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Special Documentation
Proline Prowirl F 200

Wet Steam Detection application package

Endress+Hauser
People for Process Automation

Table of contents

1 Document information

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

For the arrangement of the parameters as per the **Operation** menu, **Setup** menu, **Diagnostics** menu, along a short description, see the Operating Instructions for the device.

For information about the operating philosophy, see the "Operating philosophy" chapter in the device's Operating Instructions

1.3 Symbols used

1.3.1 Symbols for certain types of information

Symbol	Meaning
	Tip Indicates additional information.
	Reference to documentation Refers to the corresponding device documentation.
	Reference to page Refers to the corresponding page number.
	Reference to graphic Refers to the corresponding graphic number and page number.
	Operation via local display Indicates navigation to the parameter via the local display.
	Operation via operating tool Indicates navigation to the parameter via the operating tool.
	Write-protected parameter Indicates a parameter that can be locked against changes by entering a user-specific code.

1.3.2 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

All devices are supplied with Brief Operating Instructions. These Brief Operating Instructions are not a substitute for the Operating Instructions pertaining to the device!

Detailed information about the device can be found in the Operating Instructions and the other documentation:
- On the CD-ROM supplied (is 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.

W@M Device Viewer

1. Launch the W@M Device Viewer: www.endress.com/deviceviewer
2. Enter the serial number (Ser. no.) of the device: see nameplate .
   ↳ All the associated documentation is displayed.

Endress+Hauser Operations App

The *Endress+Hauser Operations App* is available for Android (Google play) and iOS (App Store).

Via the serial number:

1. Launch the *Endress+Hauser Operations App*.
2. Enter the serial number (Ser. no.) of the device: see nameplate .
   ↳ All the associated documentation is displayed.

Via the 2-D matrix code (QR code):

1. Launch the *Endress+Hauser Operations App*.
2. Scan the 2-D matrix code (QR code) on the nameplate .
   ↳ All the associated documentation is displayed.

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	
	HART	PROFIBUS PA
Prowirl F 200	BA01154D	BA01222D

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 Detection** application package. All the parameters that are not relevant for wet steam detection are described in the Operating Instructions.

The "General principles" section provides general information about wet steam detection → 16.

2 Product features and availability

2.1 Product features

2.1.1 Wet Steam Detection application package

The **Wet Steam Detection** application package has an additional function that makes it possible to monitor the steam quality.

The application package offers:
- Diagnostics information that issues a warning when the steam quality drops below the limit value for steam quality → 16 in the range between 80 to 100 % .
- Correction of the volume flow [1], mass flow and energy flow.
- An additional indicator to monitor the operation of steam traps.

2.2 Availability

The **Wet Steam Detection** application package is only available for:
- Prowirl F 200
- Nominal diameters: DN 25 to 100 (1 to 4")
- Order code for *"Sensor version"*, option 3 *"Mass flow (integrated temperature measurement)"*

If the **Wet Steam Detection** 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 [2] → Order code for *"Application package"*, option ES *"Wet Steam Detection"*

If the application package is not available in the measuring device it can be activated during the life cycle of the device. On most flowmeters it is possible to activate the package without having to upgrade the firmware.

Activation without firmware upgrade is possible with the following firmware versions or higher:
- HART: 01.02.zz
- PROFIBUS DP: 01.01.zz
- FOUNDATION Fieldbus: 01.00.zz

For all earlier firmware versions, the firmware must be upgraded in order to enable the package.

In addition, the **Wet Steam Measurement** application package is also available for steam applications as an optional extra: *"Application package"*, option EU *"Wet steam measurement"*. It complements the **Wet Steam Detection** application package by providing quantitative steam quality measurement.

2.2.1 Enabling without performing a firmware upgrade

You require a conversion kit from Endress+Hauser to enable the application package without upgrading the firmware. This kit contains a release code which must be entered via the operating menu in order to activate the application package.

1) Correction of the volume flow = correction of the primary volume flow towards condensate in a steam application (not to be confused with corrected volume flow); corrected volume flow = volume flow in relation to reference conditions
2) www.endress.com/deviceviewer

Once activated the application package is permanently available in the measuring device.

2.2.2 Enabling by performing a firmware upgrade

If you have a measuring device that requires a firmware upgrade before the function can be activated, please contact your Endress+Hauser service organization.

This function requires service-level access to the device.

