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Engineering and Operations Committee

AMENDMENT TO: THE DETERMINATION OF END-LOADS TO BE APPLIED IN THE PERFORMANCE TESTING OF END-LOAD RESISTANT MECHANICAL FITTINGS FOR BELOW GROUND

Scope

This amendment has been prepared to extend the scope of this document to include mechanical fittings for use with polyethylene pipes manufactured to WIS 4-32-13 (HPPE pipes). Appendix D contains an example of suitable forces for pull-out tests on fittings on HPPE.

4.1 Replace title with "4.1 Polyethylene pipe (to WIS 4-32-03)/fitting assemblies".

4.1.2.2 2nd line Delete "Polyethylene".

Add:

4.4 **Polyethylene pipe (to WIS 4-32-13)/fittings assemblies.**

4.4.1 *Assumptions*

In order to calculate the maximum end-loads exerted on a fitting due to the stresses in a pressurised SDR11 125mm polyethylene pipe (to WIS 4-32-13), the following assumptions are made:

Maximum working pressure (Pw)	= 16 bar
Maximum site testing pressure (Ps)	= 24 bar
Maximum temperature variation($\triangle$T)	= 40°C
Poissons ratio (v)	= 0.38
Young's modulus (E at 20°C)	= 712 MPa
Coefficient of expansion (K)	= $1.30 \times 10^{-4} C^{-1}$
External diameter (D)	= 125 mm
Wall thickness (t)	= 11.4 mm
Internal diameter (d)	= 102.2 mm
Yield stress (σ_y) (measured at a strain rate of 125% min^{-1} and 23°C)	= 19 MPa (from WIS 4-32-13)

NOTES 1, 2 and 3 from 4.1.1 apply.

4.4.2 *Calculations*

To comply with the definition given in Clause 2, the applied pull-out force, Fy (as given in 4.1.2.1) is required to be equivalent to that which causes yield in an HPPE pipe.

The test forces for pipe sizes from 90 to 1000 have been calculated using the appropriate polyethylene pipe dimensions and assuming a yield stress of 19MPa (see 4.4.1). These are presented in Table D1 of Appendix D.

4.4.2.2 Type 2 fittings

To comply with the definition given in clause 2, Type 2 fittings shall be capable of withstanding the maximum axial forces assumed to be acting on the joint under normal operating conditions. Thus, for assessment of the end-load resistance, a Type 2 fitting shall be considered to be subject to a force equivalent to that induced in a pipeline installed under conditions of maximum temperature change and operated at its site test pressure. The following details the calculations conducted to determine the appropriate test forces.

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(1) $F_L = \frac{p\Pi D^2}{4}$ .....from Equation (1)

$= \frac{2.4 \times \Pi \times 125^2}{4}$

$= 29.452$ kN

(2) $F_R = \upsilon p (D-t)A/2t$ .....from Equation (2)

$= 0.38 \times 2.4 \times \frac{(125-11.4) \times \Pi}{8 \times 11.4}$

$\times (125^2 - 102.2^2)$

$F_R = 18.487$ kN

(3) $F_T = \triangle T.K.E.A$

$= 40 \times 1.3 \times 10^{-4} \times 712 \times \frac{(125^2-102.2^2) \times \Pi}{4}$

$= 15.063$ kN

(4) *Unrestrained end-caps*

$F_{max} = F_L = 29452$ N

Restrained end-caps

$F_{max} = F_R + F_T = 18487 + 15063$

$= 33550$N

Since $F_R + F_T > F_L$ then F_{max} is assumed to be 33.6kN.

F_{max} represents the maximum longitudinal force on a fitting joined to a predicted 16 bar rated, 125mm HPPE pipe restrained at both ends and pressurised to a test pressure of 24 bar.

A Type 2 fitting is required to maintain resistance to end-loads at least equivalent to F_{max}. For a pull-out test to assess the end-load resistance, the applied pull-out test force F should be that which can be induced by F_{max} plus a safety factor (25% has been agreed for current purposes).

NOTE: A margin of safety has already been included in the calculations through the use of site test pressures and the maximum value of $\triangle T$. Only a small safety factor has therefore been added to allow resistance to be maintained during integrity testing of the pipeline.

Using appropriate values of F_{max}, test forces (F) can be calculated for each remaining combination of pipe sizes and classes. All test force values are presented in Table D2 of Appendix D.

APPENDIX D - CALCULATED TEST FORCES FOR TYPE 1 AND TYPE 2 MECHANICAL FITTINGS FOR USE WITH PE PIPES MANUFACTURED TO WIS 4-32-13.

D.1 TYPE 1 FITTINGS

Table D.1 presents the pull-out test forces for polyethylene pipe/type 1 fittings assemblies of nominal sizes over the range 90 to 1000. The properties in 4.4.1 are assumed to apply with the relevant pipe dimensions.

NOTE: For polyethylene pipes whose parameters vary from these assumed values, the criteria in Table D.2 will need to be re-calculated using the appropriate values.

Table D.1 Pull out test forces for Type 1

Nom Size	SDR 11	SDR 17.0	SDR 17.6	SDR 26	SDR 33
90	40.4		25.85		
110	59.69		39.00		
125	77.30		49.97		
160	126.71		81.97	56.92	
180	160.15		103.38	71.29	
225	250.24		162.13	111.09	
250	307.98		199.86	137.76	
280	386.01		250.65	172.00	
315	488.93		317.44	218.77	
355	622.16		401.80	277.14	223.88
400	790.00		511.23	351.33	284.65
450	1000.95		648.51	444.34	359.31
500	1234.38		796.81	548.27	442.66
560	1544.03		999.64	687.99	557.28
630	1955.70		1266.42	871.61	703.54
710			1607.22	1108.58	895.52
800			2040.69	1405.33	1134.10
900			2579.76	1787.30	1437.24
1000			3187.25	2204.09	1770.63

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D.2 TYPE 2 FITTINGS

Table D.2 presents the pull-out test forces for polyethylene pipe/type 1 fittings assemblies of nominal sizes over the range 90 to 1000. The properties in 4.4.1 are assumed to apply with the relevant pipe dimensions.

NOTE: For polyethylene pipes whose parameters vary from these assumed values, the criteria in Table D.2 will need to be re-calculated using the appropriate values.

Table D.2 - Pull out test forces for Type 2 fittings for HPPE pipe

Nom Size	SDR 11	SDR 17.0	SDR 17.6	SDR 26	SDR 33
90	17.39		11.23		
110	25.96		16.84		
125	33.55		21.68		
160	54.98		35.54	24.65	
180	69.55		44.93	31.06	
225	108.67		70.3	48.48	
250	134.03		86.74	59.96	
280	168.08		108.79	75.07	
315	212.78		137.73	95.2	
355	270.42		174.7	120.79	96.63
400	343.33		221.98	153.27	122.76
450	434.69		281.19	193.92	155.2
500	536.46		346.52	239.36	191.43
560	672.32		434.69	300.29	240.49
630	851.12		550.36	380.21	304.06
710			698.8	483.17	386.53
800			887.22	613.06	490.23
900			1122.4	777.43	620.78
1000			1386.07	959.36	765.73