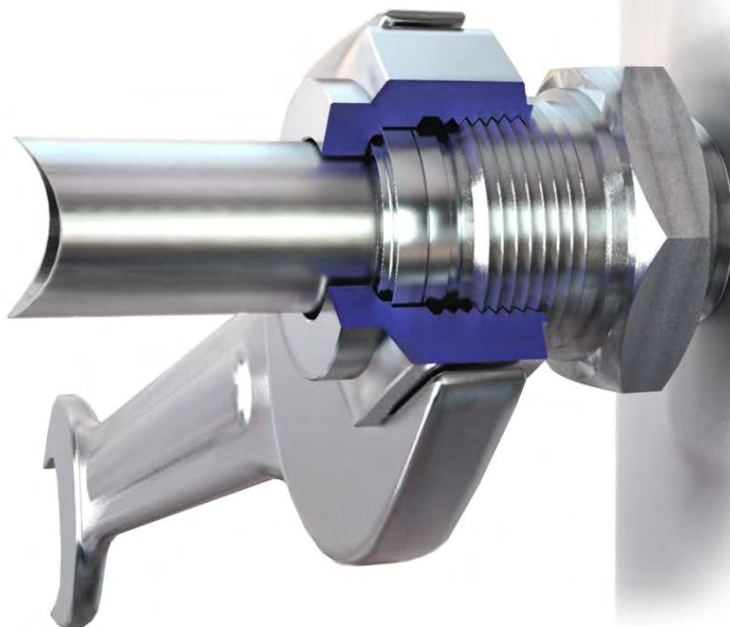




Norsk olje & gass

# FITTINGS AND SMALL BORE TUBING SYSTEMS



## Handbook

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Design: Mintra Trainingportal as



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# 1 Introduction

## 1.1 Qualifications

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It is the employer who is responsible for ensuring that the employees have the skills necessary to perform their work properly. The Norwegian Oil and Gas Association has developed a handbook for work with fittings and small bore tubing systems in pressurized systems containing hydrocarbons. This can be downloaded from [www.norskoljeoggass.no](http://www.norskoljeoggass.no).

Training shall be provided in the different makes of compression fittings that are actually going to be used. The required qualifications can be listed in the company's own governing documents, industry standards, or be defined or referred to in the contract between the operator and the contractor/between the contractor and subcontractor. This enables operationalization of the required skills.

The handbook covers three makes of compression fittings: Gyrolok, Parker A-Lok and Swagelok. However, other brands can be used. The brand to be used must be decided by the customers for each job. The Norwegian Oil and Gas Association provide no guidance on this.



# 1 Introduction

## 1.3 HSE precautions

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1. Always maintain a good overview of the work site and who is involved in the work.
2. Do not use assemblies that can injure people or damage equipment or tools.
3. Use the correct protective equipment such as protective footwear, gloves, goggles, etc.
4. Check that there is an approved and signed work permit for the job, before starting the work.
5. If working at height, the work site must be secured to prevent falling objects (tools, parts, etc.).



## 1.4 Work package checklist

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A work package shall normally contain the following:

1. A marked up P&ID or arrangement drawing that shows where the job shall be performed.
2. A job specification with the necessary detailed work drawings. If expansion loops are required, the package shall include ISO drawings of these.
3. List of materials.
4. Valve and blind lists and/or descriptions of the necessary isolation/blinding.

# 1 Introduction

## 1.4 Work package checklist

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The person responsible for planning the work shall ensure that:

1. The correct parts (tubing, compression fittings, etc.) are available and that they conform to a valid pipe class sheet (PCS)/tube specifications, if a PCS has been prepared for the relevant tubing system.
2. The necessary tools are available.
3. The need for scaffolding and barriers when working at height has been determined.
4. The operating history of the system has been investigated and assessed to ensure that required measures have been planned for and will be implemented.

## 1.5 Execution

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The qualified person who shall perform the work, and the equipment responsible person/system operator/process technician/area responsible person shall together ensure that:

1. There is an approved work permit.
2. A SJA (safe job analysis and possibly a pre-job briefing) has been carried out if required.
3. The correct location and connections have been identified.
4. Isolation/blinding has been correctly performed, and the system is unpressurized and free of hydrocarbons.
5. Valves that are going to be disassembled are in the half open position, or as shown in the valve maintenance manual, so that the valve is free of pockets of trapped pressure.
6. Any insulation has been removed and heater cables disconnected if relevant for the job.
7. The equipment has been secured against unintended displacement during disassembly.

# 1 Introduction

## 1.6 Language and use of names

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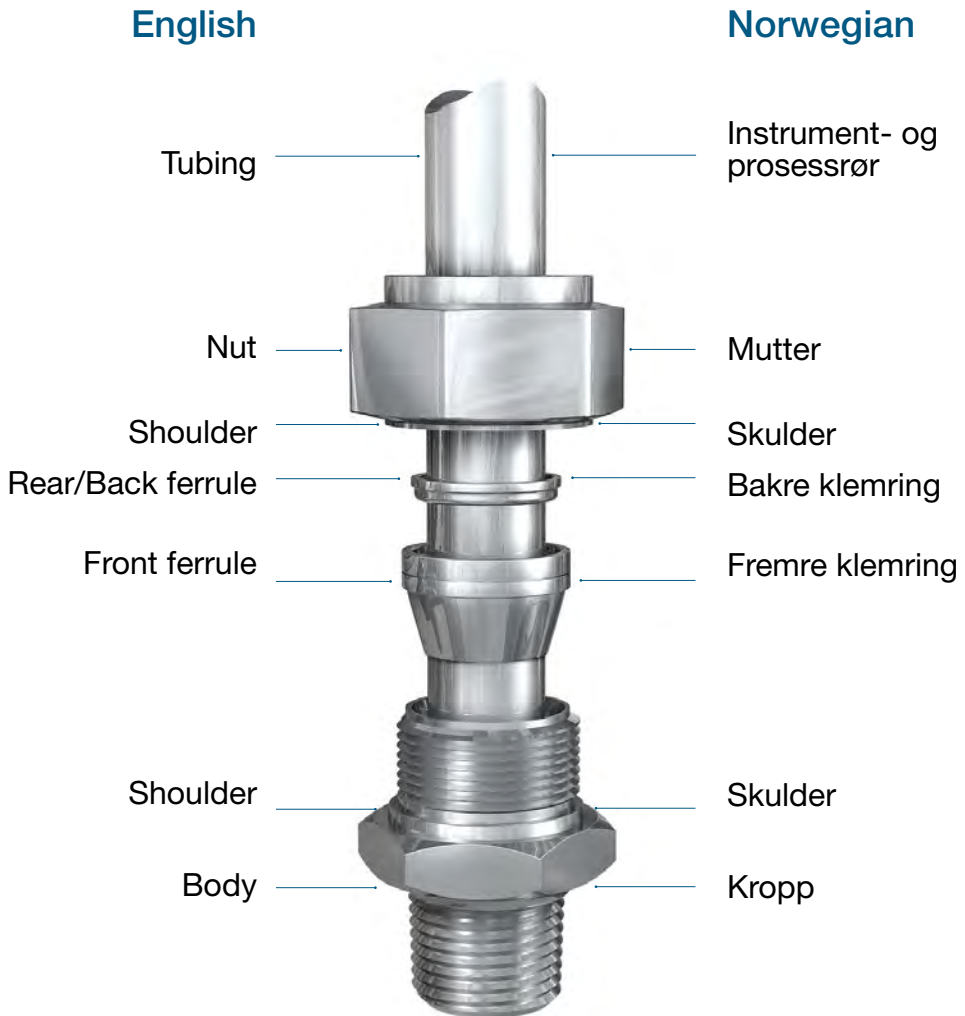
This handbook covers what are defined as small bore tubing systems, e.g. tubes with an outside diameter (OD) of less than or equal to 50 mm (2").

Small bore tubing is referred to as tubing in the handbook.

