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List of references

[1] Wagner, Walter: Rohrleitungstechnik, Vogel-Buchverlag, 10. Auflage, 2008
[2] Wagner, Walter: Planung im Anlagenbau, Vogel-Buchverlag, 2. Auflage, 2003
[3] Wagner, Walter: Festigkeitsberechnungen im Apparate und Rohrleitungsbau, Vogel-Buchverlag, 7. Auflage, 2007
[4] DVS 2210-01: Industrierohrleitungen aus thermoplastischen Kunststoffen
for additional advice on support distances determination for plastic pipes

Symbols

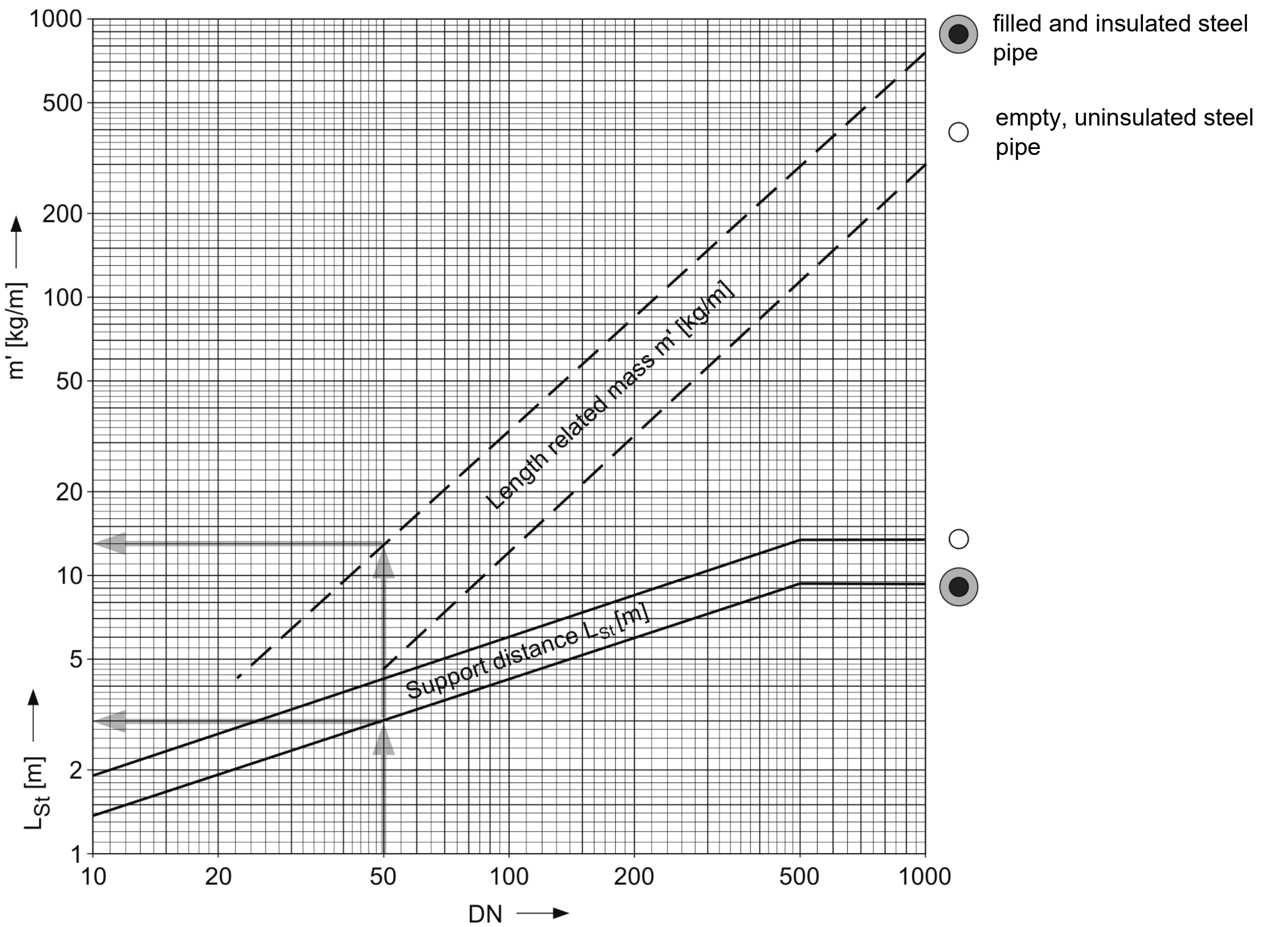
C	material property	[-]
Da	outer diameter	[mm]
Di	inner diameter	[mm]
DN	nominal diameter	[mm]
e	wall thickness	[mm]
E	modulus of elasticity	[kN/mm²]
FB	fixed point force from bending	[kN]
FF	spring force (at compensator)	[kN]
FH	hydrostatic force	[kN]
FP	fixed point force (total)	[kN]
FR	frictional force (in slide supports)	[kN]
G	weight	[kN]
G‘	weight / length	[kN/m]
KM	correction coefficient = f (medium)	[-]
KR	correction coefficient = f (row of pipes)	[-]
L	length of expanding pipe leg	[m]
LA	length of bending pipe leg	[m]
LSt	Support distance of pipe	[m]
m‘	mass / length	[kg/m]
p	internal pressure	[bar]
Re	yield strength	[N/mm²]
S	safety coefficient	[-]
T	Temperature	[°C]
ß	coefficient of thermal expansion	[mm/(m·K)]