Please contact your Endress+Hauser service or sales organization for further information regarding availability and firmware upgrades for existing measuring devices.

3 Commissioning

NOTICE

Please note the following before commissioning the Wet Steam Detection application package:

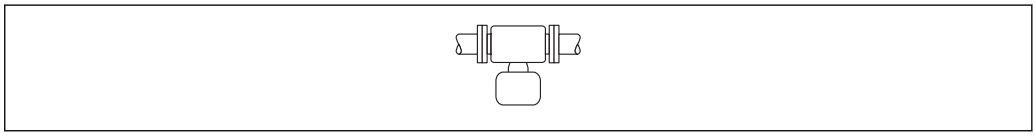
- Do not use in conjunction with the **inlet run correction** function.
- Take the specified inlet runs into account.
- Do not use in conjunction with a flow conditioner.

The **Steam quality** parameter is already visible in the device. Assigning the parameter has no effect, however, as it is not yet functional.

- The **Wet Steam Measurement** application package must be present and enabled in the device so that the parameter can be assigned and used to its full extent.
- The **Wet Steam Measurement** application package is available as an optional extra → 7.

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 detection.

Perform the following to configure the measuring device:

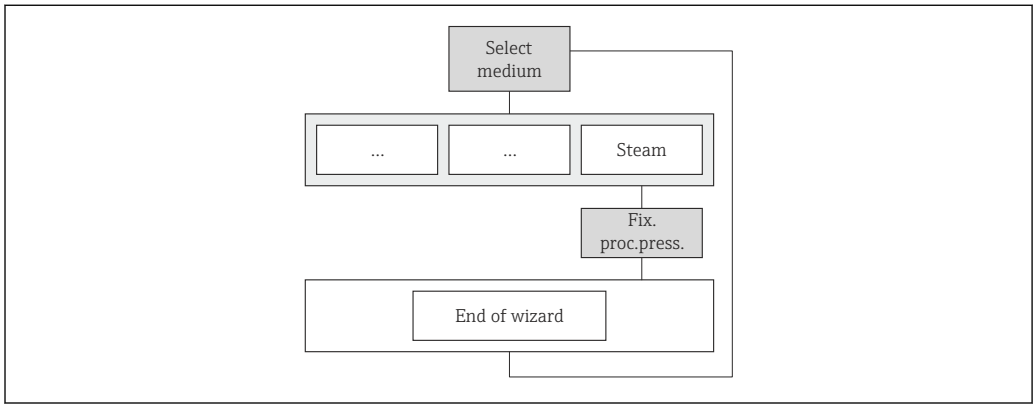
1. Set the medium → 9.
2. Set the process pressure → 10.
3. Activate pressure compensation → 12.

3.2.1 Setting the medium

1. Call up the **Medium selection** wizard.
2. In the **Select medium** parameter (→ 10), select the **Steam** option.

Navigation
"Setup" menu → Medium selection

Structure of the wizard



Parameter overview with brief description

Parameter	Description	Selection	Factory setting
Select medium	Select medium type.	Steam	Steam

3.2.2 Setting the process pressure

Switching the process pressure to activate wet steam detection

Once **"Steam"** has been selected as the medium, the process pressure present in the system must be set. The **Fixed process pressure** parameter is set to the value **0 bar abs.** (ex works) [3] In this case, the measuring device only calculates on the saturated steam curve using temperature compensation. It is only possible to perform wet steam detection if the **Fixed process pressure** parameter is set to a value ≠ 0 bar abs..

1. Call up the **Medium selection** wizard.
2. In the **Fixed process pressure** parameter (→ 🖹 11) enter the process pressure present in the system or a value ≠ 0.

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 → 🖹 12.

Navigation
"Setup" menu → Medium selection

3) This factory setting enables backward compatibility for existing measuring points fitted with the previous Prowirl 73 model.

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 (→ 🖹 12), 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 the calculation of the measured variables with steam: 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.

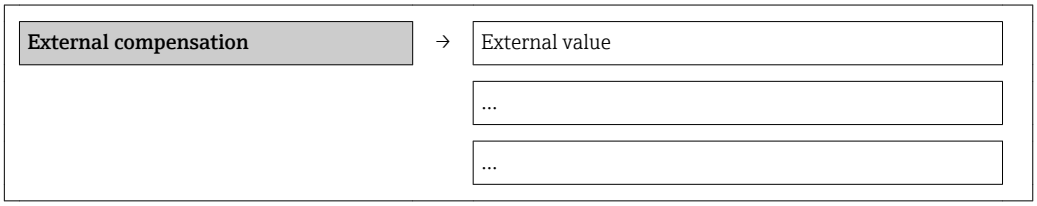
3.2.3 Activating pressure compensation

Users can choose to also perform active pressure compensation in order to minimize the effect of pressure variations. The pressure can be read in via the current input or fieldbuses.