Compression fittings is a collective term for all the parts/ components that are used to connect tubing systems.



## 1.6 Language and use of names





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## 2.1 Twin ferrule compression fittings

The most commonly used fitting in tubing systems is a compression fitting with two ferrules. Internationally, there are more than 30 different brands of this type of fitting.

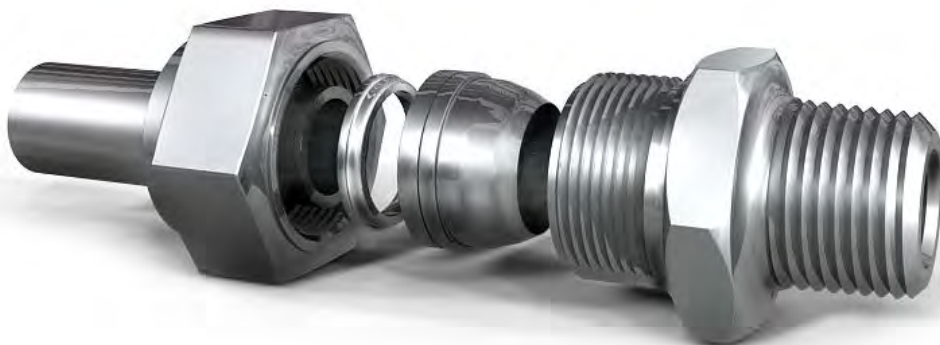
The most widely used brands in the Norwegian offshore industry are:

- Parker A-Lok
- Gyrolok
- Swagelok

These three brands are used as examples in this handbook. However, other brands can be used. The brand to be used must be decided by the customer for each job.



Never mix components from different brands.





## 2.1 Twin ferrule compression fittings

Below are shown the identifications used by the three example brands.

### PARKER A-LOK

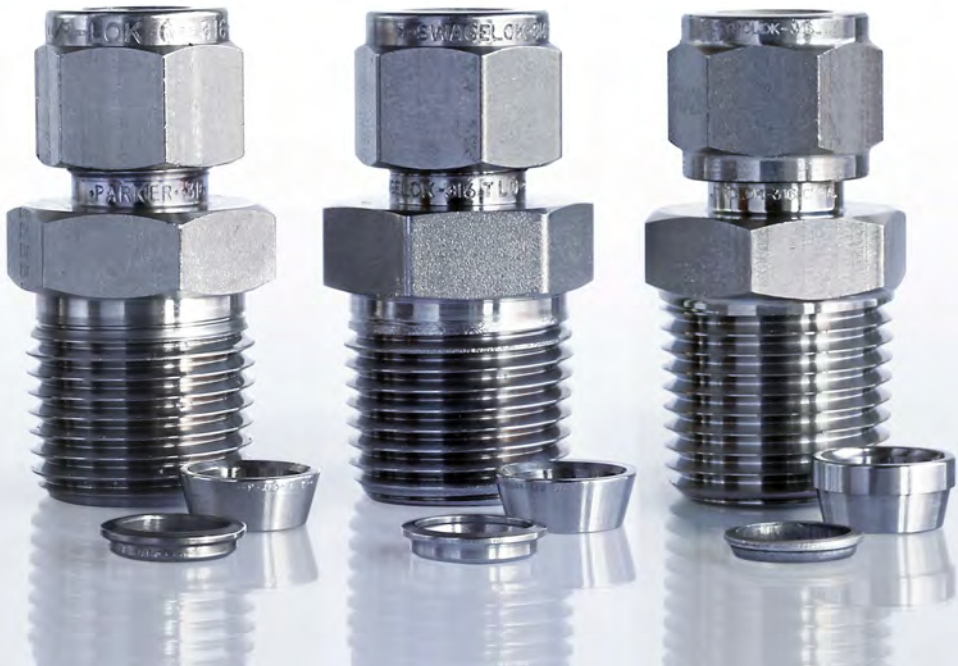
- brand on nut and body
- brand on both ferrules

### SWAGELOK

- brand on nut and body
- brand on both ferrules

### GYROLOK

- brand on nut and body
- shoulder on front ring



## 2.2 Dimensions

A compression fitting’s dimensions are stated on the basis of the outside diameter of the relevant tubing. Compression fitting are available for both metric and imperial tubing dimensions.

Each brand may have a different way of indicating the imperial (inches) and metric (millimetres) dimensions of their fittings.

The table below shows the most commonly used dimensions in inches and millimetres.

Size metric	Size imperial
3	1/8" (3,17mm)
6	1/4" (6,35mm)
10	3/8" (9,52mm)
12	1/2" (12,70mm)
16	5/8" (15,87mm)
20	3/4" (19,05mm)
25	1" (25,40mm)
32	1 1/4" (31,75mm)
38	1 1/2" (38,10mm)
50	2" (50,80mm)

Never mix imperial and metric components.



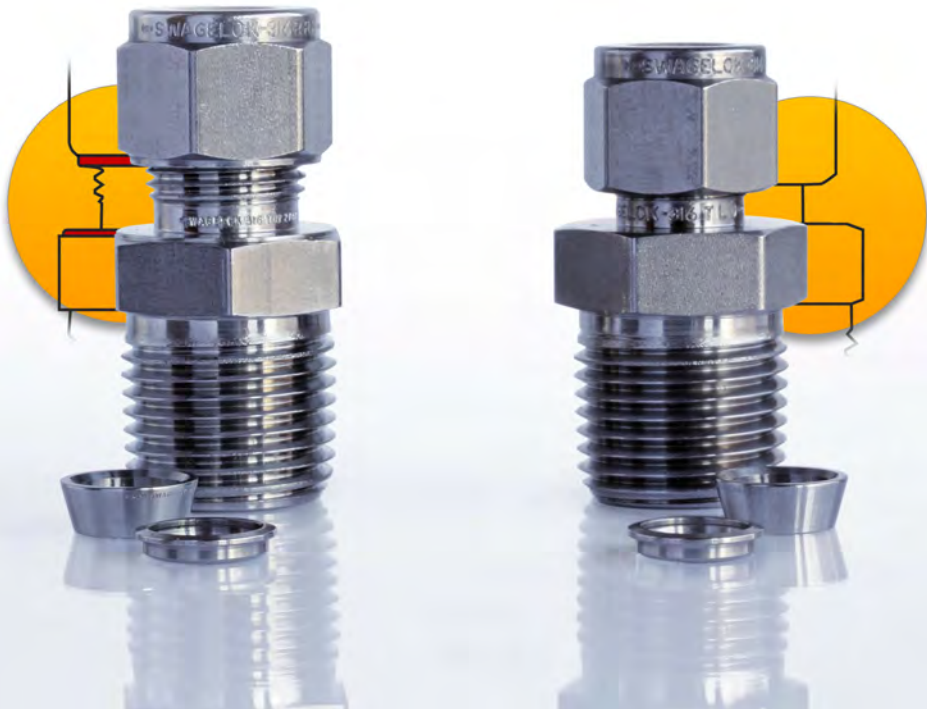
## 2.3 Markings Swagelok

### Swagelok Metric

- shoulder on the nut and on the body
- mm is die stamped on elbows, crosses and tees

