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01.01.zz (Device firmware)

Special Documentation
Proline Prowirl F 200 FOUNDATION Fieldbus

Wet Steam Measurement application package

Endress+Hauser
People for Process Automation

Table of contents

1 About this document

1.1 Document function

This document is part of the Operating Instructions and serves as a reference for application-specific parameters and notes.

It provides detailed information on:
- Every individual parameter in the operating menu
- Advanced technical specifications
- General principles and application tips

1.2 Using this document

1.2.1 Information on the document structure

Additional information regarding:
- The arrangement of the parameters, along with a short description, according to the **Operation** menu, **Setup** menu, **Diagnostics** menu: Operating Instructions
- Operating concept: Operating Instructions

1.3 Symbols used

1.3.1 Safety symbols

Symbol	Meaning
DANGER	**DANGER!** This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.
WARNING	**WARNING!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.
CAUTION	**CAUTION!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.
NOTICE	**NOTE!** This symbol contains information on procedures and other facts which do not result in personal injury.

1.3.2 Symbols for certain types of information

Symbol	Meaning
	Tip Indicates additional information.
	Reference to documentation
	Reference to page
	Reference to graphic
▶	Notice or individual step to be observed
1., 2., 3...	Series of steps

Symbol	Meaning
	Result of a step
	Operation via local display
	Operation via operating tool
	Write-protected parameter

1.3.3 Symbols in graphics

Symbol	Meaning
1, 2, 3 ...	Item numbers
A, B, C, ...	Views
A-A, B-B, C-C, ...	Sections

1.4 Documentation

1.4.1 Device documentation

Detailed information about the device can be found in the Operating Instructions and the other documentation:
- On the CD-ROM supplied (not included in the delivery for all device versions).
- Available for all device versions via:
  - Internet: www.endress.com/deviceviewer
  - Smart phone/tablet: *Endress+Hauser Operations App*

The information required to retrieve the documentation can be found on the nameplate of the device.

Technical documentation can also be downloaded from the Download Area of the Endress+Hauser web site: www.endress.com → Download. However this technical documentation applies to a particular instrument family and is not assigned to a specific device.

1.4.2 Standard documentation

This manual is Special Documentation and is not a substitute for the Operating Instructions supplied with the device. Refer to the Operating Instructions and other documentation for detailed information.

The Special Documentation is an integral part of the following Operating Instructions:

Measuring device	Documentation code
Prowirl F 200	BA01694D

1.4.3 Content and scope

This Special Documentation contains a description of the additional parameters and technical data that are provided with the **Wet Steam Measurement** application package. All the parameters that are not relevant for wet steam measurement are described in the Operating Instructions.

- The "Technical data" section describes technical specifications for wet steam measurement → 17.
- The "General principles" section provides general information about wet steam measurement → 19.

2 Product features and availability

2.1 Product features

2.1.1 Wet steam measurement application package

The **Wet Steam Measurement** application package complements the **Wet Steam Detection** application package in steam applications by providing quantitative steam quality measurement.

The application package offers:
- Steam quality as a direct measured value (local display/FOUNDATION Fieldbus)
- Diagnostics information that issues a warning when the steam quality drops below a limit value → 19 in the range between 80 to 100 %
- Calculation of the following additional process variables:
  - Total mass flow [1] (local display/FOUNDATION Fieldbus)
  - Condensate mass flow (local display/FOUNDATION Fieldbus)
  - Correction of the volume flow [2], mass flow and energy flow in the steam application

2.2 Availability

The **Wet Steam Measurement** application package is only available for:
- Prowirl F 200
- Nominal diameters: DN 25 to 300 (1 to 12")
- Order code for "Sensor version; DSC sensor; measuring tube",
  - Option CA "Mass; 316L; 316L (integrated temperature measurement)"
  - Option CB "Mass; Alloy C22; 316L (integrated temperature measurement)"
  - Option CC "Mass; Alloy C22; Alloy C22 (integrated temperature measurement)"

If the **Wet Steam Measurement** application package was ordered for the flowmeter ex works, this package is available when the measuring device is delivered to the customer. The function is accessed via the operating interfaces of the measuring device or via Endress+Hauser's FieldCare asset management software.

Ways to check function availability in the measuring device:
Using the serial number:
W@M Device viewer [3] → Order code for *"Application package"*, option EU *"Wet Steam Measurement"*

1) Total mass flow = steam mass flow + condensate mass flow
2) Correction of the volume flow = correction of the primary volume flow in relation to condensate in a steam application (≠ corrected volume flow); corrected volume flow = volume flow in relation to reference conditions
3) www.endress.com/deviceviewer

3 Commissioning

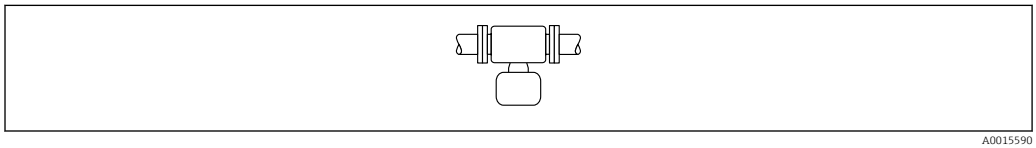
NOTICE

Note the following before commissioning the Wet Steam Detection application package:

- Do not use in conjunction with the **inlet run correction** function.
- Take the specified inlet runs into account.
- Do not use in conjunction with a flow conditioner.