Materials

A	Austenitic steel
Cu	Copper
F (Fe)	Ferritic Steel
HDPE	Polyethylene with high density
M	Martensitic steel
PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl chloride
PVDF	Polyvinyl denfluoride
St	Steel
VA	Stainless Steel

2019-10

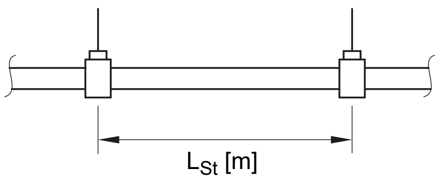
Length related mass and support distances for steel pipes for plant constructions (standard values)

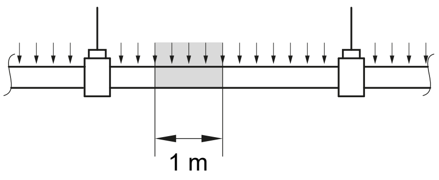


Example:
Steel pipe DN 50 with insulation (100%)

Support distance (standard values)
$L_{St} \approx 3$ m

Length related mass m' ≈ 13 kg/m



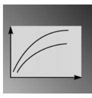


Note

(1) The given standard values are valid for steel pipes with normal thickness and up to a temperature of 400°C. the length related mass is larger when the steel is thicker. In case of weaker thickness (often in the range of stainless steel) the admissable support distance decreases.
(2) An analysis of elasticity shows the admissibility of the choosen support distance. In case of exceeding the stated standard values and/ or constraints like high temperatures or influence of vibrations, a special engeneering proof incl. an analysis of elasticity is necessary.

Sources

Wagner, Walter: Rohrleitungstechnik, Vogel-Buchverlag, 10. Auflage, 2008;
DIN EN 13480-3: Metallische industrielle Rohrleitungen, 2002



Support distances in building services for pipes made of steel, copper, plastic (standard values)

Nominal Diameter	Nominal Diameter	Outside-Ø	SIKLA-Recommandation Pipes filled with water with insulation[1)]			DIN 1988-2 Pipes filled with water			
			Steel Pipe	Steel Pipe	Cu-Pipe	Steel Pipe	Cu-Pipe	PVC-Pipe	
[DN]	[Zoll]	[mm]	EN 10220 *DIN 2448* *DIN 2458*	EN 10255 *DIN 2440*	EN 1057 *DIN 1786*	EN 10255 *DIN 2440*	EN 1057 *DIN 1786*	at 20°C	at 40°C
		12.0			1.00		1.25		
10		13.5	1.00						
		15.0			1.10		1.25		
		16.0						0.80	0.50
10	3/8“	17.2		1.20		2.25			
		18.0			1.20		1.50		
15		20.0	1.20					0.90	0.60
15	1/2“	21.3		1.50		2.75			
		22.0			1.30		2.00		
20		25.0	1.40					0.95	0.65
20	3/4“	26.9		2.00		3.00			
		28.0			1.50		2.25		
25		30.0	1.80						
		32.0						1.05	0.70
25	1“	33.7		2.50		3.50			
		35.0			1.60		2.75		
32		38.0	2.20						
		40.0						1.05	0.70
		42.0			1.80		3.00		
32	1 1/4“	42.4		2.90		3.75			
40		44.5	2.40						
40	1 1/2“	48.3		3.30		4.25			
		50.0						1.40	1.10
		54.0			2.00		3.50		
50		57.0	3.10						
50	2“	60.3		4.00		4.75			
		63.0						1.50	1.20
		64.0					4.00		
		75.0						1.65	1.35
65		76.1	3.30				4.25		
65	2 1/2“	76.1		4.75		5.50			
80		88.9	4.20				4.75		
80	3“	88.9		5.25		6.00			
		90.0						1.80	1.50
100		108.0	4.50				5.00		
100	4“	114.3		5.80		6.00			
		110.0						2.00	1.70
125		133.0	5.10				5.00		
125	5“	139.7		6.50		6.00			
		140.0						2.25	1.95
150		159.0	5.80				5.00		
		160.0						2.40	2.10
150	6“	168.3		7.20					
200	8“	219.1	7.80						

1) 100 % - Insulation with 100 kg/m³ and 1 mm steel sheat for pipes with normal thickness.

Support distances for plastic pipes (standard values according to producer)

