

FOR PROJECT, METERING AND PROCUREMENT ENGINEERS

Proof, Not Paperwork

What an orifice meter run genuinely has to demonstrate — and which tests the standards have already carried out for you

Metering requisitions are almost always written from the last one. That is sensible practice: it is fast, it carries forward hard-won lessons, and nothing gets forgotten. It also has one structural side effect. Adding a line to a specification costs nothing and feels prudent; removing a line is a decision somebody has to sign their name to. So requirements only ever accumulate, and after a few project cycles the document asks for everything anyone has ever asked for.

The cost of that is rarely money first. It is lead time — laboratory slots, reports, clarification rounds — and it is attention. Hours spent reproducing a test that has already been published are hours not spent on the straight lengths, the conditioner position and the plate tolerances, which is where measurement error actually comes from.

This paper is meant as a map rather than a criticism. It sets out what ISO 5167 and API MPMS 14.3 / AGA Report No. 3 actually require, which questions those standards have already settled once and for all, and how to write a clause that secures the assurance without buying the same test twice.

THE DISTINCTION THAT SETTLES MOST OF IT

A performance test qualifies a **design**. An inspection qualifies a **delivery**. The standards call the first one *type approval*, and they run it once. What a purchase order still has to secure is that the item in the crate is that type, and that it is installed where the qualification says. Re-commissioning the first adds weeks; getting the second right is where the accuracy is.

1. Two kinds of evidence, and why they blur together

	DESIGN EVIDENCE – TYPE APPROVAL	PRODUCT EVIDENCE – CONFORMITY
The question it answers	Does this geometry, correctly built and correctly placed, return the meter to the acceptance band?	Is the item being delivered that geometry, in that material, within those tolerances?
Who produces it, and how often	A flow laboratory, once for the design — then published	The manufacturer, on every unit of every order
Examples	The API MPMS 14.3.2 flow-conditioner performance test; the ISO 5167-1 compliance test; the discharge-coefficient database underlying ISO 5167 itself	Dimensional inspection report, EN 10204 material certificates, NDE and pressure test records, the as-built installation drawing
If it is missing	The published coefficients cannot be relied on; the meter must be calibrated	There is no basis for believing the delivered item matches the design

Table 1 — The two evidence types are complementary, not interchangeable.

Almost every avoidable line in a metering requisition comes from asking for the middle column to be regenerated on a purchase order. It reads like extra rigour. In practice it re-measures a constant, at the buyer's expense and on the buyer's schedule.

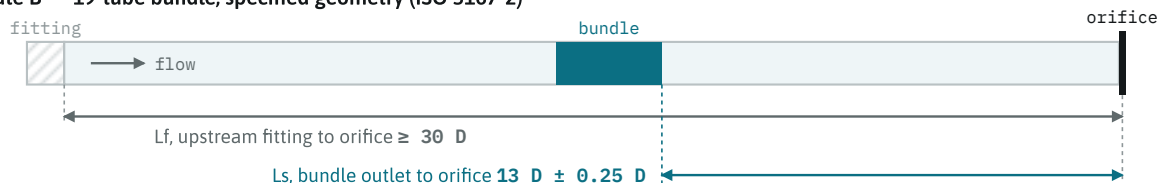
2. Flow conditioners: the standard offers three routes

AGA Report No. 3 gives the user three options, and all three are compliant. You may use no conditioner at all and buy the straight length instead; you may use a flow conditioner or conditioner whose geometry the standard specifies; or you may use a conditioner that has passed the performance test set out in the standard. ISO 5167 takes the same structure, specifying the 1998 uniform concentric 19-tube bundle and the Zanker perforated plate by geometry, and providing a compliance test for everything else.

