

Research Report

Precision and Process Viability, Certification and Testing of the deltaflow Dynamic Pressure Probe under TA-Air, § 13 and 17 of the BImSchV / TRD / VdTÜV



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Advantages of the deltaflow Compared to Sampling Apertures

Precision and Process Viability of the deltaflow Dynamic Pressure Probe

Approximately 30% of all flow measurements in plant installations are based on the principle of differential pressure. In spite of the high level of pressure loss and the energy waste associated with it, as well as the installation difficulties in comparison to dynamic pressure probes, most measurements in this area are still made using orifices.

Constant pressure lost by dynamic pressure probes is significantly less than that lost by apertures; nevertheless, these differential pressure monitors are still rather rare in current installations. Rising energy costs, increasingly stringent environmental codes, and the steadily increasing pressure of competition all force modern industry into a process of continually increasing operational efficiency. Today, new coal-fueled power stations reach an efficiency rate of up to 46%; many gas-fueled power plants report an efficiency rate of over 58%. Flow sensor technology often lags behind this development.

In the past, poor levels of precision and insufficient process viability have generally limited the application of dynamic pressure probes to “non-critical” metering sites which required less exact measurement. Insufficient documentation and the lack of reliable calibration data and up-to-date project management aids made it even more impractical to successfully install dynamic pressure probes.

Since its founding, systec Controls GmbH of Puchheim (Germany) has invested an enormous amount of resources in the effort to address these difficulties. They have performed their own research, and they have enlisted independent third parties in the effort. Naturally, this effort includes developing solid and well-established technical material, user-friendly documentation, and state-of-the-art project management aids.

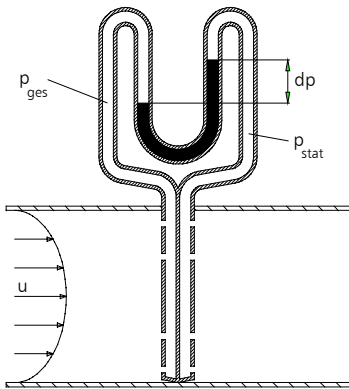
2

Measurement Principles of the deltaflow Dynamic Pressure Probe

The deltaflow series of dynamic pressure probes represents the result of all of this work. The deltaflow's high level of precision and excellent process viability—even in extreme conditions—proves that it is superior to orifices.

Similar to the Prandtl measurement tube, the deltaflow measures flow according to the differential pressure principle. In the dual chamber profile, differential pressure tapings in the flow direction and counter the flow direction result in a differential pressure between the two measurement chambers, which provides a measurement for the flow rate of the medium. Unlike the Prandtl measurement tube, the median of the flow profile is not achieved by adjusting the measurement head and the resulting average calculation. It is achieved by the advantageous positioning of multiple differential pressure tapings across the cross-section of the pipe. The following formula calculates the resulting differential pressure:

$$dp = \zeta \rho \frac{\bar{u}^2}{2}$$



ζ is the probe-specific resistance coefficient which is normally determined experimentally. ρ is the density of the medium, dp is the differential pressure, and \bar{u} represents the median flow rate. The influence of the process conditions $\zeta = f(\text{Re})$ on this resistance coefficient describes the error of the dynamic pressure probe. In this formula, Re represents the dimensionless code "Reynolds," which describes the flow ratios within the conduit. The following is valid:

$$\text{Re} = \frac{D\bar{u}}{\nu}$$

D is the interior diameter of the conduit, \bar{u} is the median medium flow rate, and ν represents the kinematic viscosity.

The ideal dynamic pressure probe would have a constant resistance coefficient; in the real world probes vary from a median value. Since this variance is difficult to describe mathematically, and since the resistance coefficient is generally applied as a constant, the variance is included as an error in the flow calculation.

This error is often indicated with “industry-standard flat rates.” All too often, the source of the calibration and error data and information about which control flow measurement devices were used and which interior diameters were investigated is kept hush-hush. Likewise, little or no information is forthcoming as to which independent third parties have performed tests or experiments.

The error in the resistance coefficient simply describes that portion of the total error of the sampling length which can be assigned to the dynamic pressure probe. General statements about the total error of a measurement cannot be made here. Asymmetries in the flow profile of the pipe or conduit as well as errors caused by the differential pressure transmitter and the evaluating electronics play the largest role in this issue. Observations and comments must be made individually to specific situations as required.

3

Precision in Development of the deltaflow Flow Profile

As with apertures, it is difficult to make a statement about the total precision of a differential pressure flow measurement. Reliable statements can only be made concerning individual differential pressure monitors. In the field, the total accuracy is dependent upon the individual flow profile, the sampling ratio, and the extended sampling length. However, the dynamic pressure probe error becomes very important, since the exponential sampling rate of this error has a highly significant effect on the total accuracy in large sampling ratios.

The precision of the dynamic pressure probe is defined by the resistance coefficient ζ . The variation of this value from the median value established by experimentation based on a various usage conditions allows us to make a definitive statement about the quality of the dynamic pressure probe.

Flow Rate Influence on the Resistance Coefficient

The break-off point of the flow when it encounters obstacles changes according to the flow conditions within the conduit. The dimensionless identifier Re (Reynolds) represents the most commonly-used parameter for these flow alterations within the conduit, which is calculated as follows:

$$\text{Re} = \frac{D\bar{u}}{\nu}$$

D represents the internal diameter of the conduit, \bar{u} the median medium flow rate, and ν the kinematic viscosity.

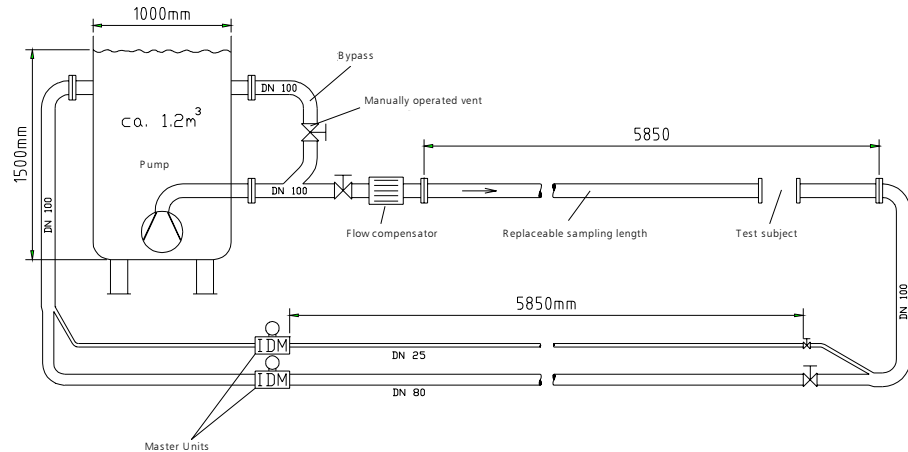
Our experiments with rounded profiles have shown that the influence of the break-off on the measured differential pressure is directly related to the spatial expansion of the differential pressure tapings.

The influence of the size of the differential pressure tapings was established by systec Controls through a series of costly and time-consuming tests, the results of which are documented below.

4

The Flow Profile is Calibrated using Extensive Tests

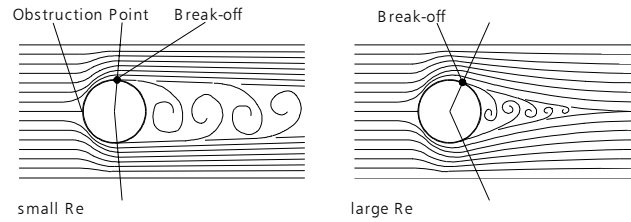
An ID 105 mm probe consisting of a round profile, outer diameter 22 mm, was selected as the test subject. Four differential pressure tapings were drilled into each side of the probe, viz. the flow side as well as the counter-directional flow side. These orifices ranged from 2 mm to 8 mm in diameter.