### Swagelok Imperial

- no shoulder on body or nut indicates imperial



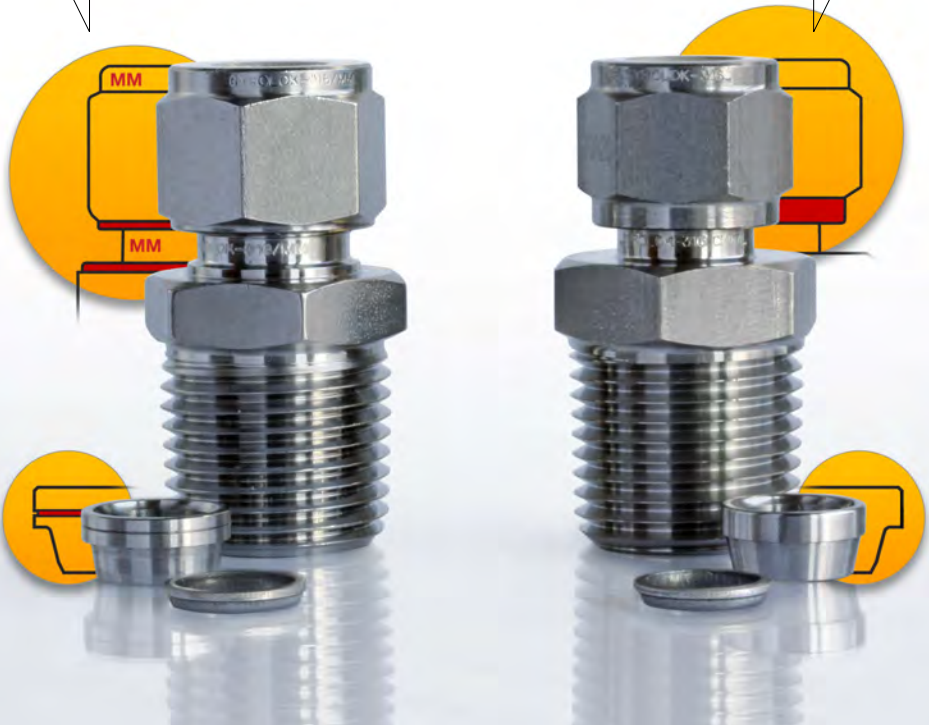
## 2.3 Markings Gyrolok

### Gyrolok Metric

- shoulder on the nut, on the body and the groove on front ring
- mm is die stamped on bodies, nuts, elbows, crosses and tees

### Gyrolok Imperial

- no shoulder on body indicates imperial
- long shoulder on nut
- no groove on front ring



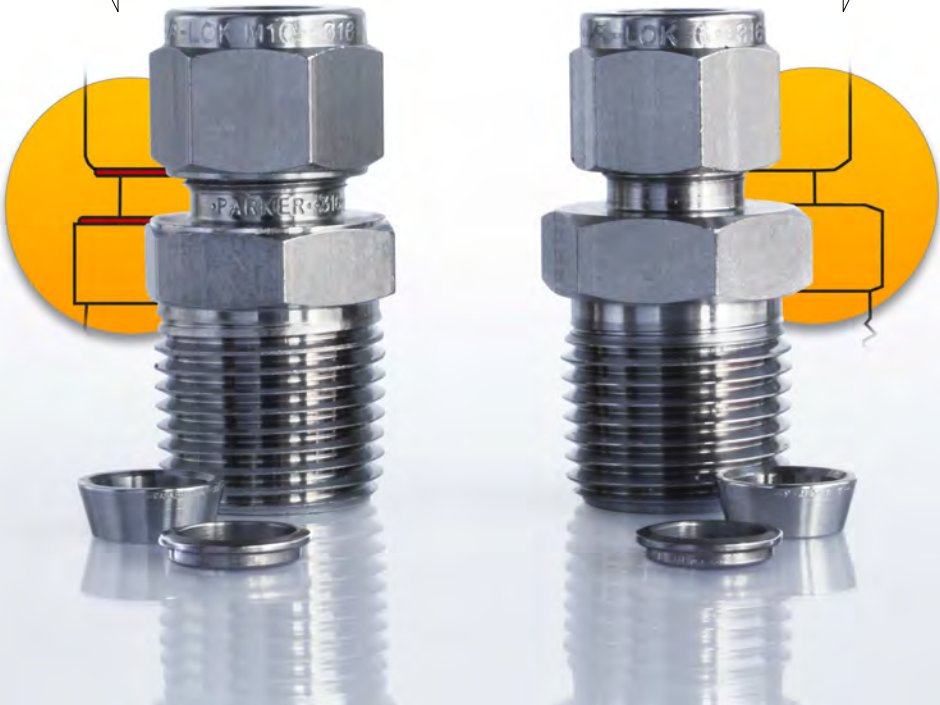
## 2.3 Markings Parker A-Lok

### Parker A-Lok Metric

- shoulder on the nut and on the body
- mm is die stamped on elbows, crosses and tees

### Parker A-Lok Imperial

- no shoulder on body or nut indicates imperial

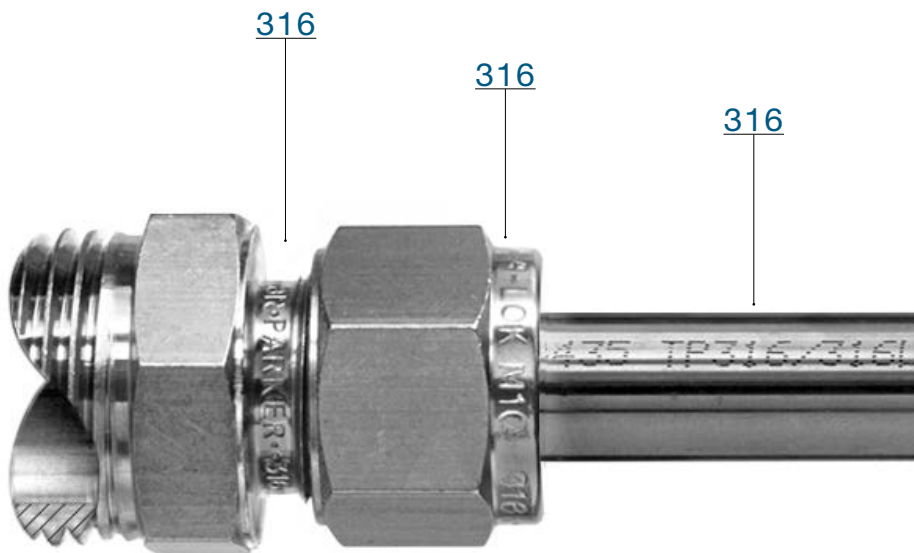


## 2.4 Materials

The material quality of the fittings (body and nut) must always be checked for compatibility. If the material types of the body and nut differ, this must be reported to the technical responsible position for the plant!

Each brand may have a different way of indicating material quality.

Never mix components from different brands.





## 2.4 Materials

Swagelok fittings in super duplex stainless steel, for example, have a recessed edge at the top of the nut for identification. The nut and body are marked with SAF 2507.



## 2.4 Materials

Gyrolok uses colour coding on the body and nut, as illustrated in the figure below.



Always check the physical markings on all components.  
Do not rely on colour coding alone.

**316ss**

p/n10CM8316ME



**Titanium**

p/n10CM8TIME



**6MO**

p/n10CM86MOME



**Hastelloy**

p/n10CM8HCME



**Duplex**

p/n10CM8DX3ME





## 2.5 Installation – precautions

Work must not be performed on pressurized systems - even in the case of a leak!

An approved bleed off point must be used for depressurization. Do not bleed off the system by loosening a nut or the body of a compression fitting!

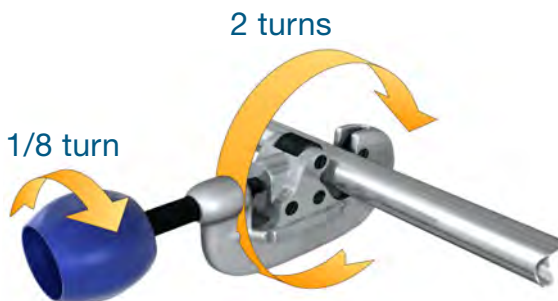
Do not mix materials or different brands of compression fittings - tubing, ferrules, nuts and bodies.

Always use the customer's recommended thread sealant / lubrication on tapered NPT threads.

## 2.6 Installation procedure

1. Cut the tube with a perpendicular cut (90 degrees) - a tube cutter is recommended.

- ensure that the tube cutter is in good condition before starting (ensure that the cutting wheel is sharp).
- do not over tighten, since this can result in an oval tube (which will not correctly fit into the fitting).
- two turns with the cutter, followed by an approx. 1/8 turn of the handle



2. Both the ID and OD of tubes shall be deburred after cutting.

- blow through the tube as a final cleaning with compressed air.
- shavings that are left behind can cause turbulence and possibly leaks in sensitive downstream equipment.



