



GS 130-5

Guidance for Specification 130-5

**FLOW ELEMENTS FOR PLANT
CONTROL AND MEASUREMENT
SERVICE**

June 1992

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
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SCOPE AND PURPOSE This BP Group Specification is intended to provide a basis for the technical specification of differential pressure flow elements (orifice plates, venturi tubes and flow nozzles), where previously BP Standard Drawings have been used as a basis for manufacture.											
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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Guidance for Specification

This Specification sets down BP additional requirements to international and industry standards for the design of flow elements and their use. This Specification replaces existing BP Standard Drawings for flow elements. These elements are main line process containing items and are subjected to full process fluid conditions, line specifications etc. and as such, material selection, welding, post-weld heat treatment, surface finish, manufacturing tolerances, quality control and inspection play a major part in ensuring fitness for purpose.

Application

This Guidance for Specification is intended to guide the purchaser in the use or creation of a fit-for-purpose specification for enquiry or purchasing activity.

Text in italics is Commentary. Commentary provides background information which supports the requirements of the Specification, and may discuss alternative options. It also gives guidance on the implementation of any 'Specification' or 'Approval' actions; specific actions are indicated by an asterisk (*) preceding a paragraph number.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Specification Ready for Application

A Specification (BP Spec 130-5) is available which may be suitable for enquiry or purchasing without modification. It is derived from this BP Group Guidance for Specification by retaining the technical body unaltered but omitting all commentary, omitting the data page and inserting a modified Foreword.



Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP Engineering or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

1.1.1 This document specifies BP requirements for the design, material selection, manufacture, quality control and inspection of differential flow elements for use in general plant regulatory control and mass balance/internal accounting measurement service. The relevant Standard Drawings with revisions have been incorporated within this Document.

1.1.2 To suit BP's particular requirements, it defines supplementary and additional requirements, exceptions and clarifications to the applicable [ISO 5167](#), the international standard for the measurement of fluid flow using pressure differential devices. Where aspects of orifice plate design are not covered by [ISO 5167](#), reference is made to the supplementary sections of [BS 1042](#) the equivalent British Standard.

[ISO 5167](#) is the international standard for flow measurement based on the differential pressure generated by an obstruction introduced into a circular conduit. The standard presents a set of rules and requirements based on theory and experimental work in the field of flow measurement. [BS 1042](#) is the British standard which is technically equivalent to [ISO 5167](#) but includes additional sections covering drain holes and non - standard orifice plates.

2. ORIFICE PLATES

2.1 Standard Orifice Plates (Ref. Figure 1)

2.1.1 Standard type Orifice plates referred to in this document are flat circular plates of uniform thickness, with a concentric hole (orifice). The hole is either square edged on the upstream and downstream faces or with a 45 degree bevel on the downstream edge, depending on the thickness of the plate.

The standard square edged orifice plates referred to in this Specification are the most common form of differential producing flowmeters used for clean liquids, gases and low velocity vapour (steam) flows. They are economic, simple, flexible and widely accepted for uses from general purpose plant measurement and control to custody transfer and fiscal purposes. In cases where the thickness of the plate exceeds the [ISO 5167](#) recommended criterion of 0.02D, a 45 degree bevel on the downstream edge of the orifice plate shall be necessary.

2.1.2 Orifice plates may be of the Paddle or Slip type (circular with a tab or handle), for use in orifice flanges, or Universal, for use in orifice fittings, carriers or ring type joint plate holders.



2.2 Non-Standard Orifice Bores

- * 2.2.1 Other types of non-standard plates with special orifice bores such as Segmental, Eccentric, and Quarter round bores are used infrequently and are therefore not covered by BP Group Recommended Practices and Specifications. Where conditions dictate their use, they shall be subject to BP approval. In such cases dimensions and tolerances shall be in accordance with [BS 1042](#), Section 1.2 or equivalent.

See Appendix C1.

2.3 Line Size Limitations

- 2.3.1 The range of line sizes covered by [ISO 5167](#) is 50 mm (2 in.) to 1200 mm (24 in.) and should be adhered to where possible.

Where flow rates or piping considerations dictate the use of line sizes between 25 mm (1 in.) and 50 mm (2 in.), the design and use of the orifice plate shall be in accordance with [BS 1042](#) Section 1.2.

Where flow rates or piping considerations dictate the use of line sizes below 25 mm (1 in.) the principles of [BS 1042](#) Section 1.2 should be used, accepting that no guidance is provided in determining the flow measurement uncertainty in this case.

ISO 5167 does not cover orifice plates for line sizes less than 2 in. (50 mm). In 0.5 to 1.5 in. (12 to 40 mm) line sizes, effects of pipe roughness, plate eccentricity and edge sharpness are much greater, resulting in unpredictable flow coefficients. For these sizes, corner taps are preferred with integral orifice assemblies for use with RTJ flanges. Proprietary special honed meter runs are available that have predictable coefficients and these should be used if accuracy is required.

For line sizes of 0.5 in. or smaller, proprietary brands of orifice plate integrated with DP transmitters are available.

2.4 Materials

- * 2.4.1 The orifice plate material shall be compatible with the process fluid. The preferred material is type 316 austenitic stainless steel. Type 304 stainless steel, Monel and Hastelloy or any other material that may be required for special applications shall be subject to approval by BP.

2.5 Design Considerations (Ref. Figure 1)

The following design considerations apply to both paddle type and universal plates unless otherwise specified.



