HANSA-FLEX

TECHNICAL INFORMATION
CONNECTION TECHNOLOGY PIPELINES

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Connection Technology: Technical Information for Pipelines

Contents

1. Pipelines

Pipelines are used to transfer energy to hydraulic systems. They are used in stationary and mobile hydraulic equipment.

The design of pipelines must consider the many loads applied to them that could affect the length of their service lives.

These include loads from:
- Pressure
- The layout and design of the pipeline system
- Temperature
- Thermal expansion

Keeping within the limits for all parameters can considerably effect the durability of pipes and pipelines and increases the safety of personnel and the surroundings.

1.1 Material

Pipes made from seamless, cold-drawn precision steel tube are used for hydraulic and pneumatic pressure lines in conjunction with pipe fittings and cutting ring connections. This tube is notable for its precisely defined dimensional tolerances and specified maximum surface roughness.

Types of steel used:

Material	Pipe	Designation	Material	Standard
Steel	PR (M)*	E235+N	1.0308	EN 10305-4
Steel	PR VZ CF (M)*	E235+N	1.0308	EN 10305-4
Steel	PR ST52 (M)*	E355+N	1.0580	EN 10305-4
Stainless steel	PR V1 (M)*	X5CrNi18-10	1.4301	EN 10216-5
Stainless steel	PR V2 (M)*	X6CrNiTi18-10	1.4541	EN 10216-5
Stainless steel	PR V4 (M)*	X6CrNiMoTi17-12-2	1.4571	EN 10216-5

* M = metric pipes

1.2 Standardisation and pressure calculation

Various standards and codes of practice are available for the layout and design of pipelines.

For example:
- DIN 2413: Seamless steel tubes for oil- and water-hydraulic systems - Calculation rules for pipes and elbows for dynamic loads
- DIN ISO 10763: Hydraulic fluid power. Plain-end, seamless and welded precision steel tubes. Dimensions and nominal working pressures
- DIN EN 13480-3: Metallic industrial piping - Part 3: Design and calculation
- DIN EN 13480-4: Metallic industrial piping - Part 4: Fabrication and installation
- DIN 2445-2: Seamless steel tubes subjected to dynamic loads - Part 2: Precision tubes for use in fluid power systems, rated for pressures from 100 bar to 500 bar

The pressure values given in our catalogues relate to the calculation principles in DIN 2413 Load Case I for predominantly static loads up to 120 °C and Load Case III for dynamic /pulsating loads up to 120 °C.

The pressure values relate to straight pipes. The appropriate wall thicknesses need to be calculated for pipes with bends as stipulated in DIN EN 13480-4.

The pressure values given in our catalogues are for guidance only and must be checked or calculated separately by the user/customer.

The manufacture of pipelines must also take into account the pressure values of the connections and connecting elements. The component with the lowest operating pressure determines the operating pressure for the whole pipeline.

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1.3 Design

The design of pipelines must take into account not only the maximum operating pressure of the pipeline but also the desired pressure loss. This is mainly determined by the flow velocity. Too high a flow velocity creates turbulence, which leads to large pressure losses and increased temperatures. This is reflected in the cost and energy efficiencies of the hydraulic system.

As a rule, the following flow velocities must not be exceeded:

- Pressure lines: max. 6 m/s
- Return lines: max. 3 m/s
- Suction lines: max. 1 m/s

Further information about pressure loss in pipelines can be found in point 2 “Determination of pressure loss in pipelines”.

1.4 Layout

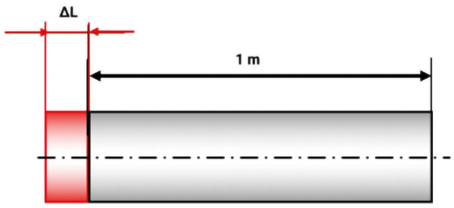
The design of pipelines must take into account the linear expansion and contraction due to temperature changes because the forces they create can lead to leakage at the connections between pipes and at connections to equipment.