Pipes made of PVC - hard

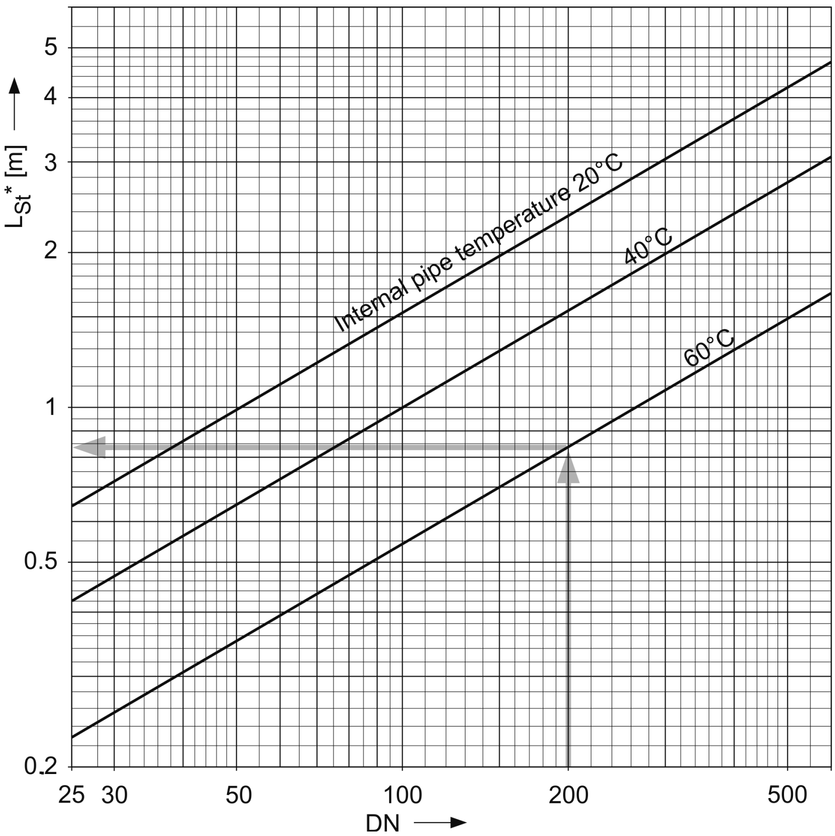
Medium	KM
gas	1.3
1 < density [g/cm³] ≤ 1.8	0.8

Pipe raw DIN 8062	KR
1	1.0
2	1.3
3	1.6
4	1.8
5	2.0
6	2.3

$$L_{St} = L_{St}^* \cdot KM \cdot KR$$

Example:
DN 200; T = 60°C; Gas; Pipe raw 5

$L_{St} = 0.83\ m \cdot 1.3 \cdot 2.0 \approx 2.1\ m$



Pipes made of HDPE or PP

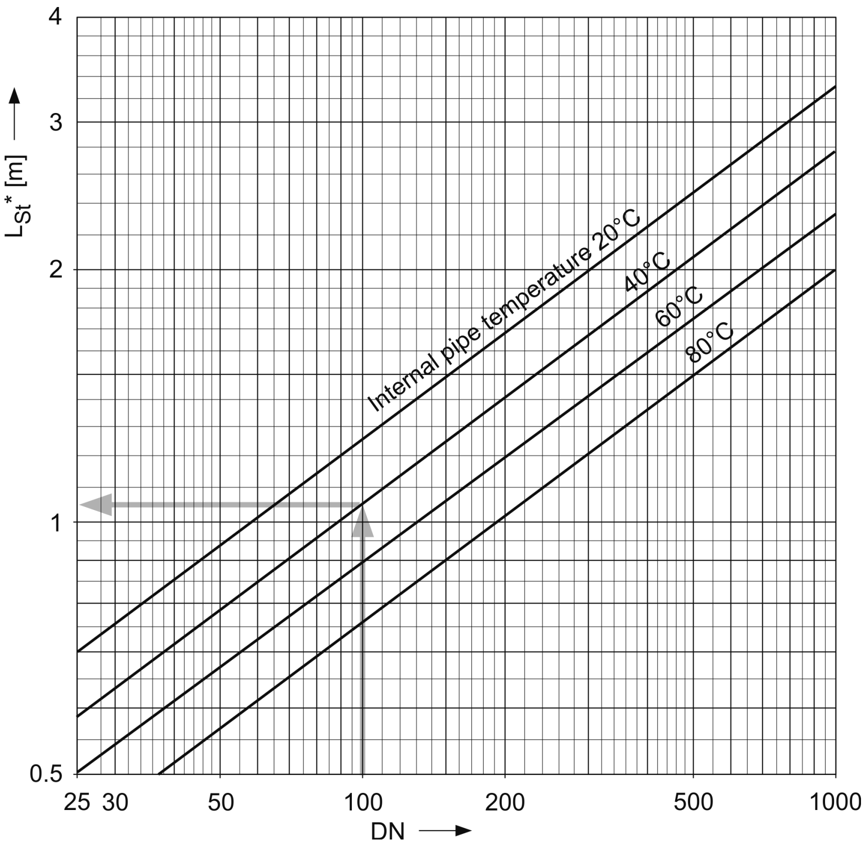
Medium	KM
gas	1.3
1 < density [g/cm³] ≤ 1.8	0.8

Pipe raw	KR	
	HDPE	PP
1 and 2	1.0	1.1
3	1.1	1.45
4	1.25	1.65
5	1.45	

$$L_{St} = L_{St}^* \cdot KM \cdot KR$$

Example:
HDPE; DN 100; T = 40°C; bulk material; Pipe raw 3

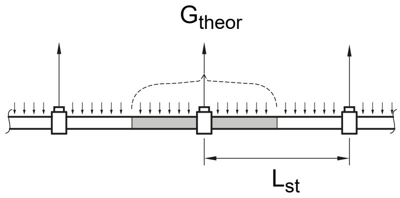
$L_{St} = 1.05\ m \cdot 0.8 \cdot 1.1 \approx 0.9\ m$



Weight per support (Calculation, Simulation and Safety Coefficient S)