2.5.1 Plate Thickness

2.5.1.1 The thickness of the orifice plate (E) be in accordance with [ISO 5167](#) Section 8.1.4.

For systems with maximum differential pressure up to 500 mbar, the thickness of the plate shall not be less than $0.0156D$, where D is the internal diameter of the line, in order to prevent plastic buckling and elastic deformation in excess of that allowed in [ISO 5167](#) Section 8.1.1.3.

For systems with maximum differential pressures over 500 mbar the plate thickness shall not be less than $0.02D$.

See Appendix C2.

2.5.2 Orifice Edge Thickness

2.5.2.1 For plate thicknesses up to $0.02D$ the orifice edge thickness (e) shall be equal to E . For plate thicknesses greater than $0.02D$, the downstream edge of the plate shall be bevelled at 45° to achieve an edge thickness of $0.02D$.

Where it is possible that higher differential pressures will exist from venting or pressurising too rapidly which can lead to permanent plastic distortion it is advisable to increase the plate thickness to the maximum quoted in [ISO 5167](#): $D/20$ to ensure an adequate safety margin. At plate thicknesses between $D/50$ and $D/20$ the plate downstream edge shall be bevelled at a 45 degree angle.

2.5.2.2 For plates which are intended for the measurement of fluid flowing in both directions, the plate shall not be bevelled.

2.5.3 Surface Finish

2.5.3.1 For plates for general use, the upstream surface finish shall be in accordance with [ISO 5167](#) where roughness criterion $R_a > 0.0001d$, where d is the orifice bore dimension. For newly manufactured plates $R_a < 1.14$ micro metres.

2.5.4 Orifice Diameter

* 2.5.4.1 The orifice diameter (d) is dependent on the particular application and shall be determined by calculation based on [ISO 5167](#). Orifice sizing calculations shall be subject to approval by BP.

2.5.4.2 For applications where the highest accuracy is required, the orifice diameter shall be calculated so that the maximum d/D ratio (where D = pipe diameter) does not exceed 0.6. For less demanding lower

accuracy, mass balance and process control applications, the maximum d/D ratio shall not exceed 0.7.

ISO 5167 states that the Beta Ratio d/D should be within the limits 0.2 to 0.75. However to keep the flow coefficient uncertainty to 0.6% the ratio should not exceed 0.6. (I.e; For beta ratios of 0.6 or less, the uncertainty is $\pm 0.6\%$. For beta ratios higher than 0.6, the % uncertainty = the beta ratio). Increasing the Beta ratio from 0.6 to 0.75 enables about 95% more flow through the meter with an increase in uncertainty in flow coefficient to 0.75%. However it is recommended not to exceed a beta ratio of 0.7.

2.5.5 Tolerance on Specified Orifice Diameter

2.5.5.1 The orifice diameter shall be machined or ground to within ground to with $+ 0.01d$ (for $d > 50$ mm) or $+ 0.05$ mm (for $d > 50$ mm) of the specified diameter determined in 2.5.4.1 above. The orifice bore shall be truly at right angles to the face of the plate. For highest accuracy measurement the actual orifice diameter shall be measured in accordance with [ISO 5167](#) Section 8.1.7.2.

2.5.6 Outside Diameter of Plate

Note: All dimensions are given in inches to correspond with [ANSI B16.36](#) inch series.

2.5.6.1 For the paddle type orifice plate, the outside diameter of the plate (dimension A) shall be machined to provide a uniformly circular disc to a tolerance of ± 0.02 in. and the dimensions shall be in accordance with the values shown in table 1.

2.5.6.2 For the universal (circular) orifice plate, dimensions are given in Table 2. These are typical values for guidance only which would be required to give concentricity in most proprietary orifice fittings.

Dimensions given are for the outside of circular orifice plates for use in proprietary orifice fittings. These sizes are standardised and are interchangeable in various different proprietary bands of fittings up to 10 in. diameter. Sizes above 10 in. may vary slightly depending on the type and make of fitting the plates are to be used with. These plates and fittings are normally used where high accuracy metering is required or plates have to be removed from the line without breaking flanges.

Various types of proprietary removable sealing units are available for the circular (universal) orifice plate which fit around the plate. Plates of 12 in. size or larger, for use in some fittings, include a synthetic rubber sealing unit bonded to both sides of the plate for non-metallic seals in the orifice fitting seat. These are standard for most applications these sizes. The type of seal used will depend on the application, product, type of fitting and standard of accuracy required and is beyond the scope of this specification.



- 2.5.7 Drain Holes
- * 2.5.7.1 Where process conditions require the use of drain holes they shall be in accordance with [BS 1042](#): Section 1.2: Part 3. The standard provides for the use of drain holes in orifice plates in line sizes greater than 4 in. (100 mm) only.
- 2.5.7.2 Orifice plates with drain holes should only be used in line sizes 100 mm (4 in.) or smaller where it is essential to do so. The additional uncertainty in the discharge coefficient arising from the use of a drain hole in these line sizes is not quantified by the Standard.
- The drain hole maximum diameter shall not exceed 0.1d. The drain hole centre shall be on a pitch circle diameter of $D - 0.15d$.
- 2.5.7.3 When installed, the plate should be positioned so that the drain hole is located at the lowest point on wet gas service and the highest point on liquid service with gas entrainment.
- 2.5.8 Marking
- 2.5.8.1 For orifice plates with handles, (paddle type) the orifice diameter, line size, plate material, instrument tag number and the word 'inlet' shall be lightly stamped on the upstream face of the handle. For the universal (circular) orifice plate, the orifice diameter, line size, plate material, instrument tag number and the word 'outlet' shall be stamped clearly on the downstream face of the plate, as near to the outer edge as possible.

