U-3ARC
TRAINING WEBINAR N°35

COPPER PIPING OF A REFRIGERATING CIRCUIT

Hammadi FERJANI

July 27, 2024

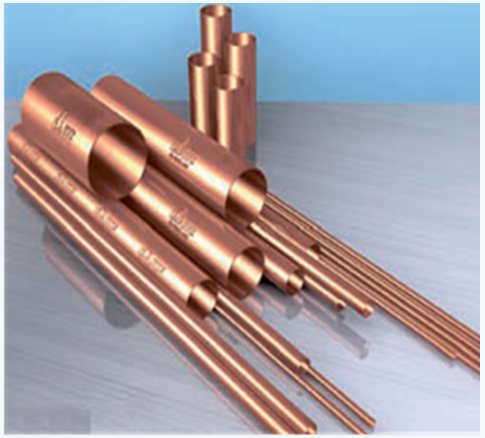
Summary

General
Copper tube expansion
Use
Standards and dimensions
Cutting
Tube deburring
Tube expansion
Flaring or socket
Copper tube connection
Refrigerant connections
Bending (on annealed tube)
Copper tube brazing
Practical sheets

Generality

- The tubes are made of electrolytic red copper, i.e. practically pure. (99.9% copper content). They are quality drawn (seamless), dehydrated and polished internally to facilitate fluid circulation.

- The copper tube is sold in “annealed” and “work-hardened” quality.



- You must use “refrigeration quality” copper tubing. The copper used for refrigeration installations is different from plumbing copper.

The success of any refrigeration installation largely depends on good piping design.

Generality

Annealed soft copper tube

- The annealed tube is delivered in the form of a crown of approximately 75 cm in diameter with a tube length of 15 or 30 m.
- Can be easily worked by hand with flared connections. This tube must be supported by clamps or fixings.
- Must be installed so as not to be subjected to stress or vibration once the work is completed.

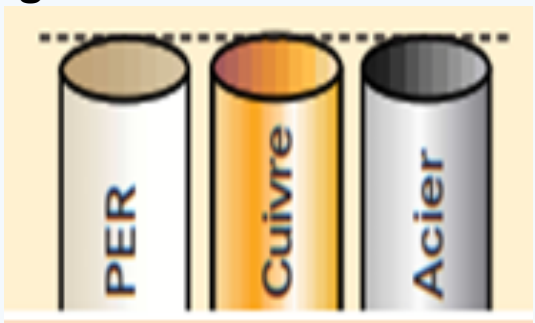
Hard, cold-worked copper tube

- The hardened tube is supplied in straight bars of 4 to 5 m, must not be bent, elbows, tee fittings, etc. are required. form the necessary tube connections. Joints must be brazed.
- The refrigerating copper tube is identified by its outer diameter OD (Outlet Diameter). Expressed as a fraction of an inch: 1 inch = 25.4 mm. The outer diameters are scaled in 1/8 inch increments. We therefore find tubes: 1/4' 3/8, 1/2' 5/8, 3/4, etc...

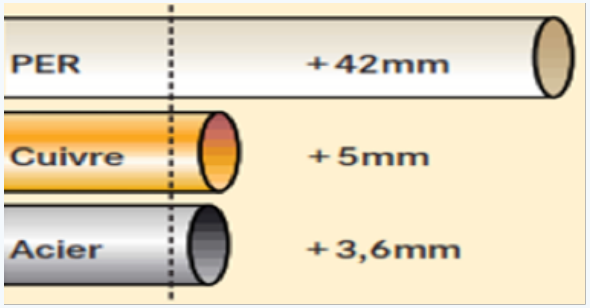
Copper tube expansion

Comparative expansion of three 10 m tubes made of different materials

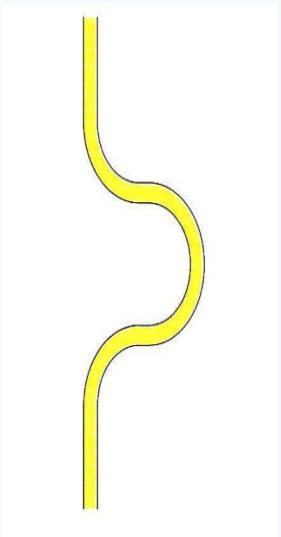
Starting situation at 20°C



Situation at 50°C



- When thermal movements are significant, they must be absorbed by expansion brackets or expansion sleeves



Copper tube expansion

Fixings

Exposedly installed copper tubes are normally secured by clamps, preferably made of copper, copper alloy or synthetic material.

The use of clamps made of zamak or other metal requires an insulator to be provided between the tube and the clamps, in order to avoid direct contact causing vibrations.

The distance to be respected between two collars depends on the diameter of the copper tube; it is indicated in the table.

Outside diameter	Distance between collars in m
3/8	1.0
½	1.1
5/8	1.2
¾	1.3
5/8	1.4
7/8	1.7
1” 1/8	1.8
1”3/8	1.9

Use

Use of tubes according to their type:	
Use annealed tube	***Use hardened tube***
For the distribution of refrigerants for air conditioning, air conditioning, refrigeration and commercial refrigeration: **•Cold bending** **•Easy installation** **•For small typical installations, split system, multi split and refrigeration**	Distribution for air conditioning, air conditioning and industrial refrigeration and cold storage **•Fixing by clamp or on cable tray** **•Use of copper accessories such as elbows, sleeves, reductions, etc.**

