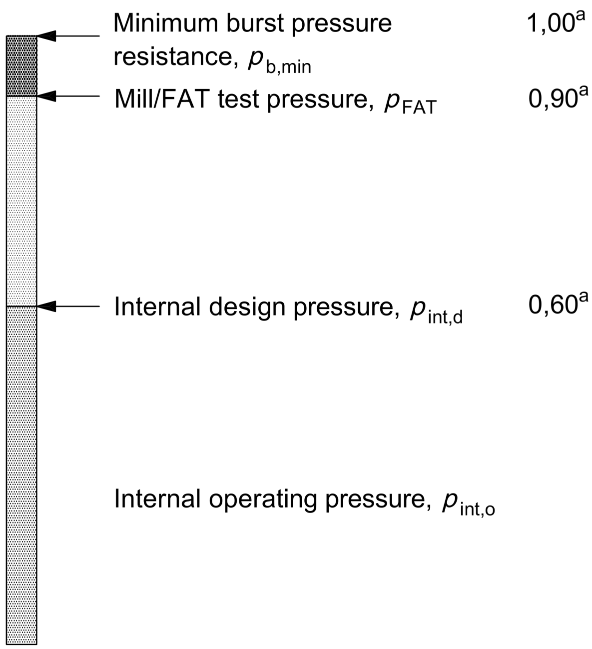
NOTE The failure mode covered is pipe wall ductile rupture due to net internal pressure, frequently referred to as "ductile pipe burst." The burst criterion is based on the burst resistance for pipes with closed (capped) ends.

The various pressure definitions and levels are illustrated in Figure 10.



Pressure	Description	Maximum fraction of $p_{b,min}$
$p_{b,min}$	Minimum burst pressure resistance	1,00
p_{FAT}	Mill/FAT pressure	0,90
$p_{int,d}$	Internal design pressure	0,60
$p_{int,o}$	Internal operating pressure	0,60

[a] Maximum fractin of $p_{b,min}$.

Figure 10 — Pressure level relations

6.5.2.3 External pressure (hoop buckling) design

The hoop buckling (collapse) pressure of the pipe shall exceed the net external pressure at all cross-sections along the riser string as follows:

$$\frac{\left(p_{od} - p_{int,min}\right)}{F_{hb} \times p_{c,min}} \leqslant 1 \qquad (11)$$

where

p_{od} is the external design pressure;

$p_{int,min}$ is the minimum hydrostatic internal pressure;

F_{hb} is the pipe hoop buckling (collapse) design factor, obtained from Table 14;

$p_{c,min}$ is the minimum pipe hoop buckling (collapse) pressure.

If the riser pipe is subjected to internal pressure, then the minimum internal pressure may be taken into account provided that it can be continuously sustained, otherwise zero or vacuum [– 0,1 MPa (– 1 bar)] internal pressure should be applied.

NOTE The C/WO riser can experience high external pressure when operating within a drilling riser; see 6.3.2.2.

External hydrostatic test pressure may be as given in I.7. Test pressure will normally not govern wall thickness.

Table 14 — Hoop buckling (collapse) design factor, F_{hb}

Pipe manufacturing process	External design pressure	Hydrostatic test pressure
Seamless	0,67	0,80

The minimum hoop buckling (collapse) pressure, $p_{c,min}$, shall be calculated as given in Equation (12):

$$\left(p_{c,min} - p_{el,min}\right) \times \left(p_{c,min}^2 - p_{p,min}^2\right) = p_{c,min} \times p_{el,min} \times p_{p,min} \times 2 \times f_0 \times \frac{D_o}{t_1} \tag{12}$$

where

$p_{el,min}$ is the minimum elastic hoop buckling (collapse) pressure (instability) of pipe cross-section;

$p_{p,min}$ is the minimum plastic pressure at hoop buckling (collapse) of pipe cross-section;

f_0 is the initial ovality;

D_o is the specified or nominal pipe outside diameter;

t_1 is the minimum pipe wall thickness without allowances and fabrication tolerances as appropriate, see 6.5.2.1.

and

$$p_{el,min} = \frac{2 \times E \times \left(\frac{t_1}{D_o - t_1}\right)^3}{1 - \nu^2} \tag{13}$$

where

E is the modulus of elasticity;

ν is the Poisson's ratio;

$$p_{p,min} = 2 \times \sigma_y \times \frac{t_1}{D_o} \tag{14}$$

where the variables are the same as for Equations (12) and (13).

$$f_0 = \frac{D_{o,max} - D_{o,min}}{D_{o,max} + D_{o,min}} \tag{15}$$

where

$D_{o,max}$ is the maximum outside diameter at any cross-section;

$D_{o,min}$ is the minimum outside diameter at any cross-section.

The initial ovality, f_0, shall not be taken less than 0,002 5 (0,25 %). Maximum initial ovality should not be greater than 0,015 (1,5 %). Ovalization caused during manufacture and fabrication shall be included in the initial ovality. The solution of Equation (12) can be found in Annex E.

For deep-water applications, initial pipe ovality should generally not exceed 0,005 (0,5 %).

The external design pressure to be taken into account for calculation purposes shall be the maximum external pressure under operating conditions or test conditions, whichever is the greater.

The failure mode covered is hoop buckling (pipe cross-section collapse) under external hydrostatic pressure. The hoop buckling pressure predicted by these equations should be compared to the hydrostatic pressure due to water depth to ensure adequate wall thickness is chosen for the range of water depths to be encountered, external pressure for concentric pipes, etc. The design formula is based on hoop buckling resistance for pipes with open ends.

6.5.3 Combined load design

6.5.3.1 General

The thickness for pipe used in combined load effect checks shall be the nominal thickness minus corrosion allowance given by Equation (16):

$$t_2 = t_n - t_{ca} \qquad (16)$$

where

t_2 is the pipe wall thickness without allowances;

t_n is the nominal (specified) pipe wall thickness;

t_{ca} is the corrosion/wear/erosion allowance.

NOTE In case of design load effects based on global riser analysis models with linear elastic materials, combined with the resistance equations set down in this part of ISO 13628, shakedown can be assumed without further checks for the pipe strength criteria.

6.5.3.2 Net internal overpressure

Pipe members subjected to effective tension, primary (load controlled) bending moment and net internal overpressure shall be designed to satisfy the following condition at all cross-sections as given in Equation (17):

$$\left(\frac{T_e}{F_d \times T_{pc}}\right)^2 + \frac{|M_{bm}|}{F_d \times M_{pc}} \times \sqrt{1-\left(\frac{p_{int}-p_o}{F_d \times p_b}\right)^2} + \left(\frac{p_{int}-p_o}{F_d \times p_b}\right)^2 \leqslant 1 \qquad p_{int} \geqslant p_o \qquad (17)$$

where

T_e is the effective tension in the pipe;

T_{pc} is the plastic tension capacity of the pipe;

F_d is the design factor as given in Table 11;

M_{bm} is the bending moment in the pipe;

M_{pc} is the plastic bending moment capacity of the pipe;

p_{int} is the internal pressure in the pipe;