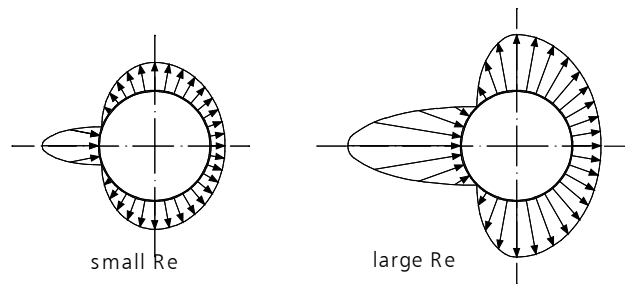
The systec Controls water calibration system was used as the test platform. A finely calibrated magnetic-inductive flow meter with a measurement precision of 0.1% (as claimed by its manufacturer) was used as the control. The differential pressure was measured with a SYS4420 differential pressure transmitter with 60 mbar test cell, which has been proven to have a precision of 0.1% of the range transmission value and a baseline variance of 0.05% of the range transmission value.

Measurement Results

The literature makes it clear that the break-off point drifts with the flow rate in round profiles (see illustration below). Even at the very point of obstruction, the maximum possible total pressure is calculated as $\rho_{ges} = \rho_{stat} + \rho_{dyn}$, in spite of the drift, since the medium rate at this point is reduced to 0. To the left and the right of the obstruction point, however, the flow profile is altered based on the drift of the break-off.



Break-off in round profile surrounded by flow



Distribution of dynamic pressure on round profile surrounded by flow

Because differential pressure tapings exhibit a spatial expansion, the drift of the break-off point will exert an influence on the resistance coefficient.

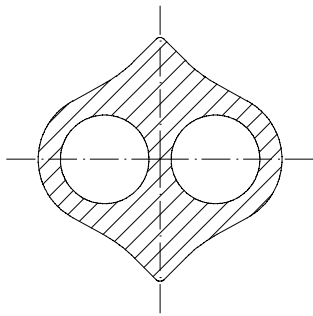
As the graphic illustrates, the effect the drift break-off point has on the resistance coefficient increases for larger differential pressure tapings. The altered flow profile which occurs with larger differential pressure tapings is particularly noticeable within the lower Reynolds area

□

It appears, then, that small differential pressure tapings are desirable. From the standpoint of process viability, however, small differential pressure tapings present difficulties. Based on this awareness, it appeared to be necessary to optimize the flow profile in such a way that the influence of the flow rate upon the resistance coefficient remains minimal, in spite of the spatial expansion of the differential pressure tapings. In the development of this profile, particular attention was paid to the following:

Text oben: Effect on Precision caused by Differential Pressure Orifices on a Round Probe

Text links: Deviation of Resistance Coefficient Value from Median Value [%]



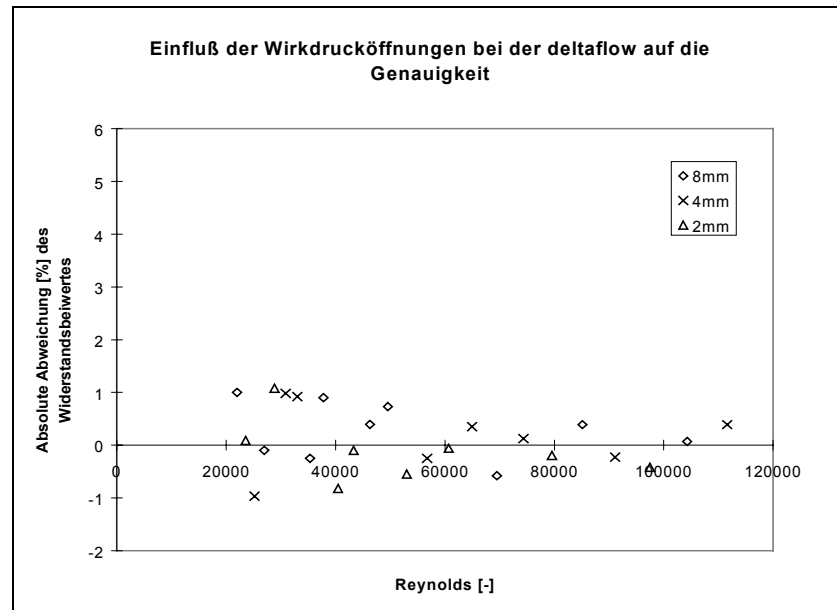
Functionally optimized flow profile of the deltaflow DF25

- Wide frontal radius, to allow the most linear dispersion of energy across the width of the differential pressure tapings as possible.
- Side acceleration fins, to sweep the medium to the edges of the probe in instances of low flow rates.
- The result is that a defined flow break-off is guaranteed at the sharp edges.

The illustration above depicts the optimized profile of the deltaflow dynamic pressure probe.

The experiment described above was initiated again, this time using the new profile. This time no difference could be detected between the measurement accuracy of differential pressure tapings measuring 2 mm and those measuring 8 mm.

Text oben: Effect on Precision caused by Differential Pressure Orifices on a Round Probe
Text links: Deviation of Resistance Coefficient Value from Median Value [%]



The above illustration depicts the measurement results on the water test platform.

While the results of this experiment did still exhibit a minimal influence on the resistance coefficient in the lower measurement area, there is no longer any difference between differential pressure tapings which measure 2, 4, and 8 mm.

It is likely that the increased effect within the lower Reynolds area can be traced back to the fact that the differential pressure transmitter error increases significantly in instances of small differential pressures, and this causes the scatter of the measurement error to become larger.

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The Technical University of Erlangen Verifies the deltaflow's Accuracy

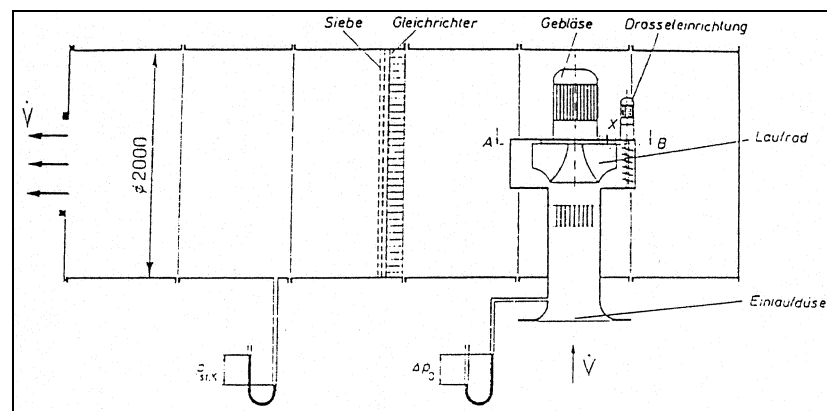
Quote from the Research Report produced by the University of Erlangen:

“Based on the calibration results, it can be definitively stated that the deltaflow flow probe causes smaller losses of pressure and energy within conduits, and allows more exact measurements to be made than the orifices which have previously been commonly used in conduits.”

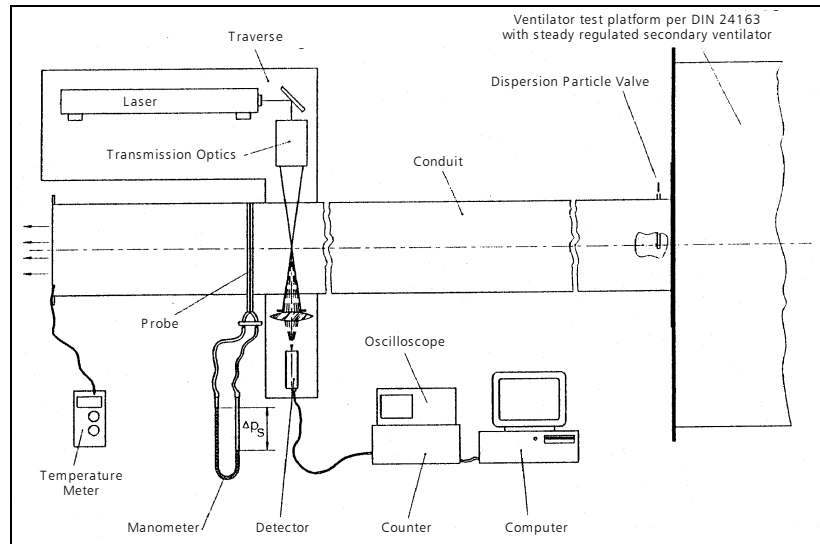
In order to acquire exact calibration data across a wide sampling region and for large values, and in order to verify independent measurement results, systec Controls GmbH has authorized the Department of Flow Mechanics at the University of Erlangen to conduct the investigation of the deltaflow dynamic pressure probes. This department is equipped with a ventilator chamber testing platform compliant with DIN24163. This platform is enhanced by control flow measurement devices which facilitate a significantly higher level of accuracy and resolution than is available through current standard industrial metering technology.

