Contents

Overview	VII
1. Considerations on the avoidance of repeat post-weld heat treatment	VII
2. Design for exceptional internal pressure	VII
3. Minimum nozzle loadings and nozzle design	VII
4. Evaluating creep damage to pressure equipment	VII
5. Fatigue assessment	VII
Considerations on the avoidance of repeat post-weld heat treatment	1
1.1 Introduction	1
1.2 Exemptions from PWHT given in the codes	1
1.2.1 When PWHT is a code requirement	1
1.2.2 When PWHT is a service requirement	3
1.2.3 Further aspects	4
1.2.4 General requirements for welds where PWHT is waived	5
1.3 Example from the power industry	5
2. Design for exceptional internal pressure	7
2.1 Introduction	7
2.1.1 Assumptions	7
2.2 Design methods	8
2.2.1 Service levels	8
2.2.2 Simple design method	8
2.2.3 Advanced design method	9
2.3 Testing	10
2.4 Comparison with EN 14460	11
3. Minimum nozzle loadings and nozzle design	12
3.1 Introduction	12
3.2 Minimum design nozzle loadings	12
3.2.1 General	12
3.2.2 Vessels in ferritic steels, austenitic steels, duplex stainless steel or nickel alloys	14
3.2.3 Vessels in glass reinforced plastic	17
3.3 Minimum pipe schedule and standout for nozzles made from pipe	17
3.3.1 Minimum pipe schedule	17
3.3.2 Nozzle standout	18
3.4 Small bore nozzle design	18

4. Evaluating creep damage to pressure equipment	20
4.1 Introduction/purpose	20
4.2 Affected materials	22
4.3 Critical factors	23
4.4 Design approach	23
4.4.1 Boiler codes	24
4.5 Guidance on assessment of creep damage	24
4.5.1 Basis of assessment	25
4.5.2 Assessment of creep	26
4.5.3 Data required	27
4.5.4 Design /FFS Codes	29
4.6 Inspection	30
4.6.1 Inspection techniques	32
4.7 Repairs	33
5. Fatigue assessment	36
5.1 Scope	36
5.2 Definition	36
5.3 Design and assessment for fatigue	37
5.4 Design methods	38
5.5 Stress	38
5.5.1 Nominal stress methods	38
5.5.2 Structural stress methods	39
5.5.3 Notch stress methods (smooth bar)	39
5.5.4 Hot spot stress methods	39
5.5.5 Differences between the hot spot stress and structural stress	40
5.6 Fatigue management in high temperature applications	40
5.7 Standards and Codes developments	41
5.8 Use of FEA in fatigue assessments	42
5.9 Practical considerations for fatigue assessment	42
5.10 Common design issues	42
5.11 Avoiding failures	43
5.12 Following a fatigue failure	44
5.13 Vibrating equipment	44
5.13.1 Asessment of vibrating equipment	45

References	46
Figures	
Figure 1 Loading convention	13
Figure 2 Design of NPS 1 (DN 25) or NPS 1½ (DN 40) nozzles	
Figure 3 A header with Serious Creep Damage	
Figure 4 Uniaxial strain under constant load	
Figure 5 Classic and Omega model creep curves	27
Figure 6 Creep Bulging under internal pressure	
Figure 7 Tube rupture caused by short-term overheating	
Figure 8 Location of creep induced cracking in welds	32
Figure 9 Susceptibility to cracking in aged HAZs	
Figure 10 Graph showing mean stress	36
Figure 11 Estimated cycles to fatigue failure	37
Figure 12 Extrapolated stress at weld toe	40
Tables	
Table 1 Maximum thickness which may be welded without PWHT	2
Table 2 Requirement for repeat PWHT on clips welded to vessels	3
Table 3 Advanced assessment methods for Levels 1 and 2 based on non-linear behaviour (limit	: load)10
Table 4 Typical maximun allowable nozzle load	14
Table 5 Class 150/Class 300 nozzle design loads with the vessel design pressure not exceeding	3 bar g 15
Table 6 Class 150/Class 300 nozzle design loads with design pressure greater than 3 bar g	15
Table 7 Class 600 nozzle design loads	16
Table 8 Class 900 nozzle design loads	16
Table 9 Minimum design nozzle loadings for vessels in glass reinforced plastic	17
Table 10 Minimum pipe schedule and standout for nozzles made from ferritic steel pipe	18
Table 11 Creep threshold temperature for various materials	22
Table 12 An example of 'Miners Rule'	26
Table 13 Common fatigue assessment standards	38