

FOR OPERATIONS & MAINTENANCE ENGINEERS

The Silent Drift

Finding lost accuracy in differential-pressure flow meters before it shows up on the balance sheet

A differential-pressure flow meter has no failure mode that announces itself. It does not alarm, it does not go to zero, and it does not drift in a way that looks like a fault. It keeps producing a smooth, plausible, entirely credible signal while the plate edge erodes, the impulse legs fill with condensate and the upstream flow profile quietly decays. The instrument is not broken. It is simply no longer telling the truth.

That is a maintenance problem disguised as an instrumentation problem, and it belongs to the people who walk the plant rather than the people who hold the calibration certificates. A transmitter calibration proves that the transmitter converts pressure to signal correctly. It proves nothing whatsoever about the primary element that generates the pressure in the first place — and the primary element is where almost all of the error lives.

WHY ONE PER CENT IS WORTH A MAINTENANCE PROGRAMME

For every 100 million Nm³ of natural gas measured per year — a mid-size industrial consumer or a modest city-gate station — a **1 % measurement bias is worth roughly €370,000 a year** at a gross calorific value of 10.55 kWh/Nm³ and a gas price of €35/MWh. A worn orifice edge alone will comfortably produce four to six times that error. Nothing else in a maintenance budget has that leverage.

1. Rank the failure modes before you chase them

Not every defect is worth the same attention. Published orifice-meter troubleshooting data puts the common faults into a clear order of magnitude, and the order is not intuitive: the mechanical condition of the meter tube around the plate matters more than the condition of the plate itself.

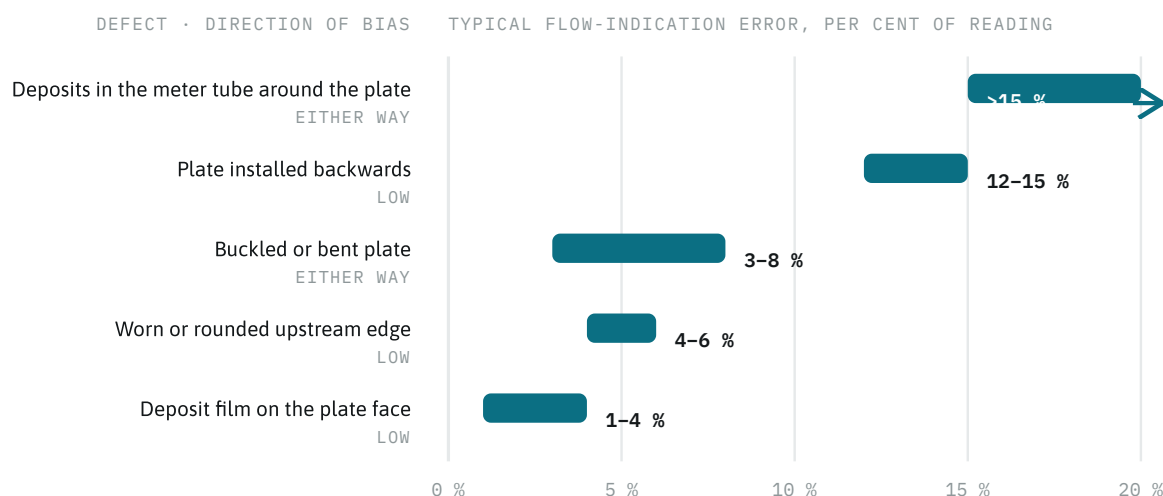


Figure 1 — Typical flow-indication error by defect type, with the direction of the bias on each row. Three of the five can only read low and two can go either way; none of them reliably reads high, which is why an unmaintained meter tends to leave the seller under-billing and the buyer under-recovering.

DEFECT	TYPICAL ERROR	DIRECTION	HOW YOU FIND IT
Deposits in the meter tube around the plate	>15 %	Either way	Borescope or plate withdrawal; a step change in Δp at a known reference flow
Plate installed backwards (bevel upstream)	12–15 %	Low	Physical inspection — the bevel must face downstream and the INLET marking upstream
Buckled or bent plate	3–8 %	Either way	Straightedge across a diameter; check the event log for over-range or slug-flow incidents
Worn or rounded upstream edge	4–6 %	Low	Edge inspection under magnification, or a measured edge radius; not visible to the naked eye
Deposit film on the plate face	1–4 %	Low	Visual on withdrawal

Table 1 — Common orifice-meter defects. Ranges compiled from published orifice-meter troubleshooting literature.

The pattern in the right-hand column matters commercially. **Three of these five faults can only make the meter read low; the other two can go either way, and none of them reliably reads high.** If you are on the selling side of the flange, that asymmetry is a standing risk of a discount you never agreed to. If you are on the buying side, it is an unrecorded liability that appears the day the meter is finally inspected.