Theory

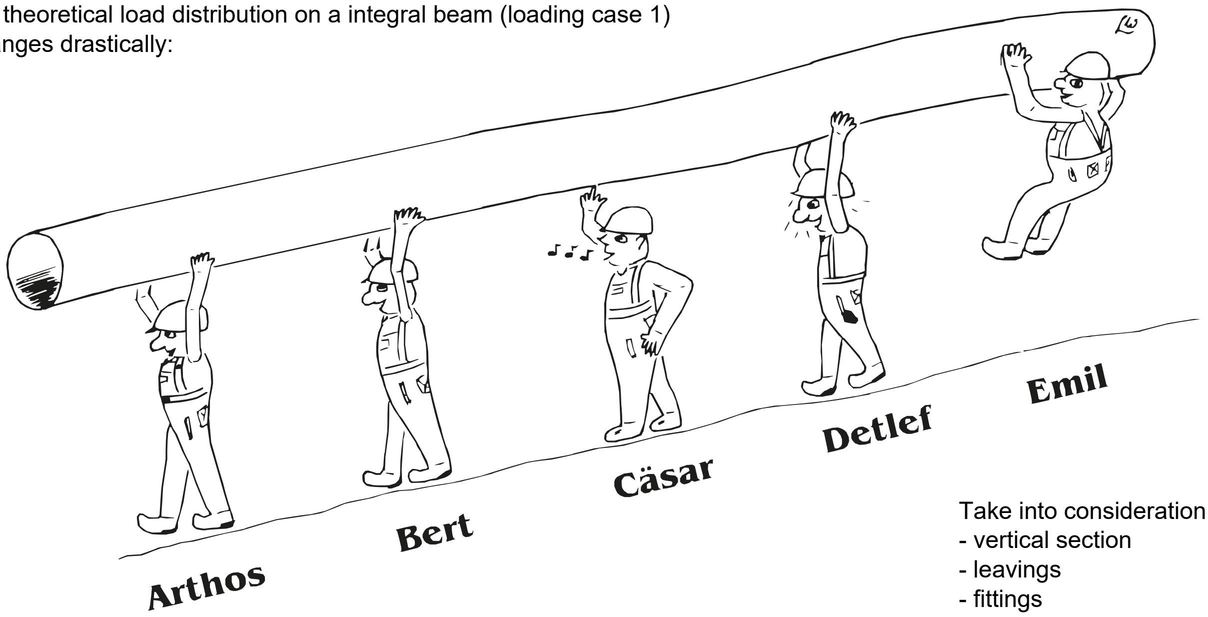
$$G_{theor} = G' \cdot L_{st}$$



Explanation:
For the static dimensioning of a pipe support, the weight which has to be carried by the clamp has to be calculated.
The length of pipe sections, assigned hypothetically, correspond with the support distance L_{st}.

Example:
D_a = 168.3 mm, DIN 2448, L_{st} = 4 m
m' = 38 kg/m ≈ 0.38 kN/m = G'
G_{thoer} = 0.38 kN/m · 4 m ≈ 1.5 kN

Practice
Considering practical margin conditions,
the theoretical load distribution on a integral beam (loading case 1)
changes drastically:



Take into consideration:
- vertical section
- leavings
- fittings
- insulating weight
- installation specialties.

loading case	loading per "support"" (kN)					max. "overweight"	valuation
	Arthos	Bert	Cäsar	Detlef	Emil		
1) all 5 supports	1.6	1.4	1.5	1.4	1.6	7 %	theory
2) Cäser pipes, 4 supports	1.3	2.5	-	2.5	1.3	67 %	normal case
3) Cäsar pipes + Emil is happy	1.7	1.2	-	4.6	-	207 %	extreme case

For this reason, in practice a security coefficient S should be taken into consideration. Based on the simulation approach, S will be rated 1.5... 2.5 depending on the application case.

