CHARACTERISTICS AND USES

Copper sheet or strip has a density of 8930kg/m^3, a melting point of 1083degC, a coefficient of thermal expansion of 1.7mm/m/degC (from -20degC to +80degC) and a minimum tensile strength of 220N/mm^2 to 290N/mm^2 (i.e. soft to hard temper).

For roofing and direct-fixed cladding 'phosphoros deoxidised non-arsenical' copper sheet or strip is used. This has the material designation under BS EN 1172:1997 of 'Cu-DHP', with very good welding, brazing and soldering properties. The old designation of 'C106' under the withdrawn BS 2870:1980 is now superseded by CW024A.

STANDARDS

Copper for roofing and cladding should comply with BS EN 1772:1997 'Copper and Copper Alloys. Sheet and Strip for Building Purposes'. There is also a British Standard Code of Practice CP143:Part 12:1970 'Sheet roof and wall coverings. Copper: metric units', although this is in need of updating.

TEMPER

The malleability of copper sheet, known as 'temper', has traditionally been described as ranging from soft to hard. BS EN 1172 describes three tempers (listed here with their traditional equivalents):

R220 (soft)
R240 (1/2 hard)
R290 (hard)

Appropriate tempers for particular details are shown in the Figures which follow.

Table A

AVAILABILITY AND USE

COPPER SHEET					
thickness (mm)	**BS 1172**	**gauge** (SWG)	**weight** (kg/m^2)	**readily available**	**main use**
0.5	✓	25	4.55	no	N/A
0.6	✓	23	5.45	yes	roofing, direct-fixed cladding, gutter linings
0.7	✓	22	6.35	yes	roofing, direct-fixed cladding, gutter linings, eaves guttering
0.8	✓	21	7.25	yes	gutter linings, eaves guttering
1.0	✓	19	9.12	yes	self-supporting cladding panel systems, gutter linings

Copper strip is manufactured and supplied as a continuous 'coil' or roll of copper. Under BS EN 1172 all copper is flat rolled to thicknesses ranging from 0.5mm to 1.0mm. Their typical uses are shown in Table A above. BS EN 1172 covers copper manufactured in widths up to and including 1250mm. To work economically it is obviously best to plan bay layouts, as much as possible, according to the standard sheet widths available. These are included on Tables E and J (p8 and p11).

Prefabricated self-supporting cladding panel systems used in curtain walling need to be made from thicker copper sheet. Copper is also prefabricated to form flashings, roofing shingles, eaves guttering and rainwater pipes.

ROOF FORMS AND PITCH

Copper is a fully supported sheet roofing material which is easily formed mechanically or by hand, on site or in the factory, to suit virtually any three dimensional shapes – including complex curves and details. Pitches from 1 to 90degrees can be accommodated, as well as negative pitches, such as soffits. Appropriate roof forms include:

- **Conical** – using tapered trays with a minimum bay width at the top of 50mm and maximum at the bottom of 800mm (subject to exposure and fixings).
- **Barrel Vaults** – straight trays can be used without pre-curving for radii over 12m.

- Domes – trays must be pre-curved to match the geometry. Use of a segmental arrangement of bays is the simplest method requiring only straight cutting of trays.
- Pagoda – for concave shapes pre-curving of trays is always necessary (either by crimping or compressing the seams).

LAYING SYSTEMS

There are two systems for laying copper roofing: Traditional and Long Strip. Half hard temper is used for Long Strip and Soft temper for Traditional. The basic difference between the two is that Traditional accommodates thermal movement in the copper roofing by introducing frequent lateral joints to limit the size of each piece of copper, while in Long Strip sliding clips allow the movement. Although the coefficient of thermal expansion was given earlier, the actual effects are more complex: as an approximation for lengths of copper sheet up to 10m, allow 1.1mm/m for expansion and 0.6mm/m for contraction. All the details which follow take into account anticipated thermal expansion and contraction for the UK. The characteristics of each system are summarised on Tables B and C (p6 and p7). Similarly information on joints, acceptable minimum pitches and fixing is given on Tables D to N (p8-12).

Most roofing and cladding details are common to both the Traditional and Long Strip systems. However, details for Long Strip have to be more specific in their allowance for movement. For this reason each drawing included in this publication features a tick-box clarifying the suitability of the detail 'as drawn'. 'Suitable with minor modifications' invariably refers to the standard 10mm of movement provided in Long Strip details but not required in Traditional.

VENTILATION

Copper is not affected by the underside corrosion which can cause premature failure of most other metal roofing materials and does not require complex ventilation measures. It is therefore entirely suitable for use on either unventilated "warm" or ventilated roof constructions. For "warm" roofs adequate vapour control layers should be properly installed with sufficient insulation. For ventilated roofs, ventilation in accordance with the Building Regulations is provided by gaps at upper and lower edges of the roof or, if these are not feasible, by formed copper hoods (see page 84). Special advice may be needed for areas with high humidity or where air conditioning is to be used: contact the CDA Roofing Technical Officer for further information.