Investigations were conducted on probes with DN100, DN200, DN300, and DN500. The finely calibrated induction nozzle of the ventilator chamber test platform was used as the control for the DN100 and DN200 probes, in conjunction with a Betz manometer; a Laser Doppler Anemometer (LDA) was added for the local resolution of the flow rate in testing the deltaflow DN300 and DN500.

The following illustrations depict the ventilator test platform and the sampling length which was developed for the deltaflow dynamic pressure probes.

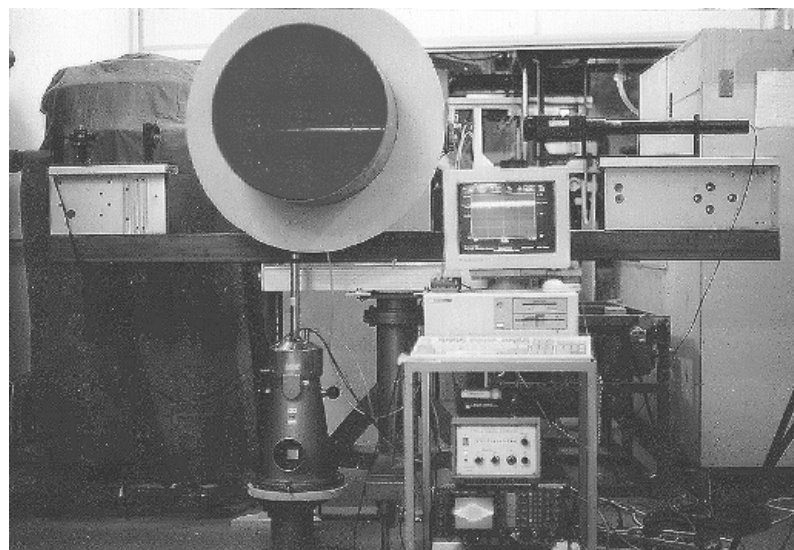


Ventilator Chamber Test Platform per DIN24163



The differential pressure on the deltaflow flow probes was also recorded via the Betz manometer, in order to exclude errors occurring through the differential pressure transmitter.

The tests were conducted under environmental conditions with a flow rate of between 3 and 30 m/s for all four probes. The flow profile previous to the probe was resolved over 40 to 60 metering points using Laser Doppler Anemometry so that it would be possible to make precise definitive statements about the median flow rate inside the pipe.



The straight inlet for the DN100 probe equaled 47xID, 30xID for the DN200, 24xID for the DN300, and 18xID for the DN500.

Impact of Humidity on Precision

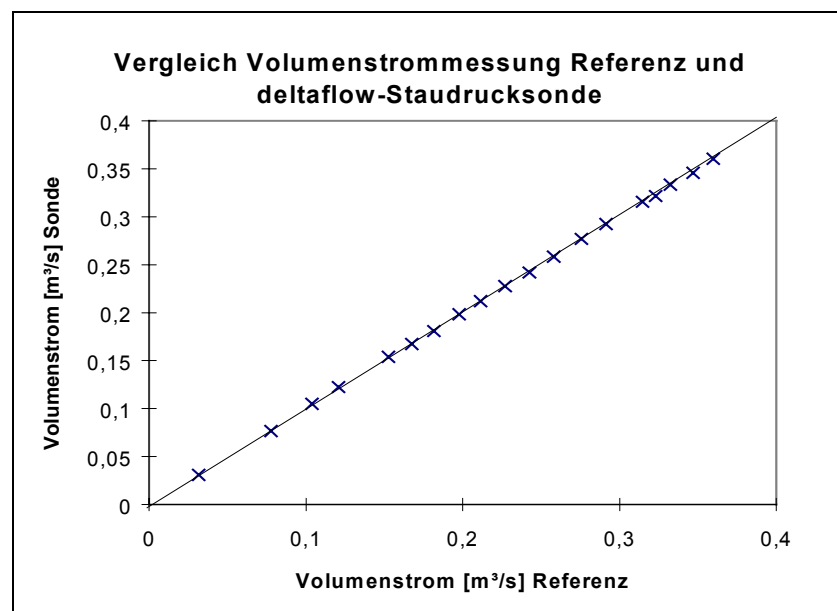
The average ambient humidity in the wind chamber test platform measured at 50% rh and, at the prevalent measurement temperatures, caused a density variation of approximately $2\text{g}/\text{Nm}^3$. Since the only effect on accuracy occurred in the lowest 1/1000th, it was not necessary to include the ambient humidity in the consideration of accuracy.

Test Results for the deltaflow DN100

The results of the test on the DN100 probe were the most widely scattered. This is probably explained by the fact that the inlet nozzle delivers only very slight differential pressures in that relatively small volume flow, and that rotation speed fluctuations at the ventilator have a greater impact at the lower levels than in the higher levels of rotation speeds. While the metered values are clearly scattered about a median value which is very well suited for calibration, the accuracy data in the lower measurement area is to be considered as somewhat less reliable than the data received from probes with larger diameters.

The exact internal diameter of the sampling length equaled 105 mm. The environmental pressure was a constant 977.9 mbar; during the testing the temperature rose from 18.3°C to 26.8°C .

Text oben: Comparison of Volume Flow Control and deltaflow Dynamic Pressure Probe
Text links: Volume Flow [m³/s] Probe
Text unten: Volume Flow [m³/s] Control



Text oben: Deviation of a DN100 deltaflow from the Control

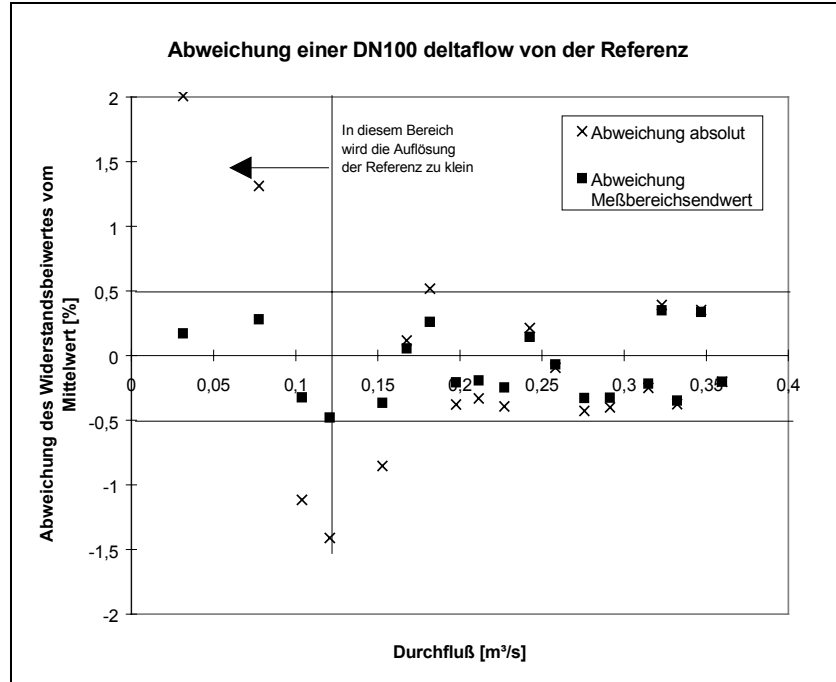
Text links: Deviation of the resistance coefficient from the median value (%)

Text unten: Flow-through [m³/s]