The following material-related coefficients of thermal expansion can be used as the basis for calculation:

Material	Coefficient of linear thermal expansion α [10-6 K-1 or µm/mK]			
	20 °C	100 °C	150 °C	200 °C
Steel	11.9	12.70	13.20	13.70
Stainless steel	16.80	17.70	18.21	18.67

<u>Example calculation:</u>

$\Delta L = L_0 \times \alpha \times \Delta t$



ΔL = Change in length
L_0 = Initial pipe length (metre)
α = Coefficient of thermal expansion
Δt = Change in temperature

L_0 = 1 metre
α = 11.9 (steel, 20 °C)
Δt = 60 °C or 60 K (Celsius and kelvin are interchangeable in this context)

$$\Delta L = 1\,\text{m} \times \frac{11.9}{10^6\,\text{K}} \times 60\,°\text{C} = 0.000714\,\text{m} = 0.714\,\text{mm}$$

This means a pipeline with an initial length of 1000 mm can change in length by 0.714 mm in response to a temperature change of 60° C.

For the fixings to accommodate thermal movements efficiently, the layout should be accordance with the following principles.

Symbols for diagrams of layout principles:

Symbol	Meaning
	Anchor point (fixed bearing)
	Guide point (sliding bearing)

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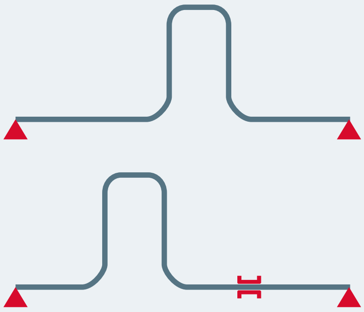
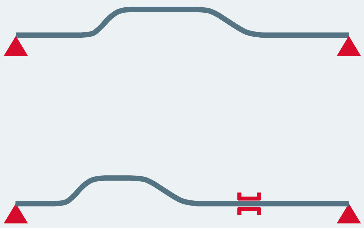
Straight pipe:

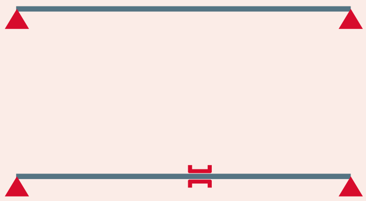
Right: Using the natural elasticity of the pipe



Right: Using the natural elasticity of the pipe

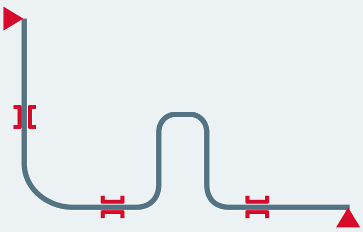


Wrong:

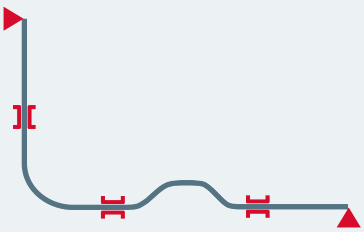


Bent pipe:

Right: Using the natural elasticity of the pipe



Right: Using the natural elasticity of the pipe



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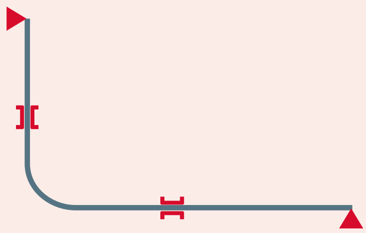
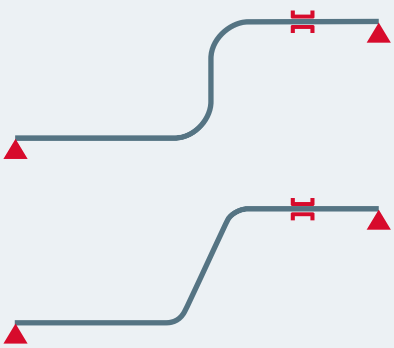


Pipe levels:

Right: Using the natural elasticity of the pipe



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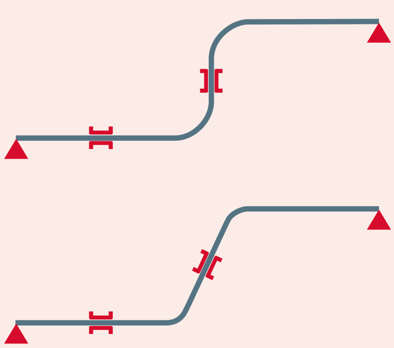