3.1 Orientation

The measuring device must be installed in the pipe as follows:



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1 Horizontal orientation, transmitter head down

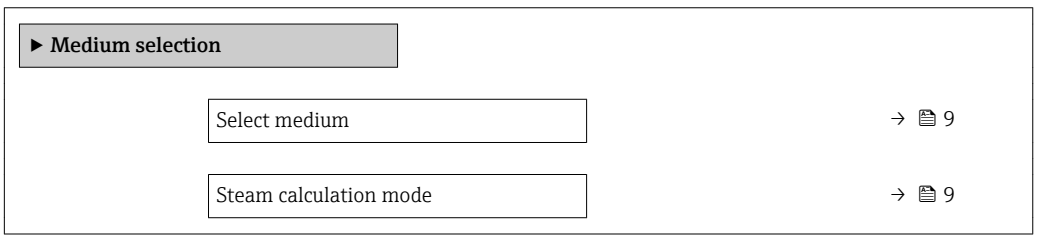
3.2 Configuring the measuring device

The **Medium selection** wizard can be used to set all the parameters that are needed to configure the measuring device for wet steam measurement.

Perform the following to configure the measuring device:

1. In the **Select medium** parameter (→ 9), select the **Steam** option.
2. In the **Steam calculation mode** parameter (→ 9), select the **Automatic (p-/T-compensated)** option.
   ↳ The measuring device does not perform a wet steam calculation in the case of saturated steam.
3. In the **Steam quality** parameter (→ 9), select the **Calculated value** option.
4. Enter a fixed value for steam quality in the **Steam quality value** parameter (→ 9).
   ↳ Desired value which the measuring device uses if calculation is not possible because the steam quality is not within the general parameters → 17.
5. For measuring devices with integrated temperature measurement only [4]:
   Activate pressure compensation → 11 or set the process pressure → 9.
   ↳ It is recommended to always activate pressure compensation and to also set the process pressure so that measuring device can use the set process pressure if pressure compensation fails.

Navigation
"Setup" menu → Medium selection



4) option CA, CB, CC

Steam quality	→ 9
Steam quality value	→ 9

Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Select medium	–	Select medium type.	▪ Gas ▪ Liquid ▪ Steam	Steam
Steam calculation mode	The **Steam** option is selected in the **Select medium** parameter parameter.	Select calculation mode of steam: based on saturated steam (T-compensated) or automatic detection (p-/T-compensated).	▪ Saturated steam (T-compensated) ▪ Automatic (p-/T-compensated)	Saturated steam (T-compensated)
Steam quality	The following conditions are met: ▪ Order code for "Application package": – Option ES "Wet steam detection" – Option EU "Wet steam measurement" ▪ The **Steam** option is selected in the **Select medium** parameter parameter. The software options currently enabled are displayed in the **Software option overview** parameter.	Select compensation mode for steam quality.	▪ Fixed value ▪ Calculated value	Fixed value
Steam quality value	The following conditions are met: ▪ The **Steam** option is selected in the **Select medium** parameter parameter. ▪ The **Fixed value** option is selected in the **Steam quality** parameter parameter.	Enter fixed value for steam quality.	0 to 100 %	100 %

3.2.1 Setting the process pressure

Once the **Steam** option has been selected in the **Select medium** parameter, the process pressure present in the system must be set.

1. Call up the **Medium selection** wizard.
2. Enter the process pressure present in the system in the **Fixed process pressure** parameter (→ 10).

Endress+Hauser recommends the use of active pressure compensation. This fully rules out the risk of measured errors due to pressure variations and incorrect entries → 11.

Navigation
"Setup" menu → Medium selection

Parameter overview with brief description

Parameter	Prerequisite	Description	User entry	Factory setting
Fixed process pressure	The following conditions are met: ▪ Order code for "Sensor version", Option "Mass flow (integrated temperature measurement)" ▪ In the **External value** parameter (→ 🖹 11) the **Pressure** option is not selected.	Enter fixed value for process pressure. *Dependency* The unit is taken from the **Pressure unit** parameter. 📖 For detailed information on setting the parameter in steam applications, see the Special Documentation for the **Wet Steam Detection** and **Wet Steam Measurement** application package	0 to 250 bar abs.	0 bar abs.