Text innen: Resolution of the control is too small in this area

Text Erklärung: Absolute deviation

Sampling area final value deviation



The illustration shows that the deviation relative to the sample area final value was always less than 0.5%. The absolute deviation is somewhat higher at the smaller flow rates, but in these instances the differential pressure of the valve was so small that a definitive resolution was no longer possible

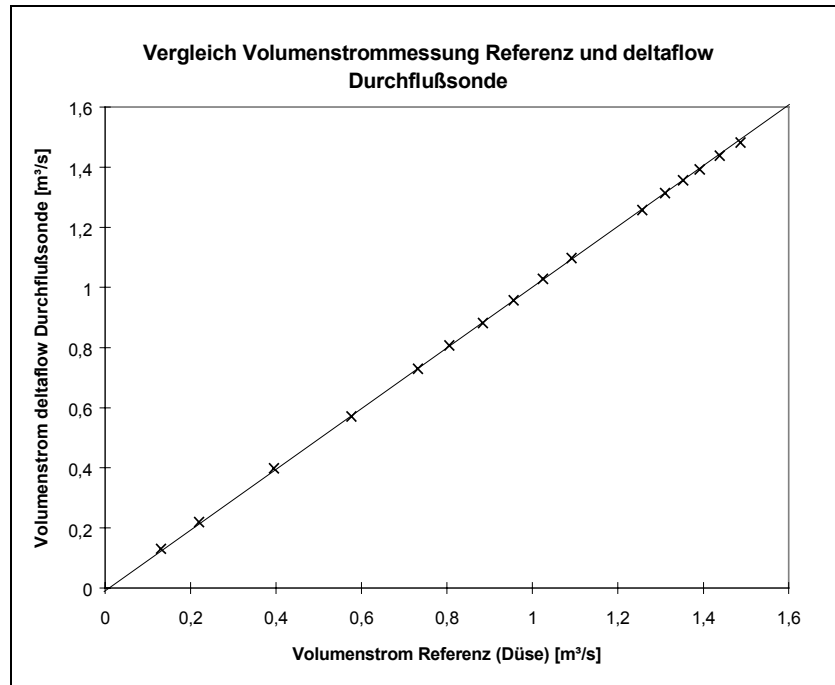
At 0.13 m³/s, the differential pressure at the valve was only equal to 19 mmWS. Here the probe delivered 45 mmWS, and thus can claim to have a stronger resolution than the valve. In the area in which the control guarantees a corresponding resolution, the absolute deviation was always better than 1%. The median value of the resistance coefficient proved to be 3.0142.

Test Results for the deltaflow DN200

In the calibration of the deltaflow dynamic pressure probe DN200, clearly reproducible and significant results were achieved. In this case, the ventilator works in an advantageous area of operation; the valve delivers high differential pressures.

The exact inner diameter of the sampling length equals 210 mm. During the test the air temperature climbed from 16.8° C to 22.2° C, and the barometric readings remained at a constant 999.3 mbar.

Text oben: Comparison of Volume Flow Control and deltaflow Dynamic Pressure Probe

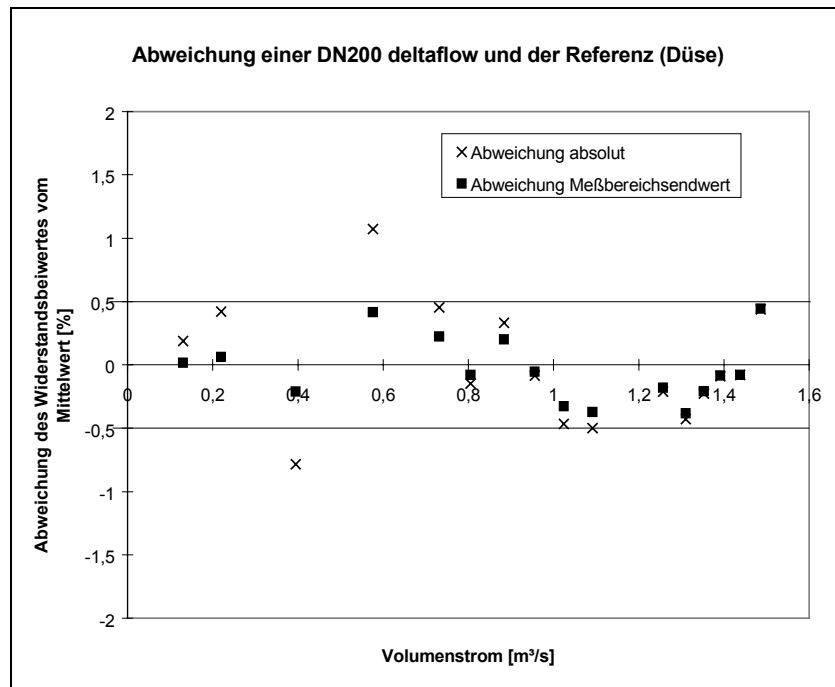


Text oben: Deviation of a DN200 deltaflow and the Control (Valve)

Text links: Deviation of the resistance coefficient from the median value (%)

Text unten: Volume flow [m³/s]

Text Erklärung: Absolute deviation
Sampling area final value deviation



Both the deviation relative to the range final value and the absolute deviation were almost always <0.5% in a range of between 0.13 and 1.488 m³/s (=3.78 to 42.9 m/s) when the 210 mm long probe was used. Occasionally, the absolute deviation on two sampling points was over 0.5%.

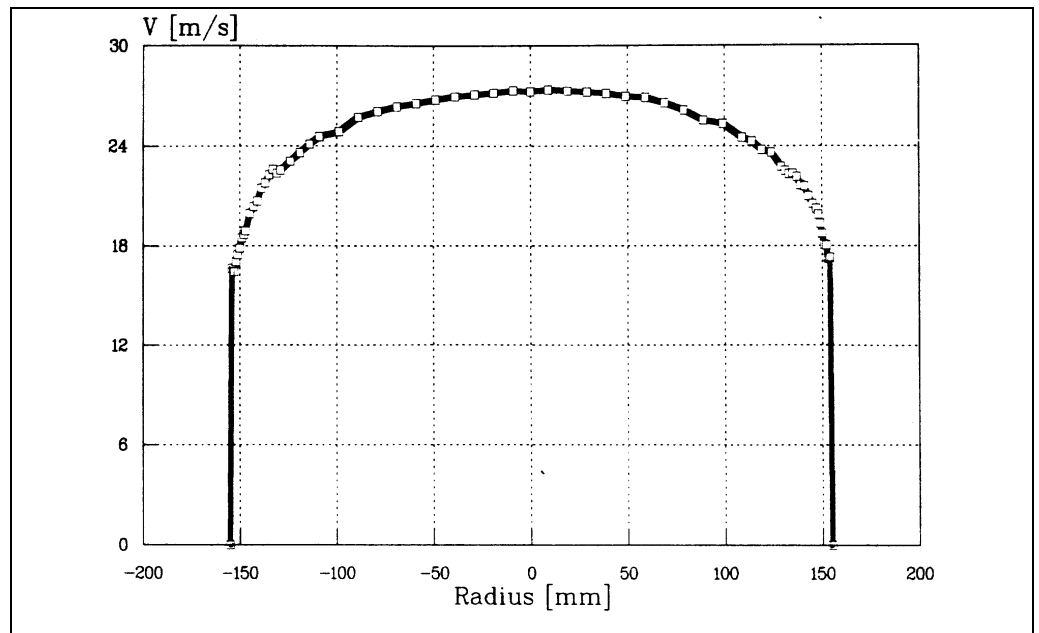
In this experiment, the median value of the resistance coefficient was located at 2.685.

Test Results for the deltaflow DN300

In the calibration of the DN300 probe, the Laser Doppler Anemometer was used in addition to the valve for the purpose of precise local investigating of the rate profile previous to the probe. Approximately 40-60 points of the flow profile were calculated. The results were then once again compared to the values from the valve, in order to re-verify the values achieved in the previous tests.

The high resolution of the flow profile lets us assume that there is an unusually high level of accuracy in the control. The ascertained values have a correspondingly high level of significance.