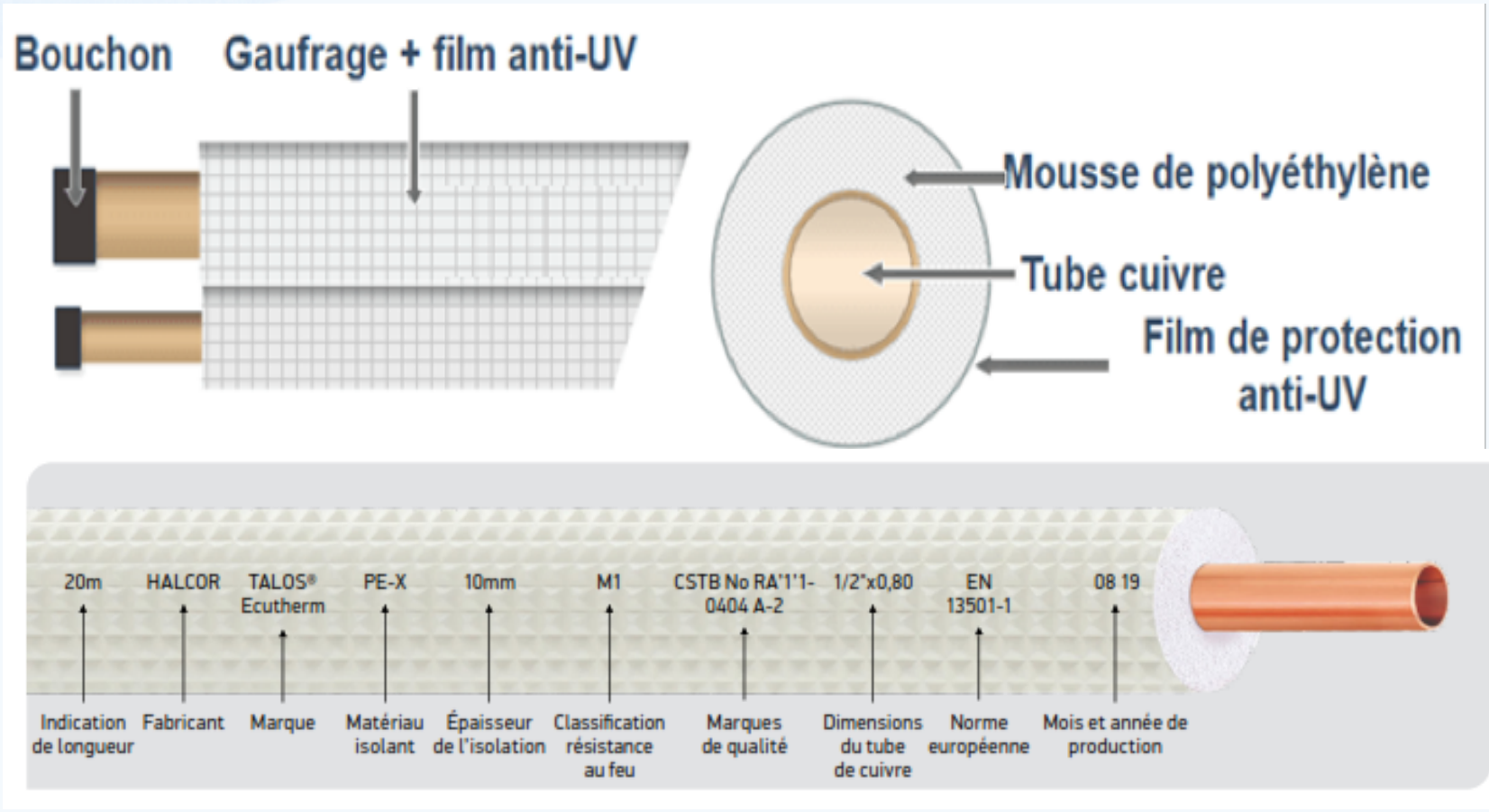
✓Crush the end of the crown after each use and plug the bar end
✓Do not introduce chips when deburring
✓Never blow into the tube (humidity)

✓ High-density polyethylene foam insulation, coated with an anti-UV and vapor barrier protective film. Fire classification: 3 qualities of insulation are available:

- *M0 Non-combustible*
- *M1 Combustible, flammable*
- *M2 Low flammable fuel*

Use

Insulation



Use

Designation	Thickness in millimeter	Inner diameter in millimeter	Exterior surface per m/l. In cm²	Interior surface per m/l. In cm²	Weight per meter in kg
1/4	0.800	4.75	199	148	0.122
3/8	0.762	8.00	299	252	0.185
1/2	0.889	10.90	399	342	0.293
5/8	1.016	13.84	499	435	0.418
3/4	1.067	16.92	598	532	0.528
7/8	1.143	19.94	698	626	0.686
1"1/8	1.270	26.03	896	817	0.950
1"3/8	1.400	32.12	1098	1010	1.280
1"5/8	1.524	38.22	1295	1202	1.670
2"1/8	1.778	50.42	1695	1582	2.540
2"5/8	2.032	62.56	2098	1969	3,700
3"1/8	2.286	74.80	2490	2350	4.000
3"5/8	2.540	86.99	2890	2738	6.300
4"1/8	2.794	99.18	3290	3120	7.700
5"1/8	3.175	127.82	4100	4010	10.200
6"1/8	3.556	148.46	4890	4670	14.900

Standards and dimensions

AMERICAN STANDARD soft copper rollers ASTM B290		
Diameter (thumb)	Length (foot)	Wall thickness (mm)
1/8”	50	0.76
3/16”	50	0.76
1/4”	50	0.76
5/16”	50	0.81
3/8”	50	0.81
1/2”	50	0.81
5/8”	50	0.89
3/4”	50	0.89
7/8”	50	1.14
1 1/8”	50	1.21
1 3/8”	50	1.4
1 5/8”	50	1.52

EUROPEAN NORM soft copper rollers DIN 8905					
Diameter (thumb)	Length (m)	Wall thickness (mm)	Diameter (mm)	Length (m)	Wall thickness (mm)
3/16”	50	1	4	25	1
1/4”	30	1	6	25	1
5/16”	50	1	8	25	1
3/8”	30	1	10	25	1
1/2”	30	1	12	25	1
5/8”	30	1	15	25	1
3/4”	15	1	16	25	1
7/8”	15	1	18	25	1
			22	25	1

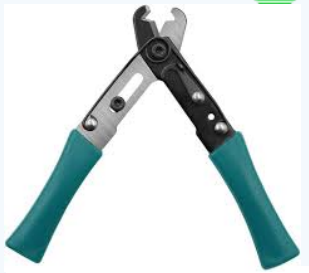
Standards and dimensions

AMERICAN STANDARD copper bars ASTM B290		
Diameter (thumb)	Length (foot)	Wall thickness (mm)
3/8”	16.4	0.76
1/2”	16.4	0.89
5/8”	16.4	1.02
3/4”	16.4	1.07
7/8”	16.4	1.14
1 1/8”	16.4	1.21
1 3/8”	16.4	1.40
1 5/8”	16.4	1.53
2 1/8”	16.4	1.78
2 5/8”	16.4	2.03
3 1/8”	16.4	2.29
3 5/8”	16.4	2.54
4 1/8”	16.4	2.79

EUROPEAN NORM copper bars DIN 8905			
Diameter (thumb)	Wall thickness (mm)	Diameter (mm)	Wall thickness (mm)
1/4”	1	6	1
3/8”	1	8	1
1/2”	1	10	1
5/8”	1	12	1
3/4”	1	15	1
7/8”	1	16	1
1”	1	18	1
1 1/8”	1	22	1
1 3/8”	1.24	28	1.5
1 5/8”	1.24	35	1.5
2 1/8”	1.65	42	1.5
2 5/8”	2.10	54	2
3 1/8”	2.50	64	2
3 5/8”	2.50	76	2
4 1/8”	2.50	89	2

Cutting

To take tube from a crown you must first unroll it on the ground following a straight line. After measuring the necessary length it is important to use a tube cutter and make the cut on a straight portion.



With a wheel tube cutter

✓You should never use a hacksaw because the copper filings will enter the tube and subsequently damage the components of the refrigeration installation.
✓To obtain a good cut, the tube cutter must rotate a minimum of 8 times around the tube.
✓The pipe cutter wheel must always be sharp, as this is the best way to limit burrs.
✓Using a dull caster will also have the effect of widening and hardening the end of the tube.
✓Replace the wheel when cutting becomes difficult or the end of the tube begins to widen.

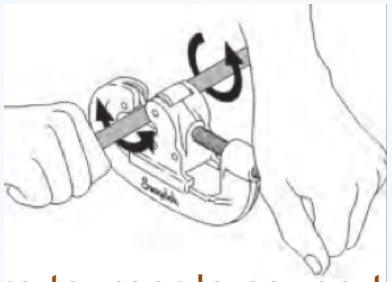
Cutting

Instructions for using the pipe cutter

1. Position the tube between the rollers and the caster.
2. Turn the handle until the caster touches the tube.
3. Make an additional 1/16 turn of the handle. (The notches on the handle are 1/8 turn apart. Use them as reference points.)