3.2.2 Activating pressure compensation

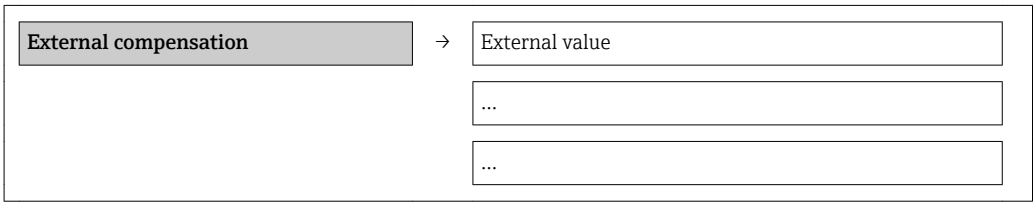
For measuring devices with integrated temperature measurement only [5]:

Active pressure compensation can be performed to minimize the effect of pressure variations. The pressure can be read in via the current input or fieldbus systems.

For detailed information on reading in the pressure, see the Operating Instructions for the device → 5

1. Call up the **External compensation** submenu.
2. In the **External value** parameter (→ 11), select the **Pressure** option.

Navigation
"Setup" menu → Advanced setup → External compensation



Parameter overview with brief description

Parameter	Description	Selection	Factory setting
External value	Assign variable from external device to process variable.	Pressure	Off

5) option CA, CB, CC

4 Operation

The measuring device calculates the steam quality in the background.

Once the **Wet Steam Measurement** application package has been successfully put into operation, the following measuring device functions can be used:
- Wet steam warning if steam quality is in the range from 80 to 100 % → 12
- Correction of the volume flow, mass flow and energy flow → 13
- Configuration of wet steam warning for the switch output
- Configuration of wet steam measurement

4.1 Wet steam warning

The wet steam warning function implemented in the measuring device makes it possible to display a configurable diagnostic message. The threshold for triggering the diagnostic message is set to 80 % steam quality at the factory but this setting can be changed by the customer.

As soon as the steam quality drops below 80 %, the diagnostic message ⚠**S872 Wet steam detected** appears on the display. This warning message disappears as soon as the steam quality exceeds 82 %. The hysteresis is fixed at 2 % (factory setting) and cannot be changed.

Changing the threshold value

The range of adjustment for the threshold value is 0 to 100 %. The limitation is also due to the fact that the calculated value cannot reach 0 %.

NOTE!

In order to make the setting, the **Calculated value** option must be selected in the **Steam quality** parameter (7605).

Navigation:

Setup → Advanced setup → External compensation → Steam quality

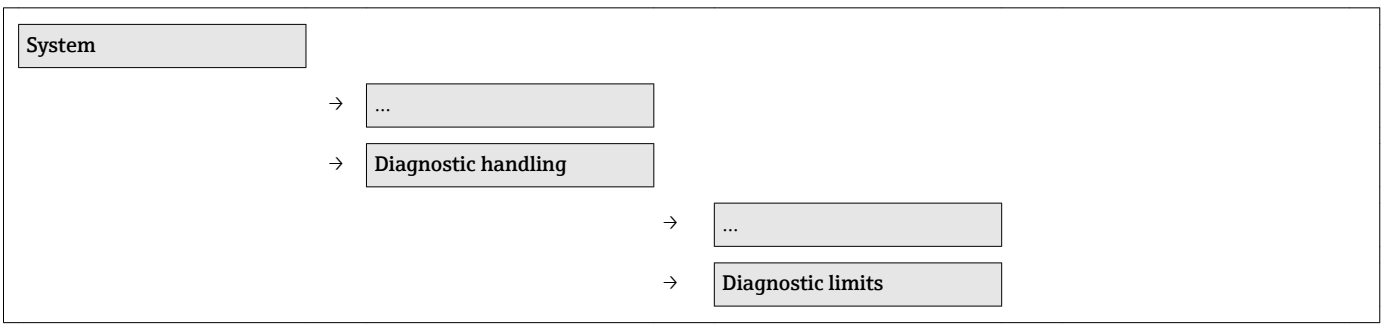
1. Call up the **Diagnostic limits** submenu.
2. In the **Steam quality limit** parameter (→ 13), enter a value from 0 to 100 %.

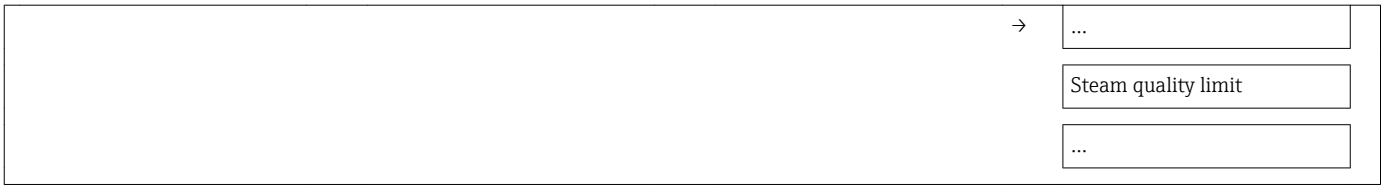
The diagnostic message ⚠**S872 Wet steam detected** is assigned the diagnostic behavior **Warning**. The measuring device displays a warning and can be evaluated via the digital interface. It is possible to change the diagnostic behavior to **Alarm**. As a result if diagnostic message ⚠**S872 Wet steam detected** is active, the current output adopts the configured failsafe mode.