The following illustration depicts a profile previous to the probe, which was established by means of the LDA.

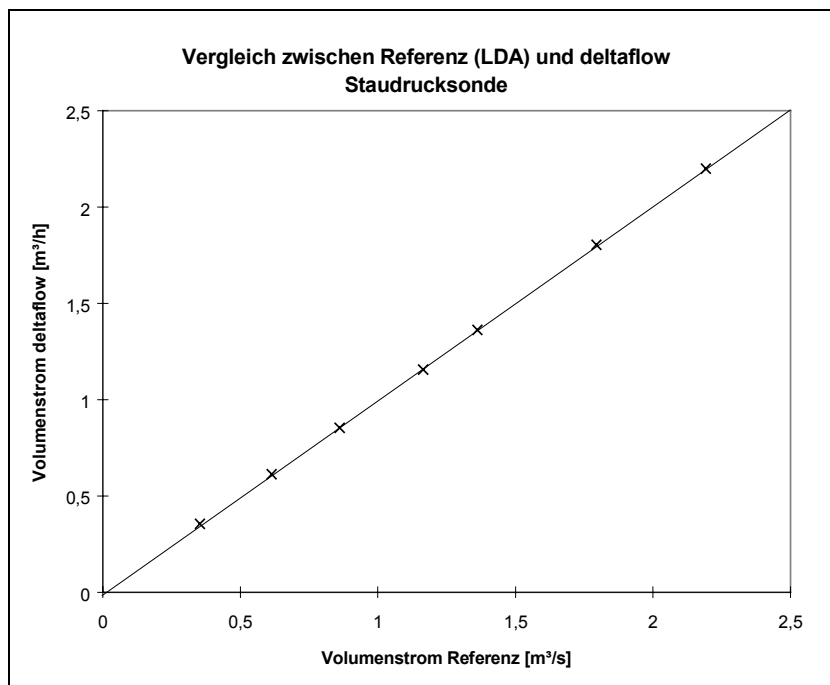


The exact inner diameter equaled 309.8 mm, the temperature varied between 24.5 °C and 29 °C during this test, and the barometric reading varied between 979 and 982 mbar.

Text oben: Comparison between Control (LDA) and deltaflow Dynamic Pressure Probe

Text links: Volume Flow deltaflow [m³/s]

Text unten: Volume Flow Control [m³/s]

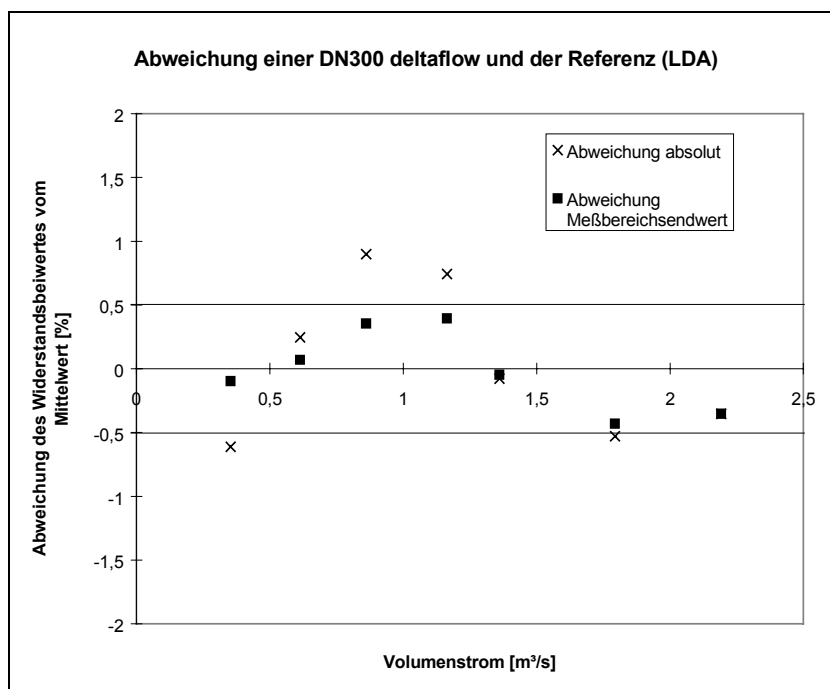


Text oben: Deviation of a DN300 deltaflow and the Control (LDA)

Text links: Deviation of the resistance coefficient from the median value (%)

Text unten: Volume flow [m³/s]

Text Erklärung: Absolute deviation
Sampling area final value deviation

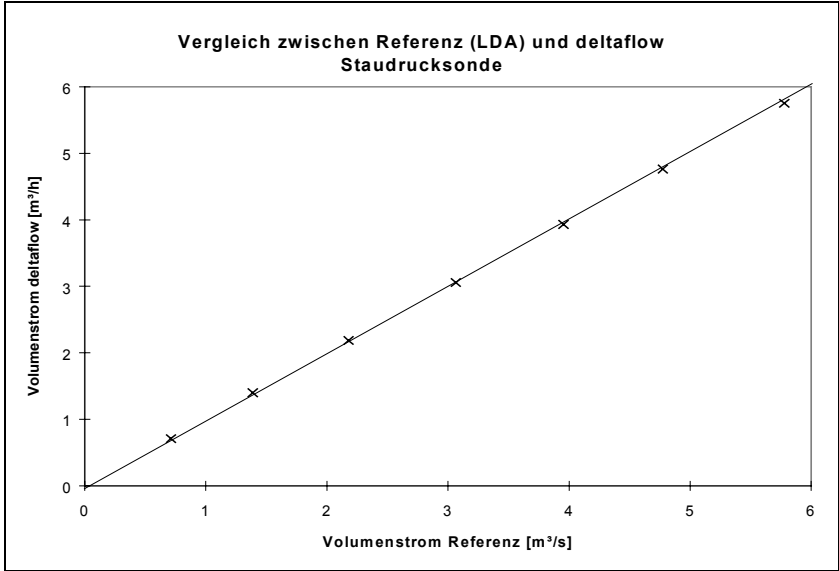


The relative error of the DN300 deltaflow probe is also always better than 0.5%, the absolute error is always smaller than 1%. The median resistance coefficient for this probe was determined to be 2.4395.

Test Results for the deltaflow DN500

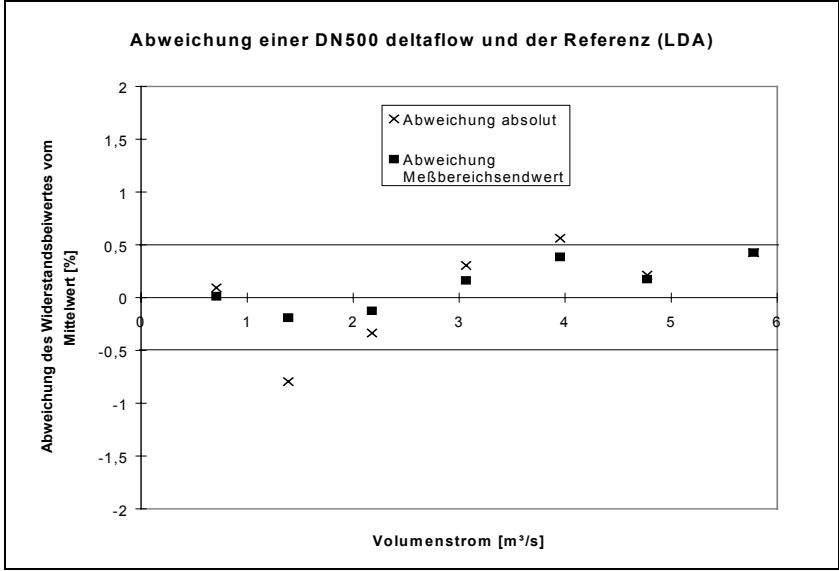
As in the tests on the DN300 probe, the LDA as well as the valve were used in the tests on the DN500. The exact inner diameter equaled 492 mm; the temperature varied between 22.2° C and 29° C during this test, and the barometric pressure fluctuated between 987 and 939 mbar.