3. ORIFICE FLANGES

3.1 General

For higher accuracy, and test separator applications where it may be necessary to inspect/change the orifice plate regularly without breaking the flanges, single chamber 'Junior' orifice fittings with universal orifice plates are preferred subject to approval by BP. If it is necessary to change the plate under pressure, proprietary 'Senior' double chamber fittings are available.

- 3.1.1 The design shall be in accordance with [ANSI B16.5](#), [ANSI B16.36](#), BP Group [GS 142-12](#) and [ISO 5167](#).

[ANSI B16.36](#) is equivalent to [ANSI B16.5](#) standard flanges with orifice pressure taps. BP Group [GS 142-12](#) modifies the requirements of [B16.5](#). [ISO 5167](#) does not specifically refer to flanges but specifies spacing of pressure taps etc. and allows corner taps to be in the pipe, flanges or carriers.

- 3.1.2 The design and selection shall be in accordance with the piping specification for the particular line containing the orifice flange.



- 3.1.3 For line sizes of 50 mm (2 in.) and above the pressure tapplings should be flange tapplings in accordance with [ISO 5167](#) Section 8.2.1. For line sizes below 50 mm (2 in.) the pressure tapplings should be corner taps in accordance with [BS 1042](#) Section 1.2.
- 3.1.4 Spreader bolts shall be provided in flanges, in diametrically opposing positions.
- 3.1.5 Inner surfaces at welds shall be ground to remove all burrs and to conform to [ISO 5167](#) Section 7.5.1.
- 3.1.6 Surface finish shall comply with BP Group GS [142-12](#) Section 3.6.
- 3.1.7 Orifice flange dimensions shall be in accordance with [ANSI B16.36](#). In particular, the flange thickness (C) shall not be less than 38 mm (1.5 in.). The flange bore should be specified to match the internal diameter of the piping schedule.

[ANSI B16.36](#) 'Orifice Flanges' covers flanges for nominal pipe sizes 25 mm (1 in.) to 600 mm (24 in.) which is considered standard. The thickness of the flanges for the smallest sizes is 38.1 mm (1.5 in.), which is the minimum allowable thickness required to accommodate the pressure taps.

3.2 Raised Face Orifice Flanges (Ref. Figure 2)

- 3.2.1 Raised face orifice flanges referred to in this document are standard raised face weld neck flanges for use with the paddle type orifice plates.
- 3.2.2 For pipework systems rated below Class 300, Class 300 shall be used.

3.3 Ring Type Joint Orifice Flanges and Carrier Rings

- 3.3.1 Ring type joint orifice flanges referred to in this document are standard RTJ weld neck orifice flanges with 'flange tap' pressure connections, for use with orifice plate carrier rings.
- 3.3.2 Ring type joint orifice flanges shall only be used on the following line sizes, in accordance with [ANSI B16.36](#):

Class 900: up to 300 mm (12 in.) NB

Class 1500: up to 150 mm (6 in.) NB

Class 2500: up to 75 mm (3 in.) NB

Size limitations are in accordance with [ANSI B16.36](#) and are due to there being insufficient metal between the groove and the pressure tap holes in larger sizes



than specified. For applications requiring larger line sizes at the above pressure ratings, use integral orifice assemblies with standard [ANSI B16.5](#) RTJ flanges.

3.3.3 Carrier rings are designed to fit directly between ring type joint orifice flanges. They contain a removable square edged universal orifice plate and do not have pressure taps. They are designed with either octagonal or oval rings.

3.3.4 Carrier dimensions shall be in accordance with [ISO 5167](#) Section 8.2.2.6.

3.4 Pressure Taps

3.4.1 Pressure taps shall be in accordance with [ISO 5167](#) section 7.2.

3.4.2 Two pairs of taps shall be provided for each orifice flange.

If possible, flanges should be oriented such that the pressure taps are offset from one another to give clearance for connections. Two sets of pressure taps are preferred to give options for use, spares, or choice of orientation.

3.4.3 For flanges and fittings below 50 mm (2 in.) nominal bore, corner taps shall be used. For pipe sizes 50 mm (2 in.) and above, flange taps shall be used.

3.4.4 Pressure tap diameter shall be in accordance with [ANSI B16.36](#), i.e:-

12.7 mm (0.5 in.) for 100 mm (4 in.) NB and above.

9.5 mm (0.375 in.) for 75 mm (3 in.) NB.

6.3 mm (0.25 in.) below 75 mm (3 in.) NB.

3.4.5 Flange connections shall be threaded, seal, butt or socket welded as specified by the purchaser. For sour service, connections shall be in accordance with BP Group [GS 136-1](#), section 2.11.

3.4.6 Unused pressure taps shall be plugged and welded. For sour service, materials, welding, heat treatment shall be in accordance with BP Group [GS 136-1](#) as above.

3.5 Gaskets

3.5.1 The use of gaskets shall in general be in accordance with [ISO 5167](#) section 7.5.3.

3.5.2 The thickness of the gaskets shall where compatible with the piping specification be 1.5 mm, and in any case not greater than 0.03D where D is the line diameter. Where gaskets thicker than 1.5 mm are required then the raised face of the orifice flange shall be suitably modified in

accordance with [ANSI B16.36](#) clause 7.1 note 1, to meet the spacing requirements of the pressure tapplings.

3.5.3 Gaskets shall not protrude at any point inside the pipe.

3.6 Marking

3.6.1 Flanges and carriers shall be marked with the letter 'R' and the corresponding API ring groove number in accordance with [ANSI B16.5](#) table 5 and [BS 1560](#) section 3.1 table 6.