For detailed information on adapting the diagnostic behavior, see the Operating Instructions → 5

Navigation

"Expert" menu → System → Diagnostic handling → Diagnostic limits





Parameter overview with brief description

Parameter	Prerequisite	Description	User entry	Factory setting
Steam quality limit	The following conditions are met: ▪ The **Steam** option is selected in the **Select medium** parameter parameter. ▪ The **Calculated value** option is selected in the **Steam quality** parameter parameter.	Enter the threshold value for the steam quality which, if undershot, causes the measuring device to display a diagnostic message.	0 to 100 %	80 %

4.2 Output variable correction

The following measured variables are corrected with the **Wet Steam Detection/ Measurement** application package depending on the steam quality:
- Volume flow
- Mass flow
- Energy flow

The correction depends on the entry in the **Steam quality** parameter (7605) (→ 9). If the **Fixed value** option is selected, the measuring device corrects the measured variables mentioned above with the **Steam quality value** parameter (→ 9) (factory setting 100 %). If the **Calculated value** option is selected, the measuring device corrects the variables using the steam quality currently measured in the process.

Information on the measured error if the **Calculated value** option is selected → 17

4.3 Configuring the wet steam warning for the switch output

NOTE!

Compared with the fixed thresholds for the wet steam warning → 12, the behavior of the wet steam warning can be individually configured so that it is assigned to the switch output.

One of the following options must be available in the measuring device:
Order code for "Output; input", option E "FOUNDATION Fieldbus, pul./freq./switch output"

Configure the wet steam warning with the values recommended by Endress+Hauser for typical steam applications.

Navigation:

Setup menu → **Advanced setup** submenu → **Pulse/frequency/switch output** wizard

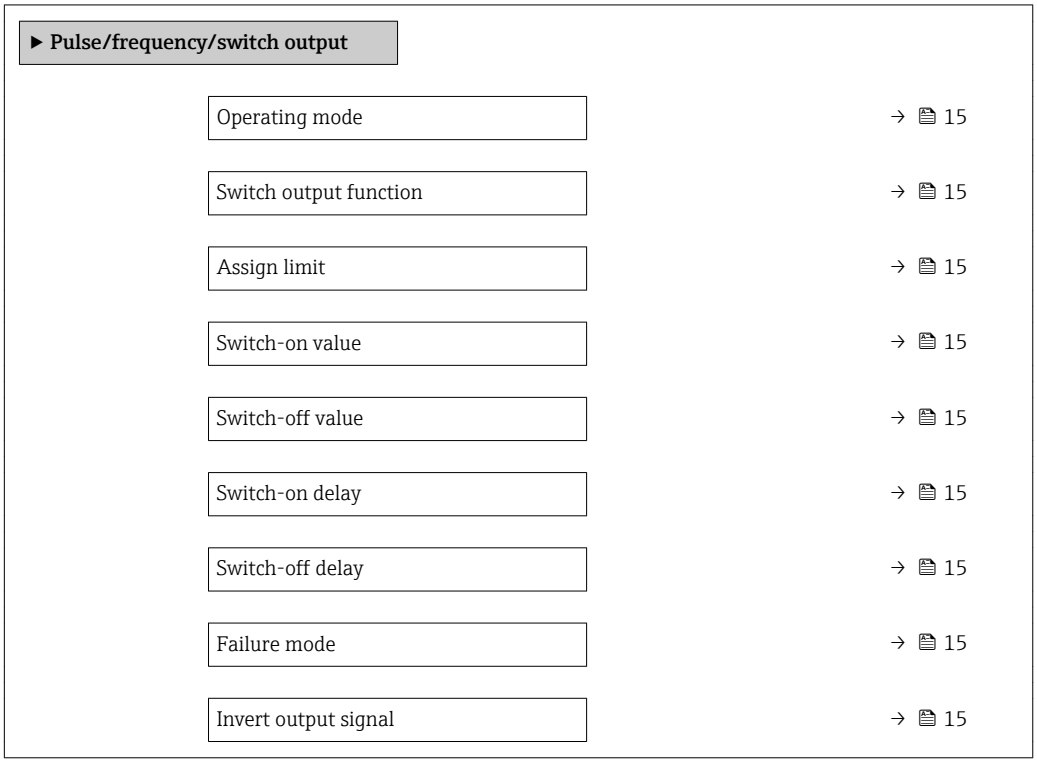
Setup menu → **Advanced setup** submenu → **Pulse/frequency/switch output** wizard

1. Specify the operating mode of the output.
   ↳ In the **Operating mode** parameter (→ 15), the **Switch** option is selected.