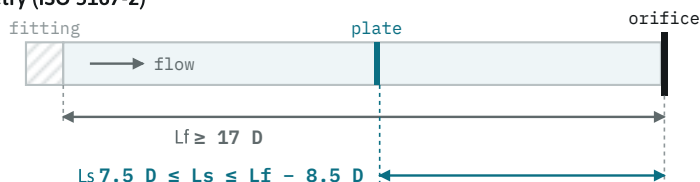
ROUTE	WHAT ALREADY PROVES IT	WHAT YOUR ORDER STILL HAS TO PROVE
A — no conditioner	The straight-length tables in the governing standard	That the piping actually delivers those lengths
B — specified geometry (19-tube bundle, Zanker perforated plate)	The standard itself: the geometry is printed in it, and these designs have already met the compliance test	Dimensional conformity to the printed geometry, and the placement window
C — type-approved design (performance-tested perforated plates)	A published performance test report for that design, to the test programme in the standard	That the supplied plate is the tested geometry, and that it sits where the qualification says

Table 2 — Three compliant routes. None of them requires a project-specific flow-loop test.

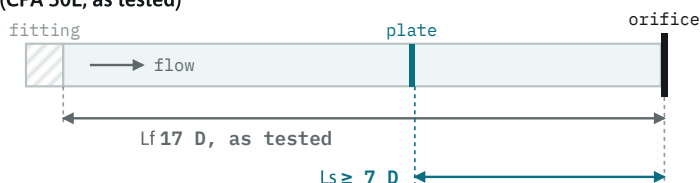
Route B — 19-tube bundle, specified geometry (ISO 5167-2)



Route B — Zanker perforated plate, specified geometry (ISO 5167-2)



Route C — performance-tested plate, type approval (CPA 50E, as tested)



Lf: upstream fitting to orifice plate · Ls: flow conditioner outlet to orifice plate · D: meter tube bore.

Drawn to scale in pipe diameters; the Zanker plate is shown at mid-window for $L_f = 17 D$.

Figure 1 — What each route fixes. In every case the qualification is already complete; what the purchase order and the piping design still have to get right is the geometry and these distances. Values are those published for these designs — other upstream fittings and β ratios have their own permitted ranges, so read the current edition for the figure that applies to your case.

WHERE THE REAL RISK SITS

On a DN 200 line, “ $13 D \pm 0.25 D$ ” is a placement window of about ± 50 mm. That is the kind of dimension that goes missing between the metering datasheet and the piping isometric — and unlike a duplicated test certificate, getting it wrong changes the reading. A requisition that spends its attention here is buying accuracy.

3. What a type approval actually contains

Route C is the one most often misread in a tender, usually because the phrase “performance test” suggests something a supplier does on your order. It is worth looking at a real one. The NOVA / CPA 50E perforated plate is a useful example because its qualification programme is published in full — the work was carried out at the GRI Metering Research Facility at Southwest Research Institute and at the NOVA Research and Technology Centre, and the authors state plainly that the tests “meet the requirements of the standard for type approval.”

