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BSI Group
389 Chiswick High Road
London, W4 4AL
United Kingdom

T: +44 20 845 086 9001
F: +44 20 8996 7400
cservices@bsigroup.com
bsigroup.com

British Standards Limited
Registered in England no: 07864997
Registered address: 389 Chiswick High Road
London, W4 4AL, United Kingdom

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BRITISH STANDARD 1549 : Part 1 : 1949

W I D 1974

Methods for Sheet Metal Pattern Development

Part 1

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THIS BRITISH STANDARD, having been approved by the Mechanical Engineering Industry Standards Committee, was published under the authority of the General Council on 19th April, 1949.

The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

A complete list of British Standards, numbering over one thousand, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

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CO-OPERATING ORGANIZATIONS

The Mechanical Engineering Industry Standards Committees, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations :—

Admiralty
Associated Offices Technical Committee (Engineering Insurance Companies)
Association of Consulting Engineers (Incorporated)
*British Chemical Plant Manufacturers' Association
British Compressed Air Society
*British Electrical and Allied Manufacturers' Association
*British Engineers Association
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Ministry of Transport
Ministry of Works
Office of the High Commissioner for India
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The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this standard :—

Aluminium Development Association
Association of British Chemical Manufacturers
Association of Engineering and Shipbuilding Draughtsmen
Association of Technical Institutions
Fan and Allied Manufacturers' Association
Individual Makers of Sheet Metal Products
Sheet Metal Industries Association
Sheet and Strip Metal Users' Technical Association
Society of British Aircraft Constructors
Society of British Gas Industries

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FOREWORD

The preparation of this British Standard was undertaken at the request of the Institution of Production Engineers.

Notwithstanding the volume of sheet metal goods now produced in Great Britain and the number of craftsmen engaged, it has been apparent for some years that there has been little or no record of technical advances in the methods of pattern drafting. Sheet metal has proved so economical in price and so satisfactory in service that it has been utilized for increasingly complex structures, thereby increasing the variables to be taken into account for accurate final assembly. Examples of these factors are the dimensional tolerances of the material (including thickness) and bend allowances.

For the dimensional tolerances of sheet metals reference should be made to the following :—

Steel.

B.S. 1449. Steel, plate, sheet and strip.

Aluminium and aluminium alloys.

B.S. 1470. Wrought aluminium and aluminium alloy sheet and strip.

Copper and copper alloys.

B.S. 265. Cold rolled brass, 61·5 per cent–64 per cent copper content.

B.S. 266. Cold rolled brass, 64 per cent–67 per cent copper content.

B.S. 267. Cold rolled brass, 68 per cent–72 per cent copper content.

B.S. 374. Nickel copper sheets and strip.

B.S. 407. Phosphor bronze, sheets, strip and foil.

B.S. 409. Naval brass plates, sheets and strip.

B.S. 711, 712, 713. Cold rolled brass, 80 per cent, 85 per cent, 90 per cent copper content.

B.S. 790. Nickel silver sheets and strip, 10 per cent–30 per cent content nickel.

B.S. 899. Cold rolled copper sheets and strip, half-hard and annealed for general purposes.

B.S. 1432. Copper for electrical purposes, sheet and strip.

Magnesium alloys.

B.S. 1353. Magnesium alloy sheet and strip.

BRITISH STANDARD METHODS FOR

SHEET METAL PATTERN DEVELOPMENT

PART 1

THE NEUTRAL LINE

There is divergence of opinion as to the location and importance of the neutral line, or, in other words, the 'bend allowance' necessary. Bend allowance may be defined as a provision that must be made in the length of the flat sheet which can then be developed accurately to finished shape when including a bend of given dimensions.

The following examples illustrate the importance of the foregoing and reveal the discrepancies liable to occur in the absence of reliable data.

A four bend channel section formed of material 0·064 in. thick is shown in Fig. 1 where :—

a. Assuming that the inside radius of any bend is taken as twice thickness of metal, or $2t$, and the position of the neutral line is taken as one-third thickness 't' from the inside and the corresponding bend as 2⅓ thickness 't,' calculation will show that the ~~width~~ length required to form the channel will be 6·150 in.

b. Assuming that the position of the neutral line is taken as the centre of the metal, or one-half thickness 't' from the inside, and the corresponding bend radius as 2½ thickness 't,' calculation will show that the ~~width~~ length required to form the channel will be 6·219 in.