2. What “sharp” actually means

The single most misunderstood requirement in flow measurement is the sharpness of the orifice edge. ISO 5167-2 is unambiguous: the upstream edge is sharp if its radius is **no greater than 0.0004 d**. On a 100 mm bore that is 40 micrometres. You cannot see 40 μm . You cannot feel it with a fingernail. It must be measured, or it must be guaranteed by the manufacturing process.

The other three geometric requirements are equally quantified, and equally easy to destroy in the field:

PARAMETER	REQUIREMENT	PRACTICAL CONSEQUENCE
Upstream edge radius	$\leq 0.0004 d$ (ISO 5167-2)	40 μm on a 100 mm bore. Any contact with a hard tool, a dropped plate or an abrasive cleaning disc puts the plate out of specification.
Flatness	Gap under a straightedge < $0.005 (D - d)/2$	Equivalent to a slope below 0.5 %. Over-range differential pressure and slug flow are the usual causes of failure.
Upstream face roughness	$Ra < 10^{-4} d$	Wire-brushing or grit-blasting a plate face to “clean” it will normally take it out of specification.
Bevel angle, when fitted	$45^\circ \pm 15^\circ$, land $\geq 1.6 \text{ mm}$ (API MPMS 14.3.2)	The land thickness, not the bevel, is the measuring feature.

Table 2 — Geometric tolerances that define a compliant orifice plate.

THE RULE THAT SAVES THE MOST MONEY

Any plate that has been dropped, hammered out of a flange, wire-brushed, grit-blasted, cleaned with an abrasive disc, or exposed to a differential pressure excursion is a **suspect plate**. It is cheaper to replace it than to argue about it. A replacement plate costs a fraction of one week of the error it may be producing.

3. The errors that live in the piping, not the plate

A perfect plate in imperfect piping is an imperfect meter. The discharge coefficients in ISO 5167 and AGA Report No. 3 are only valid for a fully developed, swirl-free velocity profile — and that profile is a property of the installation, not of the element.

FITTING, RELATIVE TO THE ELEMENT ($\beta = 0.5$)	ORIFICE PLATE	NOZZLE	CLASSICAL VENTURI
Single 90° bend	20 D	10 D	5 D
Two 90° bends, different planes	20 D+	15 D	10 D
Full-bore ball or gate valve, fully open	10 D	5 D	2 D
Downstream of the element	5 D	5 D	2 D

Table 3 — Indicative straight-length requirements at $\beta = 0.5$, expressed in pipe diameters. Requirements rise steeply with β : an orifice at $\beta = 0.75$ can need more than twice the upstream length it needs at $\beta = 0.5$. Always check the current edition of ISO 5167 for the exact value at your β .

Two consequences follow, and both are routinely missed on operating plants:

- **Raising β silently invalidates your installation.** When a plant re-bores a plate to recover capacity or to reduce pressure loss, the straight-length requirement grows — but the piping does not. The meter that was compliant at $\beta = 0.50$ may be out of specification at $\beta = 0.65$ without a single bolt moving.
- **A flow conditioner is an engineering decision, not an accessory.** Where straight length cannot be bought, a properly specified flow conditioner restores the profile — but its position relative to both the disturbance and the element is part of the calculation, not a detail to be settled on site.
- **The meter tube is part of the meter.** Internal diameter tolerance, surface roughness, weld beads, protruding gaskets, step changes at flange faces and plate eccentricity are all specified quantities in ISO 5167 and API MPMS 14.3. A meter tube that has been re-lined, patched or replaced with the nearest available pipe is no longer a calibrated instrument.

4. Impulse lines are the highest-yield place to look

When an experienced technician is handed an unstable or implausible flow reading, the impulse lines are the highest-yield place to look — and the cheapest to fix. The primary element and the transmitter are usually innocent.

SYMPTOM	MOST LIKELY CAUSE	CHECK
Noisy or spiking signal, no process explanation	Gas trapped in a liquid leg, or condensate in a gas leg	Vent and drain both legs at the manifold; watch whether the noise returns over hours or days
Slow response to a known flow change	Partial blockage, over-long or under-sized tubing	Compare response against the control valve stroke; keep runs short and bore adequate
Persistent zero offset with the line shut in	Unequal wet legs or a leaking manifold valve	Perform a dry zero with one block valve closed and the equalising valve open; verify both legs are the same temperature and level
Reading plausible at high flow, wrong at low flow	A small constant head error from a leg imbalance	Δp error is constant; flow error grows as flow falls, because flow varies with the square root of Δp

Table 4 — Impulse-line symptom map.