3.6.2 Material, line size and tag no. shall be stamped clearly on each unit.

4 INTEGRAL ORIFICE ASSEMBLIES (REF. FIGURES 3 AND 4)

4.1 General

4.1.1 The integral orifice assemblies referred to in this document are single units consisting of a fixed square edged orifice plate section, sized for a particular service, RTJ grooves and flanged corner pressure tap connections. The complete unit is designed to fit between ring type joint flanges with the use of solid metal API RTJ gaskets.

* 4.1.2 Assemblies shall be installed between [ANSI B16.5](#) RTJ flanges unless otherwise specified by BP.

4.1.3 Hydrostatic tests of the orifice assembly shall be carried out in accordance with [ANSI B31.3](#).

4.2 Pressure Tap Connections

4.2.1 Pressure tap connecting pipe positions shall be in accordance with Figure 4.

4.2.2 Welding of the pressure tap connections shall be in accordance with BP Group GS 118 and [ANSI B31.3](#).

4.2.3 Pressure tap connections shall be 0.5 NPS weld neck flanges to [ANSI B16.5](#). 'Hi' and 'Lo' shall be stamped on top of the upstream and downstream pressure tap flanges respectively. 0.05 NPS pipe used shall be suitable for line specification.

4.3 Pressure Taps

4.3.1 Corner taps shall be used. The diameter and dimensions shall be in accordance with [ISO 5167](#) section 8.2.2.



4.4 Orifice Plate Section

- 4.4.1 To eliminate distortion during welding, the orifice diameter shall not be bored until the flanged pressure connections (which connect to the corner taps) and the flow indicator pillar have been welded in position.
- 4.4.2 If drain holes (see Fig 3) are required, the diameter shall be less than 0.1d and lie on the centre line of the flag pillar.
- 4.4.3 All other dimensions and tolerances shall be in accordance with section 2 of this Specification.

4.5 Marking

- 4.5.1 The flag on the integral orifice assemblies shall be lightly stamped with the tag no., line size, and orifice diameter.

5. NOZZLES AND VENTURI TUBES

5.1 General

Nozzles and Venturi Tubes shall only be used for flow measurement where process conditions or requirements preclude the use of orifice plates. Where nozzles or venturi tubes are required their design, installation and operation shall conform to [ISO 5167](#).

Flow nozzles provide a high velocity measurement and are suitable for steam and erosive fluids. Venturi tubes may be used on clean or dirty fluids where low pressure loss is desired. Secondary instrumentation requirements for nozzles and venturis are as for orifice plate systems.

SIZE OF PIPE		ANSI B16.36					
NPS (ins.)	DN (mm)	<u>Class</u> 300 A	<u>Class</u> 600 A	<u>Class</u> 900 A	B	C	H
1	25	2.875	2.875	3.125	4	1.0	0.25
1.5	40	3.750	3.750	3.875	4	1.0	0.25
2	50	4.375	4.375	5.625	4	1.0	0.25
2.5	65	5.125	5.125	6.500	4	1.25	0.375
3	80	5.875	5.875	6.625	4	1.25	0.375
4	100	7.125	7.625	8.125	4	1.25	0.375
6	150	9.875	10.500	11.375	5	1.5	0.375
8	200	12.125	12.625	14.125	5	1.5	0.375
10	250	14.250	15.750	17.125	6	1.5	0.375
12	300	16.625	18.000	19.625	6	1.5	0.375
14	350	19.125	19.375	20.500	6	1.5	0.50
16	400	21.250	22.250	22.625	6	1.5	0.50
18	450	23.375	24.000	25.000	6	1.5	0.50
20	500	25.625	26.750	27.375	6	1.5	0.50
24	600	30.375	31.000	32.875	6	1.5	0.50

TABLE 1
DIMENSIONS FOR THE PADDLE TYPE ORIFICE PLATE
(All Dimensions in inches)



Line Sizes	Plate OD (A)	Tolerance	
1	1.312	+0.003	-0.003
1.5	2.000	+0.003	-0.003
2	2.437	+0.003	-0.003
2.5	2.812	+0.003	-0.003
3	3.437	+0.003	-0.003
4	4.406	+0.003	-0.003
6	6.437	+0.003	-0.006
8	8.437	+0.003	-0.006
10	10.687	+0.003	-0.006
12	12.593	+0.003	-0.006
14	14.000	+0.003	-0.008
16	16.000	+0.003	-0.008
18	18.000	+0.003	-0.008
20	20.000	+0.003	-0.008
24	24.000	+0.003	-0.012

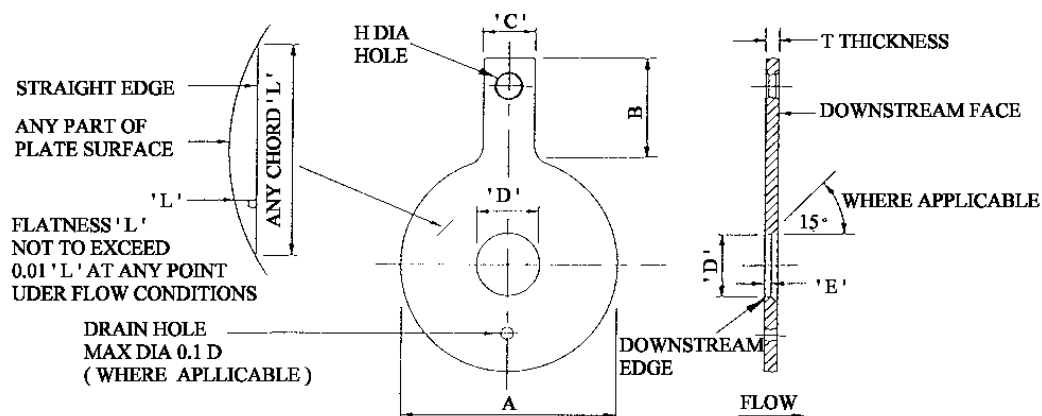
TABLE 2

TOLERANCE ON UNIVERSAL ORIFICE PLATE OUTSIDE DIAMETER

(All Dimensions in inches)



