

FOR METERING, PIPING AND INSPECTION ENGINEERS

# Flange Joints, Tapping Positions and Tapping-Hole Edges

What ISO 5167-2 allows at each, what a millimetre out of place does to the discharge coefficient, and how to check the meter as it is assembled

An orifice meter goes into service with a discharge coefficient that was never measured on it. The coefficient belongs to the geometry: build the geometry the standard describes and the published value and its uncertainty come with it. Most of that geometry is the plate. The rest is a few millimetres of steel around it that no datasheet shows — the joint in the upstream meter tube, the distance from each tapping to the plate face, and the edge where each tapping breaks through the bore.

Three questions keep coming up in design reviews and inspections. **Can the upstream meter tube be split at a flange? How far out of position may a flange tapping be? Does a chamfered tapping hole matter?** ISO 5167-2:2022 answers the first two with limits, and inside them the discharge coefficient and its uncertainty are unchanged. Outside them the meter is no longer in accordance with the standard, and ISO/TR 12767:2023 gives a way to estimate how far off it is. This note does both for standard orifice plates with flange tapplings, and puts numbers on errors that White Paper 01, Section 3 lists as living in the piping. TN-01 covers where a tapping sits around the circumference; this note covers where it sits along the axis.

## 1. A joint in the upstream meter tube: 0.3 % of D

ISO 5167-2:2022, 6.4.3 lets the upstream straight length be built from several sections, joined only beyond 2D from the plate. How large a step each joint may have depends on where it is. Between 2D and 10D the limit is 0.3 % of D, both as the difference between the two diameters and as the actual step at any point of the circumference — 0.30 mm on a 100 mm meter tube, 0.90 mm on a 300 mm one.

| DISTANCE FROM THE PLATE                                 | PERMITTED STEP                                                                                        | FURTHER CONDITIONS                                                                                                                                    |
|---------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| Up to 2D                                                | No joint: the run may be split only beyond 2D (6.4.3)                                                 | No diameter in any plane may differ from the mean diameter D by more than 0.3 % (6.4.1), including the weld plane of a weld-neck construction (6.4.2) |
| 2D to 10D                                               | 0.3 % of D, as the difference between the diameters and as the step at any point of the circumference | Bores matched and flanges aligned on installation; dowels or self-centring gaskets can be used (6.4.3)                                                |
| Beyond 10D                                              | 2 % of D; 6 % where the upstream diameter is the larger                                               | Diameter between 0.98D and 1.06D on each side; gaskets no thicker than 3.2 mm in use and not protruding (6.4.3)                                       |
| Beyond 10D and the first expander location <sup>1</sup> | 6 % of D                                                                                              | Diameter between 0.94D and 1.06D on each side (6.4.3)                                                                                                 |

**Table 1 — Steps between upstream pipe sections, ISO 5167-2:2022, 6.4.** <sup>1</sup> Beyond the first location where an expander could be fitted according to ISO 5167-2:2022, Table 3, column 10A. Clause numbers throughout this note are those of the editions listed under the sources.

A step outside Table 1 is not always the end of the meter. A single one is accepted with an additional relative uncertainty of 0.2 %, added arithmetically to that of C, if  $\Delta D/D < 0.002 \cdot (s/D + 0.4) / (0.1 + 2.3\beta^4)$  and  $\Delta D/D < 0.05$ , where s is the distance of the step from the upstream pressure tapping (6.4.4, Formula (10)). At  $s = 2D$  that allows 1.2 % of D at  $\beta = 0.6$  but only 0.58 % of D at  $\beta = 0.75$ . A second step outside 6.4.3 takes the meter out of the standard altogether (6.4.5). Longitudinal seam weld beads may stand no higher than the permitted step (ISO 5167-1:2022, 7.1.4), and the flanges have to be aligned so that they introduce no deviation from a straight line of more than 0.4 % (7.1.3).