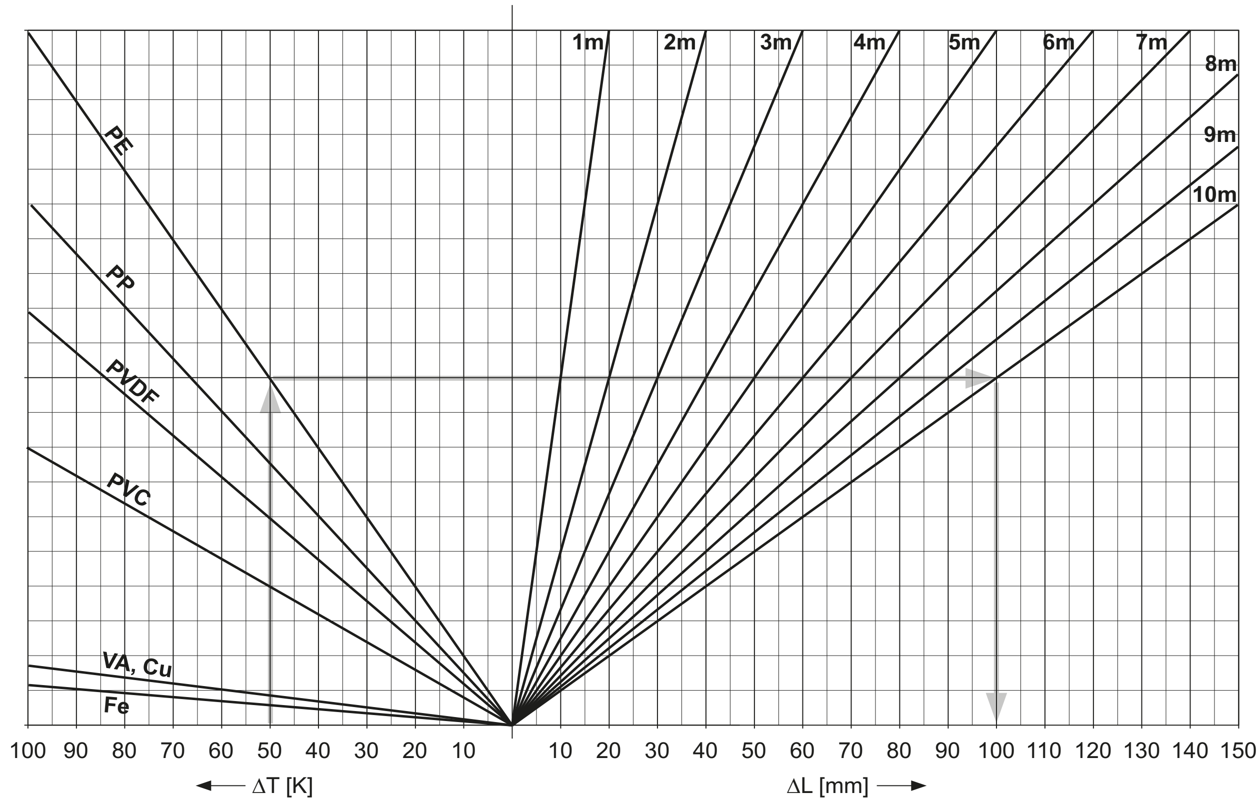
$$G_{pract} = G' \cdot L_{st} \cdot S$$

Example:
D_a = 168.3 mm, DIN 2448
L_{st} = 4 m, G' = 0.38 kN/m
S = 2.0
G_{pract} = 0.38 kN/m · 4 m · 2 ≈ 3 kN

Note:
- *According to EN 13480 at load concentration points (e.g. valves, vertical pipe sections) additional supports must be provided.*

Length variation of pipes and coefficient of linear expansion

Graphic illustration of the variation in length



$$\Delta T = T_{operation} - T_{installation}$$

$$\Delta L = L \cdot \beta \cdot \Delta T$$

Example:
PE-Pipe; L = 10 m; $T_{operation}$ = 70 °C; $T_{installation}$ = 20 °C

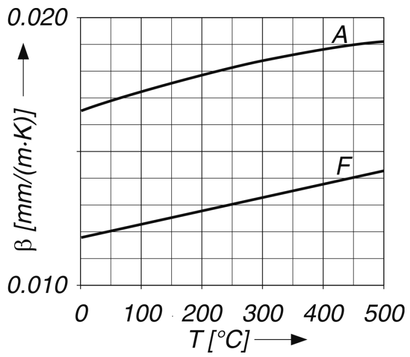
ΔT = 70 °C - 20 °C = 50 K

graphic illustration:
ΔT = 50 K → PE → L = 10 m → ΔL = 100 mm

mathematical solution:
$$\Delta L = 10\ m \cdot 0{,}2\ \frac{mm}{m \cdot K} \cdot 50\ K = 100\ mm$$

Coefficient of linear expansion

material	ß [mm/(m·K)]
HDPE, PE	0.200
PB, PP	0.150
PVDF	0.12 ... 0.18
PVC	0.080
A = Steel (VA), Cu	0.017
F = Steel (ferr.)	0.012



Note:
- *As temperature rises, the coefficient of linear expansion increases. For this reason, calculations including for the integral linear expansion coefficient have to be used where temperatures exceed 200°C.*

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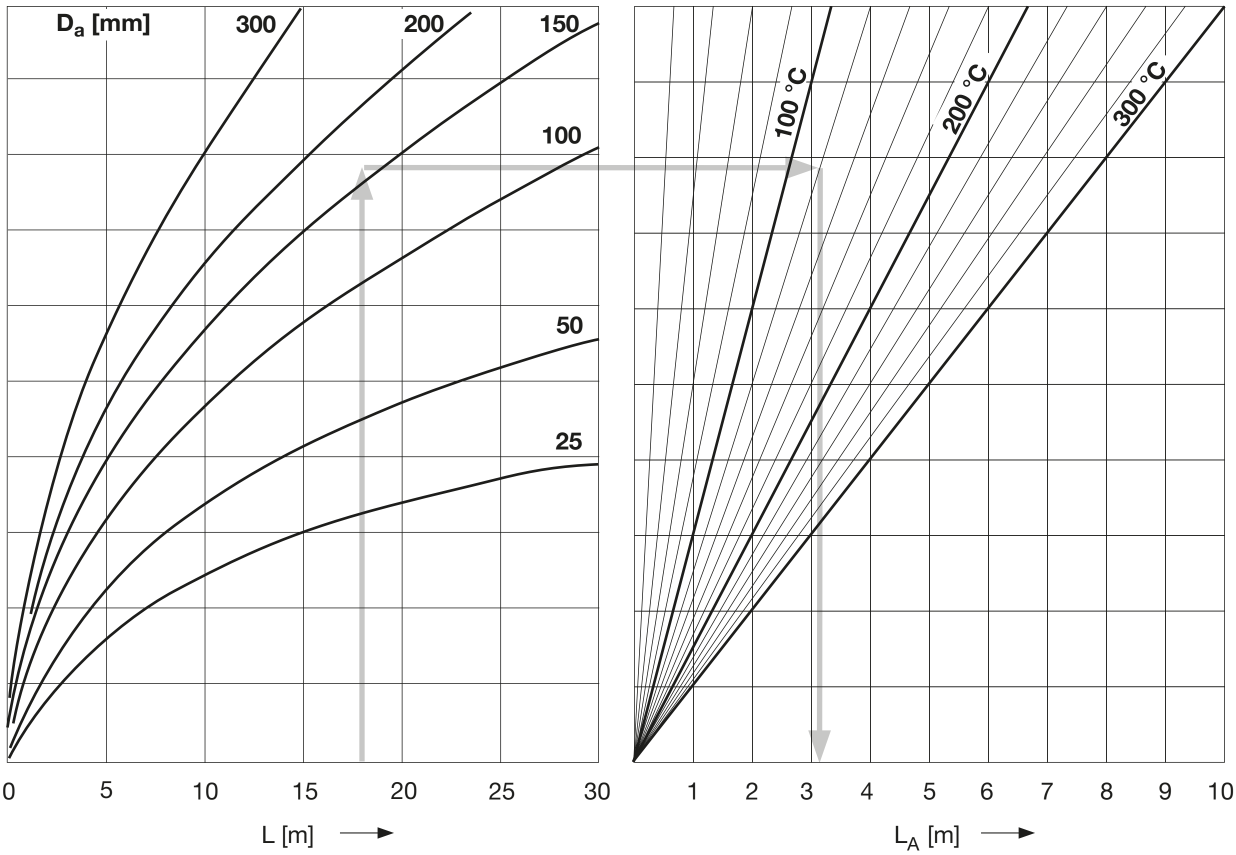
Minimum length for bending leg L_A of warming pipes (standard values)