PADDLE TYPE ORIFICE PLATE



UNIVERSAL ORIFICE PLATE

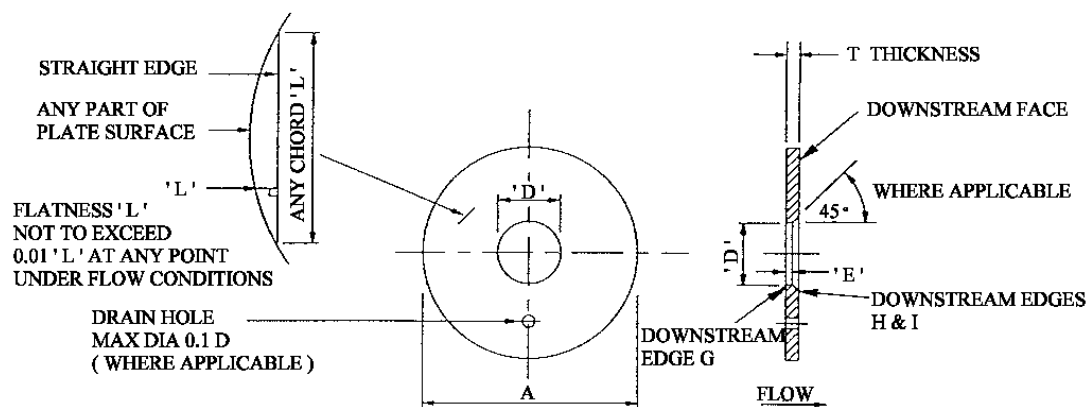


FIGURE 1

STANDARD ORIFICE PLATES

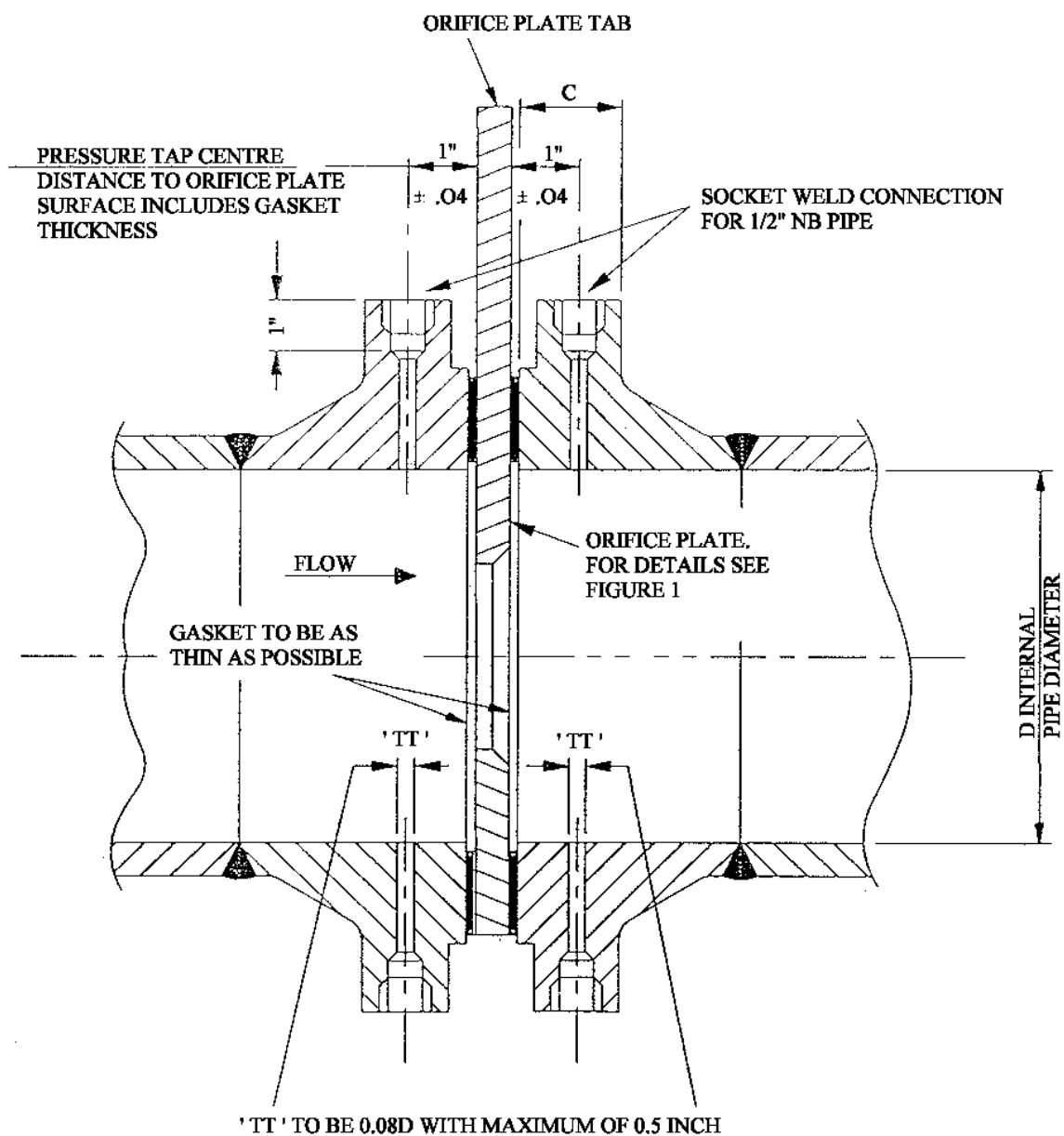


