# Copper for Steam-Condense Pipelines

## Benefits of Steam as a Heat Carrying Medium

Steam has been used to carry heat energy since the industrial revolution. It has been a versatile tool for industry wherever heat is needed and can be used in process plant, space and water heating applications, see Figure 1. One reason for steams versatility is that the temperature can be adjusted easily and very accurately by control of pressure using simple valves. Furthermore, steam carries relatively large amounts of energy in a small mass and gives up this energy easily.

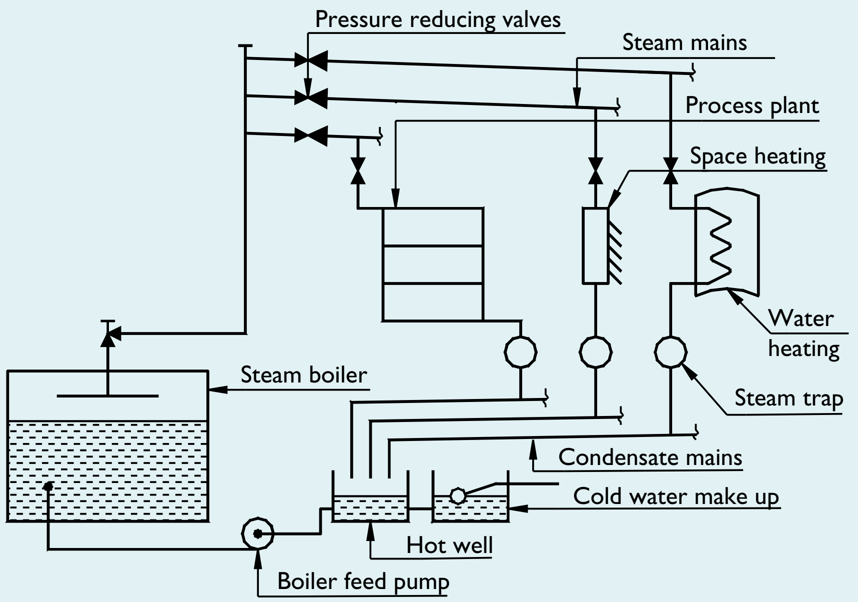


**Figure 1** Two pipe steam system

### Suitability of copper

Copper tube, being made from a tough, easily jointed, heat and corrosion resistant material, is ideal for steam-condense pipelines. The condition and wall thickness of tube that is required for a particular service can be found by using the formula:

$$t = \frac{pd}{p+20F}$$

where:

t = the minimum tube wall thickness (mm)
p = the design pressure (bar)
d = the outside diameter of the tube (mm)
F = the design stress (N/mm²) at the maximum working temperature, see Table 1. But note that if the tube is to be braze jointed at >600°C use the stress value for condition O (annealed) tube.

Table 2 indicates suitable wall thicknesses for tubes for steam-condense services operating at up to 17 bar and 205°C. (Note also that appropriate sizes of copper tube to EN 1057 up to and including 108mm diameter align in all dimensions with the low pressure range of EN 12449. Furthermore such tubes up to 22mm in diameter also align in all dimensions with the high pressure range.)

### Installation of steam-condense pipelines

For efficient use of steam it is necessary to ensure that the condense lines are properly sized in relation to the steam lines, see Table 3. Both steam and condense lines need to be insulated to reduce heat loss, correctly laid out to a slight fall and adequately drained, see Figure 2. The pipework also needs to be

**Table 1** Design stress values (N/mm²) for solid drawn copper tubes (See BS 1306 for copper alloy tubes)

| Material | Designation | Condition | Tensile strength (min.) | Values of design stress for temperature not exceeding | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | -200 to +50°C | 100°C | 150°C | 175°C | 200°C |
| Copper | Cu-DHP | Annealed O | 200 | 41 | 40 | 34 | 26 | 18 |
| | | Light drawn 1/2H | 250 | 62 | 59 | 55 | 34 | 18 |
| | | As drawn M | 280 | 70 | 69 | 55 | 34 | 18 |

**Table 2** Copper tube for steam services with plain ends EN 12449

| Size of tube (mm) | Low pressure range | High pressure range |
|---|---|---|
| | Working pressure up to and including 7 bar max working temperature 205°C | Working pressure up to and including 17 bar max working temperature 205°C |
| | Thickness (mm) | Thickness (mm) |
| 6 | 0.8 | 0.8 |
| 8 | 0.8 | 0.8 |
| 10 | 0.8 | 0.8 |
| 12 | 0.8 | 0.8 |
| 15 | 1.0 | 1.0 |
| 18 | 1.0 | 1.0 |
| 22 | 1.2 | 1.2 |
| 28 | 1.2 | 1.5 |
| 35 | 1.5 | 2.0 |
| 42 | 1.5 | 2.0 |
| 54 | 2.0 | 3.0 |
| 67 | 2.0 | 3.5 |
| 76.1 | 2.0 | 4.0 |
| 108 | 2.5 | 5.0 |

| **Table 3** Suggested diameter of copper condensate mains for various steam main diameters (mm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Low carbon steel steam main | 20 | 25 | 30 | 40 | 50 | 65 | 80 | 100 | 125 | 150 |
| Copper steam main | 22 | 28 | 35 | 42 | 54 | 67 | 76 | 108 | 133 | 159 |
| Copper condensate main | 15 | 22 | 22 | 28 | 35 | 35 | 40 | 67 | 67 | 76 |

installed with adequate provision for expansion. One metre of copper tube will expand by 1.7mm for a 100°C temperature increase, and the stresses imposed can be considerable if no allowance for expansion is made between 'fixed points'. Where long (over 10m) straight runs of tube are to be installed, consideration should be given to the use of expansion loops or bellows at strategic points.