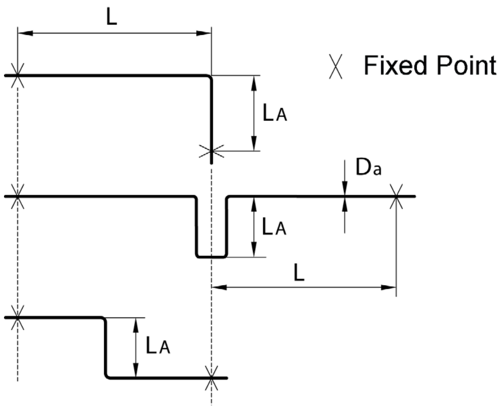
Pipes made of steel (ferritic, austenitic)



Example:
L = 18 m; DN 150 (D_a = 168.3 mm); T = 120 °C

Read: Minimum length for bending legs: L_A = 3.1 m

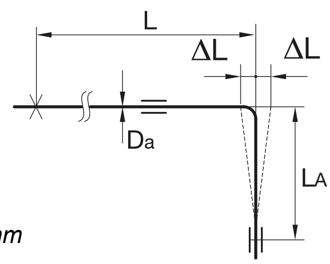
Valid for L-bending, U-bending and Z-bending according to diagram.



RPipe made from plastic

material	C
HDPE	26.0
MEPLA	33.0
PP	30.0
PVC	33.5
PVDF	21.6

$$L_A = C \cdot \sqrt{D_a \cdot \Delta L}$$



Example:
PP; L = 8 m; D_a = 160 mm; T = 80 °C

1.) Calculate linear expansion: ΔL = 72 mm

2.) $L_A = 30 \cdot \sqrt{160\text{mm} \cdot 72\text{mm}}$ *= 3200 mm = 3.2 m*

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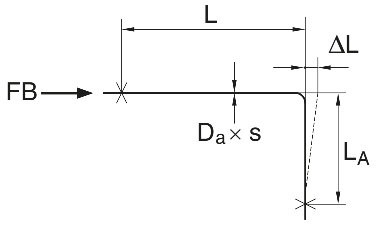
Fixed point force for pipes made of steel (approximated values)

Fixed point forces resulting from natural bends (Pipe expansion moves the bending leg)

$$FB = \frac{\Delta L}{10\ mm} \cdot FB_{10}$$

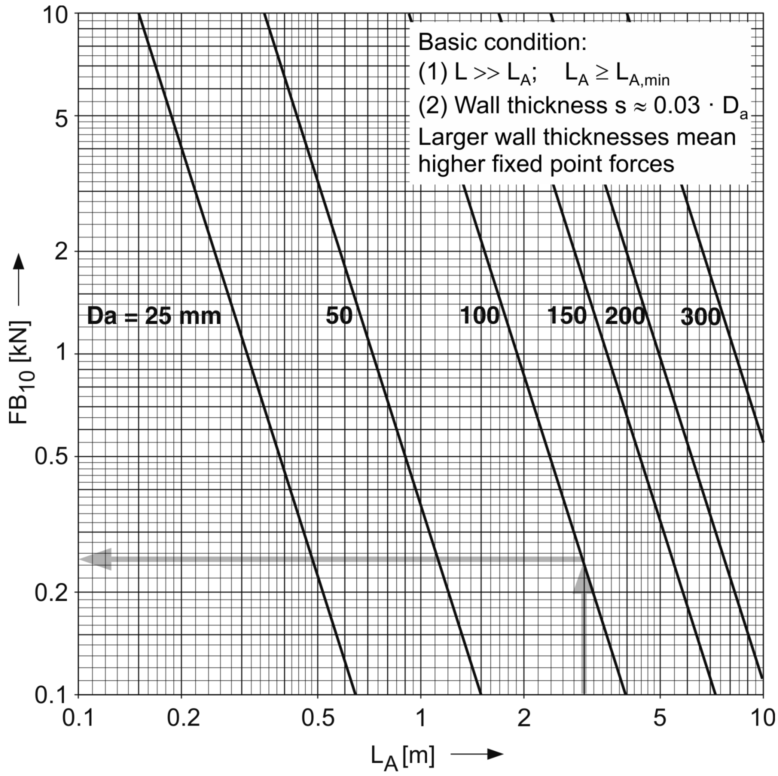


Example:
Steel Pipe DIN 2458, L = 15 m
L_A = 3 m; D_a = 101.6 mm; T = 120°C

→ Δ T = 100 K → Δ L = 18 mm

$$FB = \frac{18\ mm}{10\ mm} \cdot 0,25\ kN = 0.45\ kN$$

Note:
Fixed point force FP is larger than FB, because frictional forces of slide bearings have to be added: FP = FB + FR