FIGURE 2

STANDARD RAISED FACE ORIFICE FLANGES

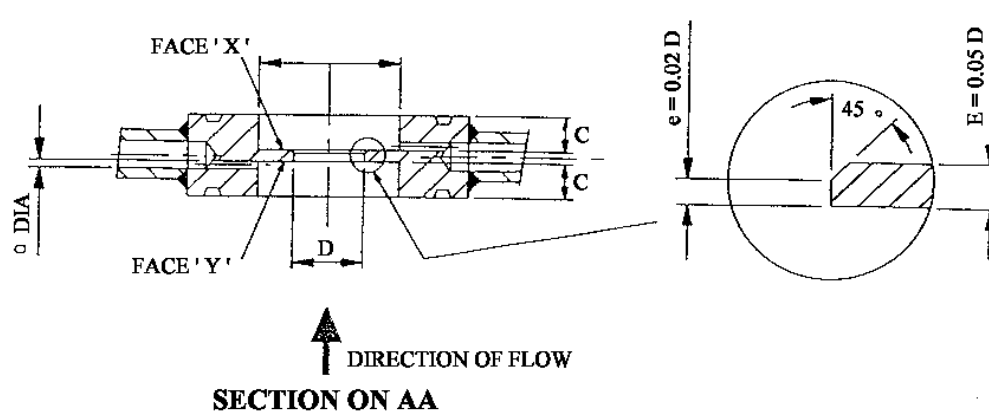
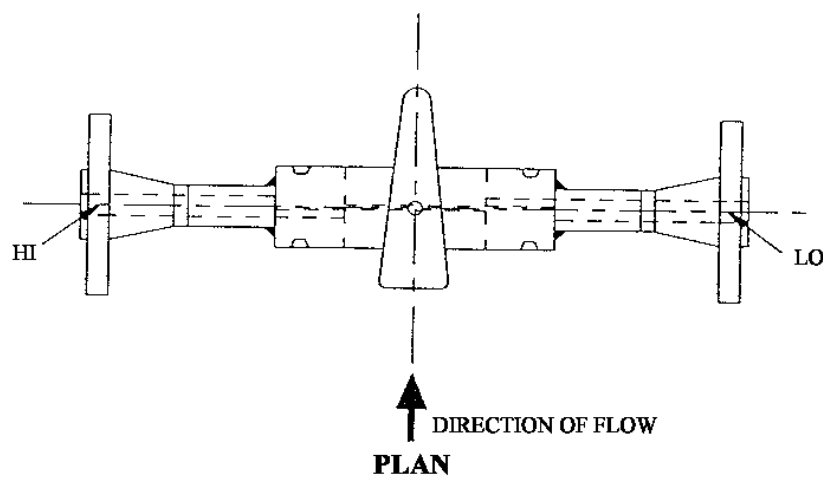
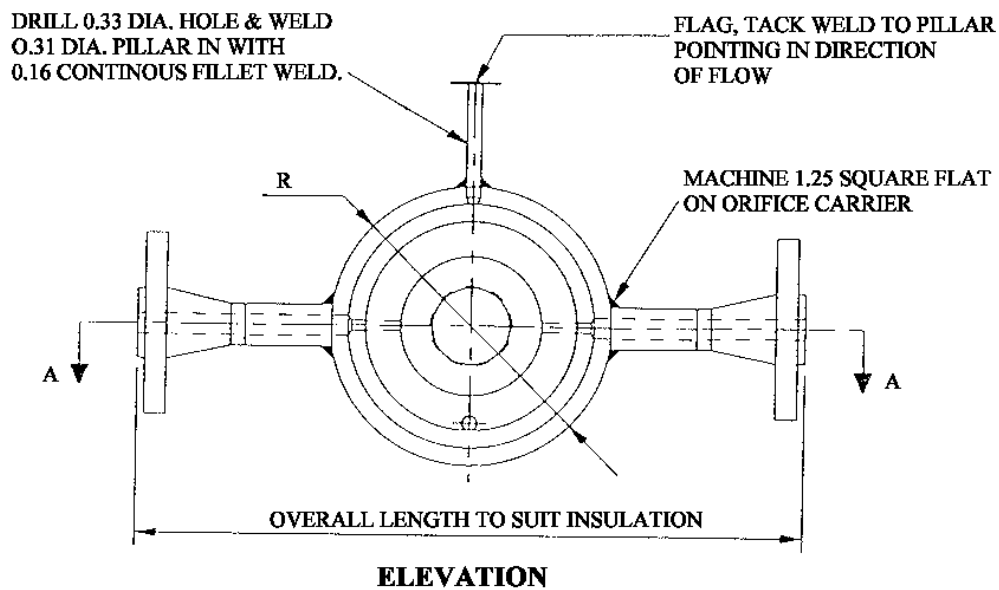