## 2.6 Installation procedure

3. Install all the components of the compression fitting on the tube. Check that all components are present and properly aligned before assembly.



4. Insert the tube into the compression fitting. Make sure that the tube rests firmly on the shoulder of the fitting.

- use the fitting manufacturer's depth marking tool, and a pen/pencil to mark the tube at the top of the tool.
- for the brands Swagelok and Gyrolok, this control line shall not be visible when the tube is inserted into the body, and the nut is snug tight. For the brand Parker A-Lok, the tool draws a line on the tubing, and the line is visible during the entire installation process.

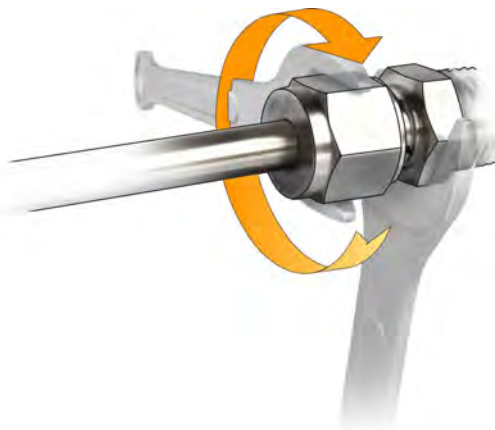


## 2.6 Installation procedure

5. Tighten the nut until the tubing cannot be rotated.
6. Mark the nut and body with vertical lines directly above each other with a felt pen.



7. Hold the body still and tighten in accordance with the table in chapter 2, page 29.



8. Use the brand manufacturer's inspection tool to verify correct tightening.  
Note! The tool only verifies that the fitting is tightened enough. It does not register over-tightening, which is a widespread problem.



## 2.7 Assembling procedure

The table shows the correct tightening procedures for Parker A-Lok, Gyrolok and Swagelok compression fittings. The columns indicate the number of turns after snug tight (the tube cannot be turned) for different tube dimensions, and when manual or hydraulic pre-assembly is used.

Size mm	Size inches	Tightening 1st Time			Remake			Manual pre-assembly	Hydraulic pre-assembly HSU
		Parker A-Lok	Gyrolok	Swagelok	Parker A-Lok	Gyrolok	Swagelok		
2	1/16"	3/4	1 1/4	3/4	1/8	1/4	1/8	•	
3	1/8" (3,17mm)	3/4	1 1/4	3/4	1/8	1/4	1/8	•	
4	3/16"	3/4	1 1/4	3/4	1/8	1/4	1/8	•	
6	1/4" (6,35mm)	1 1/4	1 1/4	1 1/4	1/4	1/4	1/4	•	
10	3/8" (9,52mm)	1 1/4	1 1/4	1 1/4	1/4	1/4	1/4	•	
12	1/2" (12,70mm)	1 1/4	1 1/4	1 1/4	1/4	1/4	1/4	•	•
16	5/8" (15,87mm)	1 1/4	1 1/4	1 1/4	1/4	1/4	1/4	•	•
20	3/4" (19,05mm)	1 1/4	1 1/4	1 1/4	1/4	1/4	1/4	•	•
25	1" (25,40mm)	1 1/4	1 1/4	1 1/4	1/4	1/4	1/4		• •
32	1 1/4" (31,75mm)	HSU + 5/8	HSU + 1/4	HSU + 1/2	1/4	1/4	1/4		• •
38	1 1/2" (38,10mm)	HSU + 5/8	HSU + 1/4	HSU + 1/2	1/4	1/4	1/4		• •
50	2" (50,80mm)	HSU + 3/4	HSU + 1/4	HSU + 1/2	1/4	1/4	1/4		• •

• = can be used, • • = must be used

Use the correct tool for the compression fitting, supplied the fitting brand manufacturer.

## 2.8 Preswaging

---

Pre-swaging shall be done whenever possible.

The ferrules are firmly swaged on the tube in advance.

Pre-swaging prevents the tubing slipping out of the body during assembly (while tightening), and ensures correct installation.



Always follow the brand manufacturer's user manual.

Oversized tubing (max. tolerance) can occasionally get stuck in the tool after pre-swaging. If this happens, carefully wiggle the tube back and forth until it loosens.

The tubing must not be twisted. Do not try to loosen it with tongs, pliers or other tools since this can destroy the seal surface.

## 2.8 Preswaging

### Manual pre-swaging tool



### Hydraulic pre-swaging tool



## 2.9 Verification of installation

Use the brand manufacturer's gauge to verify correct execution.

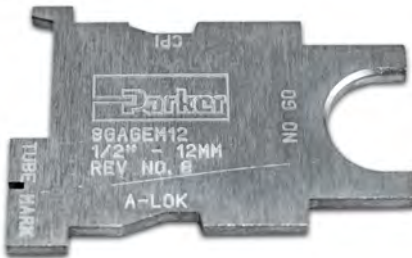
Inspection and depth marking tool

- Is used to confirm installation has been properly performed.
- Is used to ensure the tubing is in contact with the bottom of the body.
- Follow the brand manufacturer's user manual.





## 2.9 Verification of installation



Always use tools supplied by the compression fitting manufacturer.



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## 3.1 Threads

There are several types of thread specifications on the market, but in general there are two main types: parallel and taper.

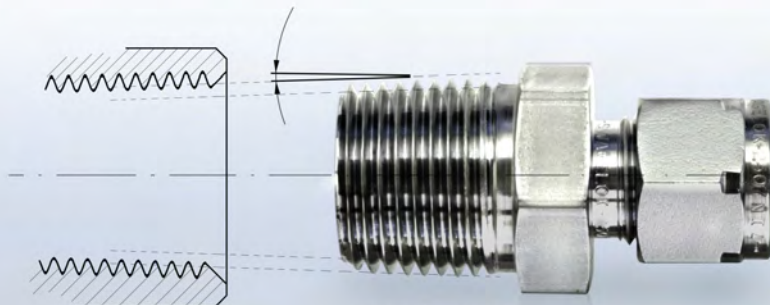
Examples of marking on the body:

1. NPT: NPT or no marking
2. BSPT: is marked with BSPT or RT
3. BSPP: is marked with BSPP or RS, RP or RG

On the Norwegian continental shelf, NPT and BSPP are the most widely used thread types.



External and internal (male and female) threads must be of the same type. If in doubt, a pipe thread gauge and thread gauge must be used.



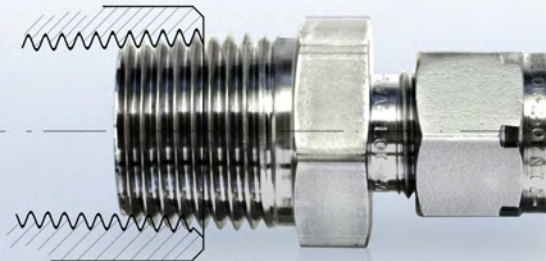
### 3.2 Tapered pipe threads (National Pipe Taper - NPT)

Tapered threads are designed to seal in the threaded part.

A sealing compound must be used on the threads in order for NPT threads to be pressure tight.

The sealing compound also has a lubricating function that prevents cold welding and galling of threads. This can easily happen to stainless steel components.

Use the sealing/lubrication compound (paste or tape) decided by the customer for the relevant connection.



## 3.2 Tapered pipe threads (National Pipe Taper - NPT)

Components with threads which are pressurized must not be unscrewed!

Ensure that no one is standing in front of a component when it is being unscrewed, even when the system has been depressurized.



### 3.3 PTFE Tape

PTFE tape is the best known Teflon tape. It provides lubrication, sealing and protection to chemical attacks, e.g. from solvents. This is the only organic lubricant permitted for oxygen in gas form.