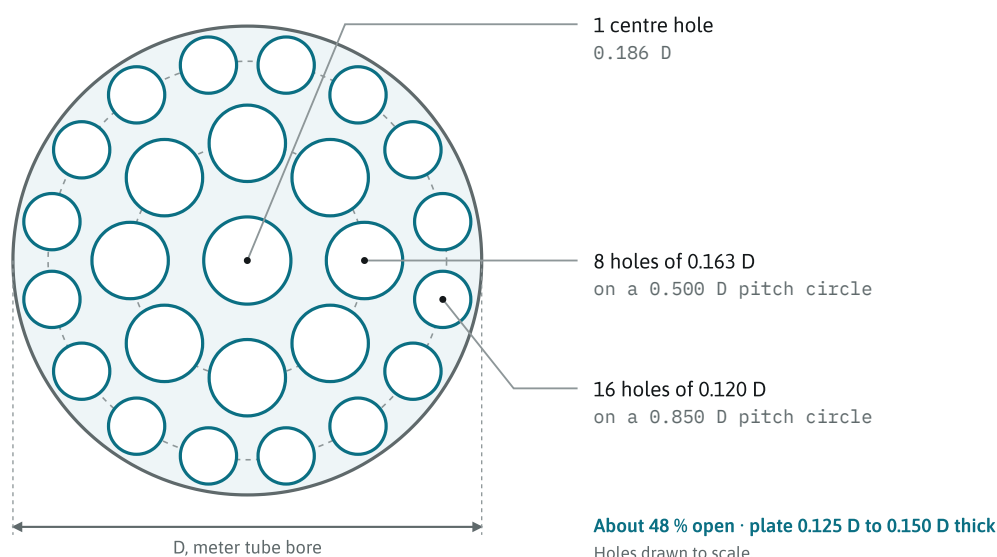


Figure 2 — The published NOVA / CPA 50E geometry: one centre hole and two concentric rings, 25 holes in a 1–8–16 pattern, all dimensions proportional to the meter tube bore D so the design scales across sizes. Patent protection on the geometry has expired and the pattern may be manufactured freely; the design names remain their owners’, so naming one in a specification still decides how many bidders can answer. İnkotek’s Laws 1-8-16 plate is made to the K-Lab NOVA geometry given in ISO 5167-2, Annex B; its ISO window is $8.5 D \leq L_s \leq L_f - 7.5 D$.

In figures: a centre hole of 0.186 D, an inner ring of eight holes of 0.163 D on a 0.500 D pitch circle, an outer ring of sixteen holes of 0.120 D on a 0.850 D pitch circle, in a plate 0.125 D to 0.150 D thick and about 48 % open.

Two things follow from Figure 2. First, every dimension is a fraction of D, which is what allows one qualification to cover a range of line sizes rather than one bore. Second, the whole of the design intent is geometric — so conformity of a delivered plate is a measurable question, answerable with a caliper and an inspection report, not with a flow loop.

The test programme behind it is demanding, and that is the point. The acceptance threshold is half the 95 % confidence band of the Reader–Harris/Gallagher equation at infinite Reynolds number — slightly more than twice the repeatability of the test facility itself, which puts it close to the limit of what the laboratory can resolve.

PUBLISHED TEST	WHAT IT ESTABLISHES	REPORTED RESULT, AT $\beta = 0.67$ UNLESS STATED
1 — Baseline	Bare meter tube, at least 70 D upstream, less than 2° of swirl — the reference the other tests are measured against	Within the uncertainty of the data set behind the flow equation
2 — Good flow	That the conditioner does not disturb a profile that is already fully developed	Within the limits from about 5 D upstream of the plate
3 — Two 90° elbows out of plane	The most common real piping arrangement	Within the limits at 7 D in a 17 D meter run; 29 D and 45 D runs gave similar results
4 — Gate valve 50 % closed	A strongly asymmetric velocity profile	Within the limits at 7 D

PUBLISHED TEST	WHAT IT ESTABLISHES	REPORTED RESULT, AT $\beta = 0.67$ UNLESS STATED
5 — High swirl	At least 24° of swirl at 17 D, from a swirl generator defined in the standard	Within the limits at 7 D
Scalability and Reynolds range	That one qualification covers more than one size and one flow rate	β from 0.31 to 0.75 in the scale-up tests; Reynolds number from 1.0×10^5 (4-inch, air) to 2.7×10^6 , with deviations of -0.08% and -0.24% at the two low-Reynolds points

Table 3 — The published NOVA / CPA 50E programme, as an illustration of what a type approval consists of. Source: Barg, Sawchuk and Sawchuk, API 14.3 Flow Conditioner Performance Test for the CPA 50E Flow Conditioner, reporting data from the GRI Metering Research Facility (MRF) and the NOVA Research and Technology Centre (NRTC).

THE ONE CAVEAT THAT DOES BELONG IN YOUR SPECIFICATION

The 5 D and 7 D figures above are properties of **the tested configuration**, not universal constants. They were obtained at a stated β , in a stated meter-run length, with a stated disturbance upstream. A specification should require the installation to follow the qualified configuration and the governing standard — which is a placement requirement, not a further test.

4. The option that looks safest is not always the one that measures best

There is a second reason this matters, and it runs against intuition. Specifying the 19-tube bundle feels like the conservative choice, because it is the geometry printed in the standard. But the testing carried out for the 2000 revision of AGA Report No. 3 showed that the tube-bundle installation lengths permitted by the earlier edition do not allow enough flow development to reproduce the long uniform pipe the flow equation was built on. Many installations built exactly to the old rules therefore do not meet the current one.

The published example is a partly closed valve upstream of a meter run: under the 1991 edition, at $\beta = 0.75$, that is 17 D overall with 7 D from the straightening-vane outlet to the plate. Re-tested at the GRI facility, that configuration drifts well beyond a -1% deviation from the baseline discharge coefficient. The correction is cheap — replacing the bundle with a type-approved conditioner restores the installation — but you only get to make it if the specification allows Route C in the first place.