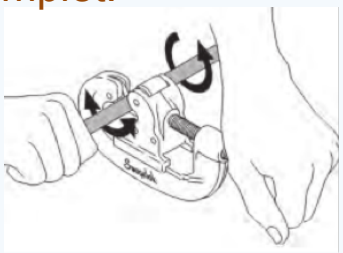
Placer la marque de mesure en face de la roulette du coupe-tube.

4. Rotate the pipe cutter around the pipe. Every two rotations, turn the handle 1/16 turn. (For softer materials, turn the handle after each rotation.)



Faire tourner le coupe-tube autour du tube en effectuant un tour complet.

5. Continue until the tube is cut.



Tourner la poignée de 1/16 de tour toutes les deux rotations

Cutting

Using a circular saw

To be used in particular for large diameters

Advantage:

A clean cut that does not deform the tube

The cut and perpendicular to the axis of the tube

Inconvenience:

Requires end work (deburring and filing)

Using a fine-toothed hacksaw

The cut and perpendicular to the axis of the tube

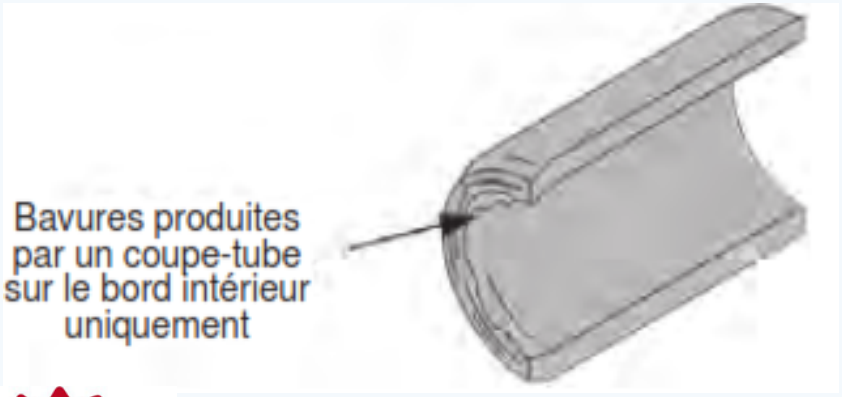
The cut must be perpendicular to the axis of the tube.

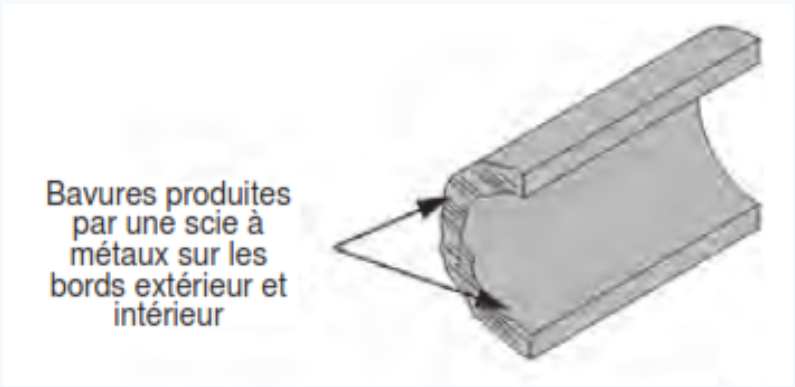
To ensure its protection. This must be maintained in a vice with lead or wooden jaws

Avoid using a fine-toothed hacksaw

Tube deburring

- During cutting, tube cutters produce burrs on the inside edge of the tube.
- The hacksaw produces them on both the inside edge and the outside edge.





Regardless of the method used to cut the tube, these burrs must be removed

Tube deburring

Deburring tools

- Deburring the outer edge can be done using a soft file
- Deburring the inner and outer edges can be done using the deburring tools

Tube expansion

Procedure for making a dudgeon

1. Cut the tube

2. Deburr the tube:

3.Fit the nut

Before carrying out the dudgeon, do not forget to put the nut in place.

4. Run the dudgeon

✓Open the die, insert the tube to be flared into the housing corresponding to its size, tighten the die fixing screw.

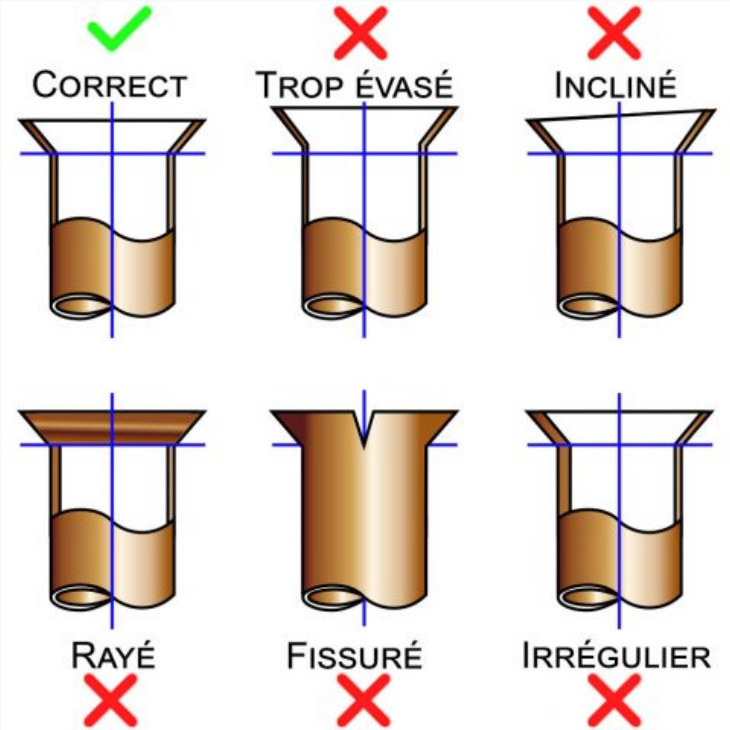
✓Insert the tube so that it protrudes 1mm to 2mm from the surface of the matrix.

✓Place the stirrup on the matrix, it must slide freely along the matrix, check that the conical part of the stirrup is in the axis of the tube.

✓Lower the cone by screwing until you obtain the collar (dudgeon) on the tube. The dudgeon should be wide enough, but the nut must remain free.

Tube expansion

It should have a smooth surface and flared edges of uniform length.



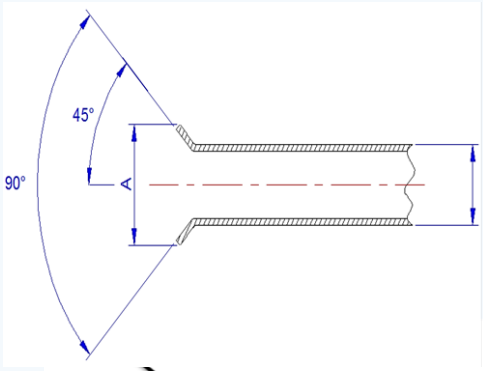
Generally, beginner refrigeration engineers have difficulty making a dudgeon of the correct size.
The best advice we can give is to start again because in 80% of cases a leak comes from a dudgeon that is too big or too small.

