

Figure A.2 Ductile failure

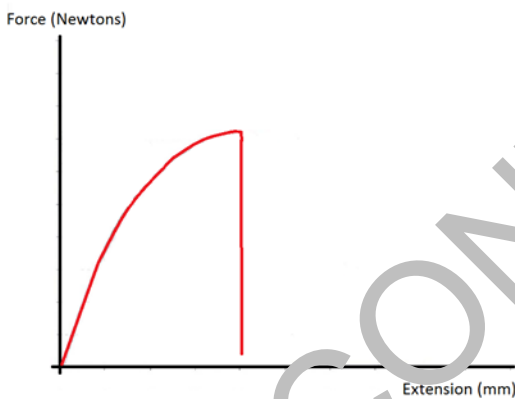


Figure A.3 Brittle failure

**A.1.4 References for further reading**

Beech S H et al; “Harmonisation of PE pipe butt fusion procedures and test methods”, PE100+ Association, Bucharest, 2009

Beech S H et al; “Harmonisation of polyethylene pipe butt fusion procedures and test methods”, PE100+ Association, Barcelona, 2012

Hill D et al; “Butt fusion welding of large diameter (thick walled) pipe”, Plastics Pipes XI, Munich 2001

Lowe D et al, “Optimisation of Butt Fusion Welding (and Testing) of Thick Walled PE100 Pipe”, Plastics Pipes XIII, Washington 2006.

Wilson K; “Verification of butt fusion welding quality in large diameter PE100 water pipes”, Plastic Pipes IX, Edinburgh 1995

**APPENDIX B – RELATIONSHIP BETWEEN INTERFACE STRESS AND GAUGE PRESSURE**

Within this specification, the Interface Stress for Bead Up, Fusion and Cooling is specified as being 0.15MPa for single pressure, (dropping to 0.025Mpa for Dual Pressure).

INTERFACE STRESS is the FORCE exerted over the AREA of the pipe ends.

To calculate the required FORCE on the pipe ends from the INTERFACE STRESS:

$$\text{Force (N)} = \text{Interface Stress (N/m}^2\text{)} \times \text{Pipe Cross Sectional Area (m}^2\text{)}$$

The interface stress in MPa needs to be converted to N/m<sup>2</sup> using a conversion factor of 10<sup>6</sup> (i.e. 1 MPa = 10<sup>6</sup> N/m<sup>2</sup>)

$$\text{Interface Stress (N/m}^2\text{)} = 0.15 \text{ (MPa)} \times 10^6 = 0.15 \times 10^6 \text{ N/m}^2$$

As an example, to produce an Interface Stress of 0.15 MPa on the pipe ends of an SDR 11 / 200 mm pipe, a force of approximately 1520 N (or 1.5 kN) is required.

In hydraulic powered butt fusion machines, the pump needs to generate a pressure on its cylinder that will produce a force on the pipe ends. This pressure is the GAUGE PRESSURE and is traditionally measured in bar (1 bar = 100,000 Pa = 0.1 MPa).

To calculate the required GAUGE PRESSURE from the FORCE required in the pipe ends:

$$\text{Gauge Pressure (N/m}^2\text{)} = \text{Force (N)} / \text{Cylinder Cross Sectional Area (m}^2\text{)}$$

So in the example, to produce a force of 1520 N using a butt fusion machine with a cylinder cross sectional area of 6 cm<sup>2</sup> (0.0006 m<sup>2</sup>), a gauge pressure of 2.5 x 10<sup>6</sup> N/m<sup>2</sup> (2.5 MPa, 25 bar) is required.