The tape supplier's application procedure must be followed.

The tape size must be suitable for the size of the male part of the compression fitting.

- 1/4" tape size tape is used for 1/8", 1/4" and 3/8" tapered male parts.
- 1/2" tape size tape is used for larger tapered male parts.



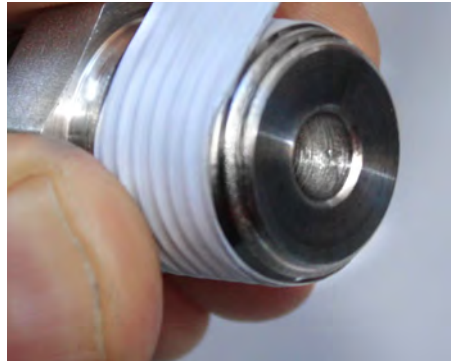
### 3.3 Tape thread sealant PTFE

#### Procedure for Silver Seal and Swagelok tape:

1. Ensure that the threads are clean and free of damage.



2. Make sure not to apply the tape to the first thread.



3. NOTE: apply the tape sealant tightly for 2-2.5 turns in the direction of the thread (thick type of tape). Always check





## 3.3 Tape thread sealant PTFE

the manufacturer's recommendations and procedure.

4. Check that the first thread is free of tape because if it is not, the tape can loosen and the system become contaminated.



5. Cut off surplus tape. Press on the overlap so that the tape is pushed down into the threads.



- It is important to ensure that the male connector does not loosen during assembly.
- Dynamic loads can cause the tape to shrink a bit and this can over time result in leaks.


### 3.4 Paste

---

The most common types of thread sealant used in today's tubing systems are Loctite 577 and Loctite 542. Other types and brands can also be used. Use only the customer's approved type.

The following points generally apply when using Loctite products:

1. **All the parts must be clean and dry before use.**  
New parts should be liberally sprayed with cleaning fluid and this should then be allowed to evaporate for 30-60 seconds before the part is ready for the adhesive to be applied.
2. Apply the Loctite all the way around on the first or second thread.  
If too much is applied, the Loctite will flow upwards and possibly into the adjoining component/tubing.
3. Activator must be used as recommended by the product manufacturer.
4. At low temperatures, applying heat must be considered in addition to the activator to ensure curing.



Always follow the paste manufacturer's procedures for application and curing.

### 3.4 Paste

Never re-tighten a nut with cured Loctite paste products. The Loctite will 'break' and the risk of cold welding will increase.



### 3.5 Assembly tolerances

---

Threaded pipe fittings, plugs and other equipment with tapered pipe threads must be correctly assembled to avoid leaks and other undesirable events. NPT pipe threads must conform to ASME B1.20.1 or API Std 5B and the customer's requirements.

ASME and API have thread tolerance requirements that can make it difficult or impossible to install the parts together with the required number of threads. This can happen with unfortunate combinations of the standards' permitted tolerances.

1. Ensure that the dimensions and the threads are correct.
2. NOTE: some thread types may have the same outside dimensions and thread pitch. Different types of threads shall not be mixed!
3. Ensure that the threads are free of damage and have smooth surfaces.
4. The threads can be refreshed by use of a thread tap or threading die. Check that the thread tolerance requirements are fulfilled after they have been refreshed.

## 3.5 Assembly tolerances



5. Requirements for fully assembled components with tapered NPT threads are:  
Minimum 4.5 threads must be fully engaged.  
Preferably 5.5 threads or more should be screwed in, without permanently deforming the threads.
6. The qualified person performing the installation work is responsible for ensuring that the required number of threads have been engaged.
7. Contact the immediate superior for further instructions if the engagement requirements are not achieved

The torque used to sufficiently tighten the assembly must not damage the threads.



### 3.5 Assembly tolerances

---

The threads can be checked with an ASME/API pipe thread gauge before assembly to check that the tolerance requirements conform to the customer's applicable specifications for the parts.

Tolerance requirements that normally ensure that sufficient threads can be assembled without damaging the parts ('small' male parts and 'large' female parts):

Male part: -1 til  $-\frac{1}{4}$  thread above the midpoint.

Female part:  $+\frac{1}{4}$  til +1 thread above the midpoint.

### 3.5 Assembly tolerances

If the threads in the female part are chamfered at the entrance, the threads are regarded as starting where the chamfering ends.



### 3.6 Parallel pipe threads - BSPP

(British Standard Pipe Parallel Threads – BSPP)

Parallel threads do not seal in the threaded part. It is a metal, rubber or plastic sealing ring that creates the seal (e.g. Dowty). Parallel threads, especially BSPP, are increasingly being used in hydraulic and nitrogen applications.

The DIN 3852 and ISO 228-1 standards stipulate requirements for both the threads and the meeting seal surface.





## 3.6 Parallel pipe threads - BSPP

Components with threads which are pressurized must not be unscrewed! Ensure that no one is standing in front of a component when it is unscrewed, even when the system has been depressurized.



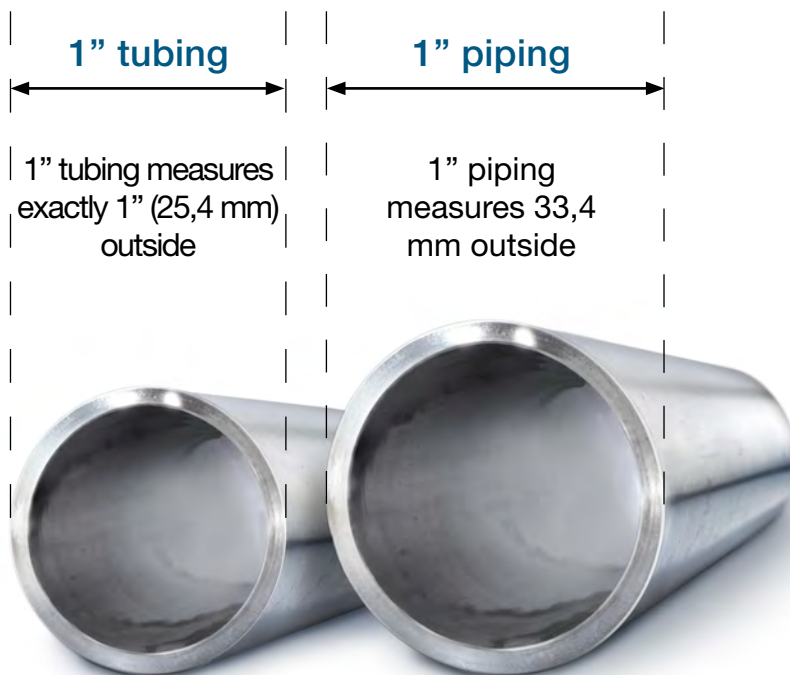


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### 4.1 Definition

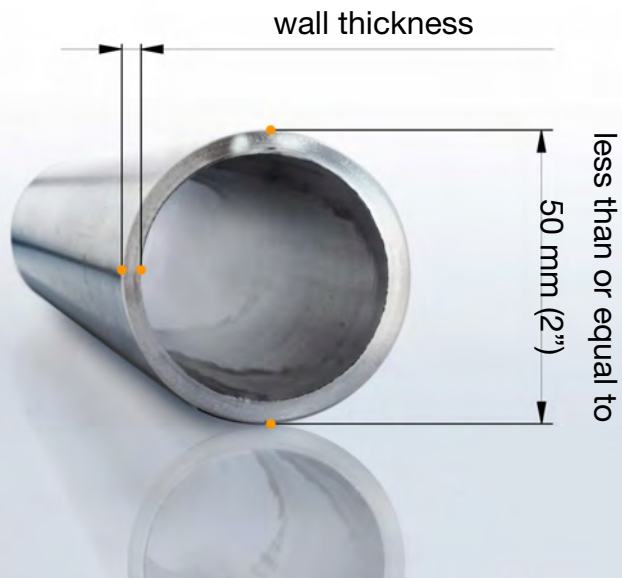
There are no structural differences between tubing and piping.