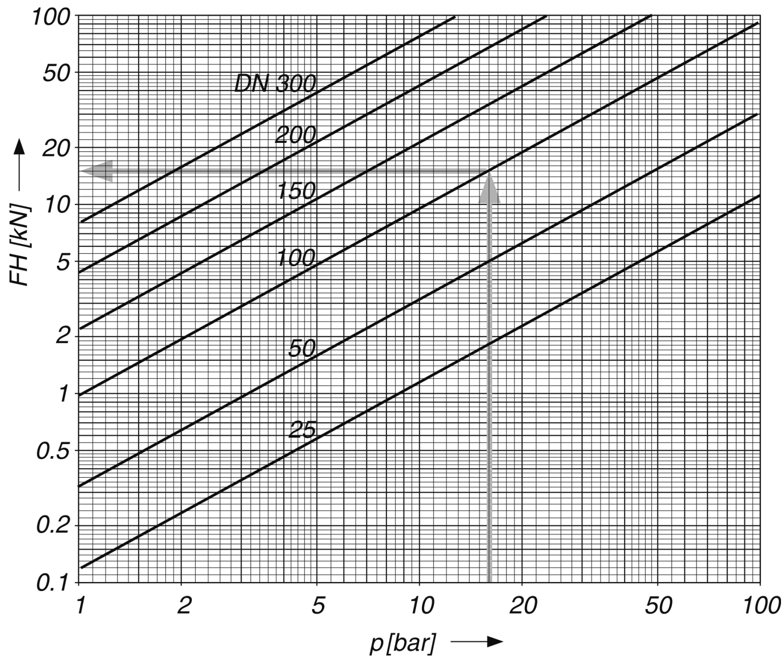
Fixed point force at axial compensators

$$FP = FH + FF + FR$$

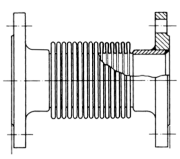
For exact calculation of hydrostatic force FH, the axial compensator (pipe expansion joint) has to be considered.

Example:
Axial compensator DN 100; p = 16 bar
→ hydrostatic force FH ≈ 15 kN

Note:
Normally FH constitutes the main part of fix point force.
But the complete fix point force FP is larger because the spring force of compensator (FF) and the frictional force of sliders (FR) have to be added.

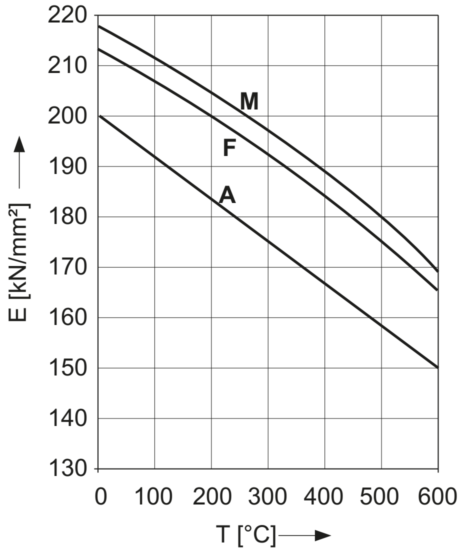


Construction of an axial compensator (expansion joint) with flange



Material characteristics and restrictions for static loadings

Material properties



material	Yield point Re [N/mm²] at a					temperature [°C]		
	50	200	250	300	350	400	450	500
S235JR (St 37)	235	161	143	122	-	-	-	-
1.4301	177	127	118	110	104	98	95	92
1.4401	196	147	137	127	120	115	112	110
1.4571	202	167	157	145	140	135	131	129

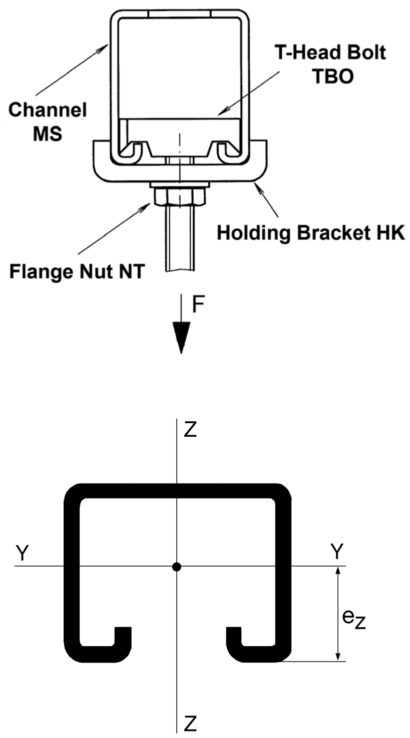
M = martensic
F = ferritic
A = austenitic

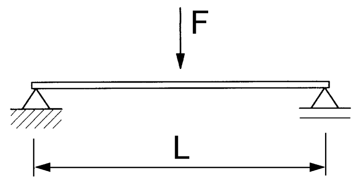
The yield point values for S235JR are valid for thickness up to 16 mm, according to AD 2000 MB W1.