2. Select the function for the switch output.
   ↳ The **Limit** option is selected in the **Switch output function** parameter (→ 15).
3. Select the process variable for the limit function.
   ↳ In the **Assign limit** parameter (→ 15), the **Steam quality** option is selected.
4. Enter the measured value for the switch-on value.
   ↳ In the **Switch-on value** parameter (→ 15), the value **85 %** has been entered.
5. Enter the measured value for the switch-off value.
   ↳ In the **Switch-off value** parameter (→ 15), the value **95 %** has been entered.
6. Enter the delay time for switching on the switch output.
   ↳ In the **Switch-on delay** parameter (→ 15), the value **0.0 s** has been entered.
7. Enter the delay time for switching off the switch output.
   ↳ In the **Switch-off delay** parameter (→ 15), the value **0.0 s** has been entered.
8. Specify the output behavior in the event of a device alarm.
   ↳ The **Open** option is selected in the **Failure mode** parameter (→ 15).
9. Invert the output signal.
   ↳ In the **Invert output signal** parameter (→ 15), the **No** option is selected.

The wet steam warning has now been configured for the switch output.

Navigation
"Setup" menu → Advanced setup → Pulse/frequency/switch output



Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Operating mode	–	Define the output as a pulse, frequency or switch output.	▪ Pulse ▪ Frequency ▪ Switch	Pulse
Switch output function	The **Switch** option is selected in the **Operating mode** parameter.	Select function for switch output.	▪ Off ▪ On ▪ Diagnostic behavior ▪ Limit ▪ Status	Off
Assign limit	▪ The **Switch** option is selected in the **Operating mode** parameter parameter. ▪ The **Limit** option is selected in the **Switch output function** parameter parameter.	Select process variable for limit function.	▪ Volume flow ▪ Corrected volume flow ▪ Mass flow ▪ Flow velocity ▪ Temperature ▪ Pressure ▪ Calculated saturated steam pressure * ▪ Steam quality ▪ Total mass flow * ▪ Energy flow * ▪ Heat flow difference * ▪ Reynolds number * ▪ Totalizer 1 ▪ Totalizer 2 ▪ Totalizer 3	Volume flow
Switch-on value	▪ In the **Operating mode** parameter, the **Switch** option is selected. ▪ In the **Switch output function** parameter, the **Limit** option is selected.	Enter measured value for the switch-on point.	Signed floating-point number	Country-specific: ▪ 0 m^3/h ▪ 0 ft^3/h
Switch-off value	▪ In the **Operating mode** parameter, the **Switch** option is selected. ▪ In the **Switch output function** parameter, the **Limit** option is selected.	Enter measured value for the switch-off point.	Signed floating-point number	Country-specific: ▪ 0 m^3/h ▪ 0 ft^3/h
Switch-on delay	▪ The **Switch** option is selected in the **Operating mode** parameter. ▪ The **Limit** option is selected in the **Switch output function** parameter.	Define delay for the switch-on of status output.	0.0 to 100.0 s	0.0 s
Switch-off delay	▪ The **Switch** option is selected in the **Operating mode** parameter. ▪ The **Limit** option is selected in the **Switch output function** parameter.	Define delay for the switch-off of status output.	0.0 to 100.0 s	0.0 s
Failure mode	–	Define output behavior in alarm condition.	▪ Actual status ▪ Open ▪ Closed	Open
Invert output signal	–	Invert the output signal.	▪ No ▪ Yes	No

* Visibility depends on order options or device settings

4.4 Configuring wet steam measurement

The **Wet Steam Measurement** application package enables the following functions:
- Steam quality as a direct measured value on the local display/FOUNDATION Fieldbus
- Calculate and output the following additional process variables:
  Total mass flow (1854) (on local display/FOUNDATION Fieldbus)
  Condensate mass flow (1857) (on local display/FOUNDATION Fieldbus)
- Correction of the volume flow, mass flow and energy flow in the steam application
- Configurable diagnostic message that is displayed if the measuring device is outside the specified ranges of the process variables (factory setting **Off**)

The steam quality is derived from the vortex signal according to a patented signal processing method.

For detailed information on the measured error and the valid ranges of the process variables: → 17

If the process variables for determining the steam quality are outside the valid ranges, the measuring device displays the diagnostic message ⚠**S874 X% spec invalid** and, in the standard configuration, performs a correction with a steam quality of 100 % (factory setting). It is possible to change this diagnostic behavior.

Example

To correct the measuring device with another steam quality if diagnostic message ⚠**S874 X% spec invalid** is present, this can be done by changing the **Steam quality value** parameter (7630) accordingly to a value of 80 %, for example. (Navigation: Setup → Advanced setup → External compensationcalibration method)

The process variables to be output are corrected depending on the **Steam quality** parameter (→ 9) [6]:
- If the **Fixed value** option is selected, the variables are always corrected using the settings in the **Steam quality value** parameter (7630)
- If the **Calculated value** option is selected, the variables are always corrected on the basis of the steam quality calculated by the system, derived from the measured DSC sensor signal. The calculated steam quality is then also directly available as an output value.