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 (→ 12), select the **Pressure** option.

Navigation
"Setup" menu → Advanced setup → External compensation



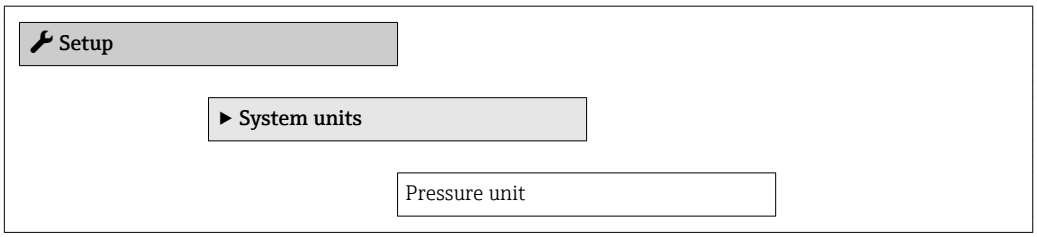
Parameter overview with brief description

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

Note on PROFIBUS PA

If an external pressure transmitter is used to read in the pressure in devices with PROFIBUS PA, set the unit to Pascal in the pressure unit parameter.

Navigation
"Setup" menu → System units



Parameter overview with brief description

Parameter	Prerequisite	Description	Selection	Factory setting
Pressure unit	For the following order code: "Sensor version", option "Mass flow"	Select process pressure unit. *Effect* The unit is taken from the: ▪ Calculated saturated steam pressure ▪ Atmospheric pressure ▪ Maximum value ▪ Fixed process pressure ▪ Pressure ▪ Reference pressure	Unit choose list	Country-specific: ▪ bar ▪ psi

4 Operation

The steam quality is constantly calculated in the background.

Once the **Wet Steam Detection** application package has been successfully put into operation, the following measuring device functions can be used:
- Wet steam warning if steam quality ≤ 80 to 100 % → 13
- Correction of the volume flow, mass flow and energy flow → 14

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 85 %. The hysteresis is fixed at 5 % (factory setting) and cannot be changed.

Changing the threshold value

The range of adjustment for this threshold value is 80 to 100 %.

NOTE!

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

Navigation:

"Setup" menu → Advanced setup → External compensation → Steam quality

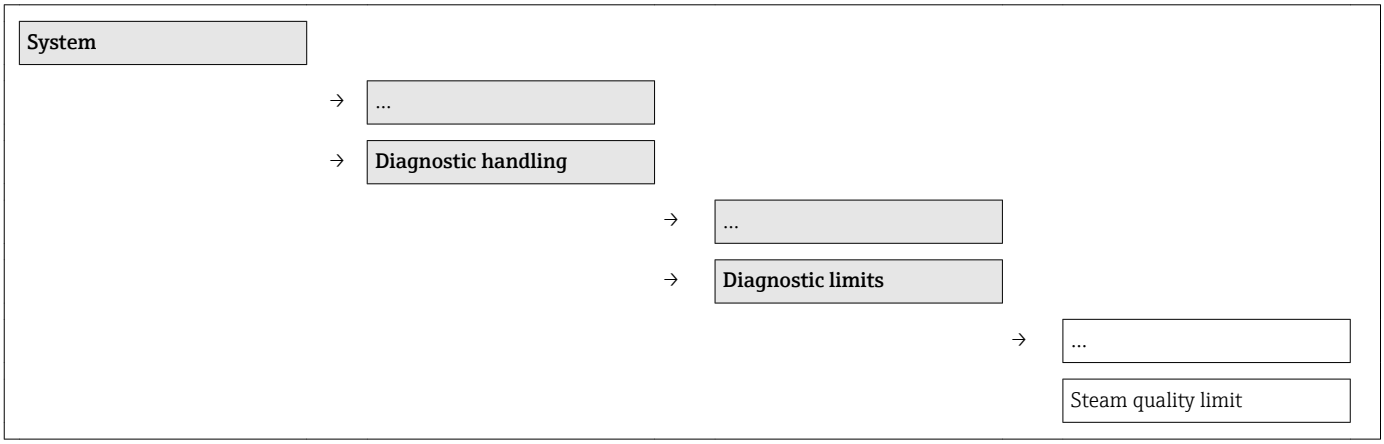
1. Call up the **Diagnostic limits** submenu.
2. In the **Steam quality limit** parameter (→ 14), enter a value from 80 to 100 %.