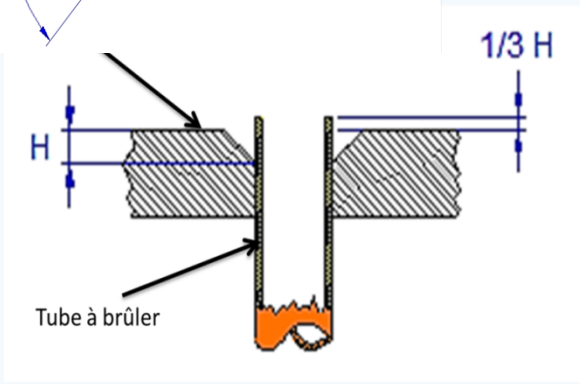
Tube expansion

Check the maximum and minimum diameter of the flare diameter

- refer to the tables below:

Nominal tube diameter	Flared diameter "A"	
	Max (mm)	Min (mm)
1/8	4,60	4,34
3/16	6,32	6,07
¼	8,25	8,00
5/16	10,26	9,85
3/8	12,37	11,96
7/16	14,25	13,84
½	15,82	15,42
9/16	17,17	16,76
5/8	18,00	18,60
¾	23,27	22,86
7/8	26,44	26,03



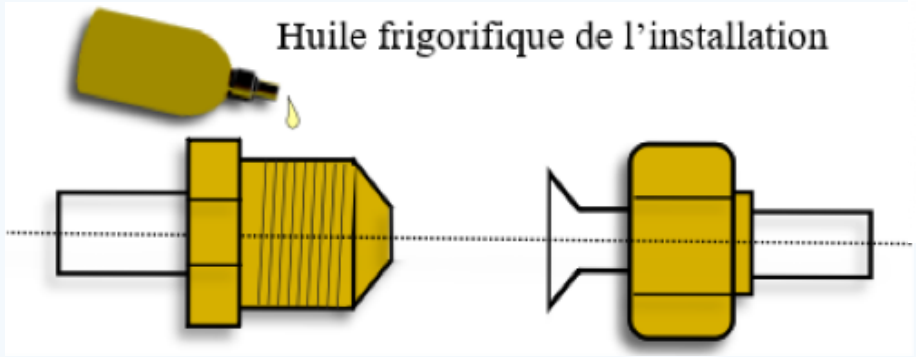


Tube diameter	1/4	3/8	1/2	5/8	3/4
Dimensions 1/3H (mm)	1.3	1.6	1.8	2	2.2

Tube expansion

Tightening the fitting

Screw the nut by hand while keeping the tube aligned, the nut must not be forced, if possible interpose a drop of refrigerating oil (the same type as oil used in the circuit) between the male and female parts to do this. will make screwing easier.



Tighten the dudgeon with 2 adjustable wrenches using sufficient force so that the dudgeon is in good contact with the conical male part. Of course the ideal is to use a torque wrench see the table below

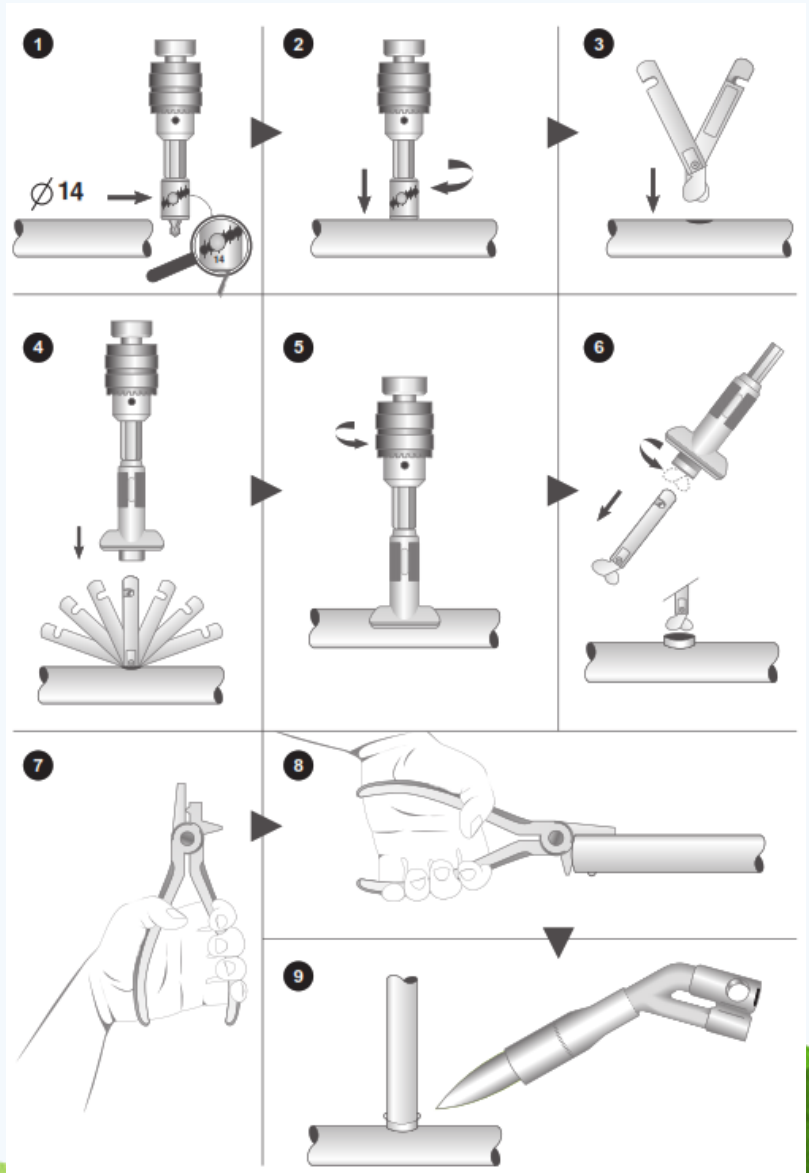
Diamètre Nominal (")	Diamètre extérieur (mm) Ø	Couple de serrage (N·m)
1/4	6.35	14 ~ 18
3/8	9.52	33 ~ 42
1/2	12.70	33 ~ 42
5/8	15.88	33 ~ 42

Flaring or Socket

The design of the mechanism and the pliers ensures:
- use in all positions,
- extraction of the head after socket in all cases.
Ergonomic polypropylene handles, resistant to solvents and grease.

Copper tube connection

The special drill (to be adjusted according to the diameters), mounted on a reversible drill, forms the hole prior to extrusion for the introduction of the tool. The pointing pliers limit the advancement of the tube inserted into the tap, for perfect flow of fluids.



Refrigerant connections

- These fittings are made from hot-forged 60/40 brass to avoid any porosity in the metal.
- They are threaded according to the American Standard "ASE" (Society of Automotive Engines). Also called "flare".
- Their denomination in inches corresponds to the diameter of the tube used.

Diamètre du tube (pouces)	Diamètre filetage (mm)	Diam. intérieur du tube (mm)	Diam. extérieur du tube (mm)
1/4	11.11	4.76	6.35
3/8	15.87	7.14	9.52
1/2	19.05	10.31	12.70
5/8	22.22	12.70	15.87
3/4	26.98	17.45	19.05
7/8	31.75	20.20	22.22
1"	34.92	22.22	25.40
1"1/8	38.10	25.40	28.57

- When the connection must be screwed onto a component of the circuit (compressor, valve, pressure gauge, etc.) we use conical threads which ensure better sealing.
- These threads are made according to the American standard known as the Briggs System (American Standard for Pipe Threads).