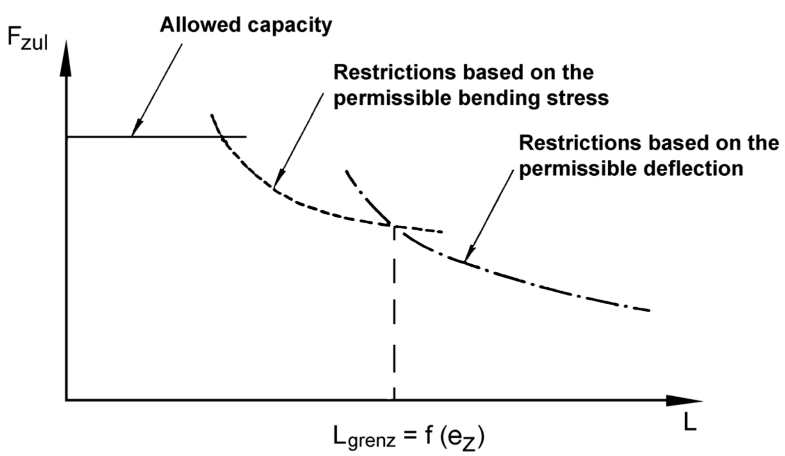
Note:
The specified values for Re are material features.
Safety factors have to be considered additionally.
For hot-dip galvanized products the maximum temperature limit is 250 °C.
S235JR (St 37) shouldn't be used at temperatures over 300°C.
Selecting the material, the creep-strength has to be considered when extraordinary high temperatures occur.

Caution!
- *Because the strength features of steel decreases considerably at high temperature, reduced values have to be considered in the calculation. Interim values have to be interpolated.*

Restrictions for dimensioning a simply supported beam





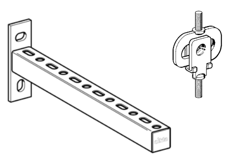
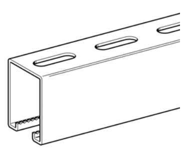
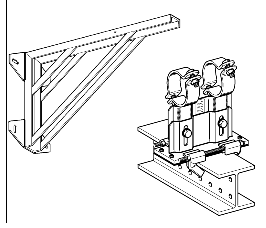
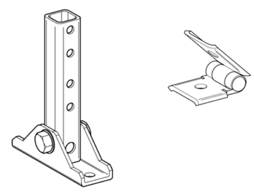


Corrosion protection

1. Corrosivity catagory acc. DIN EN ISO 12944-2

corrosivity catagory	**corrosivity catagory**	**Outdoor (typical Examples)**	**Indoor (typical Examples)**
C1	Very low	not applicable (outdoor min. C2 requirement)	Indoor dry conditions with a neutral environment. e.g. offices, shops, schools and hotels
C2	Low: minor	Atmosphere with low-level pollution. Mostly rural areas.	Unheated buildings where condensation can occur. e.g. warehouses, sports facilities
C3	Moderate	Town and industrial atmosphere. Moderate sulphur dioxide pollution. Coastal areas with low levels of atmospheric salt.	Production facilities with high humidity and moderate environmental pollution. e.g. food production plants, water treat-ment plants, dairies and breweries
C4	High	Industrial and coastal areas with moderate levels of atmospheric salt.	Chemical plants, swimming pools, boat sheds (above sea level)
C5-I (Industrial)	Very high	Industrial areas with high humidity and chemically aggressive atmospheres	Buildings or areas with almost permanent condensation or high levels of pollution
C5-M (Coastal)	Very high	Coastal and off-shore areas with high levels of atmospheric salt	Buildings or areas with almost permanent condensation or high levels of pollution

2. Coating or material selection in accordance with corrosivity category and intended use

			HCP = High Corrosion Protection = HCP Consistency at least as with hot dip metal coating	
Treatment	Electrogalvanising	Hot-dip galvanising		Zinc lamination coating
Medium	Electrolytic transfer of zinc ions	By means of temperature (≥ 450 °C): dipping in fluid zinc		Anorganic layer of zinc- and alu-lamination
Process	Galvanising, discontinuous clip	Continuous sendzimir treatment	Hot-dipped galvanised	Coating and curing at ca. 200 °C
Norms	DIN 50961	DIN EN 10346	DIN EN ISO 1461 (huge parts), DIN EN ISO 10684 (connecting elements)	DIN EN 13858 (huge parts), DIN EN ISO 10683 (connecting elements)
Coating thickness (standard values)	Sheet metal parts 8 ... 12 µm, norm- and thread parts 5 ... 8 µm	Hot-dip metal coating refined metal sheet ca. 15 µm	Small parts 55 µm, huge parts 70 µm, connecting elements ≥ M8 ca. 40 µm	Highest corrosion protection, up to more than 1200 h consistancy in salt spray test*) acc. MPA- Inspection report 901 2659 000.
Examples				

*) Salt spray test according to DIN EN ISO 9227

In cases where extraordinary corrosion occurs, we recommend additionally:
- **Cathodic dip paint -** scratch-resistant, durable, impact and saltwater resistant.
- **Powder-covering** - weatherproof and chemical resistant, RAL colour range or
- our synchronised range of stainless steel products **V4A**.

Talk to us - we will advise you.