### Where a step comes from

**Bolts do not centre flanges.** In the ASME B16.5 drilling templates for Class 150 and 300, NPS ½ to 24, the bolt holes are 1/8 in (3.175 mm) larger than the bolts, so two raised-face flanges bolted together can sit up to 3.175 mm off centre from each other. That is more than 0.3 % of D in every size the standard covers: 3.2 % of D at 100 mm, 1.1 % at 300 mm, 0.53 % at 600 mm. A raised-face joint meets the limit only when somebody centres it and measures it; nothing in its construction does.

**Bores and welds.** Pipe diameter tolerance, ovality and a change of wall thickness between two spools show up as a step before anything is misaligned, and a weld bead or a mismatch at the flange-to-pipe weld is a step of its own. An undressed circumferential weld protruding into the bore next to the primary device acts like an undersize joint ring, and its effect is difficult to quantify without a calibration (ISO/TR 12767:2023, 7.5).

**Gaskets.** A gasket or inner ring with a bore smaller than the pipe protrudes into the flow, and very large errors might occur (ISO/TR 12767:2023, 7.4). One with a larger bore leaves a recess in the wall instead.

## 2. A joint built to meet it

ISO/TR 9464:2023 recommends self-centring pipe joints — tongue and groove, male and female flanges, dowel pins, spigot and recess — and makes the point that measuring the internal diameter at the ends of each section is not enough: the coupled joint has to be checked for its step as well (5.2.6.4.3). Three features together take the step out of the tolerance question (Figure 1).

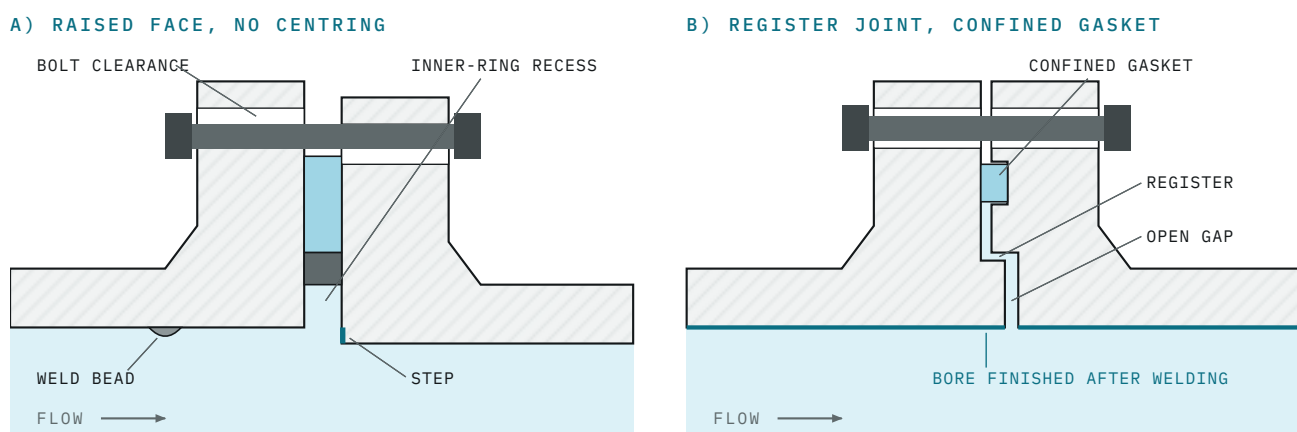


**Figure 1 — Two ways to build a joint in the upstream meter tube.** a) Raised-face flanges: the bolt-hole clearance lets one spool sit off centre, the weld bead is left in the bore and the gasket inner ring leaves a recess, so the joint carries a step. b) Register joint: the spigot centres the flanges, the gasket is confined in its groove, and the bore is finished after welding, so the wall runs through without a step. Schematic half-sections, not to scale; offsets and gaps exaggerated.