SUBSTRATES

Copper roofing and direct-fixed cladding require to be fully supported by a substrate. The substrate must be suitably durable and be able to provide a 'pull-out resistance value' of 560N for the fixings. This is an essential consideration because acceptable bay widths/clip spacings are calculated on that basis. The substrate also needs to be at least 24mm thick if the 25mm x 2.6mm diameter annular ring-shanked nails with a minimum 6mm head now recommended are not to protrude.

While in theory there are several alternative materials possible, in practice exterior quality plywood is by far the most common substrate. It should be specified squared-edged, 'good one side' and laid with this side up to provide a smooth surface for the underlay. The individual sheets should be fixed with a 3mm nominal gap between them so as not to provide a barrier to the movement of water vapour. Also laid staggered with their long side across the fall of the roof, parallel with the gutter, to minimise the number of fixing clips which might otherwise have coincided with an uninterrupted straight run of butt joints. All sheet materials should be laid in this fashion. However, other materials can be used for a substrate provided that clips can be fixed securely, including wood boarding and the appropriate grades of chipboard or cement bonded particle-boards.

With warm roof constructions rigid insulation boards can provide a suitable substrate. However because these cannot provide an adequate 'pull-out resistance value' fixing becomes more complicated. There are two basic approaches: either to provide two layers of insulation, each laid between softwood battens, with the second laid counter-battened to the first, and with the counter-battens at 300mm centres; or to use specially extended fixing clips which pass through the depth of the insulation to an additional nailable substrate beneath.

An underlay is recommended separating the substrate from the copper. This underlay can also allow movement in the copper, provide a temporary weathering for the building during construction, deal with irregularities on the substrate surface and offer some sound absorption. There are two basic types of underlay, non-waterproof and waterproof. In most circumstances, breather membranes or geotextile felts would be preferable and a waterproof breather membrane should be used |with warm roofs. For advice on underlays for particular roof types contact the CDA Roofing Technical Officer.

CORROSION & COMPATIBILITY

The natural electrical potential of copper is comparatively high and it is not affected by other metals on the outside of buildings. However, copper can cause corrosion to some other metals like steel, aluminium or zinc if there is direct contact between the metals and an electrolyte (such as water) is present. If rainwater from copper roofing or cladding runs onto other metals with a lower electrical potential, there may be interaction unless they are protected and maintained by established methods. Metals unaffected by the above are lead, stainless steel and brass. These metals can be joined to copper without any corrosion problems.

Rainwater running off bitumen exposed to the sun can cause corrosion problems for various materials including copper. Certain residues washed out of concrete or mortar can cause copper to take on a blue-green colour. Also, the wash-off from red cedar shingles can cause metals to corrode.

APPEARANCE

The natural development of a patina, with colours changing from gold to chocolate brown, and eventually to the distinctive light green seen on older roofs in our towns and cities, is a unique characteristic of copper. When exposed to the atmosphere, copper oxide conversion films form, changing the surface colour of copper from salmon pink to russet brown within a few days.
As weathering progresses over a number of years, cupreous and cupric sulphide conversion films intersperse with the initial oxide film increasingly darkening the surface to a chocolate brown. Continued weathering results in conversion of the sulphide films to the basic copper sulphate patina which, when complete, gives the distinctive light green colour of older copper roofs. In marine climates, the surface patina will also contain some copper chloride.

The eventual development of the light green patina can take 7 to 9 years in saline climates, 5 to 8 years near heavy industry, 10 to 14 years in urban surroundings and up to 30 years in clean environments. A certain amount of rainwater is necessary to form the green patina and the process takes much longer for vertical surfaces, due to rapid run-off, except in coastal areas. Apart from internal applications, the natural progression of patina cannot be successfully prevented with varnishes and other coatings.

WORKING WITH COPPER

As much of the work as possible is prefabricated in the controlled conditions of the workshop. This will be equipped with an array of cutting, bending, folding and profiling machines. On site adjustable, electrically-powered seaming machines are used for the long repetitive stretches of the job. Some handworking is always necessary and specialised tools have been evolved to cope with every condition: seamers, seaming irons, folders, grips and tongs as well as the more usual pliers, snips and mallets.

Where two pieces of copper need to be joined the specified Cu-DHP designation copper will allow good soft-soldering, brazing (hard-soldering) and welding. The working temperatures of these methods are 400degC, 750degC and 980degC respectively. However, if work of this sort is anticipated insitu, any restrictions on 'hot-working' need to be considered in planning the job. Soft-soldering might prove acceptable because a soldering-iron heated adjacent on the scaffold will hold its heat sufficiently. If not, rivetting might provide a suitable alternative. In the event of any installation problems or blemishes on the copper surface, contact the CDA Roofing Technical Officer.