## Need for condensate return lines

As soon as the steam leaves the boiler it starts to give up some of its energy to any surface at a lower temperature. This results in the formation of condensate (hot water). This condensate forms both in the steam pipework system and in the process equipment that uses the steam. It must be drained away to prevent the system becoming waterlogged and, as hot water, it has too much energy to be allowed to run to waste. The condense return lines are used to carry the condensate back to the boiler feed water tank.

## Jointing methods

Copper steam-condense lines can be jointed by means of:

- End-feed brazed joints;
- 'High-duty' integral solder ring fittings, these have a silver solder filler ring, see Table 4 for typical working pressures;
- Compression fittings;
- Rolled groove compression fittings.

| **Table 4** Typical maximum working pressures for general high duty brazed capillary fittings (bar) | | | |
|---|---|---|---|
| Fitting size (mm) | For temperatures not exceeding | | |
| | 150°C | 175°C | 200°C |
| 6 | 242 | 151 | 61 |
| 8 | 202 | 126 | 51 |
| 12 | 158 | 99 | 40 |
| 15 - 54 | 69 | 43 | 17 |

Whatever jointing method is to be used to joint the copper tube, check with the manufacturer's data that it is suitable for the working pressure and temperature required.

## Brazed joints

Capillary joints brazed with copper-phosphorus alloys (CP) or copper-silver alloys (AG) are suitable for steam-condense working temperatures of up to 200°C. Accurate control of the capillary joint gap is important with a clearance of between 0.05 and 0.2mm required. Adequate strength is achieved where the joint has an overlap of 3 to 4 times the wall thickness of the thinner tube. With a short cup joint like this it is easier to achieve full penetration of filler metal, and no material is wasted.

CP alloys do not require the use of flux when making copper to copper joints, AG alloys do, as do CP alloys when jointing copper tube to brass or gunmetal fittings. Check and adhere to the flux manufacturer's recommendations as to the upper limits of temperature. Only mix sufficient flux for one day's joints by adding a little water to the powder to produce a creamy consistency. A very thin coating of flux should be applied before joint assembly. It is important to ensure that close control of temperature is maintained whilst jointing. The joint must be heated evenly so that when the brazing temperature is reached the filler alloy melts and spreads throughout the joint, a gas/air torch is ideal. Where an oxy-acetylene torch is used, care must be taken to avoid local over-heating, particularly if using filler metals containing cadmium. Use a large flame and keep it moving to heat the tube and fitting evenly. Observe the flux for a guide to heating, it passes through four stages:

- the water boils off at 100°C;
- at about 300°C the flux looks white and puffy and is starting to work;
- by 450°C it is starting to melt and looks milky;
- when the brazing temperature of about 600°C is reached the flux is clear and looks watery.

At this point the brazing rod can be applied to the mouth of the joint. Keep the flame moving, when the correct temperature is achieved the rod will melt and should readily flow into the joint by capillary action. Once the joint is filled a continuous fillet of brazing alloy should be visible all around the joint, and no further rod should be fed in.

**Note:** If the rod 'balls up' it indicates too little heat, or else oxidation of the metal due to insufficient flux. Also, if the brazing alloy will not enter the joint, it can be that the various parts of the joint are not evenly heated.

Properly designed and installed copper steam-condense pipelines will give long-term reliable service. They are relatively light weight and can be quickly and easily fabricated and jointed without requiring the use of expensive plant and machinery, and the skills necessary are well within the scope of the professional installer.

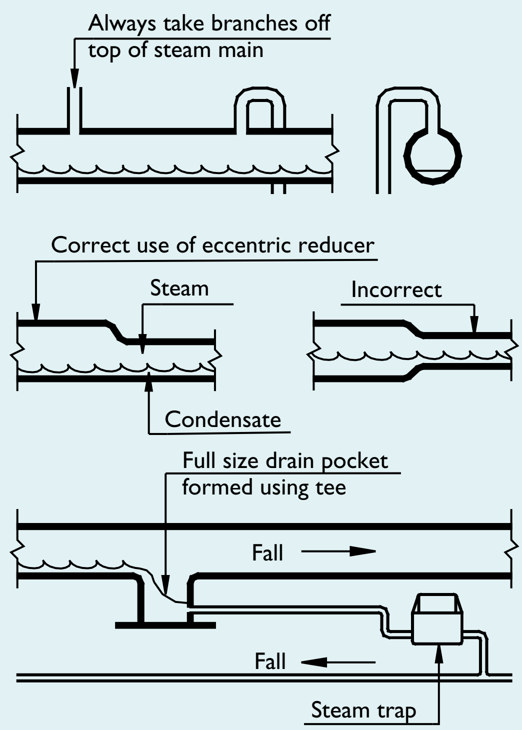


**Figure 2**