- **Bore finished after welding.** The flange is welded to its pipe first, and the bore of the whole spool — flange, weld zone and pipe — is then machined or honed as one surface. There is no weld bead and no step between flange and pipe, and the flange bore becomes part of the measured meter-tube bore.
- **A machined register.** A close-fitting spigot and recess centres the two flanges independently of the bolts; the radial offset is at most half the register's diametral clearance, 0.1 mm for 0.2 mm.

- **A confined gasket.** The gasket sits in its groove, radially outside the bore, so it cannot enter the flow in any assembly condition; the gap left between the faces is a recess in the wall, not an obstruction. ISO 5167-2 sets no explicit limit for such a recess between 2D and 10D; for gaskets at the primary device, ISO/TR 9464:2023, 5.2.6.6 advises no more than 0.03D and states that the depth of the resulting recess does not affect the flow measurement.

**Verify the coupled joint, not the spools.** For a self-centring joint, careful measurement of the bore and of the centring device gives results as accurate as external reference points (ISO/TR 9464:2023, 5.2.6.4.3). Record four bore diameters at each mating face and, at the same orientations, the radial wall width between the bore and the register; the largest possible step follows from those and the register clearance. Keep matched spools together, orientation marked. Inkotek machines or hones the whole meter run on AGA Report No. 3 / API MPMS Chapter 14.3 designs, and only the spool from the orifice plate to the flow conditioner on ISO 5167 designs.

### 3. Tapping spacing belongs to the assembled meter

For flange tapplings the spacing  $l_1$  of the upstream tapping is measured from the upstream face of the plate, and the spacing  $l'_2$  of the downstream tapping from the downstream face (Figure 2). Both are nominally 25.4 mm. They may lie within  $25.4 \pm 0.5$  mm when  $\beta > 0.6$  and  $D < 150$  mm, and within  $25.4 \pm 1$  mm in every other case, without altering the discharge coefficient (ISO 5167-2:2022, 5.2.2.3). Inside those windows Formula (4) is used with  $L_1 = L'_2 = 25.4/D$ , D in millimetres, and the uncertainty of 5.3.3.1 applies.

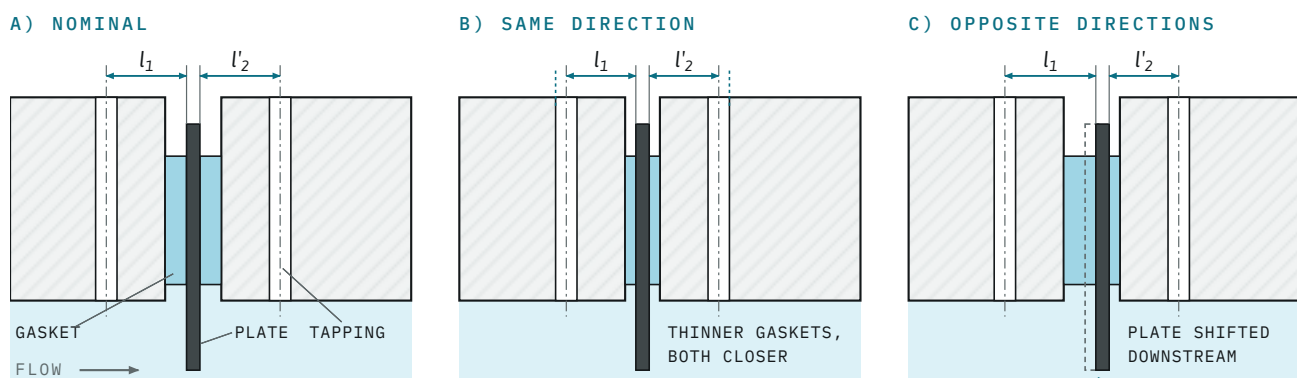


**Figure 2 — Flange tapping spacings and the two ways they move.** a)  $l_1$  and  $l'_2$  are measured from the plate faces and include the installed gasket. b) Same direction, for example thinner gaskets on both sides: both tapplings move towards the plate and their effects on C oppose. c) Opposite directions, from a plate shifted, tilted or unevenly clamped in the gasket stack: one spacing grows as the other shrinks and the effects add.  $\Delta l = l - 25.4$  mm is positive when a tapping lies farther from its plate face. Schematic, not to scale; gasket thickness exaggerated.