The diagnostic message ⚠**S872 Wet steam detected** is assigned the diagnostic behaviour **Warning**. A warning appears on the display 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: ▪ In the **Select medium** parameter, the **Steam** option is selected. ▪ In the **Steam quality** parameter, the **Calculated value** option is selected.		80 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). If the **Fixed value** option is selected, the Prowirl 200 corrects the measured variables mentioned above with the **Steam quality value** parameter (factory setting 100 %). If the **Calculated value** option is selected, the Prowirl 200 corrects the variables using the steam quality currently measured in the process.

For information on the measured error when the **Calculated value** option is selected, see the "Technical data" section → 15

5 Technical data

The **Wet Steam Detection** application package is valid for the following ranges:

SI units

DN [mm]	Velocity range in the measuring tube [m/s]	Temperature range [°C]	Pressure range [bar abs.]
25	5 ≤ u ≤ 35	120 < T < 185	2 < p < 11
40	5 ≤ u ≤ 50		
50	5 ≤ u ≤ 45		
80	5 ≤ u ≤ 50		
100	5 ≤ u ≤ 30		

US units

DN [in]	Velocity range [ft/s]	Temperature range [°F]	Pressure range [psi abs.]
1	16.4 ≤ u ≤ 114.83	248 < T < 365	29.0 < p < 159.5
1½	16.4 ≤ u ≤ 164.0		
2	16.4 ≤ u ≤ 147.64		
3	16.4 ≤ u ≤ 164.0		
4	16.4 ≤ u ≤ 98.43		

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 using the configurable diagnostic message ⚠**S874 X% spec invalid** (factory setting **Off**).

5.1 Measured error for process variables

In the event of wet steam in the region of 80 to 100 % steam quality:

Process variable	Measured error [1]
Volume flow	±3 % [2]
Mass flow	±4 %
Energy flow	±4 %

1) All the data refer to a confidence interval of 95 % and the steam phase (without condensate).
2) 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 → 5

6 General principles

6.1 Introduction

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 Prowirl F 200 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.

6.2 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.

6.2.1 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 → 🖹 17 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).

6.2.2 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.

6.3 Two-phase flow

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

6.3.1 Classifications

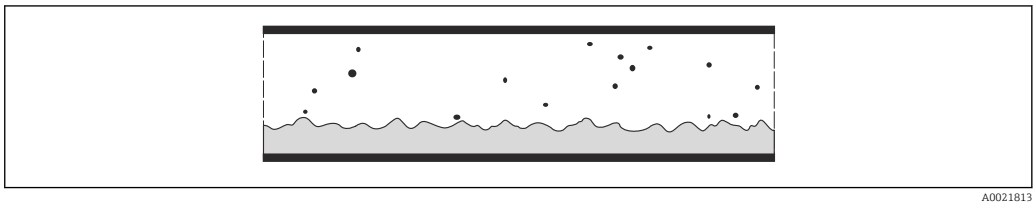
Classifications for two-phase flow (depending on the steam quality, velocity of the primary phase, pressure and temperature):

Channel flow

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

Wavy flow

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



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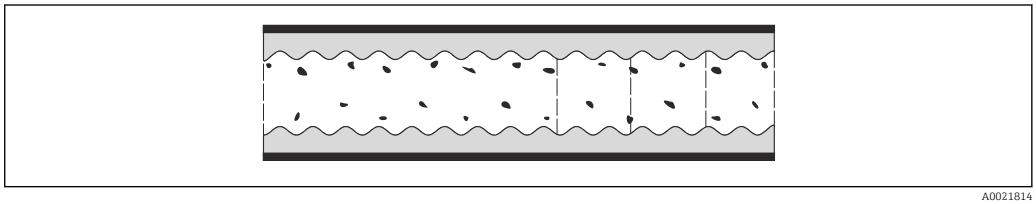
2 Wavy flow - steam, condensate

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.



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3 Annular flow - steam, condensate

6.4 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.

