COPPER IN MEDICAL GASES AND VACUUM SYSTEMS

Copper tube joined using capillary fittings is the preferred material for use with medical gas and vacuum suction pipelines. Medical gases are used extensively throughout hospitals, they usually comprise the following services: oxygen, medical compressed air, (oil and moisture free), vacuum suction, nitrous oxide, oxygen/nitrous oxide mixture, (O_2 / N_2O).

Oxygen and vacuum suction are used extensively in accident and emergency units and out-patient units; in-patient wards, operating theatre suites and maternity units. Vacuum and compressed air are used in dental surgeries and operating theatres for patient ventilators and powering surgical tools. Nitrous oxide is piped to operating theatre suites, maternity units and accident and emergency units. Also, oxygen/nitrous oxide mixture is piped to maternity delivery rooms.

Health Technical Memorandum 2022 and Model Engineering Specification C11 are the standards covering this work and manufacturers can supply the specially cleaned and degreased EN 1057 copper tube, and fittings, necessary on request. The tube is cleaned by a variety of methods including combinations of steam cleaning and drying, shot blasting, solvent degreasing followed by blowing through with medical quality air and visual inspection. Once cleaned and degreased the manufacturer fits plastic end caps to the tube to prevent contamination of the bore before bundling and labelling "medical gas pipes". Fittings and valves, (preferably lever-operated ball type) are supplied cleaned and degreased in sealed, similarly labelled plastics bags.

Table 1 Medical gas service names and identification symbols

Service name	Identification symbol	Colour as shown on BS 1319C (except vacuum)
Oxygen	O	White
Nitrous oxide	N O	French blue
Oxygen / nitrous oxide mixture, 50%V/V	O /N O	White and french blue
Medical air (or air) 400kPa	MA-4	Black and white
Medical air (or air) 700kPa and above	MA-7	
Vacuum	VAC	Yellow*
* This colour should be as close as possible to colour No 309 of BS 381C		

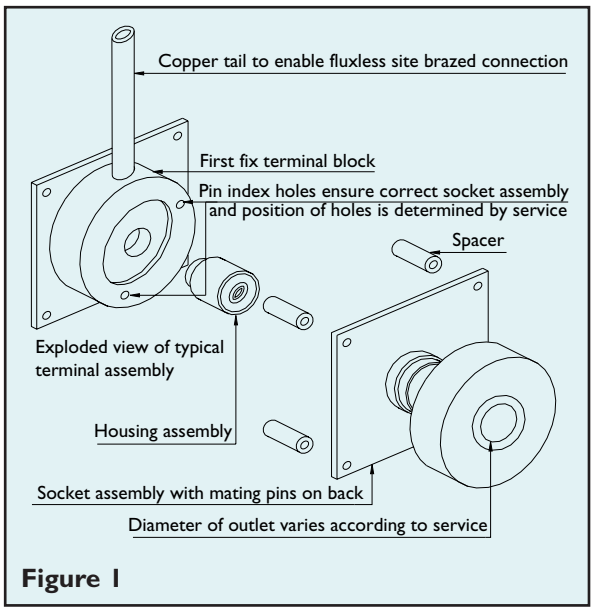

Figure 1

Site installation and jointing

Incorrect gas connections can create a hazard to the life of a patient so all medical gas cylinder and terminal connections are gas specific. Cylinder connections use a pin index system to EN 850. At the end of the pipelines a pin indexed terminal block is used for first fixing. A socket assembly with a plug-in bayonet facility designed to BS 5682 is bolted on as a second fix, see Figure 1. Great care needs to be taken to ensure that no cross-connections are made between the various gases when installing pipelines and these should be identified in accordance with BS 5682, see Table 1.

Before 1982, medical gas pipelines were installed using a fluxed brazing technique. This caused internal contamination of the pipelines by flux residues, oxide deposits and verdigris. Some of these were not always removed during commissioning operations but became loose later to cause problems with terminal units and equipment.