THE MOST USEFUL SINGLE CHANGE TO A METERING SPECIFICATION

Write the requirement as **“a flow conditioner complying with one of the routes permitted by the governing standard”**, and state the straight lengths that are actually available. A specification that names one geometry forecloses the option that may measure better in your piping — and it does so without anyone having decided to.

5. An orifice plate is verified, not calibrated

The same confusion appears one component further downstream. ISO 5167 states its own philosophy plainly: each of these devices *“can only be used uncalibrated in accordance with this standard within specified limits of pipe size and Reynolds number, or alternatively they can be used across their calibrated range.”* The CPA 50E authors put the same idea in working language — an orifice meter can be used *“without having them proved or calibrated ... achieved by precisely defining the geometry of the meter, so that each meter reacts similarly to the flow of gas”*. The property has a name: **dynamic similarity**.

That is the whole design philosophy of ISO 5167 and AGA Report No. 3. Decades of calibration work were done once, collectively, so that a plate manufactured to the published tolerances and installed in a compliant meter run carries a known discharge coefficient and a known uncertainty without visiting a flow laboratory. And the same authors add the distinction that a specification most often misses: the **instruments** measuring pressure, differential pressure and temperature do require calibration; the primary element does not.

This is not an argument against flow calibration — it is an argument for using it where it changes what you know. Three cases where it is exactly the right answer:

- **The duty falls outside the standard's validity limits** — diameter ratio, pipe size or Reynolds number outside the published range. The tabulated coefficient does not apply, and calibration is the only route to a defended uncertainty.
- **The geometry is not a standard one** — a bespoke element, a non-standard tap arrangement, or an installation that cannot meet the straight-length requirement even with a conditioner fitted.
- **The contract requires a lower uncertainty than the standard delivers.** Then what is calibrated is the meter run as a whole, and the laboratory's Reynolds range and traceability chain become part of the specification rather than a detail.

6. What does belong in the requisition

None of the above is an argument for asking less. It is an argument for asking for the things that change what you know. Every item below does.

DOCUMENT	WHAT IT ESTABLISHES
Governing standard and edition — named singly	ISO 5167-2 or API MPMS 14.3.2 / AGA Report No. 3 Part 2. The two have different straight-length tables and tolerance sets; citing both without saying which governs moves the conflict into the bid clarification round
Process datasheet	Fluid, flow range, pressure, temperature, density, design β and full-scale differential pressure — the basis on which everything else is sized
Available straight lengths, stated as a fact	What the upstream piping can actually deliver, so a bidder can propose the right conditioning route instead of quoting around the problem
Material certificates, EN 10204 3.1	That the material is what the design assumed. Type 3.2 where the pressure code or the contract genuinely requires third-party endorsement
Dimensional inspection report against the named standard	Plate bore, upstream edge radius, flatness, face roughness, bore roundness, thickness and bevel; conditioner hole pattern and thickness; meter tube internal diameter, roundness and roughness; eccentricity; achieved straight lengths
Welding, heat-treatment, NDE and pressure test records	Integrity of the pressure boundary, to the pressure design code that applies to the assembly
General arrangement / installation drawing	Conditioner position, tap arrangement and straight lengths as built — the document that carries Figure 1 into the field
Quality management certificate (ISO 9001)	That the inspection records above are produced under a controlled system rather than on request
Legal-metrology approval	Required where the measurement is fiscal and the jurisdiction says so — named because it is legally required, not as a general quality signal

Table 4 — A complete document package for a standard orifice meter run.

7. Five requirements worth a second reading

These appear in a great many tender documents, usually because they were in the previous one. In each case the concern behind the requirement is legitimate; it is the instrument chosen to satisfy it that has drifted.