Because the spacing is measured from the plate face, the thickness of the gaskets has to be taken into account when the tapplings are positioned (5.2.2.1), and the gaskets are to be as thin as possible while holding the specified spacing (6.6.2). The spacing is therefore fixed only in the assembled meter:

**$l$  = flange face to tapping centreline + installed gasket thickness**, plus any offset between the holder face and the plate face.

A tapping drilled for a given gasket stays in tolerance over a window of installed gasket thickness. With the tapping centre 22.4 mm from the flange face on a meter of  $D \geq 150$  mm, any installed gasket from 2.0 mm to 4.0 mm keeps the spacing within  $25.4 \pm 1$  mm; under the  $\pm 0.5$  mm tolerance the same window is 1 mm wide. **Specify the gasket type and its compressed thickness together with the tapping position**, and show the window on the drawing.

## 4. What a millimetre outside the tolerance is worth

A tapping outside its tolerance takes the meter out of the standard: ISO 5167-2:2022, 5.3.2.1 does not allow pairs of  $L_1$  and  $L_2$  that match none of the three standard tapping arrangements to be put into Formula (4). The way back to a number is ISO/TR 12767:2023, 6.4. Calculate the actual  $L_1 = l_1/D$  and  $L_2 = l_2/D$  and, provided  $L_1 \leq 1$  and  $L_2 \leq 0.47$ , estimate  $C$  from Formula (4) with those values (6.4.2). Then add an uncertainty  $\delta U'$ , in per cent, arithmetically to that of  $C$  (6.4.3, and the example of 6.4.4):

- tappings between the flange and the corner positions:  $\delta U' = 25 \cdot |C_F / C_{CT} - 1|$ , Formula (2);
- tappings between the  $D$  and  $D/2$  and the flange positions:  $\delta U' = 25 \cdot |C_{D \text{ and } D/2} / C_F - 1|$ , Formula (3),

where  $C_F$ ,  $C_{CT}$  and  $C_{D \text{ and } D/2}$  are the coefficients for flange, corner and  $D$  and  $D/2$ appings. At  $\beta \leq 0.6$ ,  $\delta U'$  stays below 0.1 percentage point for  $D$  from 100 mm to 1 000 mm. At  $\beta = 0.75$  it does not: Formula (3) gives 0.24 to 0.56 percentage points over the same range, the same order as the 0.75 % uncertainty of  $C$  itself.

ISO/TR 12767 has no formula for the mixed case, one tapping displaced towards the plate and the other away from it. A conservative approach is to apply the estimated coefficient and add the larger of 100 % of the correction — the general rule of 5.2 — and the sum of Formulas (2) and (3). Correcting the geometry or calibrating the meter is the better answer; a non-standard tap arrangement is one of the cases where White Paper 04, Section 5 names calibration as the right tool.

**Signs.**  $\Delta C/C = C_{\text{actual}}/C_{\text{standard}} - 1$ , and a meter computed with the standard coefficient is in error by about  $-\Delta C/C$ : a higher actual coefficient makes it under-read (ISO/TR 12767:2023, 5.1).  $\Delta l = l - 25.4$  mm is positive when the tapping lies farther from its plate face.