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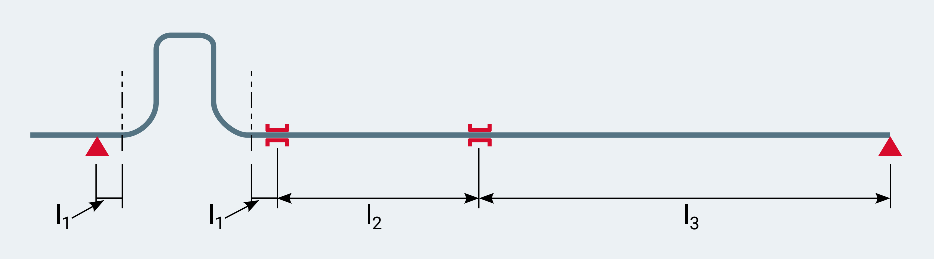
1.5 Fixings

Pipeline fixings (e.g. SRS clamps) hold and guide pipelines. They must absorb the generated forces and prevent or dampen movements.

The correct selection and determination of the required clamp spacing over the length of the pipes is based on specific principles and can be calculated using approximation formulae.

Recommendations for the distances between fixing points:



l_1 = Expansion compensation loop – guide point/anchor point = 2 × D* (mm)
l_2 = Guide point – guide point = 0.7 × l_3 (mm)
l_3 = Guide point – anchor point = 400 × √ D (mm)

* D = Outer pipe diameter

Rounded guidance values:

Outer diameter D (mm)	l_1 Compensation loop – guide / anchor point	l_2 Guide point - guide point	l_3 Guide point - anchor point
6	30*	700	1000
8	30*	800	1150
10	30*	900	1300
12	30*	1000	1400
15	30	1100	1550
16	35	1150	1600
18	40	1200	1700
20	40	1300	1800
22	50	1350	1900
25	50	1400	2000
28	60	1500	2150
30	60	1600	2200
35	70	1700	2400
38	80	1750	2500
42	85	1800	2600

* Take the size of the clamps into account when determining the spacing l_1

2. Determination of pressure loss in pipelines

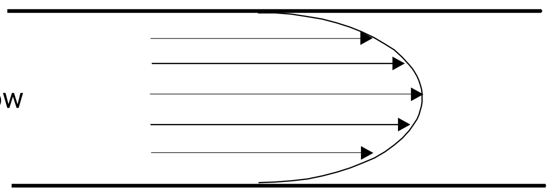
The pressure losses that inevitably occur in pipeline systems can be determined either by metering or by calculation.

Determination of these losses precisely by calculation is impossible without considerable effort, but the few simple equations we give here can be used to determine approximate pressure losses in straight pipelines and fittings.

Pressure losses and flow resistance in a line system depend on the internal diameter of the pipe, the flow velocity and the properties of the hydraulic oil (density and viscosity). Pressure losses are caused by “fluid friction”, i.e. the friction between the oil and the pipe walls, and the internal friction within the fluid.

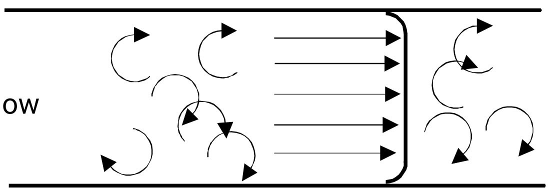
Above a certain velocity, the laminar flow of the oil becomes a turbulent flow. Turbulent flows lead to greater heat generation in the system, with consequential losses of pressure and performance.

Laminar flow



The behaviour of the flow is also characterised by the Reynolds number Re.

Turbulent flow



When this Re number exceeds a given value, the laminar oil flow becomes a turbulent flow.

In pipelines, laminar flow is desirable. Turbulent flow occurs most often in valves, couplings and ball valves.

Pressure losses in straight pipelines can be determined approximately using the following equations:

$$\Delta p = \lambda \times \frac{l \times \rho \times V^2 \times 10}{d \times 2} \text{ in bar}$$

Δp = Pressure loss in a straight pipeline (laminar or turbulent flow) in bar
λ = Pipe friction factor
ρ = Density of the hydraulic oil in kg/dm^3, $\rho = 0.89 \; kg/dm^3 = 890 \; kg/m^3$
l = Line length in metres m
V = Flow velocity of the oil in the line in m/s
d = Internal diameter of the line in mm
v = Kinematic viscosity in cSt or mm^2/s
Q = Volumetric flow in the line in l/min

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Pipe friction factor for laminar flow

$Re<2320$

$\lambda_{lam} = 64/Re$

Pipe friction factor for turbulent flow

$Re>2320$

$\lambda_{turb.} = \frac{0.316}{\sqrt[4]{Re}}$

Reynolds number

$$Re = \frac{V \times d}{v} \times 10^3$$

Flow velocity

$$V = \frac{Q}{6 \times d^2 \times \frac{\pi}{4}} \times 10^2$$

Example:

For a straight pipeline of length l = 1 m and inner diameter d = 25 mm.