AS OFTEN WRITTEN	WHAT IT IS PROTECTING AGAINST	WORDING THAT KEEPS THE PROTECTION
Witnessed flow-loop performance test of the flow conditioner, on this order	A conditioner that does not actually correct the profile	"Supply the published approval-of-type test report for the conditioner design offered, together with dimensional inspection showing the supplied item conforms to the tested geometry, and a drawing showing it installed within the qualified configuration."
Flow calibration certificate for each orifice plate	A plate that does not measure what it should	"Confirm the device is within the validity limits of the governing standard for β , pipe size and Reynolds number, and supply the dimensional inspection report. Where the duty falls outside those limits, propose a flow calibration."
A single named conditioner geometry, with no alternative permitted	Getting an unproven device	"The conditioner shall comply with one of the routes permitted by the governing standard. Available upstream straight length is [x] D."
ISO 5167 and AGA Report No. 3 both cited as governing	Missing a requirement by naming the wrong standard	"The governing standard is [one standard, with edition]. Where the datasheet conflicts with it, the standard governs."
Legal-metrology approval on a plant utility meter	Insufficient accuracy on an important measurement	"State the required measurement uncertainty and the method of demonstrating it. Legal-metrology approval applies where the measurement is fiscal."

Table 5 — Same protection, without the duplicated evidence.

8. Two clauses you can lift straight into a specification

FLOW CONDITIONER

"The flow conditioner shall comply with one of the routes permitted by the governing standard: a geometry specified in that standard, or a design for which a published approval-of-type performance test report is available. The Supplier shall provide (a) the geometry reference or the published test report for the design offered; (b) a dimensional inspection report demonstrating conformity of the supplied item to that geometry; and (c) a general arrangement drawing showing the installed position and the distances to the upstream fitting and to the orifice plate, within the range permitted by the governing standard or by the qualified test configuration. No project-specific flow-loop test is required for a design that is already specified in the standard or already type-approved."

METER RUN ACCEPTANCE

"Acceptance of the orifice meter run shall be demonstrated by complete dimensional inspection and testing against [governing standard and edition], supported by material certificates to EN 10204 3.1, welding and heat-treatment records, non-destructive examination and pressure test records to the applicable pressure design code, and an as-built general arrangement drawing showing achieved straight lengths. Individual flow calibration of the primary element is not required where the device is applied within the validity limits of the governing standard. Calibration certificates shall be provided for the pressure, differential-pressure and temperature instrumentation."

9. What this is really about

The purpose of a requisition is not to assemble documents. It is to make reasonably sure that the thing installed in the pipe will measure correctly for the next twenty years. Judged against that purpose the package divides cleanly. A dimensional inspection report tells you something you could not otherwise know. A repeat of a published type approval tells you something that was already known, in a folder, before the enquiry was issued.

It is worth saying plainly that none of this is anybody's error. Specifications grow because the engineers writing them are protecting a measurement they will have to live with, usually without a clear map of what the standards have already settled. The remedy is not less diligence. It is putting the same diligence where it changes the answer: on the straight lengths, on the placement window, on the plate and conditioner tolerances, and on the records that prove them.

AN OPEN OFFER

If you are preparing a metering enquiry, we are glad to read the draft technical requirements and mark up which items the governing standard already covers, which are genuinely required, and which will cost lead time without adding assurance. There is no charge and no obligation to buy anything — a clearly written enquiry produces better bids from everyone who answers it.

SOURCES AND STANDARDS REFERENCED

ISO 5167-1 and ISO 5167-2, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full* · API MPMS Chapter 14.3, Part 2 / AGA Report No. 3, Part 2, *Orifice Metering of Natural Gas — Specifications and Installation Requirements* (1991 and 2000 editions) · P. Barg, B. Sawchuk and D. Sawchuk, *API 14.3 Flow Conditioner Performance Test for the CPA 50E Flow Conditioner*, Canada Pipeline Accessories, reporting GRI/SwRI Metering Research Facility and NOVA Research and Technology Centre data · U. Karnik, *A Compact Orifice Meter/Flow Conditioner Package* (1995) and Karnik & Kowch, *Scale Up Tests for the NOVA Flow Conditioner* (1999) · T. Morrow, *GRI/SwRI, Development of a Flow Conditioner Performance Test* (1997) · EN 10204, *Types of inspection documents*.

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. Published test figures are quoted from the sources listed above and apply to the configurations tested there. Clause wording is a drafting aid, not legal or contractual advice; adapt it to the governing standard, edition and jurisdiction of your project. © 2026 İnkotek Enerji Sanayi ve Ticaret Ltd. Şti. · WP-04 Rev 02 · 3 October 2026