Text oben: Comparison between Control (LDA) and deltaflow Dynamic Pressure Probe
Text links: Volume Flow deltaflow [m³/s]
Text unten: Volume Flow Control [m³/s]



This test also exhibited an excellent correlation between Laser Doppler Anemometer and the deltaflow dynamic pressure probe.

Text oben: Deviation of a DN500 deltaflow and the Control (LDA)
Text links: Deviation of the resistance coefficient from the median value (%)
Text unten: Volume flow [m³/s]
Text Erklärung: Absolute deviation
 Sampling area final value deviation



The deviation from the range final value was always <0.5%, the absolute deviation was always <0.8%.

The resistance coefficient of the probe was determined to be 2.4096.

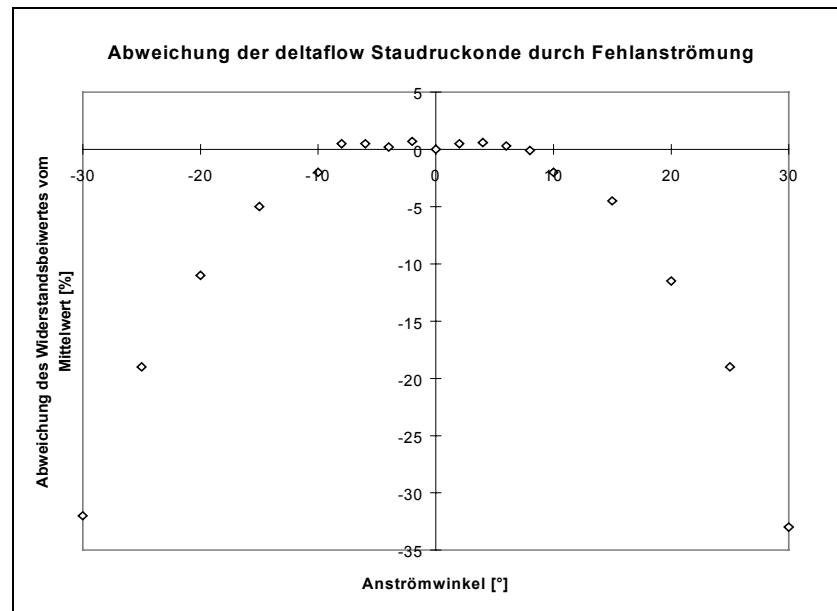
Incorrect Installation has Minimal Effect

In addition to the level of accuracy determined in the laboratory, the user will be chiefly interested in the impact of an incorrect installation. In the field, it is not always possible to insure that probes will be installed perfectly, as they are in a laboratory. A statement concerning allowable installation tolerances is an important element of ease of use. In order to document the impact of an incorrect installation, the deltaflow was installed backwards in a test canal at LSTM; the effect on the measured differential pressure and on the resistance coefficient calculated from it was documented. The following illustration depicts the test results.

Text oben: Deviation of the deltaflow Dynamic Pressure Probe Under Incorrect Flow

Text links: Deviation of the resistance coefficient from the median value (%)

Text unten: Angle of Flow Approach ($^{\circ}$) value deviation



The impact of a misaligned installation remains significantly lower than 1% at angles of $<10^{\circ}$. This means that relatively little attention must be paid to the installation.

6

Summary of Measurement Results for the deltaflow DF25

The illustration below depicts the resistance coefficients established by experimentation, including the possible deviations in the control measurement. The results have shown that the resistance coefficient can be relied upon as a constant with a high degree of accuracy at internal diameters of 350 mm and above.

The following illustration depicts the measured values and the curve of a semi-empirical approximation formula useful for determining resistance coefficients.

Text oben: Resistance Coefficients DF25

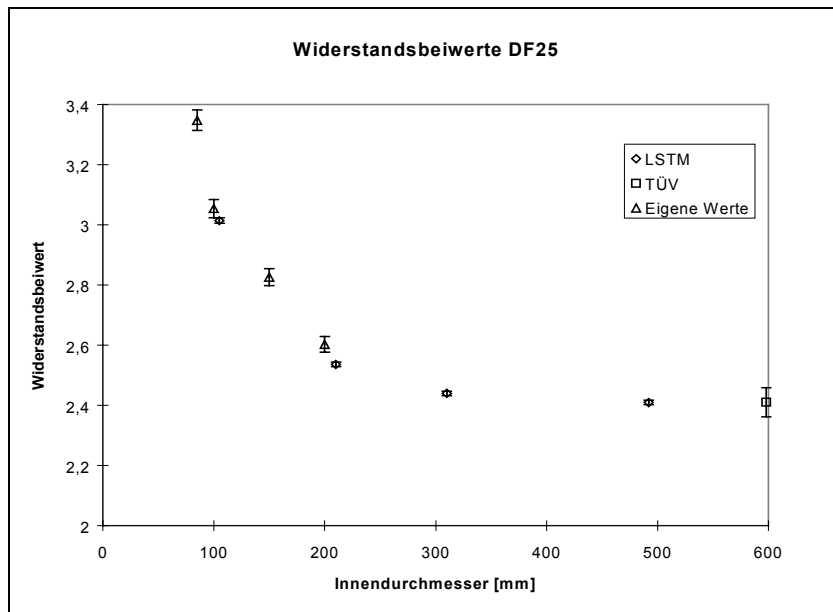
Text links: Resistance Coefficient

Text unten: Internal diameter (mm)

Text Erklärung: LSTM

TÜV

Proprietary Values



Text oben: deltaflow Resistance Coefficients

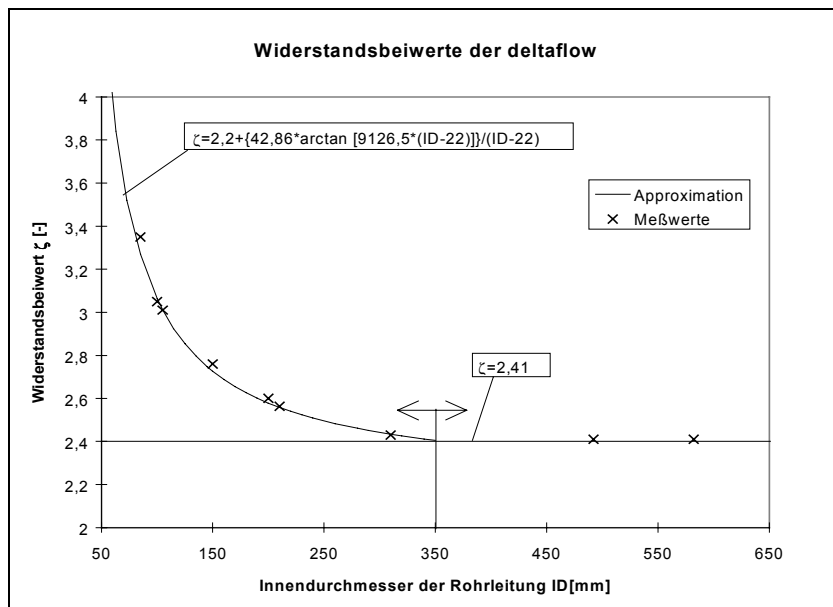
Text links: Resistance Coefficient ζ [-]

Text unten: Conduit ITD Internal diameter (mm)

Text Erklärung:

Approximation

Measured Values



The following approximation formula can be used to determine values for internal diameters <350 mm:

$$\zeta = 2,20 + \frac{42,86 \arctan(9126,5(ID - 22))}{ID - 22}$$

[80mm < ID < 350mm]

In this formula, ID represents the internal diameter of the conduit in mm. The following formula can be applied for internal diameters ID > 350 mm:

$$\zeta = 2,41 \quad [ID \geq 350\text{mm}]$$

7

Perfection in Details: Structural Characteristics of the deltaflow

It is rare that media are available that are completely pure in technical processes. Particles of solid matter, condensation phenomena and the deposits resulting from them are the rule. Most dynamic pressure probes exhibit failings in this area: their viability for application is reduced or their maintenance requirements are extensive.

The deltaflow is structurally different in a few points which are essential for process viability.