The volumetric flow Q is 150 l/min and the flow velocity of the oil is 5 m/s.

A standard hydraulic oil HLP 46 with a kinematic viscosity of $v = 46\ mm^2/s$ = 46 cSt and a density of $0.89\ kg/dm^3$ is used.

Calculate the pressure loss occurring over the total length of 1 m.

Solution:

1. Determination of Reynolds number Re:

$$Re = \frac{V \times d}{v} \times 10^3 = \frac{5\ m/s \times 25\ mm}{46\ mm^2/s} \times 10^3 = 2713$$

In this case, the Reynolds number is greater than 2320, so turbulent flow conditions exist.

2. Determination of the pipe friction factor for turbulent flow

$$\lambda_{turb.} = \frac{0.316}{\sqrt[4]{Re}} = \frac{0.316}{\sqrt[4]{2713}} = 0.0437$$

3. Calculation of pressure loss over the total length

$$\Delta p = \lambda \times \frac{l \times \rho \times V^2 \times 10}{d \times 2} = 0.0437 \times \frac{1\ m \times 0.89\ kg/dm \times (5\ m/s)^2 \times 10}{25\ mm \times 2} = 0.194\ bar$$

However, it should be noted that these equations are valid only for straight pipeline sections. But a pipeline system consists of straight and bent sections, as well as fittings and other hydraulic connection technology products.

Therefore the pressure losses of the individual components must be considered separately. This is done by calculation or by metering the components and the results added together to give a total pressure loss.

For the purpose of determining the approximate pressure losses in individual components a drag coefficient ξ is assumed.

The pressure loss in a component can be determined using the following equation:

$$\Delta p = \xi \times \rho \times \frac{1}{2} v^2$$

Δp = Pressure loss in the component in bar
ξ = Drag coefficient (dimensionless)
ρ = Density of the hydraulic oil in kg/dm^3, $\rho = 0.89\ kg/dm^3 = 890\ kg/m^3$
v = Flow velocity of the oil in the line in m/s

It should be noted that the pressure losses can be affected by many other factors occurring in the components discussed here, and these calculations allow only an approximate determination. Therefore, in important situations, tests should be carried out on a test bench.

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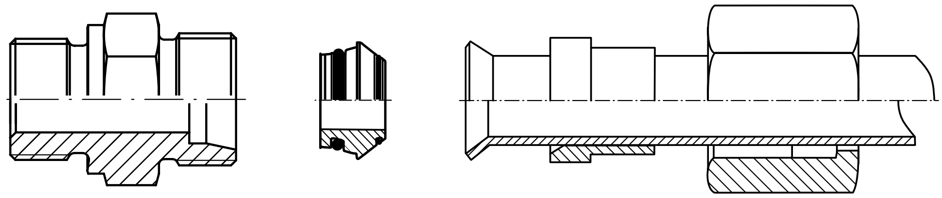
3. Design and function of flare fittings



HANSA-FLEX flare fittings are designed for high pressures and are used widely in applications where there are strong vibrations.

They can be assembled using standard threaded connectors. However, in preparation for assembly, the pipe ends must be given a standardised 37° flare cone.

A flare fitting consists of the threaded connector, the formed 37° pipeline, the support ring or pressure ring and a union nut.