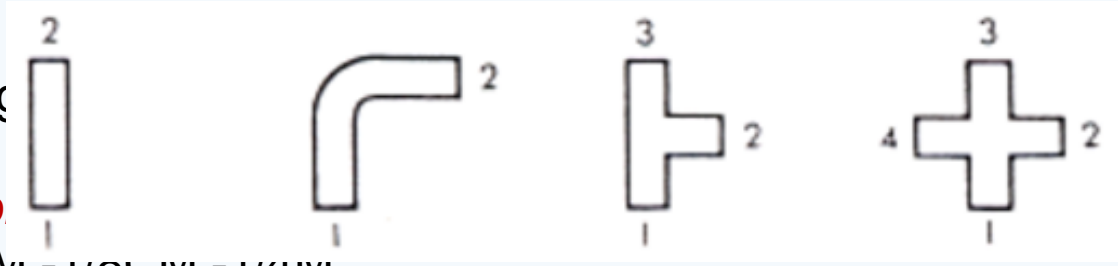
SYSTEME BRIGGS (conicité 6,25 % NPT)		
Diamètre nominal	Diamètre effectif	Longueur de filetage utile
1/8 C	10.2	6.7
1/4 C	13.7	10.2
3/8 C	17.1	10.3
1/2 C	21.3	13.5
3/4 C	26.6	13.8
1" C	33.4	17.3
1"1/4 C	42.1	17.9

Refrigerant connections

Designation of a connection:

a) Designate the type of connection desired (e.g.: nut, tee, elbow).

b) Designate the nominal diameter of the different pipes following the order indicated by the following drawings:



c) Desig e. In the case of conical

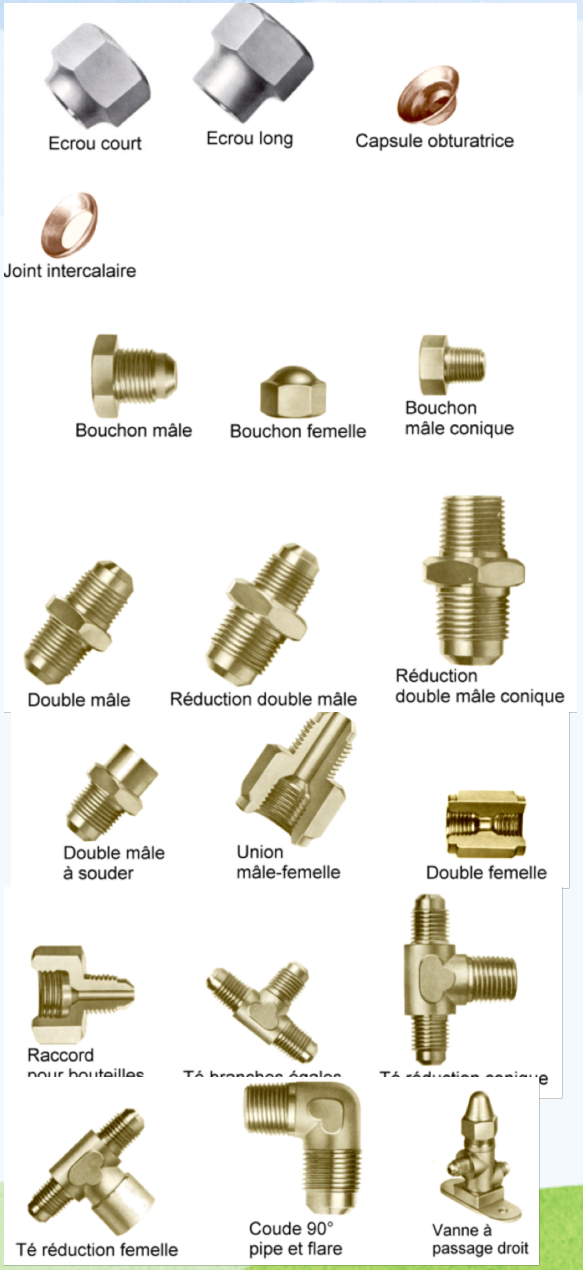
Examp

TE 1/4M - 1/8CM - 1/4M

UNION 1/4M -1/8CF

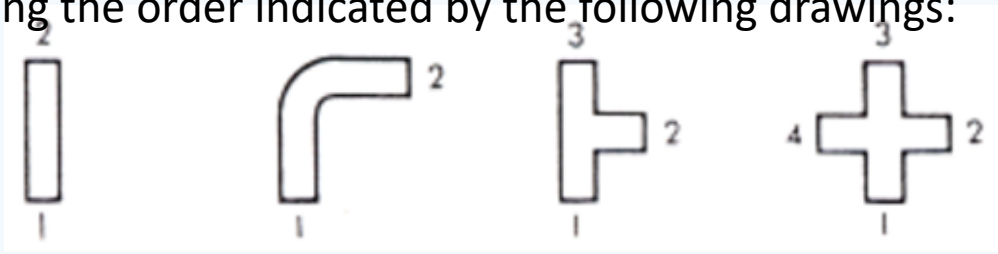
COUDE 90° 1/4CM -3/8M

Refrigerant connections



Designation of a connection:

- Designate the type of connection desired (e.g.: nut, tee, elbow)
- Designate the nominal diameter of the different pipes following the order indicated by the following drawings:



- Designate the nature of the thread, either: Male or Female. In the case of conical thread, follow with the letter C

Examples:

TE1/4M – 1/8CM – 1/4M

UNION 1/4M – 1/8CF

COUDE 90° 1/4CM – 3/8M

Bending (on annealed tube)

Hand bending

Easy to execute for ¼’ - 3/8’ – ½’ tubes.

The minimum interior radius to be obtained must be at least four times the exterior diameter of the tube

Example:

Tube ½’ = 12,7 mm

Bending radius 12,7 x 4 = 50,8 mm

Inconvenience:

Tube flattening → Load losses

Bending on template

By using a hardwood roller fitted with a circular groove of a pulley, electric motor, compressor flywheel, fitter's bottle, the knees, but there still remains the disadvantage of flattening the tube

Bending (on annealed tube)

Bending with spring

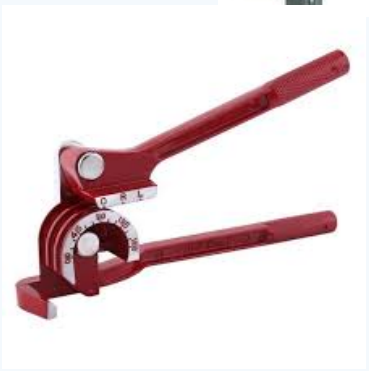
There is a range of ¼', 3/8', ½' and 5/8' springs.
We use the spring to prevent the tube from flattening.
The minimum bending radius will be equal to 3 times the diameter of the tube.
To release the spring, simply rotate it while pushing in the opposite direction of its winding. The enlarged part being released last ***Inconvenience:***
Traces on the tube and particularly
when bending to the minimum radius

Bending (on annealed tube)

Bending with a hand bender (Currently the most used metho

Two kinds of benders:

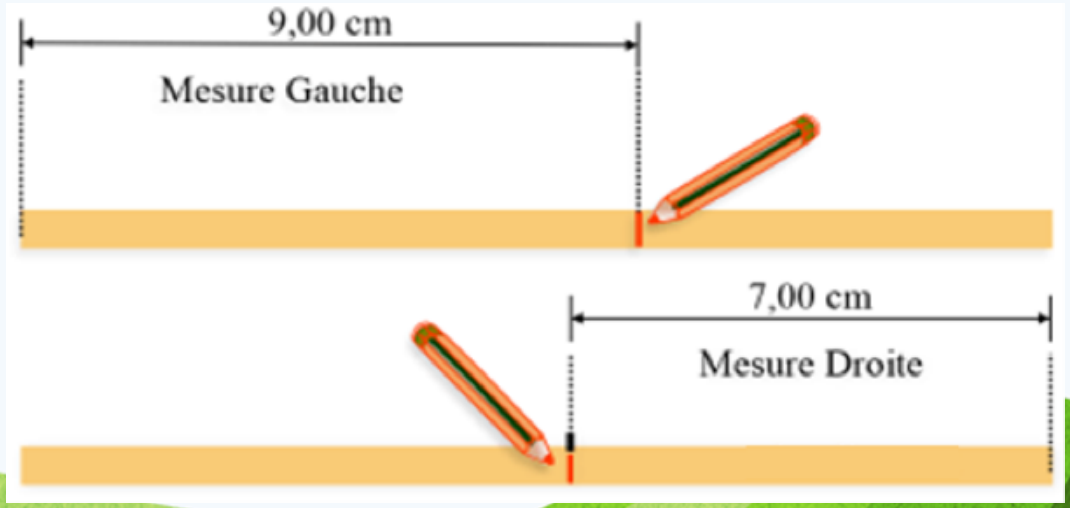
- With interchangeable rollers often used in workshops
- With fixed rollers in this case a bender is mandatory for each tube dimension: ¼, 3/8, ½, 5/8 and 3/4



Consignes d'utilisation du cintreuse à main coude 90°

Step 1:

Let's see how to simply make a 90° angle, transfer the desired measurement to the tube, pay attention to the direction of folding, here we will use the left side measurement 9 cm.

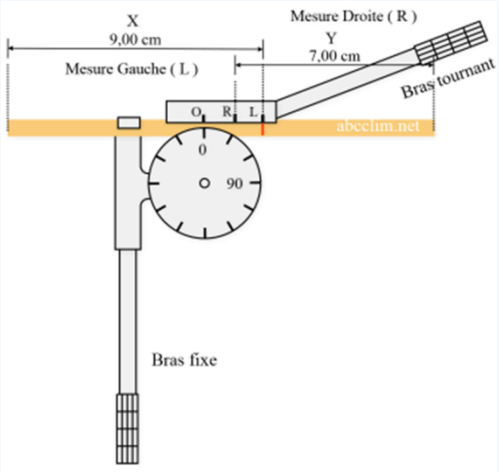


Bending (on annealed tube)

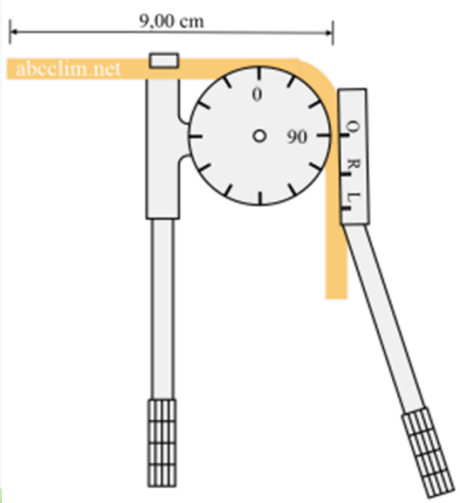
Instructions for using the 90° elbow hand bender

Step 2:

Place the tube in place in the bender making the mark on the tube (x side) coincide with the L (Left) mark on the bender, if we use the right side measurement (Y side) the mark should be on the R (Right) mark.



Step 3:



Bend the tube by bringing the arm back until the 0 mark on the arm is opposite the 90° mark on the roller.

Note that the total length when folded is between the start of the tube and the outer edge of the tube (tense fiber) and not at the axis of the tube (neutral fiber).

Bending (on annealed tube)

Instructions for using the 45° elbow hand bender

Pour cintrer à 45°, il faut utiliser le repère (45°).
Pour contourner un obstacle, tel que celui de la figure 2, on procédé de la manière suivante :

1. Mesurer la cote y de l'obstacle.
2. Calculer la cote X

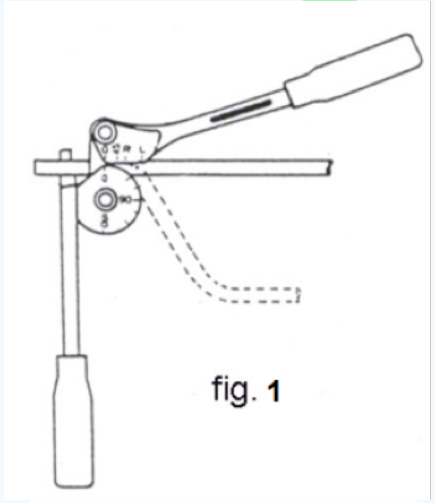


fig. 1

$X = y \cdot \sqrt{2}$ soit $X = y \times 1.414$

3. Tracer sur le tube les points A et B
4. Placer la cintreuse de manière à faire correspondre le point A avec le repère 45° puis cintrer jusqu'à 45° (point O sur 45 de la roue guide).
5. Positionner la cintreuse sur le point B (point B sur 45°) puis cintrer comme indiqué en Figure 1.

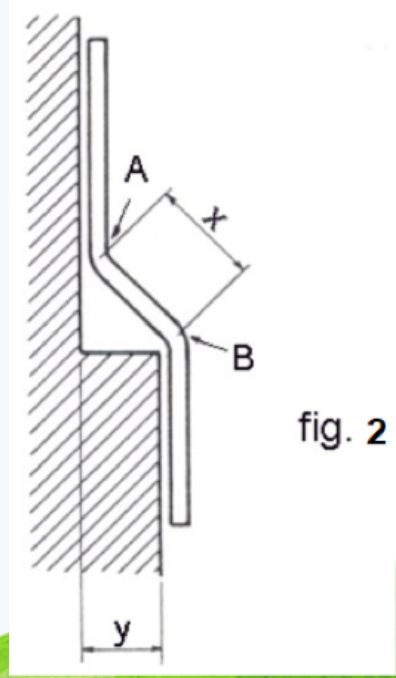


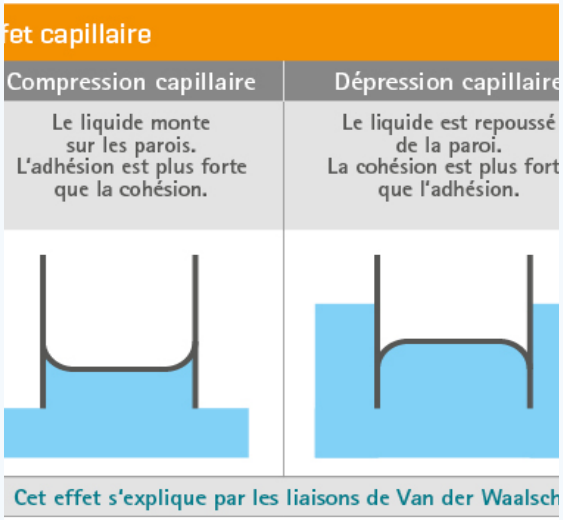
fig. 2

Copper tube brazing

Brazing is the basic process for assembling copper tubes

Capillary soldering, an easy technique particularly suited to copper and very reliable, has contributed very significantly to the development of the use of copper tubes.