| $\beta$ | $D$      | UPSTREAM ONLY | DOWNSTREAM ONLY | SAME DIRECTION | OPPOSITE DIRECTIONS |
|---------|----------|---------------|-----------------|----------------|---------------------|
| 0.4     | 100 mm   | +0.0036       | -0.0070         | -0.0034        | +0.0106             |
|         | 300 mm   | +0.0019       | -0.0039         | -0.0020        | +0.0058             |
|         | 1 000 mm | +0.0004       | -0.0016         | -0.0012        | +0.0021             |
| 0.6     | 100 mm   | +0.0202       | -0.0130         | +0.0072        | +0.0332             |
|         | 300 mm   | +0.0109       | -0.0085         | +0.0024        | +0.0193             |
|         | 1 000 mm | +0.0025       | -0.0037         | -0.0013        | +0.0062             |
| 0.75    | 100 mm   | +0.0630       | -0.0156         | +0.0473        | +0.0786             |
|         | 300 mm   | +0.0342       | -0.0146         | +0.0196        | +0.0488             |
|         | 1 000 mm | +0.0078       | -0.0071         | +0.0006        | +0.0149             |

**Table 2 — Change of  $C$  per millimetre of tapping displacement,  $\Delta C/C$  in % per mm.** From ISO 5167-2:2022, Formula (4), at  $Re_D = 10^6$ , with the actual spacings entered as described in ISO/TR 12767:2023, 6.4.2; slope at the flange position. A positive displacement moves a tapping away from its plate face; in the opposite-direction column the upstream tapping moves away and the downstream tapping towards it.

- The two tappings pull in opposite directions.** Moving the upstream tapping away from the plate raises  $C$ ; moving the downstream one away lowers it.
- Size and  $\beta$ .** The sensitivity rises steeply with  $\beta$  and falls as  $D$  grows — for the upstream tapping roughly in inverse proportion to  $D$ , for the downstream one more slowly.

- **Same direction, partly cancelled.** When both tappings move the same way — thinner or thicker gaskets on both sides — the two effects partly cancel, almost completely near  $\beta = 0.6$  at about 500 mm. At  $\beta = 0.75$  and  $D \leq 300$  mm the combined effect is still more than half that of the upstream tapping alone, and at  $\beta = 0.4$  the downstream tapping dominates.
- **Opposite directions, added.** When the plate is shifted, tilted or unevenly clamped, one spacing grows as the other shrinks and the two effects add. This is the pattern to watch for in assembly.

Between  $Re_D = 10^5$  and  $10^7$  these sensitivities stay within 4 % of their values at  $10^6$ , or within 0.002 % per millimetre for the same-direction case. Table 3 works the four patterns through on one meter.

| DISPLACEMENT PATTERN ( $\Delta l_1, \Delta l'_2$ ) | $\Delta l = \pm 1$ mm <sup>1</sup> | $\pm 2$ mm      | $\pm 5$ mm      | $\pm 10$ mm     |
|----------------------------------------------------|------------------------------------|-----------------|-----------------|-----------------|
| Upstream tapping only ( $\Delta l, 0$ )            | +0.011 / -0.011                    | +0.022 / -0.022 | +0.055 / -0.054 | +0.109 / -0.105 |
| Downstream tapping only ( $0, \Delta l$ )          | -0.008 / +0.009                    | -0.017 / +0.017 | -0.041 / +0.044 | -0.078 / +0.093 |
| Same direction ( $\Delta l, \Delta l$ )            | +0.002 / -0.002                    | +0.005 / -0.004 | +0.014 / -0.010 | +0.030 / -0.013 |
| Opposite directions ( $\Delta l, -\Delta l$ )      | +0.019 / -0.019                    | +0.039 / -0.038 | +0.099 / -0.094 | +0.201 / -0.184 |

**Table 3 —  $\Delta C/C$  in % for displaced tappings on one meter:  $D = 300$  mm,  $\beta = 0.6$ ,  $Re_D = 10^6$ .** Each cell gives the value at  $+\Delta l$  / the value at  $-\Delta l$ , estimated with Formula (4) as described in ISO/TR 12767:2023, 6.4.2. <sup>1</sup> Inside the  $\pm 1$  mm tolerance, shown for comparison only: there the standard coefficient applies.