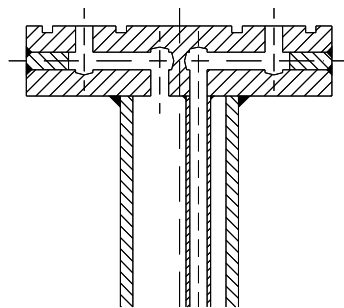
✓ Large Differential Pressure Orifices

Differential pressure tapings which are too small have a negative impact on process viability in two ways. When used in media which are laden with particles of solid matter, one or more orifices can become plugged up, thereby making it impossible to achieve an exact measurement. When used in condensing media, individual differential pressure tapings can become blocked by drops of condensation. The effects resulting from these blockages are difficult to describe, and errors resulting from them generally remain unnoticed.

The deltaflow has differential pressure tapings which are 8 mm large. These remain unclogged at normal levels of particulate matter. Droplets are smaller in diameter and thus cannot block the differential pressure tapings.

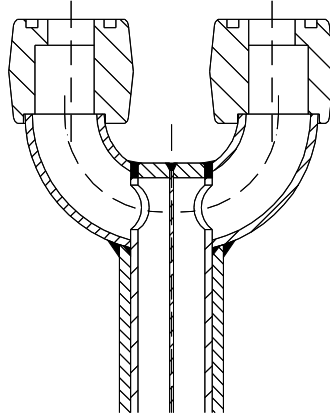
✓ Capillary-free Construction

Using capillaries as differential pressure channels can cause problems when measuring gas-laden liquids or condensing or liquid-laden gasses. A bubble of water and/or gas lodges itself within the capillaries, and the resulting effect on the capillary adulterates the differential pressure at the transmitter.



Traditional connection geometry within well-known dynamic pressure probes, containing differential pressure capillaries and angled channels within the mounting block (theoretical diagram).

This effect makes measurement practically impossible, especially in the metering of gasses, because in this application the differential pressures measure only a few mbar.



Improved connection geometry with flow-through dual chamber profile, 1/2" conduit arc, and oval adapters for connection to transmitter.

The deltaflow construction is entirely free of capillaries. For measuring condensing media, the probe is installed with a steady gradient toward the point of the probe. This allows any accumulated condensation to drain away freely. To measure gas-laden liquids, the probe is mounted from below. Thanks to its large differential pressure channels, the forced ventilation functions with no problem whatsoever.

- ✓ **No Angled Channels Drilled into the Connection Head (Mounting Block)**

8

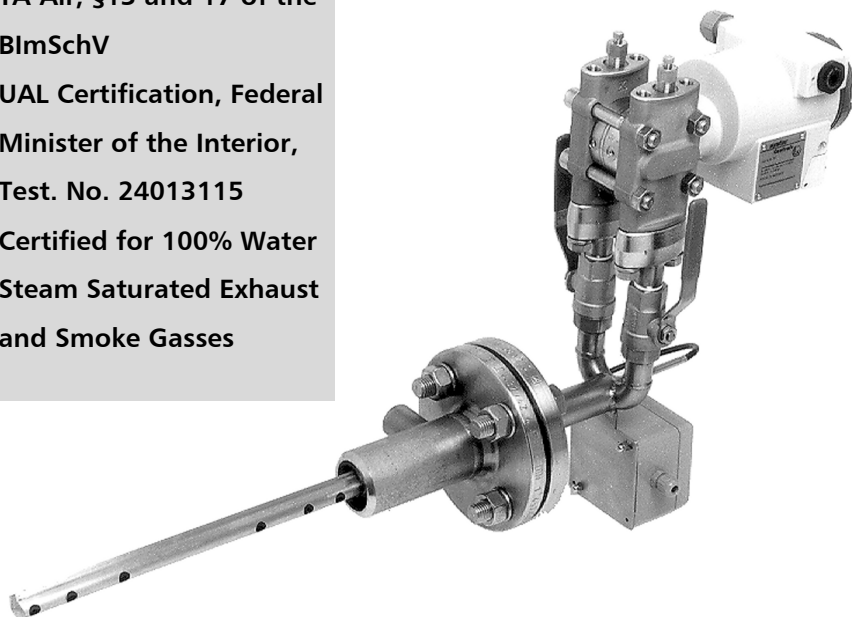
Successful Certification under TA-Air, Sections 13 and 17 of the BImSchV, Subject to Testing by the Environmental Testing Agency of Bavaria/Saxony

Angled channels within the mounting head make excellent crystallization sites. When measuring media where salt content and or crystallization must be expected (for example, steam), these points have proven in the past to be particularly vulnerable. In steam applications, dynamic pressure probes often broke down and were occasionally irreparably clogged.

The deltaflow is produced without any angled channels, and directs the differential pressure channels as 1/2" conduit arcs leading from the probe. For steam applications, the differential pressure pathways are continued an additional 1/2" to the condensation blocks. Steam barriers of 1/2" are used as a primary barrier.

In order to prove the process viability of the deltaflow, systec Controls GmbH requested the Bavarian TÜV (an environmental protection agency) to perform extensive field and laboratory testing. Models DF25 and DF50 were used during these tests.

- **Certification under TA-Air, §13 and 17 of the BImSchV**
- **UAL Certification, Federal Minister of the Interior, Test. No. 24013115**
- **Certified for 100% Water Steam Saturated Exhaust and Smoke Gasses**



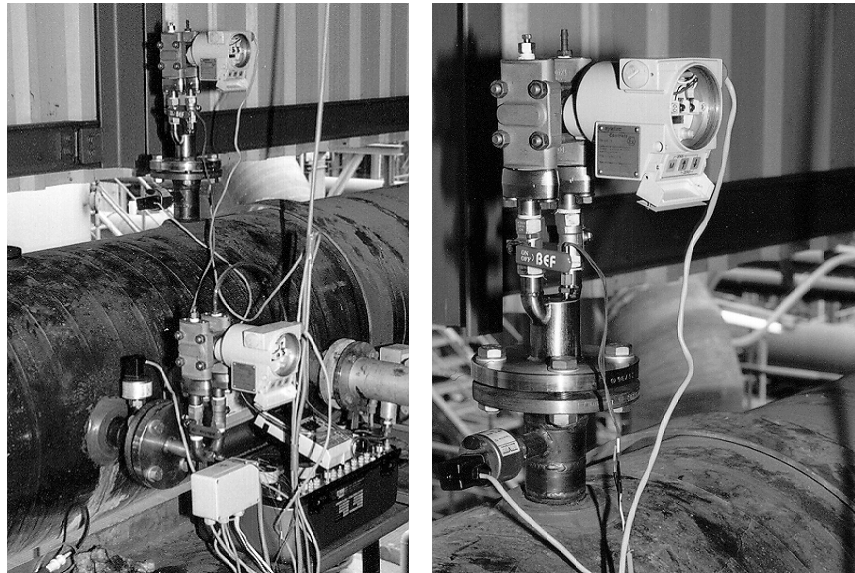
deltaflow DF25FF for water steam saturated and dry smoke gasses (horizontal installation)

The field test was conducted in an ID598 mm GFK conduit in the residue disposal furnace system at Wacker Chemie AG in Burghausen during June, July, and August

Field Test
Measurement Site

of 1995. The medium was 100% water-steam saturated, polluted and acidic smoke gas. Two uncorrelated and unconnected deltaflow dynamic pressure probes were placed in the system, spaced approximately 1m from each other. One probe was installed horizontally, and one was installed vertically.

Both probes were equipped with integrated pressure and temperature recorders as compensation. Two SYS4420 units were used as differential pressure transmitters. The average smoke gas temperature measured 45° C; the pressure was nearly equal to the external atmospheric pressure at a median of approximately 98 kPa. The measurement was interpreted based on a maximum of 15000 Nm³/h. In actuality, the maximum flow measured approximately 11000 Nm³/h. The differential pressure of the interpreted data measured approximately 3.1 mbar; at 11000 Nm³/h the differential pressure measured approximately 1.7 mbar.