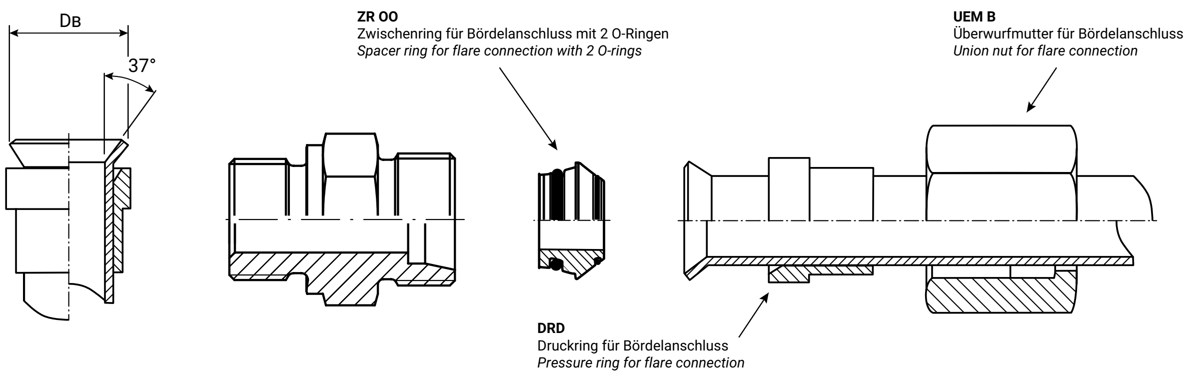
Using an additional HANSA-FLEX ZROO spacer ring in accordance with DIN 3949, UEM B union nut and DRD pressure ring (full designation: BOOK), a form-fitting (i.e. positive) connection to a 24° pipe fitting in accordance with ISO 8434-1 can be achieved.

Sealing is ensured on the fitting side by the O-ring of the spacer ring, and on the pipe side sealing is normally provided by the metal surfaces of the flare cone and the spacer ring.

The HANSA-FLEX flare system can also be used directly with HANSA-FLEX HJ (JIC) series adapters.

It should be noted that the flare (DB), the support ring (pressure ring) and the union nut differ depending on whether they are used with the ZROO or the HJ (JIC) adapter, and the 37° flare is further deformed. Refer to table in 3.1.

3.1 37° flare form using the HANSA-FLEX ZROO double conical ring



Pipe outer diameter	6	8	10	12	15	16	18	20	22	25	28	30	35	38	42
DB min	9.1	11.3	13.1	15.3	19.1	20.6	23.2	25.6	26.5	31.1	32.7	37.0	41.8	46.0	48.8
DB max	10.0	12.0	14.0	16.0	20.0	22.0	24.0	26.8	27.5	33.0	33.3	38.7	42.7	47.2	49.8

Assembly with double conical ring:
Insert the double conical ring (ZROO) into the body of the screw fitting. Using a suitable wrench, apply approximately ¼ turn to the mounted union nut (UEM B), flared pipe and pressure ring (DR D). This presses the double conical ring tightly into the body of the screw fitting. Repeat assemblies can be done without exerting a high degree of force.

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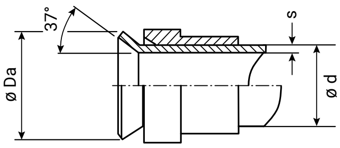
3.2 Determination of pipe lengths for 37° flare fittings

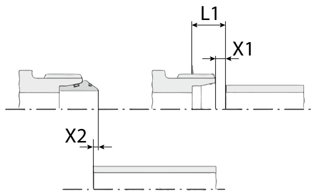
When using HANSA-FLEX flare fittings with a spacer ring (BOOK), the following cut-off factors must be adopted when determining the pipe lengths.

The diameter of the flare must fulfil the requirements shown.



Kontrolldurchmesser (Da min, Da max.)

Check diameter (Da min., Da max.)



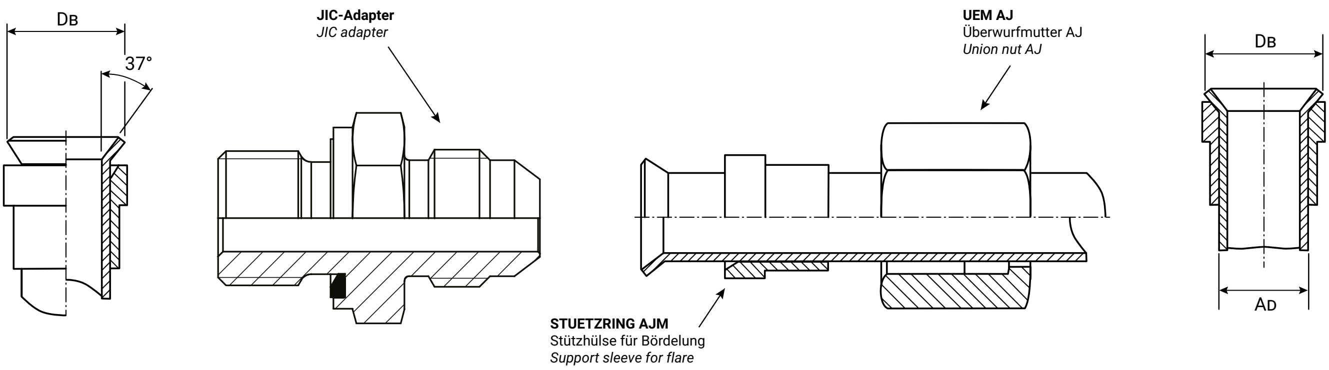
Rohrlängenbestimmung (X1, X2, L1)