On this meter, opposite-direction displacements of 5 mm move C by about 0.1 %, one fifth of the 0.5 % uncertainty of C; same-direction ones of 5 mm move it by 0.010 to 0.014 %. The values drift apart for large displacements because Formula (4) is not linear in  $L_1$  and  $L'_2$ . ISO/TR 12767 treats each deviation as the only one present, and several can interact (Clause 1).

## 5. A tilted plate moves the tappings too

ISO 5167-2:2022, 6.5.2 requires the plate to be perpendicular to the pipe centreline within  $1^\circ$ . Tilt the plate by  $\theta$  relative to the flanges that carry the tappings, about a diameter perpendicular to the plane of a tapping pair, and the plate faces at that tapping azimuth move by  $\delta = (D/2) \cdot \tan \theta$ : one spacing grows by  $\delta$  and the other shrinks by  $\delta$  — an opposite-direction displacement. At other azimuths  $\delta$  is reduced by the cosine of the angle between the tapping plane and the plane of largest tilt. If a flange face is itself out of square and the plate follows it, the spacings do not change.

| PIPE INTERNAL DIAMETER D                        | 100                  | 150     | 200     | 300     | 500     | 750     | 1 000 mm |
|-------------------------------------------------|----------------------|---------|---------|---------|---------|---------|----------|
| Tilt that moves a tapping by 1 mm               | 1.15°                | 0.76°   | 0.57°   | 0.38°   | 0.23°   | 0.15°   | 0.11°    |
| Tapping displacement at $1^\circ$ tilt          | 0.87 mm              | 1.31 mm | 1.75 mm | 2.62 mm | 4.36 mm | 6.55 mm | 8.73 mm  |
| $ \Delta C/C $ at $1^\circ$ tilt, $\beta = 0.6$ | 0.029 % <sup>1</sup> | 0.040 % | 0.046 % | 0.051 % | 0.054 % | 0.056 % | 0.057 %  |

**Table 4 — Plate tilt relative to the tapping flanges, at the most affected tapping azimuth.**  $\Delta C/C$  covers the tapping-spacing effect only, at  $Re_D = 10^6$ , and is the larger of the two tilt directions. <sup>1</sup> Inside the  $\pm 1$  mm tolerance, shown for comparison only.

Above  $D \approx 115$  mm a tilt as large as the  $1^\circ$  perpendicularity limit can therefore move a tapping out of a  $\pm 1$  mm tolerance, and above  $D \approx 57$  mm out of a  $\pm 0.5$  mm one; on a 500 mm meter  $0.23^\circ$  is enough for 1 mm. Where the plate can tilt relative to the tapping flanges, the tapping tolerance is the tighter requirement at the affected azimuth. The gasket stack bounds the tilt as well: a plate face can approach a flange face only by the installed gasket thickness, so with 3 mm gaskets the displacement stays below about 3 mm. Table 4 covers only the changed spacings, not the other effects of an inclined plate.

**Plausible magnitudes.** Gasket compression alone cannot move a tapping towards the plate by more than the installed gasket thickness on that side. A displacement of several millimetres points somewhere else: a tapping drilled at the wrong distance, a missing, additional or wrong gasket or spacer, an offset between the plate holder and the plate face, or flange faces that are not parallel.

## 6. The edge of the tapping hole

ISO 5167-2:2022, 5.2.2.5 asks for a hole that is circular where it breaks through, with edges flush with the pipe wall and as sharp as possible. Rounding is permitted only to remove burrs or wire edges, kept as small as possible and, where it can be measured, with a radius under one tenth of the tapping diameter; conformity may be judged by eye (5.2.2.6). ISO/TR 12767:2023, 6.5 adds that burrs or deposits at the edge can create large errors, particularly at tapplings in the main flow stream, while upstream corner tapplings and downstream tapplings in relatively dead zones are much less liable to them.