6) Navigation: **Setup** menu → **Advanced setup** submenu → **External compensation** submenu

5 Technical data

The **Wet Steam Measurement** application package can be used for the following ranges:

SI units

DN [mm]	Velocity range in the measuring tube [m/s]	Steam quality [%]	Temperature range [°C]	Pressure range [bar abs.]
25 to 300	5 ≤ u ≤ 50	80 ≤ x ≤ 100	82 < T < 320	0.5 < p < 100

US units

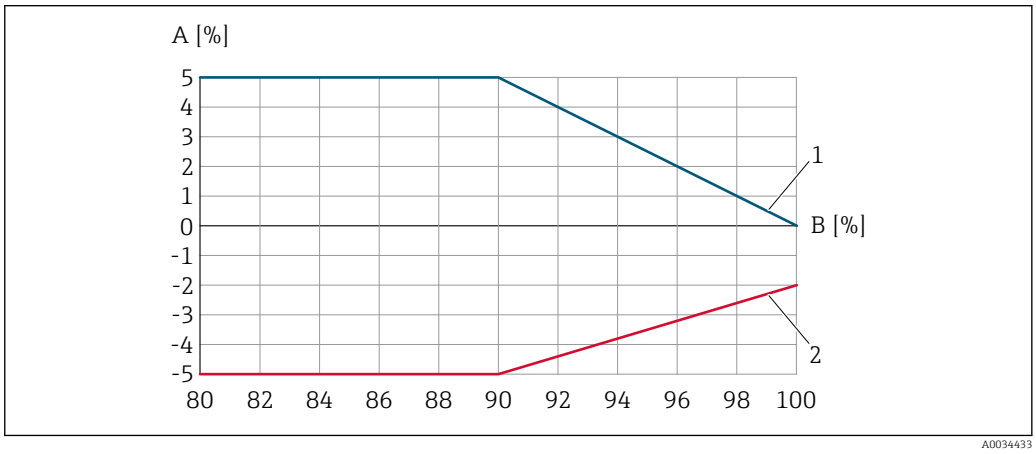
DN [in]	Velocity range [ft/s]	Steam quality [%]	Temperature range [°F]	Pressure range [psi abs.]
1 to 12	16.4 ≤ u ≤ 164	80 ≤ x ≤ 100	179 < T < 608	7.25 < p < 1450

NOTICE

Outside the valid ranges, the volume flow, mass flow and energy flow are no longer corrected.

Outside the valid ranges, these output variables are corrected with the value saved in the Steam quality value parameter (factory setting: 100 %). (Navigation: Setup menu → Advanced setup submenu → External compensation submenu → Steam quality value parameter)

- This can be displayed with the configurable diagnostic message ⚠**S874 X% spec invalid** (factory setting **Off**).



A Maximum measured error
B Steam quality
1 Positive error curve
2 Negative error curve

Maximum measured error [1]*:*

Process variable	Measured error [2]
Volume flow	±3 % [3]
Mass flow	±4 %
Energy flow	±4 %
Steam quality	−2 to 0 % if steam quality is 100 to 98 %
	±2 % if steam quality is 98 to 95 %
	±2.5 % if steam quality is 95 to 90 %
	±5 % if steam quality is 90 to 80 %

Process variable	Measured error [2]
	Repeatability of steam quality measurement 2 %
Total mass flow	±11 %

1) In the event of wet steam in the range of 80 to 100 %steam quality for nominal diameters DN 25 to 100 (1 to 4") at a pressure of 2 to 11 bar abs.
2) All the data refer to a confidence interval of 95 % and the steam phase (without condensate)
3) If the volume flow is not corrected on the basis of the measured steam quality, as happens in devices that do not have a wet steam measurement application package, for example, a measured error of up to 7 % can be expected.

For additional information about measured errors, see the "Maximum measured error" section in the Technical Information document

6 General principles

The vortex flow measuring principle is a universal measuring principle that allows users to measure liquids, gases and steams. Thanks to its very robust design, the measuring device is the flowmeter of choice in steam applications. Boilers are used for industrial steam generation. Steam is the most efficient energy transfer medium. The two primary applications are the transfer of thermal energy (building heating, boiling and heating processes) and kinetic energy (turbines in power stations). The steam present immediately at the outlet of a boiler that does not have a superheater is in a saturated state and is known as saturated steam. This type of steam has a theoretical steam quality of 100 % (x = 1). In relation to a closed volume, saturated steam describes the state when the last droplet of water changed to gas. As soon as energy is withdrawn from this steam condensate forms. This heat transfer involves a lot of energy (latent enthalpy h_{fg}). Superheated steam is formed from saturated steam if the temperature is increased at a constant pressure or the pressure drops at a constant temperature.

6.1 Steam quality

Wet steam describes a two-phase mixture. Saturated steam and condensate are in thermodynamic equilibrium. A steam quality of 80 %, for instance, means that 80 % of the mass flow is in a gaseous state and 20 % in a liquid state.

The steam quality x is referenced to the mass flow. A steam quality of 50 % does not mean that half the pipe is filled with water.