FIGURE 3

INTEGRAL ORIFICE ASSEMBLY

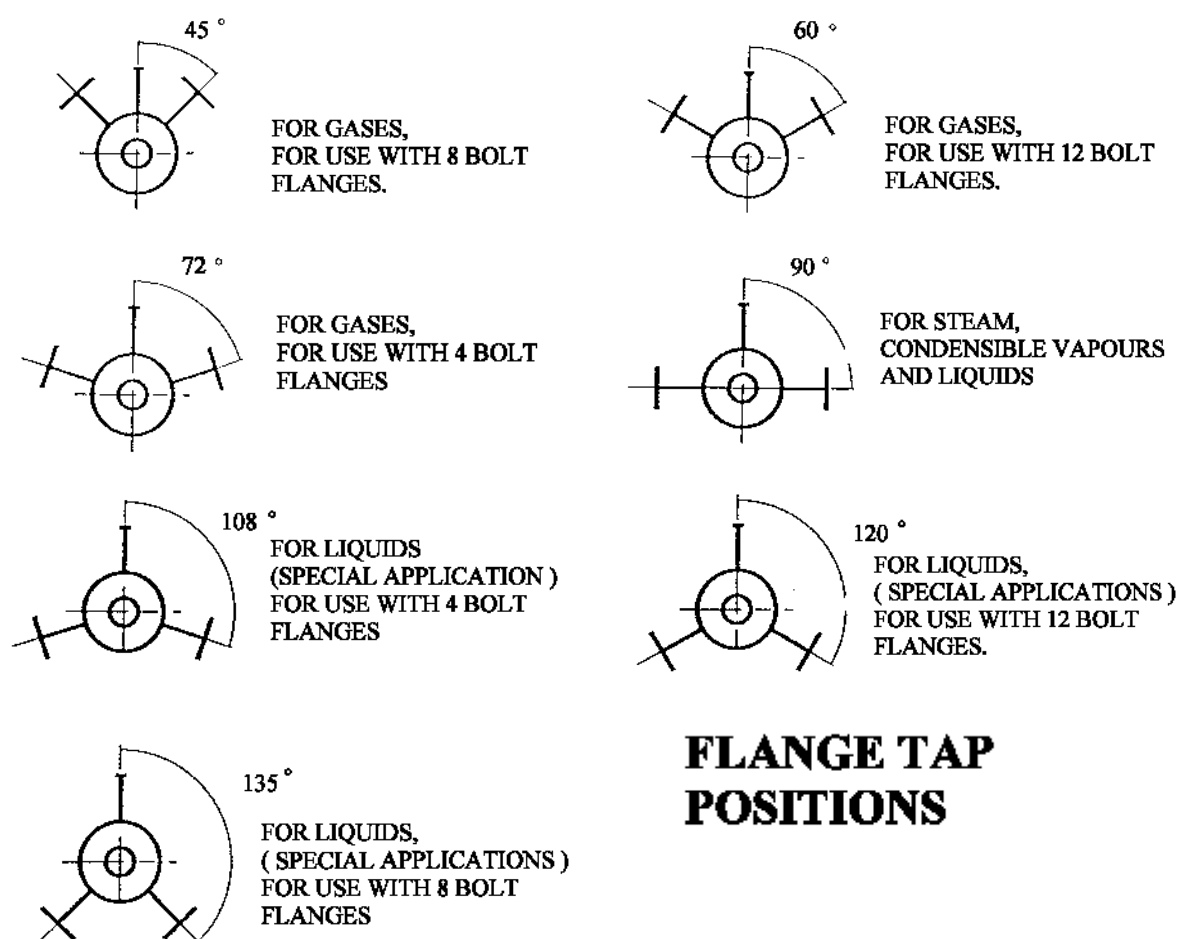


FIGURE 4
PRESSURE TAP POSITIONS

DEFINITIONS AND ABBREVIATIONS

Definitions

Standardised definitions may be found in the BP Group RPSEs Introductory volume.

Vendor	The main supplier of a complete packaged metering system including items of equipment designed and manufactured by others. (Sub-Vendors).
Paddle Type Orifice Plate	Flat circular plate of uniform thickness with a concentric hole and a tab or handle which is in the vertical position when the plate is installed between orifice flanges.
Universal Orifice Plate	Flat circular plate of uniform thickness and a concentric hole, designed to fit in ring type holders, orifice carriers, flanges or fittings.

Abbreviations

ANSI	American National Standards Institute
API	American Petroleum Institute
BS	British Standard
D	Inside pipe diameter
DN	Nominal bore (millimetres)
DP	Differential pressure
d	Orifice diameter
ISO	International Organisation for Standardisation
NPS	Nominal pipe size (inches)
NB	Nominal bore
NDT	Non destructive testing
OD	Outside diameter
QA	Quality Assurance
RTJ	Ring type joint



LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

International Documents

[ISO 5167](#) Measurement of Fluid Flow by means of Orifice Plates, Nozzles and Venturis inserted in cross-section conduits running full. 1980.

Amercian Documents

[ANSI B16.5](#) Pipe Flanges and Fittings (inch series) 1988.
[ANSI B16.20](#) Ring Joint Gaskets and Grooves for Steel Pipe Flanges. 1973
[ANSI B16.36](#) Orifice Flanges (inch series) 1988.
[ANSI B31.3](#) Chemical Plant and Petroleum Refinery Piping.

British Standards

[BS 1042](#) Section 1.2 Specification for Square - Edged Orifice Plates and Nozzles (with drain holes, in pipes below 50 mm diameter) and other Orifice Plates.
[BS 1560](#) Circular Flanges for Pipes, Valves and Fittings. 1989.

