Ramsay Maunder ASSOCIATES *Finite Element Specialists and Engineering Consultants*

Accuracy of Thermal Expansion Properties in ASME B&PV Code

In a recent technical note, [1], the consistency of the thermal expansion data provided in the ASME Boiler & Pressure Vessel Code, [2], was considered and questioned. In particular it was noted that the thermal strain calculated from the mean coefficient of linear thermal expansion provided in [2] did not agree precisely with the thermal strain listed in the adjacent column. For example, taking the value of the mean coefficient of expansion for a temperature rise from 20°C to 50°C from the data shown and highlighted in Figure 1 gives a thermal strain of 10.6x30/1000=0.318mm/m which is about 6% greater than the value listed (0.3mm/m).

TABLE TE-1 (CONT'D) (10)
THERMAL EXPANSION FOR FERROUS MATERIALS

Temperature, °C	Coefficients for 9Cr–1Mo Steels (Including Grades 9, 91, 911, and 92)			Coefficients for 5Ni–¼Mo Steels			Coefficients for 8Ni and 9Ni Steels		
	A	B	C	A	B	C	A	B	C
20	10.5	10.5	0	11.2	11.2	0	9.9	9.9	0
50	10.8	10.6	0.3	11.6	11.4	0.3	10.5	10.2	0.3
75	11.0	10.7	0.6	12.0	11.6	0.6	11.1	10.5	0.6

Figure 1: Sample data taken from ASME Boiler & Pressure Vessel Code (p709)

The practising engineer is left with a predicament it he/she wishes to use the most accurate value available. It is clear that as the thermal strain, being the quantity that is measured during experiment, is the basic data from which the coefficients of expansion have been derived. It is also clear that some processing of the thermal strain data must have taken place in order, for example, to provide single values of the instantaneous coefficients of expansion at the given temperatures.

As the thermal strain is listed with only a 1 decimal place accuracy the engineer cannot assess the accuracy of the thermal strain calculated from the coefficients of expansion, i.e., in the example given above is the thermal strain of 0.318mm/m more accurate than 0.300mm/m?

If one accepts that the thermal strain listed could be ±0.05mm/m different from the value shown then the accuracy of a 1DP representation of the thermal strain decreases as the thermal strain becomes smaller. For 0.3mm/m the accuracy is ±16.6'%.

A practical engineering example where the thermal expansion is important is the case of a shrink fit between a shaft and a bearing. If the materials for both the shaft and the bearing have a thermal strain known only to ±16.6'% then the fit between them could, in the worst case, only be accurate to about 2x16.6'%, i.e., about 34%. Whilst engineers are accustomed to working with approximate data, this level of inaccuracy would, at first sight, appear to be beyond even that which might be considered acceptable to most engineers.

Presumably thermal strain can be measured to a greater accuracy than presented in the ASME tables and the question arising from this technical note is whether or not ASME should present thermal strain to a higher level of accuracy.

References

[1] Angus Ramsay, ANSYS/ASME: Potential Issue with Thermal Expansion Calculations, Technical Note, July 2017.

http://www.ramsay-maunder.co.uk/knowledge-base/technical-notes/asmeansys-potential-issue-with-thermal-expansion-calculations/

[2] ASME Boiler & Pressure Vessel Code, II, Part D, 2010.