

# ISO/TR 10400:2018-08 (E)

## Petroleum and natural gas industries - Formulae and calculations for the properties of casing, tubing, drill pipe and line pipe used as casing or tubing

---

<b>Contents</b>		<b>Page</b>
Foreword .....		vi
Introduction .....		vii
1	Scope .....	1
2	Normative references .....	2
3	Terms and definitions .....	2
4	Symbols .....	4
5	Conformance .....	13
5.1	References .....	13
5.2	Units of measurement .....	13
6	Triaxial yield of pipe body .....	13
6.1	General .....	13
6.2	Assumptions and limitations .....	13
6.2.1	General .....	13
6.2.2	Concentric, circular cross-sectional geometry .....	14
6.2.3	Isotropic yield .....	14
6.2.4	No residual stress .....	14
6.2.5	Cross-sectional instability (collapse) and axial instability (column buckling) .....	14
6.3	Data requirements .....	14
6.4	Design formula for triaxial yield of pipe body .....	14
6.5	Application of design formula for triaxial yield of pipe body to line pipe .....	16
6.6	Example calculations .....	16
6.6.1	Initial yield of pipe body, Lamé formula for pipe when external pressure, bending and torsion are zero .....	16
6.6.2	Yield design formula, special case for thin wall pipe with internal pressure only and zero axial load .....	18
6.6.3	Pipe body yield strength .....	18
6.6.4	Yield in the absence of bending and torsion .....	19
7	Ductile rupture of the pipe body .....	20
7.1	General .....	20
7.2	Assumptions and limitations .....	20
7.3	Data requirements .....	21
7.3.1	General .....	21
7.3.2	Determination of the hardening index .....	21
7.3.3	Determination of the burst strength factor, $k_a$ .....	22
7.4	Design formula for capped-end ductile rupture .....	23
7.5	Adjustment for the effect of axial force and external pressure .....	24
7.5.1	General .....	24
7.5.2	Design formula for ductile rupture under combined loads .....	25
7.5.3	Design formula for ductile necking under combined loads .....	26
7.5.4	Boundary between rupture and necking .....	27
7.5.5	Axisymmetric wrinkling under combined loads .....	27
7.6	Example calculations .....	28
7.6.1	Ductile rupture of an end-capped pipe .....	28

7.6.2	Ductile rupture for a given true axial load .....	28
8	External pressure resistance .....	29
8.1	General .....	29
8.2	Assumptions and limitations .....	29
8.3	Data requirements .....	29
8.4	Design formula for collapse of pipe body .....	30
8.4.1	General .....	30
8.4.2	Yield strength collapse pressure formula .....	30
8.4.3	Plastic collapse pressure formula .....	31
8.4.4	Transition collapse pressure formula .....	33
8.4.5	Elastic collapse pressure formula .....	34
8.4.6	Collapse pressure under axial tensile stress .....	35
8.4.7	Collapse pressure under axial stress and internal pressure .....	35
8.5	Formulae for empirical constants .....	35
8.5.1	General .....	35
8.5.2	SI units .....	36
8.5.3	USC units .....	36
8.6	Application of collapse pressure formulae to line pipe .....	37
8.7	Example calculations .....	37
9	Joint strength .....	37
9.1	General .....	37
9.2	API casing connection tensile joint strength .....	37
9.2.1	General .....	37
9.2.2	Round thread casing joint strength .....	38
9.2.3	Buttress thread casing joint strength .....	40
9.3	API tubing connection tensile joint strength .....	42
9.3.1	General .....	42
9.3.2	Non-upset tubing joint strength .....	42
9.3.3	Upset tubing joint strength .....	43
9.4	Line pipe connection joint strength .....	44
10	Pressure performance for couplings .....	44
10.1	General .....	44
10.2	Internal yield pressure of round thread and buttress couplings .....	44
10.3	Internal pressure leak resistance of round thread or buttress couplings .....	45
11	Calculated masses .....	48
11.1	General .....	48
11.2	Nominal linear masses .....	48
11.3	Calculated plain-end mass .....	48
11.4	Calculated finished-end mass .....	49
11.5	Calculated threaded and coupled mass .....	49
11.5.1	General .....	49
11.5.2	Direct calculation of $e_m$ , threaded and coupled pipe .....	50
11.6	Calculated upset and threaded mass for integral joint tubing .....	50
11.6.1	General .....	50
11.6.2	Direct calculation of $e_m$ , upset and threaded pipe .....	51
11.7	Calculated upset mass .....	51
11.7.1	General .....	51
11.7.2	Direct calculation of $e_m$ , upset pipe .....	52
11.8	Calculated coupling mass .....	52
11.8.1	General .....	52
11.8.2	Calculated coupling mass for line pipe and round thread casing and tubing .....	52
11.8.3	Calculated coupling mass for buttress thread casing .....	55
11.9	Calculated mass removed during threading .....	56
11.9.1	General .....	56
11.9.2	Calculated mass removed during threading pipe or pin ends .....	56
11.9.3	Calculated mass removed during threading integral joint tubing box ends .....	58
11.10	Calculated mass of upsets .....	59

11.10.1	General .....	59
11.10.2	Calculated mass of external upsets .....	59
11.10.3	Calculated mass of internal upsets .....	60
11.10.4	Calculated mass of external-internal upsets .....	61
12	Elongation .....	61
13	Flattening tests .....	62
13.1	Flattening tests for casing and tubing .....	62
13.2	Flattening tests for line pipe .....	62
14	Hydrostatic test pressures .....	63
14.1	Hydrostatic test pressures for plain-end pipe and integral joint tubing .....	63
14.2	Hydrostatic test pressure for threaded and coupled pipe .....	64
15	Make-up torque for round thread casing and tubing .....	64
16	Guided bend tests for submerged arc-welded line pipe .....	65
16.1	General .....	65
16.2	Background .....	67
16.2.1	Values of $\sigma_{eng}$ .....	67
16.2.2	Values of $\sigma_{gbtj}$ .....	67
17	Determination of minimum impact specimen size for API couplings and pipe .....	67
17.1	Critical thickness .....	67
17.2	Calculated coupling blank thickness .....	68
17.3	Calculated wall thickness for transverse specimens .....	71
17.4	Calculated wall thickness for longitudinal specimens .....	71
17.5	Minimum specimen size for API couplings .....	71
17.6	Impact specimen size for pipe .....	73
17.7	Larger size specimens .....	73
17.8	Reference information .....	74
Annex A (informative) Discussion of formulae for triaxial yield of pipe body .....		75
Annex B (informative) Discussion of formulae for ductile rupture .....		88
Annex C (informative) Rupture test procedure .....		126
Annex D (informative) Discussion of formulae for fracture .....		128
Annex E (informative) Discussion of historical collapse formulae .....		135
Annex F (informative) Development of probabilistic collapse performance properties .....		149
Annex G (informative) Calculation of design collapse strength from collapse test data .....		188
Annex H (informative) Calculation of design collapse strengths from production quality data .....		191
Annex I (informative) Collapse test procedure .....		205
Annex J (informative) Discussion of formulae for joint strength .....		211
Annex K (informative) Tables of calculated performance properties in SI units .....		219
Annex L (informative) Tables of calculated performance properties in USC units .....		221
Bibliography .....		223