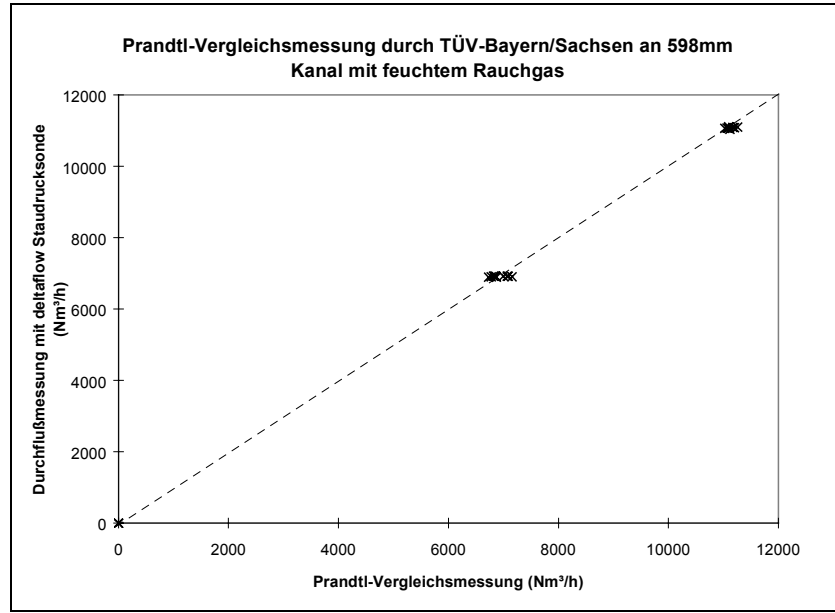


The deltaflow units DF25FF and DF50FF during the final testing by the Bavaria/Saxony TÜV.

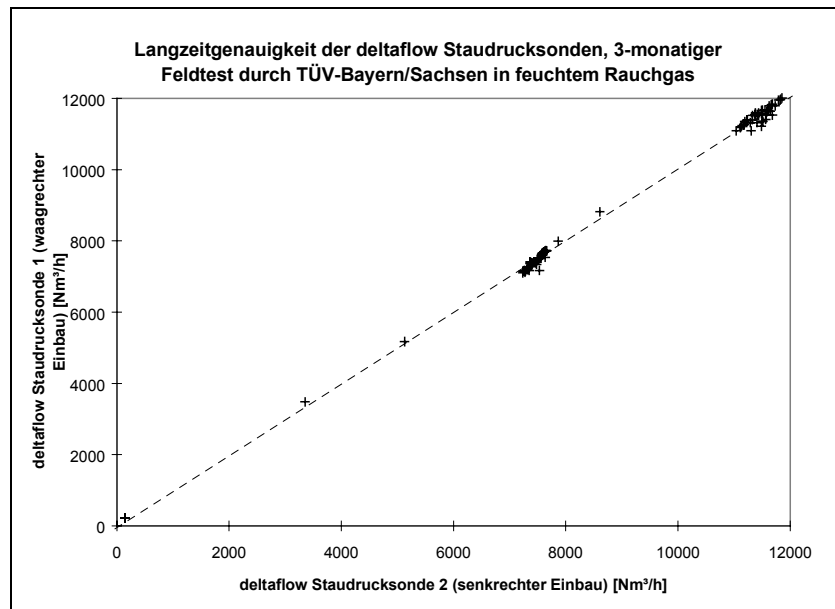
Both the DF25 and the DF50 met the requirements of the TÜV with flying colors. The reward for the effort is certification under TA-Air, Sections 13 and 17 of the BlmSchV.

The two illustrations below illustrate (1) the high level of consistency with the Prandtl comparative measurement which was performed, and (2) the excellent long-term accuracy of the measurement data during the 3-month long testing usage. All data were provided by the Bavarian TÜV (environmental testing agency).

Text oben: Prandtl Comparative Measurement Performed by Bavaria/Saxony TÜV on a 598 mm Channel with Wet Smoke Gas
Text links: Flow Measured by deltaflow Dynamic Pressure Probe (Nm³/h)
Text unten: Prandtl Comparative Measurement (Nm³/h)



Text oben: Long-term Accuracy of the deltaflow Dynamic Pressure Probe, 3-month Field Test Performed by Bavaria/Saxony TÜV in Wet Smoke Gas Application
Text links: deltaflow Dynamic Pressure Probe 1 (horizontal installation) (Nm³/h)
Text unten: deltaflow Dynamic Pressure Probe 2 (vertical installation) (Nm³/h)



Security Tested by
 TÜV — Available from
 systec Controls



systec Controls is a TÜV-certified manufacturer of high pressure/high temperature steam probes. In addition, we have received certification for steam and feed water dynamic pressure probes for temperatures up to 650°C and pressures up to 400 bar. Our TÜV Test Number is AW5/7794. The procedure testing was conducted by the Bavaria/Saxony TÜV in accordance with AD-Memorandum HP2/1 in conjunction with DIN EN 288-3. The BAM Test Number is DAP-P02-722-03-93-01.

The testing is valid for the following materials:

1.5415	15 Mo 3
1.7380	10 Cr Mo 910
1.7353	13 Cr Mo 44
1.4922	X 20 Cr Mo V121
1.4903	P 91 (in progress)

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deltacalc Software for Windows Simplifies deltaflow Operation

To simplify operation of the deltaflow dynamic pressure probes, systec Controls has developed an easy-to-use interpreting program. The program datacalc is very self-explanatory and intended for use under Windows 3.1 or higher. The program calculates the differential pressure at the probe which can be expected under a wide variety of media and operational conditions. Results can be output or printed in the form of a report.

The screenshot shows the 'deltaFlow DF25' software window. It contains several input fields and buttons:

- Medium: Luft
- Betriebsdruck: 1013.2 mbar/abs
- Betriebstemperatur: 20 °C
- Maximaler Durchfluß: 15000 Nm³/h
- Normdurchfluß: 7500 Nm³/h
- Minimaler Durchfluß: 3750 Nm³/h
- Rohrleitungsquerschnitt: rund, rechteckig
- Innendurchmesser: 489 mm
- Buttons: Calc !, Abbrechen

The results are displayed in an easy-to-understand format, and contain a great deal of additional information such as, for example, density, viscosity, and medium rate within the conduit.

The screenshot shows the 'Ergebnisse' (Results) window of the 'deltaCalc 1.1c' software. It displays the following information:

- deltaCalc 1.1c**
- Medium:** Luft
- Betriebsdruck:** 1013,2000 mbar/abs
- Betriebstemperatur:** 20,0000 °C
- Dichte:** 1,2048 kg/m³
- Viskosität:** 0,0181 cP
- Kunde:** Irgendwo KG, Gabriele Mustermann, Hans-Dampf-Gasse 7, 89898 Wömmers, 0123-456/789
- Meßstellenbezeichnung:** TAG FIQ455856
- Anfrage/Auftrag:** 02345
- deltaflow DF25**
- Rohr:** rund, ID=489,00mm
- Table of flow rates and factors:**

	Q min	Q norm	Q max
Durchfluß Nm³/h	3750,0000	7500,0000	15000,0000
Reynolds	194924,56	389849,12	779698,24
SYS-BlockageFaktor	2,457E-05	2,464E-05	2,464E-05
Differenzdruck mbar	0,53195	2,13427	8,53735

Buttons: Kopfdaten bearbeiten, Drucken, Details, Abbrechen

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Extensive

Informational Material is Available

In addition to the information contained in this document, there is a great deal of helpful information which serve to simplify the installation and operation of the deltaflow dynamic pressure probe.

deltaflow Product Information

Product information, including formulas, provides an overview of the product line and the possible areas of application. This document is available in German and English.

deltaflow Selection Catalog

Selection Catalog identifies the various construction models of the deltaflow. Available in German and English.

deltaflow Installation and Operation Guide

Instructions for installation and operation when using the deltaflow. Available in German and English.

Engineering, Service, Hotline

In addition to all of the above, our Service Team is always at your service. We are happy to help you plan your project by providing further details. Our Hotline is available to you 24 hours a day, 365 days a year.

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