

### 7.2.16 Sample calculation

A number of values will be calculated for the isometric pipe system illustrated below.

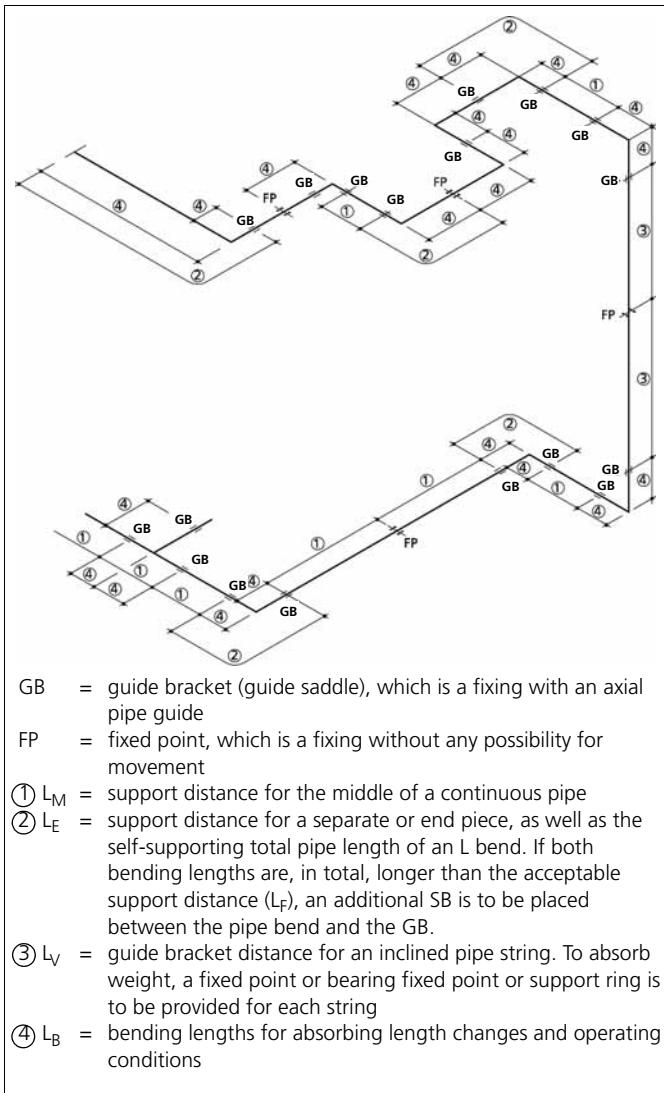


Figure 7.12 Pipe isometrics

Explanation of terms ① ② ③ ④ for equations 7.66 to 7.73. The numbering and short symbols provide information about the variables being calculated and where their location in the isometric diagram. The illustration is therefore a guide and helps the user to obtain an overview of a pipe system and its calculations.

#### 1. Load on brackets

Brackets are subject to both horizontal and vertical loads. Simultaneous loads produce a resulting total force ( $F_R$ ), which can be calculated using the following equation 7.66. Figure 7.13 shows a bracket with the effective forces and the calculated bracket distance ( $B_d$ ).

$$F_R = \sqrt{F_B^2 + F_V^2}$$

Equation 7.66

FB = axial fixed-point force ( $F_{FP}$ ) or friction force ( $F_\mu$ ) as a result of a length change in the pipe string  
 FV = transverse force ( $F_{TV}$ ) for fixed-point load and/or pipe weight ( $F_W$ ) between two brackets with or without additional load