This technique has become widely used with the increasingly widespread use of **capillary brazed connections.**



Soft soldering

Soft soldering is the operation of assembling parts metal by melting a filler metal, whose melting point is **less than 450 °Celsius**, in a interval between coins of a few centimes of mm

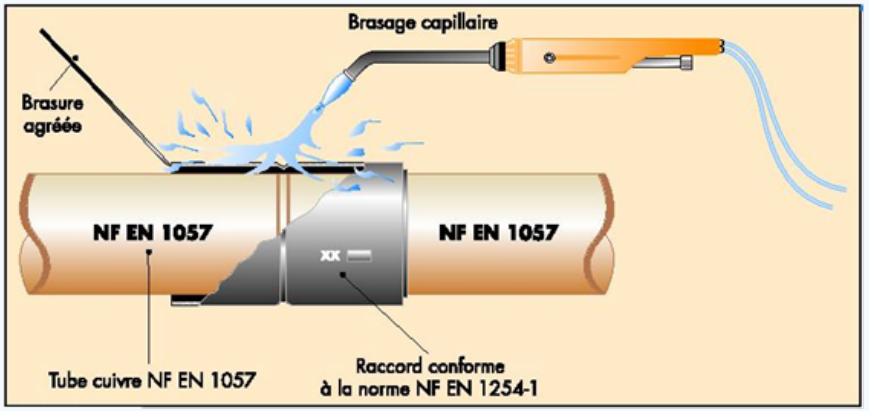
Copper tube brazing

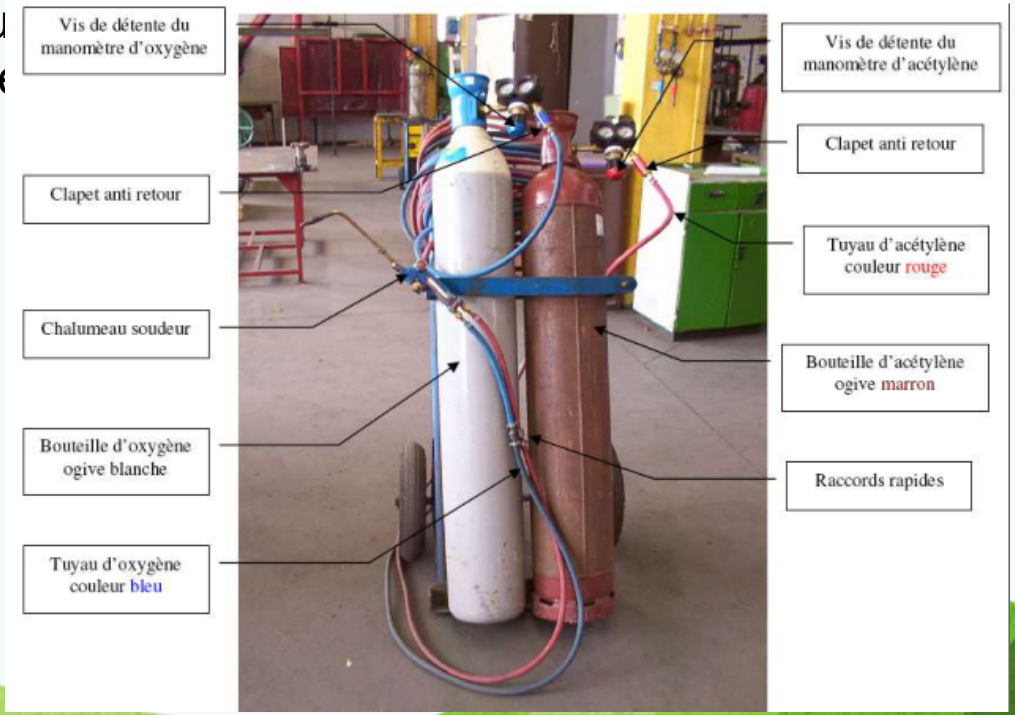
Implementation principle :

The phenomen of Capillary is a phenomenon by which a liquid spreads **on action** betwee the of the two parts in n interstices contact and progresses step by step regardless of the position of the parts.

In the case of copp tube, this er capillarity is all the better when

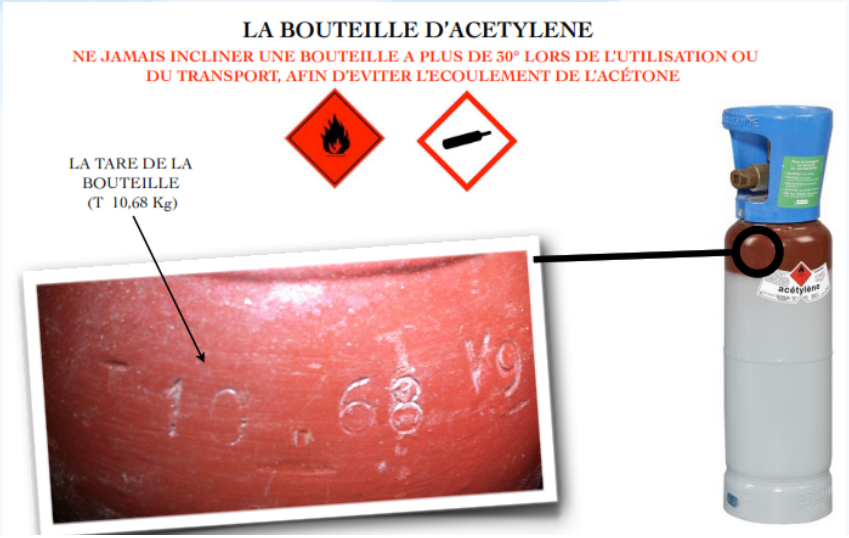
the annular space existing between the tu and the fitting is small and regular, i.e. a fe hundredths of a mm.