The structural calculations for both of them are based upon ASME B 31.3. This standard is used for designing tubing and piping for both process and instruments pipes and tubes.



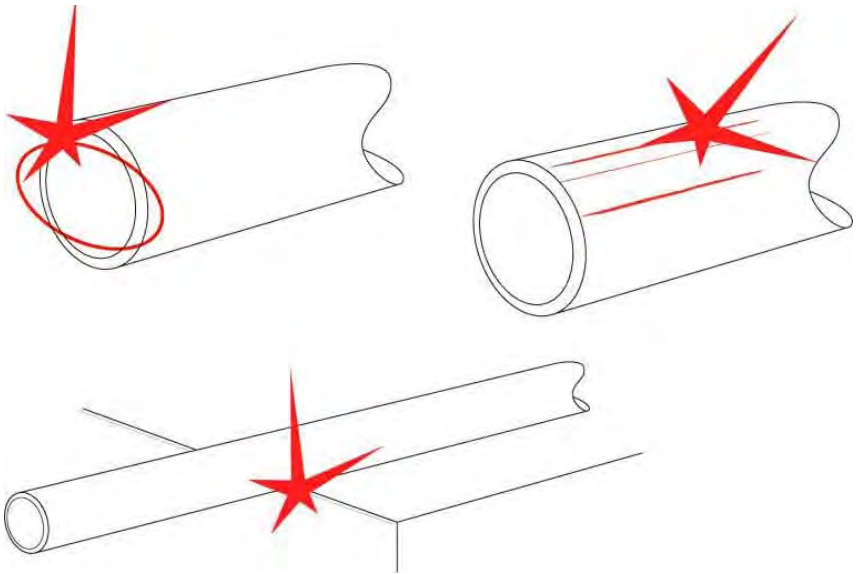
## 4.1 Definition

Tubing (small bore tubing) means tubes with an outside diameter that is less than or equal to 50 mm (2").

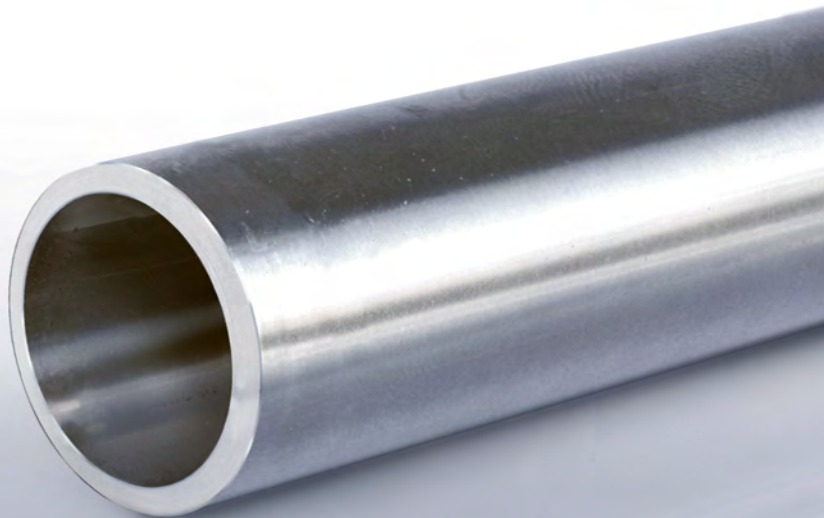


# 4 Tubing

## 4.2 Handling



Tubing



## 4.2 Handling

The surface condition of the tubing is very important for achieving tight connections. Longitudinal grooves, welding seams, scratches or flat sections, etc. will normally prevent a tight seal.

The quality of tubing can easily deteriorate if handled carelessly.

Careful handling from the moment the tubing is received until it is installed is a must in order to achieve a leak free installation.

Good handling practices will prevent scratches and nicks that could prevent adequate sealing (especially on gas lines).

Tubing must never be dragged across hard surfaces.

Tubing made of softer materials like copper and aluminium requires extra care.

If the tubing has been damaged/deformed such that it is no longer completely round (difficult to insert through nuts, rings or bodies), it must be recut.

Never force oval tubing into a compression fitting.

### Preservation:

Normally tubing shall not be painted. However, AISI 316 tubing can be susceptible to pitting corrosion in salty atmospheres. If AISI 316 tubing has to be used in a salty atmosphere, paint can be one way of avoiding pitting corrosion.

## 4.2 Handling

Tubing must be marked with its size, material type/quality, specification of standard, heat number and other information.

For example:

10.00 x 1.50 MM HT 014211 SS LOT 57534 DIN 2931

1. Outside diameter = 10.00 mm
2. Wall thickness = 1.50 mm
3. Heat number = HT 014211
4. Material = SS (Stainless Steel 316/316 L)
5. LOT number = LOT 57534
6. Standard = DIN 2931





## 4.2 Handling

Ensure the tubing chosen is suitable for the relevant process, medium, temperature and environment.

As these are ferrule connections they are subject to requirements concerning both tolerances and the hardness of the tubing. Always follow the fitting brand manufacturer's requirements.

Always check the tubing and fittings to identify the material quality. These shall have the same material quality unless otherwise has been approved by the technical responsible person. The choice of material must be approved by the technical responsible person.

For example, the ferrules in AISI 316 SS fittings cannot be installed in a SAF 2507 Super Duplex tube, since Super Duplex is much harder than 316 SS.

Mixing materials may result in galvanic corrosion due to the galvanic differences between the materials.

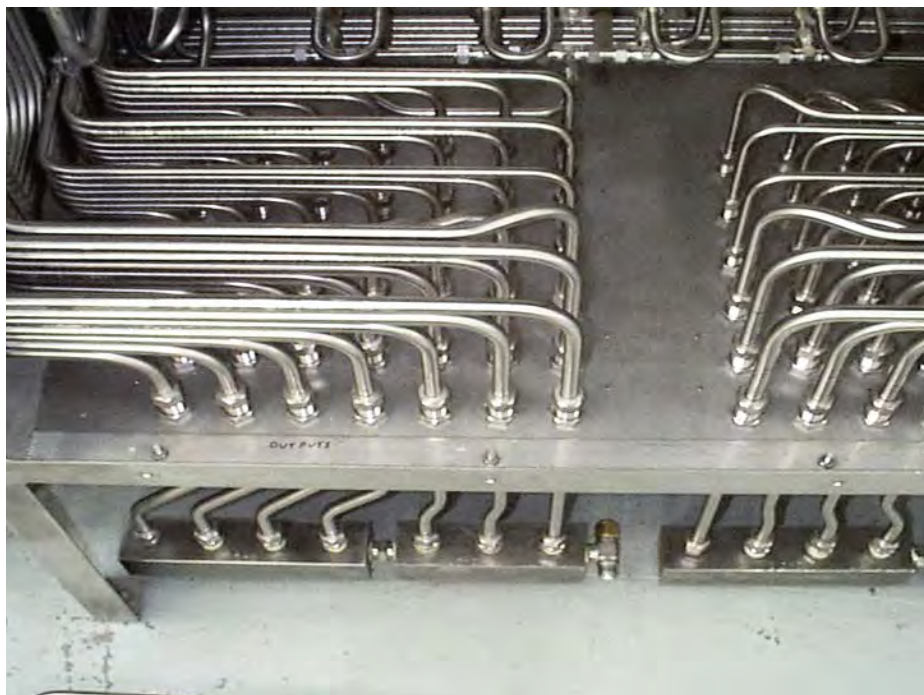
Where the materials are located in the galvanic series depends on the medium passing through the pipe. Any mixing of materials must be approved in advance by the technical responsible person.



### 4.3 Dimensions and wall thicknesses

It is usually the tube's outside diameter, wall thickness and material that limits the tubing system's operating pressure. However, this is not always the case when tube fittings with threads is used. The threads are usually the weakest link in a tubing system.