It will be seen that the above examples give an overall difference of 0·069 in., or well over one-sixteenth of an inch. This discrepancy is important where accurate calculation is concerned.

A further study of the problem suggests that, so far as bend allowance is concerned, sheet metal structures may be divided into two classes :—

Class 1. Assemblies where, in most cases, by reason of size, simplicity of outline, or thinness of material, the neutral line may safely be ignored.

Class 2. More complex structures in which high dimensional accuracy is required, where the bend allowance is a factor of importance.

It has, therefore, been decided to confine Part 1 of this standard mainly to Class 1 and to make further investigation as to the actual incidence of the neutral line.

Experimental work is now being undertaken to establish by practical trial the position of the neutral line in specific cases and this will be the subject of a later part of this standard. Consideration of structures which necessitate allowance for the neutral line will also be deferred until Part 2 of this standard is completed.

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METHODS OF DEVELOPMENT

There are three methods only by which patterns for single curvature work can be developed. These are :—

See Amdt 3 A. Radial line,
B. Parallel line, and
C. Triangulation methods.

Method A. Patterns for all bodies which taper to a single point or apex, or which would taper to an apex if the sides were produced and which belong geometrically to the class of pyramids, can be developed by the radial line method.

Method B. Patterns for all bodies which preserve a constant shape or cross-section throughout their length, and which belong geometrically to the class of prisms, can be developed by the parallel line method.

Method C. Patterns for all bodies which do not taper to an apex and have no constant cross-section can be developed by the method of triangulation, which includes (*a*) setting out by measurement, and (*b*) by the calculation of co-ordinates.

It may be appropriate here to note that the method of triangulation C may be applied in place of the radial line and parallel line B methods, but methods A and B cannot be applied in place of triangulation to bodies of type C. Radial line and parallel line methods, however, have the advantage of accuracy in their particular fields of application.

Examples of the application of the radial line Method A are shown in Figs. 2 and 3. Examples of the application of the parallel line Method B are shown in Figs. 4 and 5. Examples of the application of the method of triangulation C are shown in Figs. 6 and 7.

The methods illustrated are purely geometrical constructions, in which accuracy of necessity depends upon the care with which the patterns are developed. In many cases the patterns may be checked by, or even set out from, calculated values of the essential lines forming the developments.

The diagram in Fig. 8 illustrates how the heights of the vertical parallel lines in Fig. 5 may be calculated. In an elbow of any given angle, the height GH is first obtained from the given angle and then the remaining heights determined by multiplying the value of GH by the corresponding factor shown against each height line in the diagram. See Amdt 3

In the construction diagram adjacent to Fig. 7, the only two true length lines to be determined for the pattern are FC and GC. These may be calculated from the given dimensions as below :—

$$FC = \sqrt{AB^2 + AD^2 + BC^2}$$

by Pythagoras

$$\text{and } GC = \sqrt{HB^2 + HE^2 + BC^2}$$

$$= \sqrt{(AB - \tfrac{1}{2}R)^2 + (AD + 0{\cdot}134R)^2 + BC^2}$$

In amplification of the foregoing it is desirable to consider the basic principles which form the foundation of pattern development.

Firstly, all the lines which are used in the setting out of a pattern must be true lengths. From this it follows that all the lines obtained for the development of the pattern must lie on the surface of the body, or as near the surface as possible. Those which do not lie strictly on the surface, as often occurs in triangulation, must necessarily introduce error in proportion to the deviation from that condition.

Beginning with the right cone example Fig. 2 it will be seen that the inner and outer radii used in developing the pattern are true distances from the apex down the slant of the cone and the lengths of the arcs in the pattern correspond to the circumferences of the base and the top.

In the case of Fig. 3, which shows a right cone cut off at an angle to the base, the inner and outer radii in the pattern are the same as for the full cone, but intermediate points in the pattern must be plotted in order to obtain the base curve for the cut-off. Thus, the principle of projecting the points on the cut-off in the elevation to the side of the cone, either side, is a measure for obtaining their true distances from the apex before swinging them into the pattern. This fundamental principle applies to the development of all right conic frustums cut off in any way. The remainder of the development shown in Fig. 3 will be clear from that figure. (See Amdt. 3)

From the right conic frustum, the principles involved in the surface development of the oblique cone and its frustums should follow.