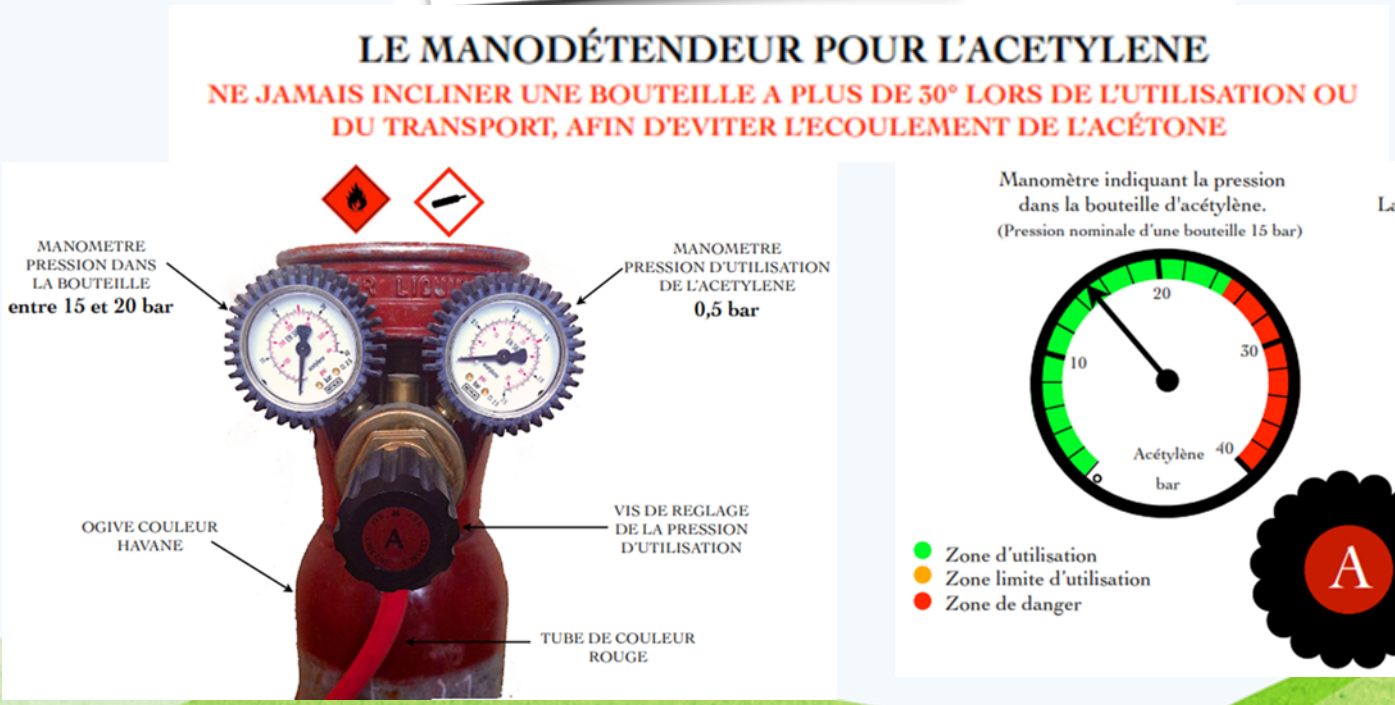




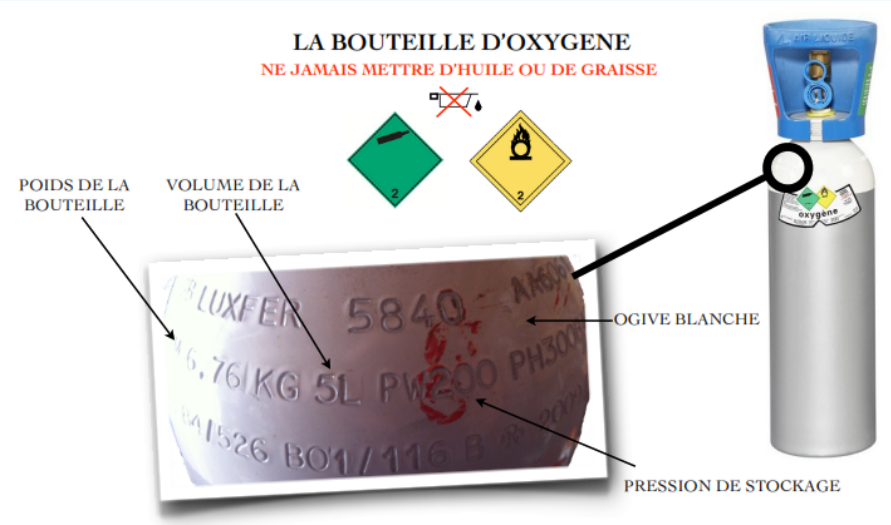
Oxyacetylene station

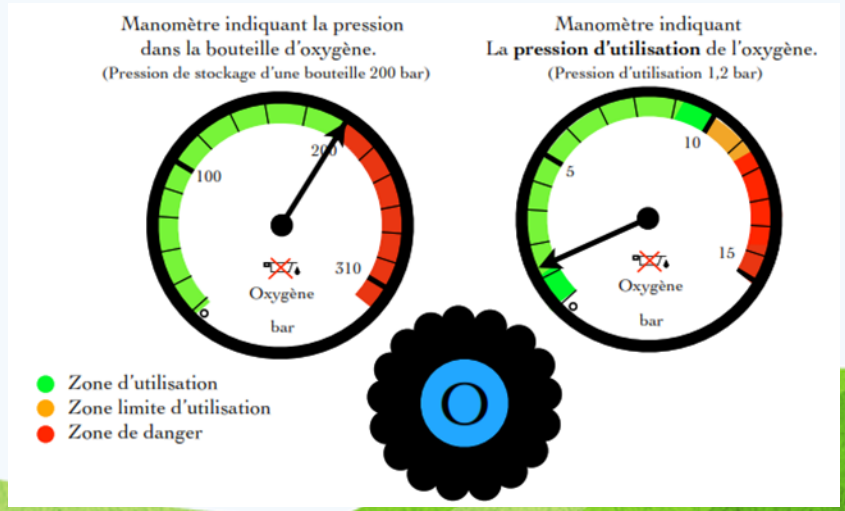
Copper tube brazing





Copper tube brazing





Copper tube brazing

Memory of temperatures

Gas usage table

GAZ	UTILISATION	LIMITE
PROPANE	BRASAGE **1750 °C**	- 17 ° C
BUTANE	BRASAGE **1450 °C**	7 °C
MELANGE BUTANE/PROPANE	BRASAGE **1550 °C**	- 8 °C
OXYGENE + PROPANE	BRASSAGE , SOUDO BRASURE **2850 °C**	
OXYGENE + BUTANE	N'EXISTE PAS	
OXYGENE + ACETYLENE	BRASAGE FORT SOUDO BRASURE ET SOUDURE AUTOGENE **3100 °C**	A éviter au delà de 3mm en une passe

Copper tube brazing

Precautions to take :

The capillary soldering operation requires certain precautions concerning **the calibration of the tube ends** and **the cleaning** of the parts in contact:

- ✓ Perfect fit of the sockets
- ✓ Straight and square tube cut
- ✓ Burrs carefully removed
- ✓ Cleaning with steel wool externally and internally.
- ✓ Personal protective equipment

Stripping fluxes:

✓After cleaning and to avoid oxidation during heating, a layer of stripping flux will be applied moderately over the entire exterior surface of the tube to be brazed (male part).

✓The flux must be applied without excess so as not to cause dripping inside the tube.

Rosin-based **organic fluxes**, which are non-corrosive and do not require disposal after soldering.

Note: some filler metals have an active core consisting of a generally non-corrosive flux.

Copper tube brazing

Filler metals:

Conventional filler metals are of the copper type. phosphorus or copper-phosphorus-silver.

Filler alloys based on phosphorus are "self-stripping", and allow flux, said because phosphorus to avoid the use of eliminates extent of its oxidizes gradually formation.

The damage that the structure of the metal may undergo depends on:

- Temperature
- Duration of maintaining this temperature

Heavy operations with a melting point of the filler alloy of around 700°C must be carried out as quickly as possible and without hesitation.

Practical sheets

To consult the practical sheets of the copper center

click

شكرا
Merci
Thanks
Gracias
Obrigado

Hammadi FERJANI

BP 66 Minaret Hammamet 8056 TUNISIE

hammadi.ferjani@laposte,net

+ 216 98 227 249