6.1.1 Volumetric comparison

Steam quality is a mass ratio:

$x = \dot{m}_{steam} : (\dot{m}_{steam} + \dot{m}_{condensate})$

Example 1

In a closed volume, 80 % of the mass fraction is in the form of saturated steam and 20 % in the form of condensate (= 80 % steam quality). At 10 bar (145 psi) absolute pressure, the volume consists of 99.9 percentage volume saturated steam and 0.1 percentage volume condensate because the density of the condensate is 200 times greater than that of steam.

Example 2

At a pressure of 8 bar (116 psi) and a temperature of +170 °C (+338 °F), 4 000 kg (8 818.5 lb) of steam flow through a pipe (DN 100 (4")) per hour. The steam quality is 80 %. The steam flows at a velocity of 36 m/s (118.1 ft/s). Presuming that the flow involved is annular flow → 🖹 20 and that the velocity of the condensate is 2 m/s (6.6 ft/s), a volumetric comparative variable can be calculated. With a steam quality of 80 %, the resulting annular flow would have a thickness of 0.5 mm (0.02 in).

6.1.2 Mass compensation

Volume flow is the primary measuring signal used in the vortex meter measuring principle. The volume flow of the gas phase (primary phase) can be measured with sufficient accuracy using conventional vortex flowmeters. However most users are more interested in the mass flow or energy flow of the steam as the transfer or release of energy is the primary task in steam applications. Modern vortex flowmeters offer users gas phase compensation for such situations. In our previous example, mass compensation of the gas phase means that only 80 % of the total mass flow is measured.

This consequently results in problems when analyzing the energy of a client's process:
- The client has no information about the quality of the steam or process.
- The process is inefficient as only the mass flow of the primary phase can be factored into efficiency calculations.
- The absence of an indicator for the quality of the steam means that an efficiency or safety analysis must be based on assumptions, making the process unsafe as a result.

6.2 Two-phase flow

In flow measurement, "two-phase flow" occurs when a gas phase and a liquid phase are present at the same time.

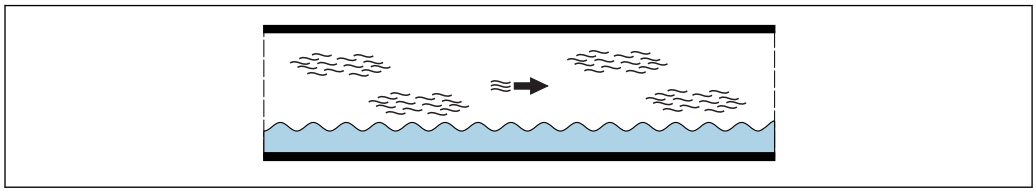
There are 3 classifications for two-phase flows (depending on the steam quality, velocity of the primary phase, pressure and temperature):
- Channel flow
- Wavy flow
- Annular flow

6.2.1 Channel flow

The liquid phase stays at the bottom half of the pipe, while the gas phase flows over it at a higher flow velocity.

6.2.2 Wavy flow

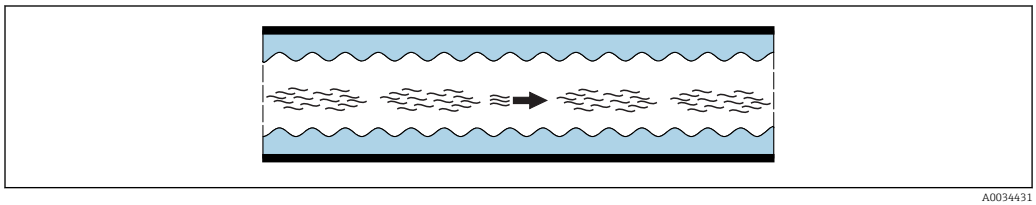
The liquid phase stays at the bottom half of the pipe, while the gas phase causes waves to occur in the liquid (increasing the risk of steam and water hammer).



2 Wavy flow - steam, condensate

6.2.3 Annular flow

The liquid phase (condensate) is present in the form of an annular-shaped film on the pipe wall, while the gas phase flows through the middle of it.



3 Annular flow - steam, condensate

6.3 System efficiency

For efficient energy transfer it must be ensured that the optimum steam state is provided for the individual application:
- Transfer of energy through a distribution system: slightly superheated steam
  The heat transfer coefficient is lower than in the case of saturated steam → less heat loss
- Operation of a turbine (gas kinetic energy does the work): highly superheated steam
  Dry steam → no liquid parts, therefore less risk of abrasion on the turbine blades.
- Transfer of energy to the process: saturated steam
  The heat transfer coefficient is higher than in the case of superheated steam → most of the energy can be transferred to the process.

Once steam has been generated, it is distributed through pipes to the various processes. During this distribution process, make sure to keep heat loss to a minimum.

Reasons for heat loss:
- Poor insulation
- Long distribution routes

The proportion of heat lost directly affects the system efficiency. Boilers operated incorrectly drive down system efficiency. The steam produced is of a poorer quality and can therefore not store the same amount of energy as saturated steam (100 % steam quality). If the steam quality drops below 100 %, the steam is known as wet steam. This wet steam contains a lower latent enthalpy h_{fg} in proportion to the steam quality that can be transferred to the process.