BP Group Document

BP Group GS 118 Fabrication of Pipework to ANSI B31.3
 (All Sections) (was BP Std 167 Pt. 1, 2 & 3)

BP Group [GS 136-1](#) Materials for Sour Service to NACE Standard MR0175-90.
 (was BP Std 153)

BP Group [GS 142-12](#) Pipe Flanges and Fittings.
 (was BP Std 260)



SUPPLEMENTARY COMMENTARY

C1 Non-Standard Orifice Bores

This Commentary relates to clause 2.2.1.

Special non-standard orifice plate bores are available for use where the field of application includes viscous fluids, dirty fluids, two phase flow or solids entrained in a gas or liquid flow stream. These are very rarely used for applications covered within this specification. In every case the accuracy is more than half that of a conventional orificeplate. Some of the more common are listed below:

- (1) *Quadrant-Edged Orifice - The quadrant or quarter circle bore is an orifice where the inlet edge is rounded. The radius of the quarter circle bore is a function of the beta ratio. This bore is specially designed for fluids of high viscosity and low Reynolds number such as heavy crudes, syrups and slurries. The disadvantages are critical manufacturing dimensions and lower accuracy.*
- (2) *Conical Entrance Orifice - The quarter circle of the quadrant is replaced by a conical entrance. Considered to be more difficult to manufacture than the quadrant. Uses are similar to the above but can be used on viscous fluids with a very low Reynolds number.*
- (3) *Eccentric and Segmental Orifice - These orifices were developed to meter both liquids containing sediment and gases entrained within liquids. Both the segment and the eccentric orifice are inscribed in a circle which is 98% of the pipe diameter. Construction materials, plate thickness, edge sharpness, etc, are identical to those for the square edged concentric orifice. Sizing and flow equations are the same as for other differential producers. The segmental orifice allows drainage of foreign material at the side of the pipe where the opening is located to a greater extent than the eccentric orifice. This characteristic makes it useful for measuring wet steam, liquids containing granular solids and oils containing water. For liquids containing gas or vapour the segment may be located at the top of the pipe. However, for these fluids, a concentric orifice located in a vertical pipe with upward flow would be preferred for greater accuracy. In all other respects the eccentric orifice is superior to the segmental orifice.*

C2 Design Considerations

This Commentary relates to clause 2.5.1.1.

- * *In special applications where 500 mbar is exceeded, (which shall be subject to BP approval), the thickness of the plate can be extended to a maximum of $1/20 \times$ the nominal pipe diameter (0.05D) the criteria being that the dynamic elastic*

deformation of the plate, caused by the differential pressure, shall be less than 1%, in accordance with [ISO 5167](#) sections 7.1.1.3 and 7.1.2.1.

The plate thickness should be such that it meets the following criteria:

$e\%$ = error in metering due to elastic deformation $< 0.1\%$.

h/D :ratio of plate thickness (t) to inside pipe diameter (D) $>$ calculated minimum t/D

Where

Error (Elastic deformation)

$$= (\Delta P/E) \times (D/t)^2 \times (a(D/t)-b)$$

Calc minimum t/D (plastic deformation)

$$= \text{sq.rt.} [(\Delta P/s_y) (0.681 - 0.651d/D)]$$

Where

'a' and 'b' are constants whose values are given as functions of the ratio of orifice diameter d to orifice plate support diameter D in the following table assuming constant units of pressure and stress.

d/D	0.2	0.3	0.4	0.5	0.6	0.7
a	0.0218	0.0275	0.0295	0.0280	0.0246	0.0187
b	1.1023	0.9745	0.8499	0.7299	0.6158	0.5082

$E = 19.3 \times 10^5$ bar.

The Young's Modulus for stainless steel.

$s_y = 1000$ bar.

Conservative estimate for the yield stress of stainless steel. Data books quote approximately 3000 bar.

ΔP = Maximum differential pressure (bar).

The results of these equations are tabulated below for some typical values of ΔP , d/D , t/D .

Beta ratio	0.2	0.3	0.4	0.5	0.6	0.7	t/D	DP Max (mbar)
% Error	0.03	0.08	0.1	0.1	0.1	0.07	$\frac{1}{64}$	500
Calc t/D	0.0166	0.0156	0.0145	0.0133	0.012	0.0106	0.0156	
% Error	0.06	0.16	0.2	0.2	0.19	0.14	$\frac{1}{64}$	1000
Calc t/D	0.023	0.022	0.021	0.019	0.017	0.015	0.0156	
% Error	0.06	0.16	0.2	0.2	0.19	0.14	$\frac{1}{50}$	1000
Calc t/D	0.023	0.022	0.021	0.019	0.017	0.015	0.020	
% Error	0.02	0.01	0.02	0.03	0.03	0.02	$\frac{1}{40}$	1000
Calc t/D	0.023	0.022	0.021	0.019	0.017	0.015	0.025	
% Error	0.01	0.01	0.005	0.003	0.002	0.002	$\frac{1}{20}$	1000
Calc t/D	0.023	0.022	0.02	0.019	0.017	0.015	0.05	
% Error	0.03	0.016	0.01	0.006	0.005	0.005	$\frac{1}{20}$	2000
Calc t/D	0.03	0.03	0.03	0.03	0.02	0.02	0.05	

Ref: R. Norman. M.S. Rawat. P. Jepson: Buckling and Eccentricity effects on orifice metering accuracy 1983 International Gas Research Conference. IP Pet Meas Manual Part XV section 2 - A Guide to Gas Metering Systems.

500 mbar maximum differential pressure is specified for high accuracy metering systems and is the preferred maximum value for all applications. Where it is found necessary to exceed 500 mbar, the plate thickness should be increased to a minimum of 0.02D. Where the above table or equations show 0.02D to be sufficient, the plate need not be bevelled on the downstream edge.