TRAINING

'Hands on' training in the latest copper roofing techniques is available for roofing contractors through specifically tailored modular courses organised by CDA.

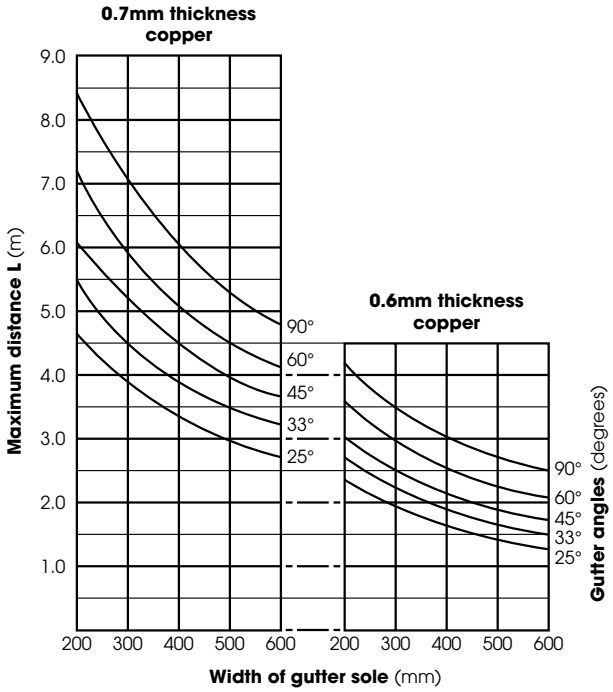
PARAPET GUTTERS

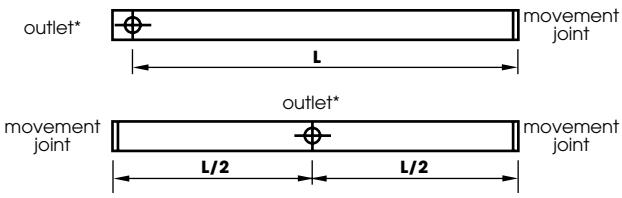
The following information applies to both parapet and central valley gutters. There has not been sufficient space in this publication to cover the sizing of these gutters to BS 6367:1983 nor to illustrate them in detail. However, by referring to Fig 30 (p77-79) and Fig 52 (p118-119) which show recessed pitched valley gutters for double-lock standing seam and batten roll respectively, it will be apparent how they are formed. The flashing details shown in Figs 11a, 11b and 11c (p44-46) will also be useful.

As with other aspects of copper detailing it is important to accommodate movement.
The adjacent nomograms (see right) give the maximum interval allowable from the outlet and they assume, with reference to how the roofing sheets connect to the gutter, that the gutter lining is free to move independently. The nomograms take into account how the frictional resistance of different gutter shapes affects this free movement. The dimension 'L' can also be taken to show the maximum distance allowable between movement joints. Pitched valley gutters are dealt with on Tables P and T (p13).

Falls in these gutters are usually below 10degrees. Movement joints in the fall of the gutter will be either drip-steps 60mm minimum or a vulcanised neoprene strip such as T-Pren. Previous guidance suggested that these gutters could be laid to a fall of less than 1degree, but this is not realistic unless the resulting build-up of debris can frequently be cleared away. While neoprene strips would seem to allow really flat pitches, such gutters will not be self-clearing below 6degrees. A minimum pitch of 3degrees should be the aim. To prevent the gutter lining from creeping down the fall, some sort of 'fixed' clips will be required (see Table L).
The movement joint at the head of the gutter fall will be a capped seam or batten 50 x 50mm, with the capping turn-out engaging the copper of the gutter so that 10mm movement is allowed.

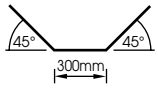
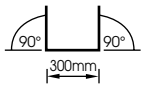
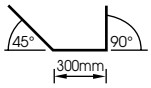
If on a particular project it proves impossible to provide the movement shown, greater intervals can be achieved by using thicker copper for the gutter. Taking a 300mm width / 90degree angle as an example, using 0.8mm copper would increase the interval 'L' to 8.75 metres; and using 1.0mm to 18 metres. Contact the CDA Roofing Technical Officer for further information. This information does not apply where the detailing prevents the gutters from moving. In such cases a drip-step 60mm minimum must be provided so that no section of gutter exceeds 3 metres in length. This joint need not be a movement joint as its purpose is to limit the size of the copper sheet.





** Outlets should be detailed to allow free movement between the spigot and substrate of 5mm in each direction*

EXAMPLES

copper thickness (mm)	 for gutter with both angles at 45 degrees	 for gutter with both angles at 90 degrees	 for gutter with angles of 45 degrees and 90 degrees (ie sum of individual distances ÷ 2)
0.6	***2.5m***	***3.5m***	***3.0m***
0.7	***5.150m***	***7.0m***	***6.075m***

maximum distance L between rainwater outlet and movement joints