Tables and piping class sheets (pipe/tube specifications) for outside diameter and wall thickness state the tubing's maximum operating pressure.



It is important to plan the tubing arrangement before installation.

## 4.4 Installation

### Check points for installing tubing:

- Working drawings shall be available.
- The tube routing shall not come into conflict with existing equipment. Contact the technical responsible person if in doubt.
- The tubing routing must not block access for maintenance.
- Tube support must be used on long spans of tube. If in doubt check with a ASME B 31.3 qualified designer

Imperial	Metric	Spacing
1/4" - 1/2"	6 - 12 mm	0,6 m
5/8" - 7/8"	14 - 22 mm	0,6 m
1"	25 mm	1.5 m

Separate tables must be used for imperial and metric tubing

### Examples of the recommended spacing between tube supports:

- Tubing must not be used to support equipment.
- The tubing must, if necessary, be protected against careless impacts (e.g. footsteps and ladders).
- The need for expansion loops must be assessed by a ASME B 31.3 qualified designer. Bend tubing before installation, if bending is required.

## 4.4 Installation

Imperial	
T Tube OD (inches)	L Length straight tubing (inches)
1/16	1/2
1/8	23/32
3/16	3/4
1/4	13/16
5/16	7/8
3/8	15/16
1/2	1 3/16
5/8	1 1/4
3/4	1 1/4
7/8	1 5/16
1	1 1/2
1 1/4	2
1 1/2	2 13/32
2	3 1/4

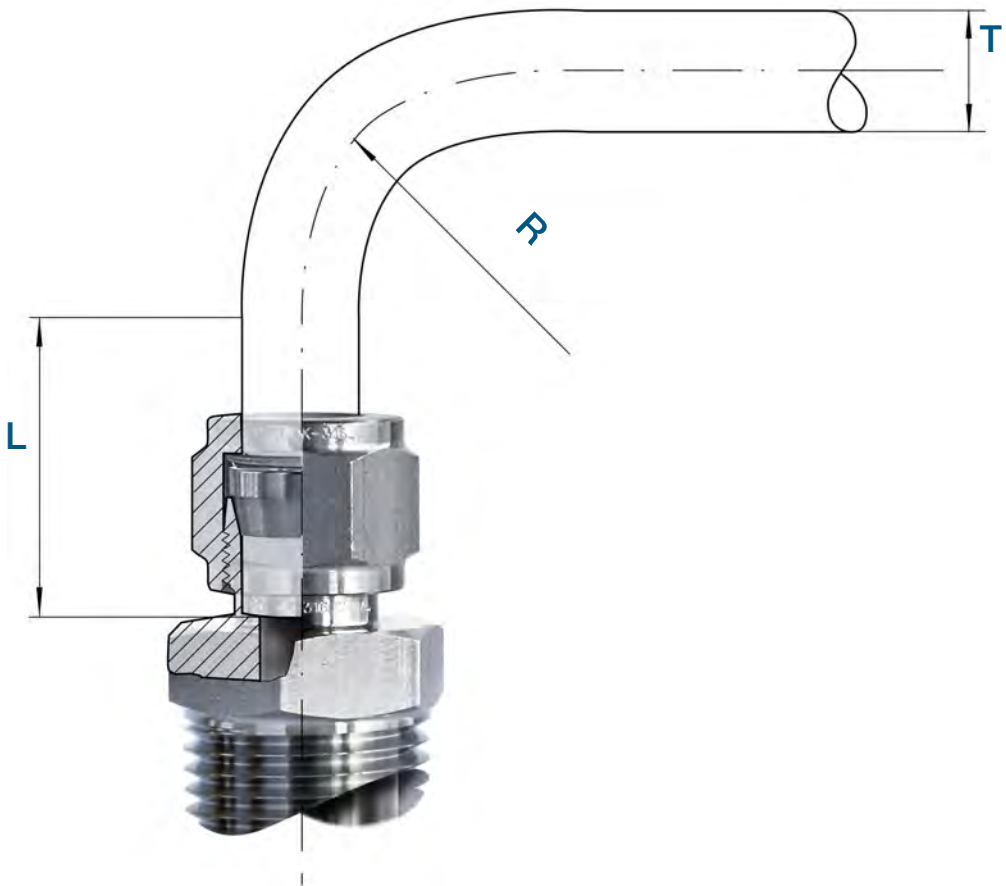
Metric	
T Tube OD (millimetres)	L Length straight tubing (millimetres)
3	19
6	21
8	22
10	25
12	29
14	31
15	32
16	32
18	32
20	33
22	33
25	40
28	40
30	52
32	51
38	60

## 4.4 Installation

L - Straight tube length required from end of tube to beginning of bend.

R - Radius of tubing bend as required or minimum allowed for specified wall thickness and tube size as recommended by bender manufacturer.

T - Tube outside diameter



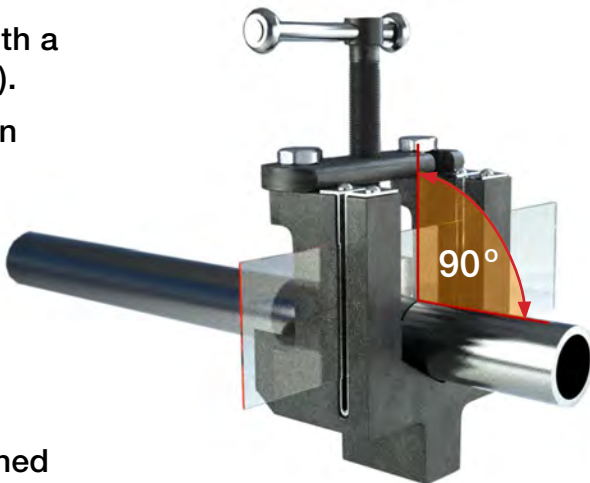
## 4.5 Cutting

Tubing must be cut with a perpendicular cut ( $90^\circ$ ).

There are two common methods of cutting tubes:

- Tube cutter
- Hacksaw

The use of a fine-toothed hacksaw (in guide block) is recommended for dimensions greater than  $3/4"$  (20 mm).



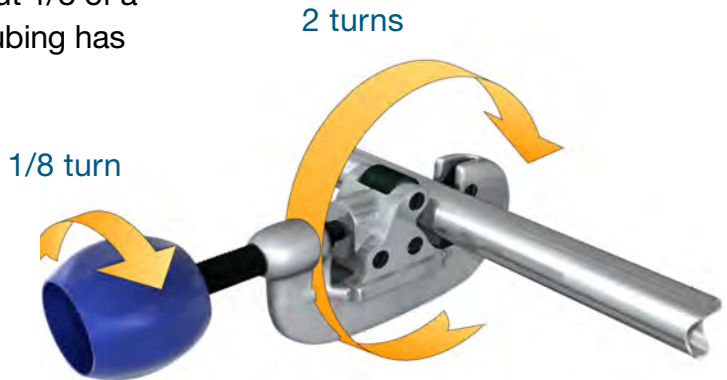
When using a tube cutter:

1. Ensure that the cutting wheel is sharp and suitable for the material the tool will be used on.
2. Do not over tighten. Tubing can easily be deformed (become oval).

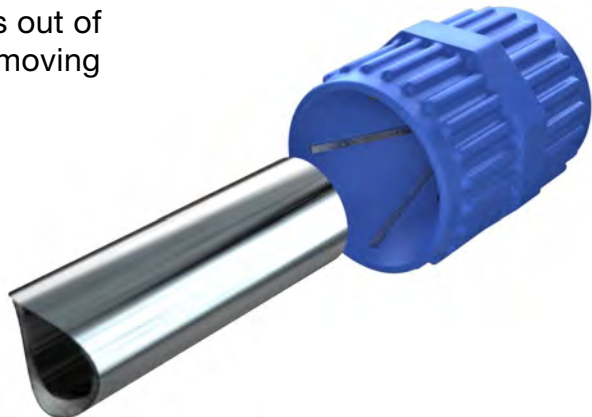


## 4.5 Cutting

3. After every second turn of the cutter, tighten the handle by about 1/8 of a turn until the tubing has been cut.



4. After cutting, remove internal and external burrs with a tool. Clean all the metal shavings out of the tubing after removing burrs.



