**INFORMATION AND GUIDANCE NOTE**

# Using Ductile Iron Elastomeric Joint Fittings with Plastics Pipes

## Disclaimer



## Copyright



## 1 INTRODUCTION

Ductile iron socketed fittings were originally designed for use with ductile iron pipes. However, AS/NZS 2280 ductile iron socketed fittings are now also commonly used with plastics pipes. AS/NZS 2280 fittings have been successfully used with PVC-U and glass reinforced plastic pipes and more recently with PVC-M and PVC-O pipe materials.

## 2 REQUIREMENT FOR GUIDANCE

AS/NZS 2280 first addressed ductile iron fittings socket compatibility with PVC-U pipes in the 1996 edition, when a table of minimum depths of engagement was included. During the revision of AS/NZS 2280 in 2003 the Standards Australia Committee WS-016 AS/NZS 2280 Working Group recognised the emergence of new plastics pipe formulations and processes and undertook to provide a technical note, which would enable specifiers and users to assess socket entry requirements for particular pipe materials and installation conditions.

This IGN details factors that are considered in determining the minimum required depth of engagement for ductile iron fittings when used with plastics pipes. It also details the recommended minimum depth of engagement for ductile iron fittings used with plastics pipe systems and the methodology used.

## 3 JOINT BEHAVIOUR — PLASTICS VS METALLIC PIPES

The major differences between metallic pipes and plastics pipes, in relation to elastomeric seal joint behaviour, are:

(a) Plastics pipes exhibit a thermal contraction potential (shortening of length due to reduction in temperature) compared to a negligible thermal contraction effect in metallic pipes.

(b) Plastics pipes exhibit a Poisson contraction compared to a negligible Poisson contraction for metallic pipes.

An increased depth of engagement (beyond the elastomeric seal) is required to accommodate thermal and Poisson contractions of plastics pipes, when compared to that required for metallic pipes. Higher hoop stress plastics materials result in a larger Poisson contraction.

## 4 SOCKET DEPTH OF ENGAGEMENT

The minimum required depth of engagement for a particular pipe material can be determined from the characteristics of the pipe material and associated field installation and service variables.

In a string of consecutive PVC pipes each pipe is assumed to be anchored at its midpoint, with movement occurring equally at each pipe end. Calculations for thermal and Poisson contraction take into account movement from each pipe end, the calculation therefore being equivalent to the movement over one full length of one pipe.

When PVC pipes are jointed to metal sockets, such as in fittings and valves, the effect of thermal and Poisson contraction is negligible for a metal fitting and so the calculation for entry for metal sockets need only take into account half the length of one PVC pipe.

As reported in the WSAA March 2004 Bulletin and the WSAA May 2004 Journal, experiments were undertaken to determine whether the above theoretical view is correct. The results demonstrated that pipes are effectively anchored at the midpoint, and that an effective length of 3 m is appropriate for joints comprising 6 m long plastics pipe and elastomeric jointed ductile iron fittings.

The factors that are considered when assessing the required depth of engagement beyond the seal are listed below:

(a) *Poisson contraction* - Poisson contraction is a shortening effect on a length of a pipe when pressurised.

(b) *Thermal contraction* - This may occur when a pipeline experiences lower temperatures after construction at elevated ambient temperatures.

(c) *Joint angular deflection* - This is the retraction effect of one side of the spigot due to angular deflection at the joint.

(d) *Spigot chamfer length* - The length of chamfer of a spigot. Chamfer lengths applied to pipes cut on site are usually less than those provided in the factory.

(e) *Spigot end squareness* - The allowable pipe end squareness is specified in the relevant pipe Standard. End squarenesses of pipes cut on site are usually equal to or more than those cut in the factory.

(f) *Soil friction* - This factor recognises that soil friction will reduce the thermal and Poisson contraction by constraining the pipe.

(g) *Pipe length* - This is the unanchored length of pipe that is applicable to Poisson and thermal contraction.

## 5 METHODOLOGY

A methodology for calculating the potential effect of each of the above factors is provided below.

### 5.1 Notation

$D$ = Mean external diameter of pipe, in mm

$Ec$ = Long term elastic modulus in the circumferential direction, in MPa

$f$ = Soil friction factor (unitless). f = 1 for no anchoring, f = 0 for total anchoring.

$L$ = Effective length of unanchored pipe, in mm

$L_c$ = Length of chamfer on spigot, in mm

$m$ = Socket entry, in mm

$S$ = Hydrostatic stress in the circumferential direction, in MPa

$\Delta t$ = Temperature difference between operation and installation (°C). This value is positive when installation temperature is higher than operation temperature.

$\lambda$ = Coefficient of linear expansion, in $°C^{-1}$

$\theta$ = Maximum angle of deflection of spigot within socket, in degrees

$\Phi$ = End squareness of spigot pipe end, in degrees

$\mu$ = Poisson ratio, unitless

### 5.2 Formulae

(a) Poisson contraction

$m_p = L\ S\ \mu\ /\ Ec$

(b) Thermal contraction

$m_t = L\ \lambda\ \Delta t$

(c) Joint angular deflection
$m_a = D \sin \theta$

(d) Spigot chamfer length
$m_c = L_c$

(e) Spigot end squareness
$m_e = D \tan \Phi$

### 5.3 Minimum depth of engagement

It is extremely unlikely that all of the above factors would occur simultaneously at maximum effect. To determine what the effective minimum depth of engagement should be, a statistical approach, that combines the above independent inputs, was used to determine the probability of socket pull-out. By limiting this probability to a very low level, a high degree of confidence can be obtained that socket pull-out will not occur.

Dr Richard Jarrett (CSIRO Mathematical & Information Sciences Group Leader Production and Process Improvement, who is an Industrial Statistician) has provided the equations for the calculations, which are included in the accompanying interactive Excel spreadsheet calculator. The spreadsheet contains explanatory notes and a worked example is given for a DN 100 Series 2 PVC-O Class 500 pipe. The basis for acceptance is that the chance of pipe pull-out is less than one in a million, i.e. negligible. This is based on the pipeline material with the highest movement, PVC-O pipe. A review of the PVC-M and PVC-U data shows that the lower operating stresses associated with those products gives a lower chance of socket pullout. Data from the spreadsheet was used to produce the recommended minimum depths of engagement shown in Table 1.

Note that a plastics pipe spigot should always be fully inserted into a metal socket in accordance with the pipe manufacturer's recommendation.

## 6 INSTALLATION GUIDELINES FOR RISK MIMIMISATION

Materials with high hoop stresses (i.e. highly stressed material such as PVC-O) require a greater depth of engagement past the seal to cater for the increased Poisson contraction.

To minimise risk of failure the installer should always:

(a) Minimise joint deflection;

(b) Minimise temperature variation;

(c) Ensure end squareness at cuts;

(d) Provide minimum practical chamfer lengths; and

(e) Ensure pipes are fully inserted into the socket.

Where it is considered that the cumulative effects of the pipe material properties and associated installation variables necessitate a longer than available socket entry, the pipe may be cut to a shorter length or a higher pressure class pipe may be specified.

**TABLE 1**

**MINIMUM DEPTH OF ENGAGEMENTFOR DUCTILE IRON FITTINGS SOCKETS**

| Nominal socket size<br>DN | Recommended minimum depth of engagement beyond the elastomeric seal for all plastics pipes<br>mm |
|---|---|
| 100 | 42 |
| 150 | 50 |
| 200 | 58 |
| 225 | 62 |
| 250 | 66 |
| 300 | 71 |
| 375 | 83 |
| 450 | 95 |
| 500 | 102 |
| 600 | 118 |
| 750 | 131 |