**Every tapping already reads high.** Part of the near-wall flow turns into any wall tapping, so it reads slightly above the true wall static pressure, by  $\Delta p_{\text{error}} = \Pi \cdot \tau_w$ , with  $\Pi$  several times one and still rising with the tapping Reynolds number  $d \cdot u_\tau / \nu$  (Shaw 1960; Franklin and Wallace 1970; McKeon and Smits 2002). With  $\tau_w = (f/4) \cdot q$ ,  $f$  the Darcy friction factor and  $q = \rho U^2/2$  the pipe dynamic pressure, each unit of  $\Pi$  is 0.25 % of  $q$  at  $f \approx 0.01$ : the whole error of a square-edged tapping is of the order of one per cent of  $q$ . It is part of every standard tapping, including those behind Formula (4). Only a change caused by a different edge is a deviation — a radius changes how the flow separates at the hole, and with it the size of the error, and so do burrs.

**From the tapping to the flow.** In an orifice meter the pipe dynamic pressure is an almost fixed fraction of the differential pressure at every flowrate, because  $C$  and  $\epsilon$  vary only slightly:  $q / \Delta p = C^2 \epsilon^2 \beta^4 / (1 - \beta^4)$ . An additional error  $e$ , as a fraction of  $q$ , at the upstream tapping changes  $\Delta p$  by  $e \cdot q$  — by  $e \cdot q / \Delta p$  in relative terms — and the flow by half of that.

| $\beta$ | $q / \Delta p$ | FLOW CHANGE PER 1 % OF $Q$ AT THE<br>UPSTREAM TAPPING | TAPPING ERROR THAT MOVES THE FLOW<br>BY 0.1 % |
|---------|----------------|-------------------------------------------------------|-----------------------------------------------|
| 0.4     | 0.0095         | 0.005 %                                               | 21 % of $q$                                   |
| 0.5     | 0.024          | 0.012 %                                               | 8.2 % of $q$                                  |
| 0.6     | 0.054          | 0.027 %                                               | 3.7 % of $q$                                  |
| 0.7     | 0.115          | 0.057 %                                               | 1.7 % of $q$                                  |
| 0.75    | 0.165          | 0.083 %                                               | 1.2 % of $q$                                  |

**Table 5 — Sensitivity of the flow to an additional error at the upstream tapping.**  $C$  from Formula (4) at  $D = 300$  mm and  $Re_D = 10^6$ ,  $\epsilon = 1$ , which is the liquid case; on gas  $\epsilon < 1$  and the effect is slightly smaller.

Up to  $\beta = 0.6$  an edge defect would have to shift the upstream reading by several per cent of  $q$  — more than the whole error of a well-made tapping — to move the flow by 0.1 %. At  $\beta = 0.75$  about 1.2 % of  $q$  is enough, the same order as that error, so high- $\beta$  meters deserve the most care; the downstream tapping, in the low-velocity region behind the plate, is less sensitive.

- **Deburr at the bore** and keep any edge radius below one tenth of the tapping diameter — below 0.8 mm on an 8 mm tapping.
- **Make no deliberate chamfer**, countersink or radius beyond that; one that is found is a deviation, to be recorded and read against Table 5.
- **Keep the hole circular and cylindrical** for at least 2.5 tapping diameters from the pipe wall (5.2.2.8).
- **Inspect the edges** before use and at intervals, and remove deposits (ISO/TR 12767:2023, 6.5).