The rules themselves are short: slope every line continuously at a minimum of 1:10 in one direction only — falling back to the tapping on gas, falling to the transmitter on liquid and steam; keep both legs equal in length, temperature and elevation; take gas from the horizontal centreline or above it, and liquid and steam on the centreline, as ISO 2186 sets out, with steam through condensate pots set at the same level. Where those rules are followed, most impulse-line faults simply do not occur.

5. A thirty-minute field check

This is a check that a maintenance engineer can run at the next available opportunity, without a calibration rig and without taking the meter out of service for anything but item 7.

1. Confirm the plate data — bore, β , material, service — against the datasheet and against the plate marking. Mismatches between the as-built and the as-installed plate are more common than any mechanical defect.
2. Confirm the plate is the right way round. The bevel faces downstream; the INLET marking faces upstream.
3. Walk the upstream pipe and count diameters to the nearest fitting; compare against Table 3 at the *current* β , not the design β . Look for anything added since commissioning — a thermowell, a sample point, a temporary strainer, a replacement valve that is not full-bore.
4. Check both impulse legs for slope, equal length and equal elevation. Look for a sag, a loop, or a leg routed over an obstruction.
5. Vent and drain both legs at the manifold. Record whether the zero moves.
6. With the line shut in, verify the transmitter zero with one block valve closed and the equalizer valve open, and check the static-pressure and temperature inputs — a flow computer compensating on a failed RTD produces a perfectly stable, perfectly wrong number.
7. At the next opportunity to open the line, withdraw the plate and inspect: edge condition under magnification, flatness against a straightedge, bore diameter, face deposits, and the condition of the pipe wall immediately upstream.
8. Photograph the plate on withdrawal, both faces, with the tag visible, and log the finding against the tag rather than against the work order. Work orders are closed and forgotten; tag histories set inspection intervals.
9. Record the differential pressure at a known, repeatable reference flow. That single number, trended over years, is the best early-warning indicator available to you.

6. Setting an inspection interval you can defend

Standards specify what a compliant meter looks like; they do not tell you how often to look. A defensible interval is built from evidence, not from habit.

SERVICE	SUGGESTED FIRST INTERVAL	THEN
Clean, dry natural gas; custody transfer	12 months	Extend to 24–36 months once two consecutive inspections show no measurable edge or face change
Wet gas, glycol carryover, amine or compressor-oil carryover	6 months	Hold until the carryover source is engineered out
Erosive, abrasive or particulate-laden liquids	3–6 months	Consider a wedge meter or a nozzle, whose rounded profile resists erosion far better than a sharp edge
Any service, after a trigger event	Immediately	Triggers: differential-pressure over-range, liquid slug, chemical clean, upstream piping modification, unexplained step change in the reference Δp

Table 5 — A starting framework for condition-based inspection intervals.

The economics favour looking more often than feels comfortable: at the leverage shown on page 1, finding a 4 % error six months early pays for a decade of inspections.

7. Where the problem is actually solved: at manufacture

Everything above is downstream of one decision — the tolerance you bought. A plate made to a drawing rather than to ISO 5167 starts life at the edge of the uncertainty band and falls out of it within months. A plate whose edge radius, flatness, roughness, bore roundness and concentricity are verified and documented at manufacture gives the maintenance engineer something field practice can preserve. That is the difference between a component and an instrument, and it is what İnkotek Enerji is built around.

THREE QUESTIONS WORTH ASKING YOUR NEXT SUPPLIER

1. What edge radius do you verify to, and how do you measure it?
2. Will you supply the dimensional inspection record with the plate?
3. At my β and my piping, what straight length does ISO 5167 require, and does my meter run meet it?

SOURCES AND STANDARDS REFERENCED

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements* · ISO 5167-2, ... *Part 2: Orifice plates* · API MPMS Chapter 14.3 / AGA Report No. 3, *Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids*; Part 2 covers specification and installation requirements · ISO 2186:2007, *Fluid flow in closed conduits — Connections for pressure signal transmissions between primary and secondary elements* · OIML R 140, *Measuring systems for gaseous fuel* · Management system certification: ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018. Defect magnitudes in Table 1 and Figure 1 are compiled from published orifice-meter troubleshooting literature; they are indicative, not a correction factor. Read the current edition of every standard cited.

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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Figures are worked examples based on published standards and openly available industry data; they are illustrative and do not replace a site-specific calculation. Gas valued at a gross calorific value of 10.55 kWh/Nm³ and a price of €35/MWh. © 2026 İnkotek Enerji Sanayi ve Ticaret Ltd. Şti. · WP-01 Rev 02 · 28 September 2026