Pipe length determination (X1, X2, L1)

d	s	X1	X2	L1	Da min	Da max
mm	mm	mm	mm	mm	mm	mm
6	1	1	3.5	8	9.1	10
	1.5	2	2.5	9		
8	1	1	4	8	11.3	12
	1.5	2	3	9		
	2	2.5	2.5	9.5		
10	1	1	4.5	8	13.1	14
	1.5	2	3.5	9		
	2	3	2.5	10		
12	1	1	4.5	8	15.3	16
	1.5	2	3.5	9		
	2	3	2.5	10		
14	1.5	0.5	5.5	8.5	18.6	19.6
	2	1	4	9		
	2.5	2	4	10		
	3	3	3	11		
15	1.5	1	4.5	8	19.1	20
	2	2	3.5	9		
	2.5	3	2.5	10		
16	1.5	0	6.5	8.5	20.6	22
	2	1	5.5	9.5		
	2.5	1.5	5	10		
	3	2.5	4	11		
18	1.5	0	5.5	7.5	23.2	24
	2	1	4.5	8.5		
	2.5	1.5	4	9		
20	2	1	7	11.5	25.6	26.8
	2.5	2	6	12.5		
	3	3	5	13.5		
	3.5	4	4	14.5		

d	s	X1	X2	L1	Da min	Da max
mm	mm	mm	mm	mm	mm	mm
22	1.5	1	5.7	8.5	26.5	27.5
	2	2	4.7	9.5		
	2.5	3	3.7	10.5		
	3	3.5	3.2	11		
25	2	1	7	13	31.1	33
	2.5	1.5	6.5	13.5		
	3	2.5	5.5	14.5		
	4	4	4	16		
28	2	1.5	5.7	9	32.7	33.3
	2.5	2.5	4.7	10		
	3	3	4.2	10.5		
30	2	-0.5	9	13	37	38.7
	2.5	0.5	8	14		
	3	1	7.5	14.5		
	4	3	5.5	16.5		
	5	4.5	4	18		
35	2	1.5	6.5	12	41.8	42.7
	2.5	2	6	12.5		
	3	3	5	13.5		
	4	4.5	3.5	15		
38	2.5	0	10	16	46	47.2
	3	0.5	9.5	16.5		
	4	2	8	18		
	5	4	6	20		
	6	2.5	7.5	18.5	46	48
42	2	1.5	7	12.5	48.8	49.8
	3	3	6.5	14		
	4	4.5	5	15.5		

3.3 37° flare form flare fitting ISO 8434-2



Pipe outer diameter	6	8	10	12	15	16	18	20	22	25	28	30	35	38	42
DB min	8.6	10.2	11.7	16.0	19.3	19.3	23.4	23.4	26.5	29.7	37.6	37.6	43.2	43.2	52.0
DB max	9.7	11.3	12.7	17.3	20.2	20.2	24.7	24.7	27.8	31.0	38.9	38.9	45.3	45.3	54.8

3.4 37° flare form preparations for assembly and installation

- Cut the pipe to length at right angles ±0.5°. Do not use a pipe cutter for this.
- Gently deburr the inside and outside of the pipe, e.g. with the HANSA-FLEX ROHR ENTGRATER pipe deburrer.
- Push the union nut and pressure ring/support sleeve over the pipe (see figures).
- Flare the pipe with an appropriate flaring tool.
- The flare must be at right angles and central to the sleeve. The resulting 37° cone of the pipe must not have any defects such as grooves or cracks.
- The appropriate dimensional tolerances given in points 3.2 and 3.3 must be observed for the flare diameter DB.
- In addition, in the case of the 37° flare form (JIC) flare fitting ISO 8434-2, the flare diameter DB must not be larger than the outer diameter of the support sleeve and not smaller than the inner diameter of the support sleeve at the end face.