Too much de-burring of the outside diameter may prevent the connection from sealing properly.



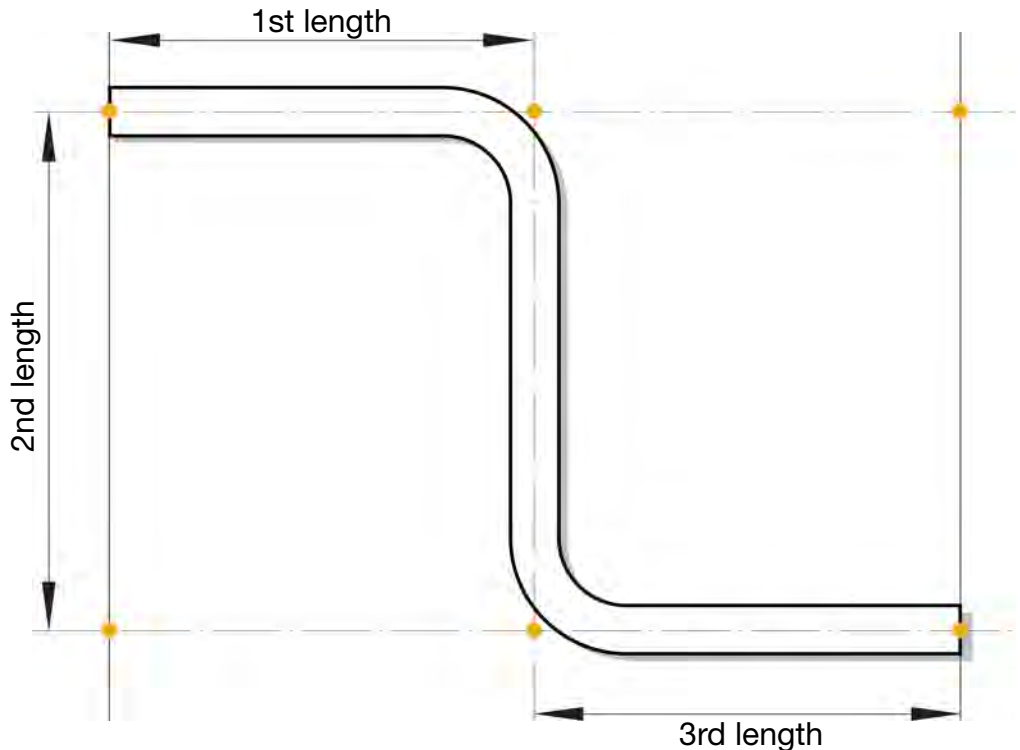
# 4 Tubing

## 4.6 Bending

Always use a bending tool suitable for the tubing's size.

It is recommended to use a bending machine when bending larger dimensions (e.g. from 20 mm) and thick wall tubing.

It is good practice to measure up, mark and bend lengths one at a time. **Remember to measure from centre line to centre line.**





## 4.6 Bending

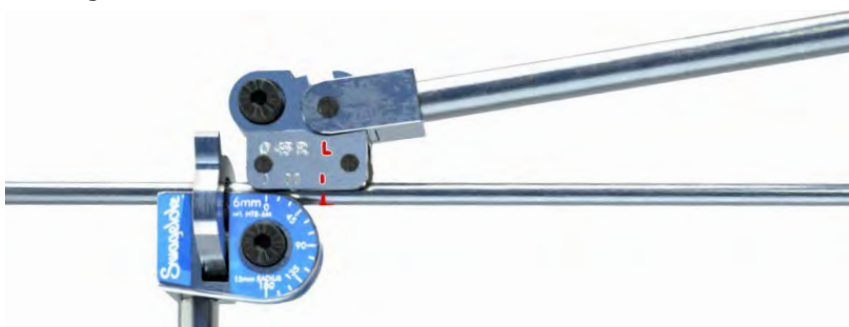


## 4.6 Bending

90 degree bend:



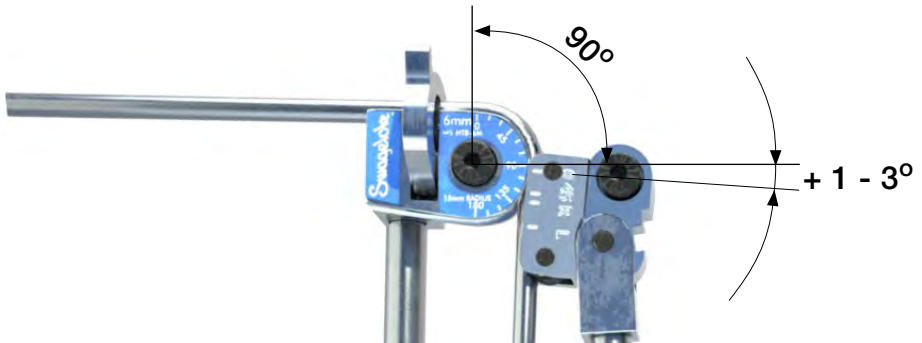
1. Place the tubing so that the mark lies directly below the 90 degree mark on the hand tube bender.



2. Depending on the type of bender, this is marked with 90 or 'L' (left).
3. If your reference measuring point is from the right, the 'R' (right) mark must be used.
4. Make sure the 0 marks on the hand tube bender are directly above each other and lock the tubing in place in the bender.

## 4.6 Bending

5. Make sure that bending is in the right direction (use a help line).
6. Bend the tubing in a controlled manner to the 90 degree mark.
7. Check the angle. Experience shows that one has to compensate for tensions in the tube, approx. 1-3 degrees.



### 45 degree bend:

1. Place the tubing so that the mark lies directly below the 45 degree mark on the hand tube bender.
2. Lock the tubing in place in the bender.
3. Bend the tubing in a controlled manner to the 45 degree mark.
4. Check the angle.

Always handle tubing with care to avoid scratches and damage!

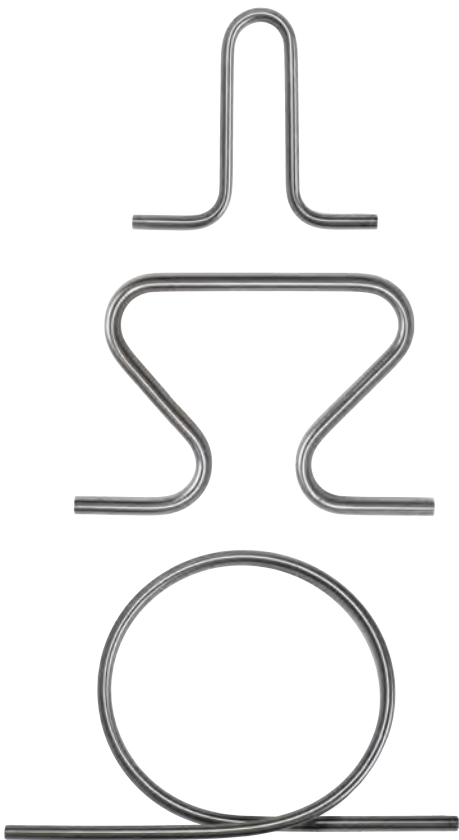


## 4.7 Expansion loops

The work package must contain a design drawing of the expansion loops. Expansion loops must be designed in conformity with ASEM B31.3, or its equivalent.

Follow the customer’s guidelines (company specifications) when designing expansion loops.

The technical responsible person must always be involved in order to clarify how much movement the expansion loops must absorb (how big the loop must be) and whether any hoses should be used.







## Notes

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## Notes

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If you have any questions, feedback or comments on the contents of the handbook, please contact the **Norwegian Oil and Gas Association's** technical manager for HSE who can be reached via the switchboard by calling (+47) 51 84 65 00.

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