. 2.

Allowables are fetched from Table 1A of ASME Sec II, Part D, but Autopipe gives you different options for the same material as shown in Fig. 3 below.

Ring Type	Reverse	Flange Material Library	Flange Material	Select Material	Di
	☐				
None	☐	ASME Section VIII Div. 1	SA-182-F1	Select	B16
None	☐	B313-12	SA-182-F304H-3		
None	☐	B313-12	SA-182-F304H-4		
None	☐	B313-12	SA-182-F304L-1		
None	☐	B313-12	SA-182-F304L-2		
None	☐	B313-12	SA-182-F304L-3		
None	☐	B313-12	SA-182-F304L-4		
None	☐	B313-12	SA-182-F310-2		
None	☐	B313-12	A106-B	Select	B16
None	☐	B313-12	A106-B	Select	B16
None	☐	B313-12	A106-B	Select	B16

Fig. 3 – Snap from Autopipe for different material options

While choosing a material from the option, manually ensure from the code that there is no note "G5" mentioned against the selected material. A snap of Note G5 from ASME Sec II. Part D is shown in Fig. 4 below

G5 Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66⅔% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction. For Section III applications, Table Y-2 lists multiplying factors that, when applied to the yield strength values shown in Table Y-1, will give allowable stress values that will result in lower levels of permanent strain.

Fig. 4 – Snap of Note G5 from ASME Sec II. Part D

3.3 Interpretation

It is to be noted that the various option provided in Autopipe for the same pipe material has different allowables and different governing notes. As an user we have to manually check in the code and select the correct material for our calculation purpose. And Code has specifically mentioned this difference in allowables only for Austentic stainless steel and Nickel alloy flanges.

4 Conclusion

It is generally noted that the various option provided in Autopipe for the same pipe material is often ignored and users selects the material with higher allowables to qualify the flange leakage calculations. But it is to be noted that these options has its own significance and as a stress engineer it is our

responsibility to select the correct material. And it is also our responsibility to check once and confirm if the calculations done by any Software is following all the requirements mentioned in the applicable codes and standards.

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6 Abbrevations

ASME – AMERICAN SOCIETY OF MECHANICAL ENGINEERS
BPVC – BOILER PRESSURE VESSEL CODE
SEC – SECTION
DIV – DIVISION
NB – SUBSECTIONS IN ASME SEC III
NC – SUBSECTIONS IN ASME SEC III
Fig - FIGURE

7 References

[1] ASME BPVC Sec VIII Div 1 – Rules for construction of Pressure Vessels
[2] ASME BPVC Sec VIII Div 2 – Alternate Rules
[3] ASME BPVC Sec II Part D - Properties
[4] ASME B31.3 Process Piping Code
[5] Bentley Autopipe User Manual