## 7. What to do with this

None of these faults shows at the zero: each shifts C, the same fraction of the flow at every rate, and only a dimensional record finds it. At design stage two questions settle most of this note: **where are the joints in the upstream meter tube, and for what gasket — type and compressed thickness — are the flange tapplings drilled?** Both answers, with the gasket-thickness window, belong on the approval drawing. In the shop or on site, six checks:

1. **Joints.** None within 2D; at each joint between 2D and 10D, the largest possible step (Section 2) under 0.3 % of D.
2. **Welds and gaskets.** Bore finished after welding, seam weld beads no higher than the permitted step, no gasket or inner ring protruding into the bore, at a joint or at the plate.
3. **Tapping positions, as drilled.** For each tapping, the distance from the flange face to the hole edge and the hole diameter, and the spacing they give with the specified installed gasket.
4. **Tapping positions, as assembled.** After final tightening, where the design gives access, measure flange face to plate face at three or more positions — preferably four, 90° apart — on both sides of the plate, fit a plane to each set and evaluate it at every tapping, at radius D/2. Measure the sides separately: flange to flange cannot see an opposite-direction displacement.
5. **Tapping holes.** Diameter under 0.13D and under 13 mm, the same on both sides; axis within 3° of perpendicular; cylindrical over 2.5 diameters or more (5.2.2.4, 5.2.2.7, 5.2.2.8); edges flush and sharp, any rounding under one tenth of the diameter (5.2.2.5, 5.2.2.6).
6. **Records.** Meter run, tapping set, side, azimuth, gasket type, installed thickness and tightening condition with each value; every tapping judged on its own — no averaging of tapplings, sides or azimuths.

A tapping outside its tolerance that cannot be put right is estimated with Section 4, recorded as a deviation with its additional uncertainty and corrected at the next opening; a step at a joint is judged against Formula (10).

### SOURCES AND STANDARDS REFERENCED

ISO 5167-1:2022 and ISO 5167-2:2022, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full* · ISO/TR 9464:2023, *Guidelines for the use of ISO 5167:2022* · ISO/TR 12767:2023, *Measurement of fluid flow by means of pressure differential devices — Guidelines on the effect of departure from the specifications and operating conditions given in ISO 5167* · ASME B16.5, *Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard* · API MPMS Chapter 14.3, Part 2 / AGA Report No. 3, *Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids — Part 2: Specification and Installation Requirements* · Shaw, R. (1960), *The influence of hole dimensions on static pressure measurements*, Journal of Fluid Mechanics 7, 550–564 · Franklin, R. E. and Wallace, J. M. (1970), *Absolute measurements of static-hole error using flush transducers*, Journal of Fluid Mechanics 42, 33–48 · McKeon, B. J. and Smits, A. J. (2002), *Static pressure correction in high Reynolds number fully developed turbulent pipe flow*, Measurement Science and Technology 13, 1608–1614 · İnkotek Enerji, White Paper 01, *The Silent Drift*, Section 3 · White Paper 04, *Proof, Not Paperwork*, Section 5 · Technical Note TN-01, *Tapping Orientation on Steam, Gas and Liquid Service*.

### ABOUT İNKOTEK ENERJİ

İnkotek Enerji is an Ankara-based engineering and manufacturing company specialising in differential-pressure flow elements and integrated metering systems: orifice plates, Venturi tubes, flow and Venturi nozzles, cone and wedge meters, averaging, grid-type and retractable Pitot assemblies, dual chamber orifice fittings, flow conditioners, meter runs, custody-transfer and fiscal metering skids, and SWAS sampling stations. Engineering is supported by CFD analysis, high-precision machining, precision welding, post-weld heat treatment, ultrasonic and radiographic examination and corrosion-protection coatings. Designs are prepared to ISO 5167, AGA Report No. 3 / API MPMS 14.3 and OIML R 140, under a management system certified to ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018. Served sectors: natural gas transmission and distribution, power generation, petrochemicals, refining and general process industry.

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Worked examples are calculated with ISO 5167-2:2022, Formula (4), as described in ISO/TR 12767:2023, 6.4.2; they are illustrative, not an assessment of the meter in hand. An estimate of the effect of a deviation does not make a non-conforming meter conform to ISO 5167-2. Clause and formula numbers are those of the editions listed; read the current edition of every standard cited. © 2026 İnkotek Enerji Sanayi ve Ticaret Ltd. Şti. · TN-07 Rev 01 · 27 September 2026