As a result, the poorer the quality of steam the lower the system efficiency.

6.4 Safety risk

Further to this wet steam is also a considerable safety risk. Large amounts of condensate can cause considerable damage in systems.

Typical risks presented by poor steam quality:
- Water hammer
- Steam hammer
- Frothover in the start-up phase

Danger	Description	Effect
Water hammer	Condensate fills up the entire pipe for a short time and travels through the pipe at the speed of the steam.	▪ Destroys pipes, valves, measuring technology equipment ▪ Loud banging
Steam hammer	A certain volume of steam is trapped between condensate at both ends for a short while → A sudden phase change of the trapped steam produces a local vacuum and causes the condensate fronts to collide → Shock waves with pressures up to 160 bar (2 320.6 psi) are generated	▪ Destroys pipes, valves, measuring technology equipment ▪ Loud banging
Frothover in the start-up phase (priming or carryover)	In the start-up phase of a steam system, it must be ensured that the connected steam consumption processes do not draw in more steam than can be generated. If this does nevertheless happen, the boiler pressure falls. If the boiler pressure is too low, this causes a pull over the surface of the water → some of the liquid water enters the flow of steam	▪ Boiler starts up and shuts down frequently ▪ In extreme situations boiler can explode (if heating pipes are exposed and low-water alarm is defective at the same time) ▪ Frothover, corrosive boiler water destroys pipes, valves, measuring technology equipment ▪ Loud banging

Therefore, the poorer the quality of steam the higher the safety risk.

The risk of water hammer or steam hammer increases with decreasing steam quality. For this reason condensate traps are used in modern steam systems. A condensate trap removes the condensate from the pipe and increases the quality of the steam.

6.5 Wet steam measurement with Prowirl F 200

6.5.1 Prowirl F 200: the steam expert

The **Wet Steam Measurement** application package in conjunction with active pressure compensation makes the Prowirl F 200 device an expert for steam applications. In industrial process engineering, steam is one of the main heat transfer media. It is important for businesses to make energy transfer as efficient as possible. To properly size and assess efficient steam facilities, exact information about the total mass flow or energy flow is needed. Steam has different states. Knowledge of these states is essential for accurate and correct measurement. For this reason, the customer is asked to enter the steam state in conventional vortex flowmeters. In many cases, customers enter this information based on an assumption or a preference. Prowirl F 200 is the first vortex flowmeter on the market that enables automatic steam measurement across all steam states. Prowirl F 200 with wet steam measurement and active pressure compensation enables an accurate energy balance and gives users a unique opportunity to appraise their process quality.

6.5.2 Advantages over conventional process for determining steam quality

The current state of the art for determining steam quality uses sampling methods, usually in conjunction with throttling calorimeters. This process was first introduced as early as 1888 by Cecil Hobart Peabody.

Wet steam measurement with Prowirl F 200 offers several clear advantages over this process:
- Continuous monitoring and measurement of the steam quality
- Continuous calculation of corrected measured variables that depend on the steam quality
- No additional manpower needed to determine the steam quality (2 people and roughly 3 h work time are generally needed for a single sample using the conventional method)
- As there is no need to open the process the safety risk is considerably lower.

7 Application example

The following section provides an example of a practical application of the **Wet Steam Measurement** application package in order to illustrate the advantages this package offers.

- Customer: food industry
- Application: ensure energy efficiency during heat transfer through steam and identify any energy loss immediately
- Process data
  - Nominal diameter: DN 50 (2")
  - Process pressure:3 bar abs. (43.51 psi abs.)
  - Process temperature: +133 °C (+271.4 °F)
  - Flow range: 200 to 500 kg/h (7.35 to 18.37 lb/min)

The customer has a main boiler and adds additional boilers where needed. The steam is delivered to the subsystems via a large steam distribution system. The pipes to the consumers are > 50 m (164 ft) and some are not insulated for reasons of the plant layout. The customer wanted a solution that provided information about the steam quality and therefore the energy efficiency of the system.

Endress+Hauser's patented, innovative solution meets the customer's requirements with the **Wet Steam Measurement** application package.

The following advantages won the client over:
- Measurement of the steam quality
- Correct measurement of the primary phase (gaseous steam) taking into consideration the steam quality present at the measuring point
- The ability to output mass flow and energy flow as process variables

Endress+Hauser sold the following solution in this application:
- Prowirl F 200
- Order code for "Nominal diameter", option 50 "DN50 2" "
- Order code for "Output; input", option E "FOUNDATION Fieldbus, pul./freq./switch output"
- Order code for "Sensor version; DSC sensor; measuring tube", option CA "Mass; 316L; 316L (integrated temperature measurement), –200 to +400 °C (–328 to +750 °F)"
- Order code for "Application package", option EU "Wet steam measurement"

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