Because of this, all on site medical gas installation work must therefore be planned to make use of copper-to-copper joints using carbon dioxide as an internal shield gas in a fluxless brazing

Table 2 Carbon dioxide purge times, in seconds per 100m of tube							
Tube dia (mm)	12	15	22	28	35	42	54
Time	10	15	30	45	80	110	180
Supply pressure regulator set at 4 bar, flow rate 100 l/min							

process, (using EN 1044 type CP1 alloy, 80% copper, 15% silver, 5% phosphorous). Carbon dioxide is used because the cylinders have a different connector from other medical gases and this prevents the possibility of cross-connection.

Purging before brazing

Connect a supply of carbon dioxide (CO_2) to the pre-assembled, unbrazed pipework through a pressure regulator, (set to 4 bar) and flow indicator, (able to read to 100 l/min). Then purge to remove air, see Table 2 for estimated purge times. The purge gas flow can then be reduced to 1 to 2 l/min to save gas whilst brazing is carried out.

Safety

Precautions need to be taken if working for prolonged periods in confined spaces to avoid the build up of CO_2, see Table 3 for effects. This can be achieved by ventilation or piping the waste gas out of the space. Note that CO_2 is heavier than air so do not vent to an enclosed space at a lower level. The theoretical safe limit of CO_2 for an 8 hour day is 0.5%, but up to 4% can be tolerated for a short period, however changes in breathing rate may be experienced.

Copper to brass joints

Where copper is to be braze jointed to brass, gunmetal or bronze terminal fittings the joints are usually made using a copper-silver-zinc alloy and a suitable flux. This means that sub-assemblies, such as terminal fittings should be brazed up with a copper tail before cleaning, degreasing and bagging to the required standard. This involves immersion in hot water and brushing with stainless steel wire brushes to remove flux residues, followed by oxide removal by immersion in a 5-10% sulphuric acid solution at 65°C to which 25 to 50g/litre of potassium dichromate has been added, and final rinsing in hot water at 80°C. This should result in a bright clean component.

Mechanical joints

Where pipelines connect to valves and control equipment compression joints or screwed fittings are allowed, the threads being sealed using unsintered (degreased) PTFE tape.

Inspection and testing

Once the installation of tube is complete a proportion of site brazed joints, (1:200, minimum 2 maximum 5) will have to be cut out and quartered to establish the quality of workmanship.

Table 3 Effect of increased carbon dioxide levels	
0.03%	Normal atmospheric level - no effect.
1%	Slight increase in breathing rate.
2%	Breathing rate increases plus headache.
3%	Breathing laboured, headache, reduction in hearing ability.
4-5%	Signs of intoxication, slight choking feeling.
5-10%	Visual disturbance and confusion, followed by loss of conciousness within minutes.

Penetration of brazing alloy

Due to tolerances of the capillary gap between tube and fitting, full penetration of the brazing alloy may not always occur, and is not necessary. A sound and mechanically strong brazed joint will result provided that the minimum penetration at any point is at least 3 x the tube wall thickness. The tube and fitting should be internally clean, free from oxides and particulate matter, some heat burnishing of the tube may be apparent, but this is acceptable.

Purging carbon dioxide and particulates

Once the cut-out joints have been reinstated the pipeline system can be purged with medical air to remove any particulate matter and CO_2. The pipeline system can then be tested by a suitably qualified person for particulates using a paper filter with the flow limited to 1.5 times design maximum flow rate. There should be no visible particles on the filter after a 1 minute test.

Carbon dioxide is unlikely to be present in the system after the particulate test, even so every terminal unit has to be tested for residual CO_2.

Once purging is complete the system has to be maintained pressurised with medical compressed air until hand-over to the client. Final commissioning, which includes filling and testing each pipeline system with its working gas and terminal fitting connection, to ensure correct identity, gas quality and purity will be supervised by the responsible officer and suitably qualified person.

Jointing procedure:

- cut tube with a wheel cutter, not a hacksaw
- de-burr the tube, holding the end downwards
- clean tube and fitting with a plastic scourer, not wire wool
- assemble the joints
- connect the shield gas, purge, then reduce the shield gas flow
- heat the joint quickly
- add filler metal
- allow to cool before stopping the shield gas flow
- cap ends of tube to prevent the ingress of dirt