A RIGHT CONE may be defined as having a circular base, the body tapering to an apex which lies perpendicularly over the centre of the base. An OBLIQUE CONE may be defined as having a circular base, the body tapering to an apex which does NOT lie perpendicularly over the centre of the base.

This difference necessitates a modification of the method for finding the true lengths of lines on the surface of the cone. Whereas, in the elevation of the right cone, the points on the cut off are projected to the side of the cone in order to obtain their true distances from the apex, this cannot be done in the case of the oblique cone because the angle of slant from the apex is not constant around the cone. Thus, the projection of a point to the side would not necessarily represent its true distance from the apex.

The method of obtaining the true distance of any point from the apex on the surface of an oblique cone is shown in Fig. 9. Let ABC represent an oblique cone with A as apex, MN the position of a cut-off and D any point on MN. It will be evident that to project point D to either side of the cone will not give its true distance from the apex at A, since both sides are different. To obtain its true distance from A, produce AD to E. Describe a semicircle on BC to represent a half plan of the

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base, and drop A to A′ on BC produced to represent the plan of the apex A. Draw EE′ perpendicular to BC, and with centre A′ and radius A′E′ describe the arc E′E″. Join E″ to A. Then AE″ represents the true length of AE, and the point D projected horizontally to D″ will give the required true distance AD″ from the apex A.

This method of determining true distances from the apex to any point on the cone applies to all oblique conic developments. The full development of the pattern for the oblique cone cut off at MN is shown in Fig. 10. A further example of oblique conic development based on the above principle is shown in Fig. 13, ~~which is a typical form of steam hood for a boiling kettle.~~

As a further step in development by the parallel line method of pattern drafting, the diagram in Fig. 11 may be taken as typical. This shows an intersection between two cylindrical pipes of unequal diameters ~~and, to those versed in the methods of orthographic projection, the development of the pattern should present no difficulty.~~

~~It is necessary first to determine the line of intersection between the~~ two cylinders. This is obtained by projecting ~~the end view~~ above and returning the intersection ~~points~~ to meet the lines on the branch pipe in the elevation. ~~Then~~ the ' unrolling ' of the pattern will be similar to that ~~shown in Fig. 5.~~

The basic principle of triangulation is embodied in the rule that ' the plan length of any line when placed at right angles to its vertical height gives a diagonal equal to its true length.' The plan length of a line is its actual distance taken from the plan, which is the horizontal distance between its extremities ; its vertical height is the height perpendicular to its plan length. From the above definitions it will be evident that the diagonal on these two co-ordinates must always represent the true length of the line.

An alternative, employing as co-ordinates the actual length of the line taken from the elevation placed at right angles to the perpendicular distance between its extremities, which may be taken from the plan or from a side elevation, may also be used effectively. This is generally known as lay-out system.

Typical examples based on the former method are given in Figs. 12 and 14. In the case of Fig. 12, the oval base is divided into six parts to correspond to the six divisions on the circular top, and the surface is divided into triangles by the zigzag line running between the points on the top and the bottom. Fig. 14 represents a junction piece as used in ductwork, and the surface is divided into triangles by joining the appropriate points in the plan as shown in the diagram. The true lengths of the lines may then be obtained by placing the plan lengths at right angles to the corresponding vertical heights in the elevation, when the diagonals will give the required true lengths.

(See Amdt. 3)

Typical geometrical examples based on the lay-out system are given in Figs. 15, 16 and 17. The horizontal distances in the lay-out diagram are taken direct from the elevation, and the vertical distances represent the amounts by which the lines are inclined at right angles to the plane of elevation. The diagonals in the lay-out diagram then represent the true lengths.

As previously stated, the method of triangulation can be applied to the development of patterns by the calculation of co-ordinates. Mathematical formulae based on the lay-out system are of particular value in the drawing office, as they enable accurately dimensioned development drawings to be prepared and issued to the workshop. One of the advantages of using patterns made by these methods is that tooling, for many types of work, can proceed without the need for ' try-out runs.'

Examples of calculation methods given in Figs. 18, 19 and 20, are typical for many standard forms. The diagrams should be self-explanatory. In each example, mr is the mean radius of the top of the article and MR is the mean radius of the base. The necessary calculations are shown on the figures.

NOTE. The error which can occur in circular work by stepping out the chord of a circle in 30 degree segments is 1·15 per cent. Greater accuracy can be obtained by reducing the angle or by methods of calculation.

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