6.5 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.

6.6 Wet steam detection with Prowirl F 200

Owing to its special signal processing system the Prowirl F 200 is able to detect the presence of a second phase (liquid phase or condensate). Endress+Hauser was able to develop a function for wet steam detection on the basis of generally accepted, dimensionless flow variables. The Wet Steam Detection function has been implemented in Prowirl 200 in such a way that it is triggered if the steam quality drops below a certain threshold. 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. The range of adjustment for the threshold value is 80 to 100 %. In this way, the Prowirl F 200 with wet steam detection can help detect safety risks (e.g. defective steam traps, frothover etc.).

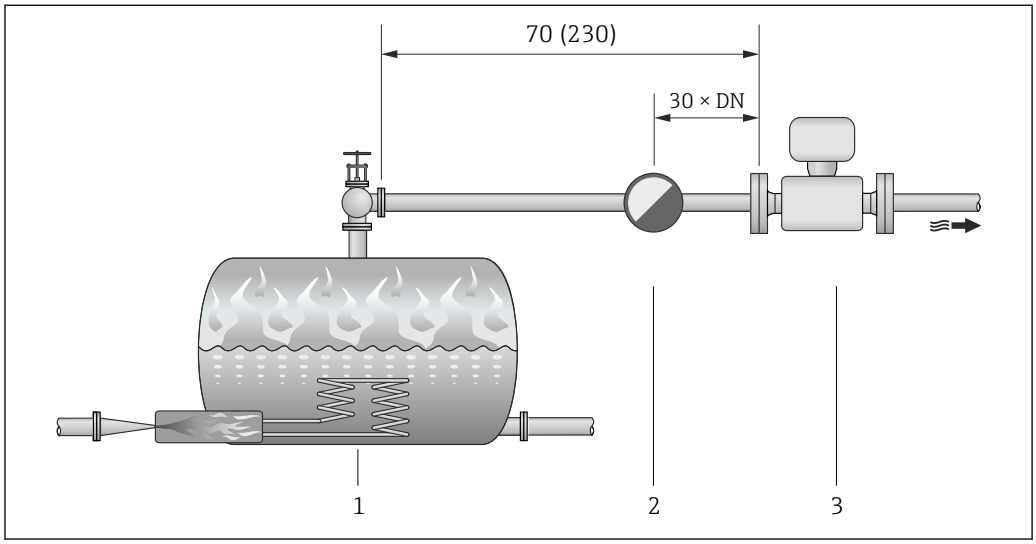
6.6.1 Advantages over conventional processes for determining steam quality

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 detection with Prowirl F 200 offers several clear advantages over this system:
- Steam quality continuously monitored and wet steam warning triggered when steam quality drops below 80 %
- No additional manpower needed (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 Detection** application package in order to illustrate the advantages this package offers:



4 Engineering unit m (ft)

1 Steam boiler
2 Steam trap
3 Prowirl 200 with the Wet Steam Detection application package

Greater safety in the chemical industry
- Customer: chemical industry
- Application: distribution of saturated steam to consumers for process heating
- Process data:
  - Nominal diameter: DN 80 (3")
  - Process pressure: 5 bar abs. (72.52 psi abs.)
  - Process temperature: 152 °C (305.6 °F)
  - Flow range: 800 to 1 800 kg/h (29.39 to 66.14 lb/min)

The boiler and consumer are connected by a 70-meter pipe (230 ft). The consumer needs dry saturated steam. This is guaranteed by a steam trap which is located 30 × DN upstream from the measuring point. Steam traps have a typical failure rate of around 10 % per year in an industrial facility.

If the steam trap fails, large amounts of condensate pass through the pipe. The uncontrolled formation of condensate presents a high safety and process risk. The Prowirl F 200 flowmeter with the **Wet Steam Detection** application package can detect this condition in a facility. As a result, a timely warning can be sent to the control system, steam trap failures can be detected in time and damage can be avoided.

In this application example, Endress+Hauser's patented, innovative solution increases system safety thanks to the **Wet Steam Detection** application package.

Endress+Hauser sold the following solution in this application:
- Prowirl F 200
- Order code for *"Nominal diameter"*, option 80 *"DN80 3" "*
- Order code for *"Sensor version"*, option 3 *"Mass flow (integrated temperature measurement)"*
- Order code for *"Application package"*, option ES *"Wet steam detection"*

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