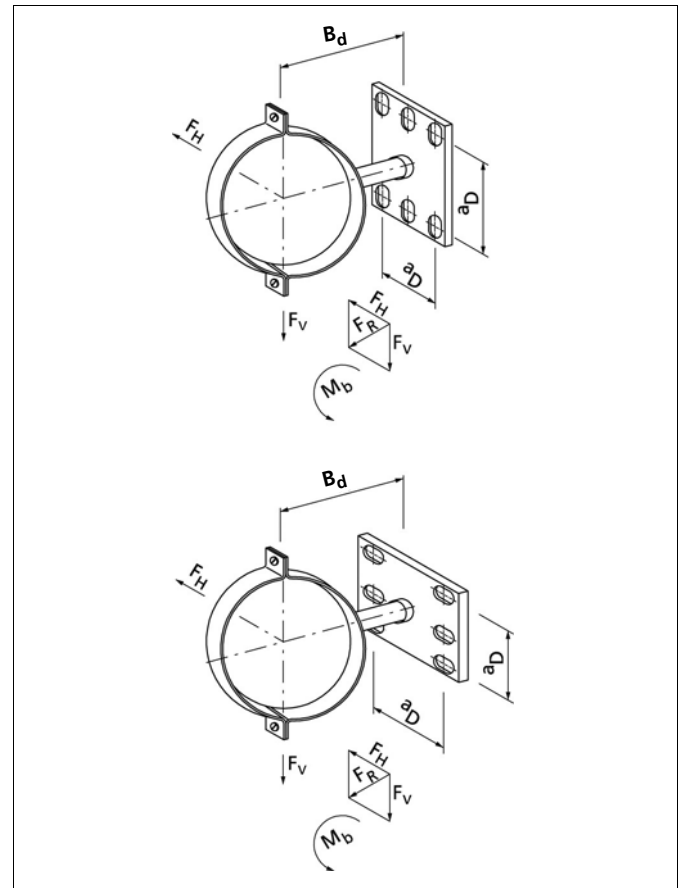


Figure 7.13 Pipe saddle load

#### Determination of the force components

$F_{FP}$  = see equation 7.34

$F_\mu = F_{V'} \cdot \mu$

$F_{TV}$  = based on system calculation

$F_W = F_{W(Pipe)} + F_{W(Fill med)} + F_{W(Add load)}$

Equation 7.67

$\mu_F$  = friction coefficient usually between 0.3 and 0.5  
 $F_{FP}$  = force at fixed point (N)  
 $F_W$  = weight (N)  
 $F_{TV}$  = transverse force (N)  
 $F_{W(Pipe)}$  = weight (pipe weight) (N)  
 $F_{W(Fill med)}$  = weight (weight of fill medium) (N)  
 $F_{W(Add load)}$  = weight (additional weight) (N)

#### 2. Bracket distances ( $B_d$ )

The fixing distances of a plastic pipe are to be determined in such a way that no excessive stresses arise both under operating conditions and during testing. Similarly, consideration is also to be given to the deflection limits of the pipe. The arrangement of various brackets and their distances from each other can be seen in the illustrated example (figure 7.12) of pipe isometrics.

## Basic calculations

### 3. Calculating acceptable bracket distances

$$L_M = 1,86 \cdot \sqrt[4]{\frac{E_{cR} \cdot f_{acc} \cdot (d_e^4 - d_i^4) \cdot 10^5}{(d_e - d_i) \cdot e \cdot \rho_p + \frac{d_i^2}{2} \cdot \rho_f}}$$

Equation 7.68

- $L_M$  = support distance for the middle of a continuous pipe (mm)
- $E_{cR}$  = creep modulus of the pipe material for  $t = 25a$  (N/mm<sup>2</sup>)
- $f_{acc}$  = acceptable pipe deflection according to the recommendations in table 7.16 (mm)
- $d_e$  = outside diameter of the pipe (mm)
- $d_i$  = inside diameter of the pipe (mm)
- $e$  = pipe wall thickness (mm)
- $\rho_p$  = density of the pipe medium (g/cm<sup>3</sup>)
- $\rho_f$  = density of the flow medium (g/cm<sup>3</sup>)

$$L_E = 0,67 \cdot L_M$$

Equation 7.69

$$L_V = Y \cdot L_M$$

Equation 7.70

- Values for Y:
- $\leq \varnothing d_e$  110 mm → Y=1,1
  - $\varnothing d_e$  125 - 200 mm → Y=1,2
  - $\leq \varnothing d_e$  225 mm → Y=1,3

$L_B$  = Rekenkundige bepaling in formule 7.28 resp. met bijlage B3 t/m B7

Equation 7.71

Explanation of symbols in equations 7.69 to 7.71:

- $L_M$  = support distance for the middle of a continuous pipe (mm)
- $L_E$  = support distance for a separate and end piece, as well as the self-supporting total pipe length of an L bend.
- $L_V$  = guide distance for an inclined pipe string (mm)
- $L_B$  = length of the expansion bend (mm)
- Y = factor (dependent on pipe dimensions) (-)

To calculate the support distances, the following deflections are recommended as acceptable values:

$\varnothing d_e$	20 - 110	125 - 200	225 - 355	400 - 600
$f_{acc}$	2 - 3 mm	3 - 5 mm	5 - 7 mm	7 - 10 mm

Table 7.16 Deflection  $f_{acc}$  for pipes

If larger deflections are permitted, the pipe should not be axially constricted.

### 4. Verifying the acceptable buckling length

If pipes are installed so that axial expansion of all or individual strings is no longer possible (axial constriction), the calculated fixing distance must be tested for its buckling resistance. To avoid the risk of buckling due to constricted thermal expansion, the length of pipe between two brackets must be no more than  $L_K$ .

$$L_{K_{acc}} \leq 1,12 \cdot \sqrt{\frac{d_e^2 - d_i^2}{\alpha_g \cdot \Delta\vartheta}}$$

Equation 7.72

See appendix B10.

- $L_{K_{acc}}$  = acceptable buckling length between two brackets (mm)
- $\alpha_g$  = thermal expansion coefficient (K<sup>-1</sup>)
- $\Delta\vartheta$  = temperature difference (K)
- $d_e$  = outside diameter of the pipe (mm)
- $d_i$  = inside diameter of the pipe (mm)

The following applies to all pipe systems without linear compensation:

$$L_{B_{acc}} \leq L_{S_{acc}}$$

Equation 7.73

Values for LB are found in appendix B10:

- $L_{B_{acc}}$  = acceptable pipe length between two brackets (mm)
- $L_{S_{acc}}$  = available or calculated support distance according to equations ① ② ③ (equations 7.68 to 7.70)
- $d_e$  = outside diameter of the pipe (mm)
- $d_i$  = inside diameter of the pipe (mm)
- $\alpha_g$  = thermal expansion coefficient (K<sup>-1</sup>)
- $\Delta\vartheta$  = temperature difference (K)

Note to equations 7.72 and 7.73:

Axially constricted pipe systems operated at raised temperatures or an expected reduction of the creep modulus ( $E_{cR}$ ) as a result of chemical effects will both give rise to risks of buckling.

Raised operating temperatures are:

PE →  $T_{crit} \geq 45^\circ\text{C}$

PP →  $T_{crit} \geq 60^\circ\text{C}$

The buckling risk is strengthened due to bending along the pipe axis or insufficient pipe storage practices. Bending can result from too long support distances, improper storage of pipe and lasting pipe impacts during welding.

In such case, it is recommended that the buckling distances either calculated or interpolated from appendix B10 are reduced by a factor of 0.8. Pipe systems with  $d_e \leq 50$  mm should be equipped with continuous support for economic reasons.

### 5. Determining pipe deflection for calculated support distances.

Pipe deflection for the calculated support distance ( $L_M$ ) (from equation 7.68) is determined by means of the following equation.

Pipe deflection for the calculated support distance ( $L_E$ ) (from equation 7.69) is also determined by means of equation 7.74

$$\textcircled{1} f_D = \frac{2,6 \cdot q \cdot L_M^4}{E_{cR} \cdot J_P} \quad \textcircled{2} f_D = \frac{5,4 \cdot q \cdot L_E^4}{E_{cR} \cdot J_P}$$

Equation 7.74

- q = weight of the filled pipe along with any insulation (N/mm<sup>2</sup>)
- $E_{cR}$  = creep modulus of the pipe material (N/mm<sup>2</sup>)
- $L_M, L_E$  = bracket distance (m)
- $L_B$  = acceptable bracket distance (m)
- $J_P$  = pipe moment of inertia (mm<sup>4</sup>)
- $f_D$  = deflection (mm)

At position 3, the pipe is not subject to deflection but to buckling.