SD02034D/06/EN/01.18
71380973

Valid as of version
01.02.zz (Device firmware)

Special Documentation
Proline Prowirl F 200
PROFIBUS PA

Wet Steam Detection application package

Endress+Hauser
People for Process Automation

Table of contents

1 About this document 4
1.1 Document function 4
1.2 Using this document 4
1.3 Symbols used 4
1.4 Documentation 5

2 Product features and availability 6
2.1 Product features 6
2.2 Availability 6

3 Commissioning 7
3.1 Orientation 7
3.2 Configuring the measuring device 7

4 Operation 11
4.1 Wet steam warning 11
4.2 Output variable correction 12

5 Technical data 13

6 General principles 14
6.1 Introduction 14
6.2 Steam quality 14
6.3 Two-phase flow 15
6.4 System efficiency 16
6.5 Safety risk 16
6.6 Wet steam detection with Prowirl F 200 17

7 Application example 18

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	BA01690D

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 → 14.

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 → 🖹 14 in the range between 80 to 100 %
- Correction of the volume flow [1], the mass flow and the energy flow
- 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 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 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"*

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.

1) 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
2) www.endress.com/deviceviewer

3 Commissioning

NOTICE

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

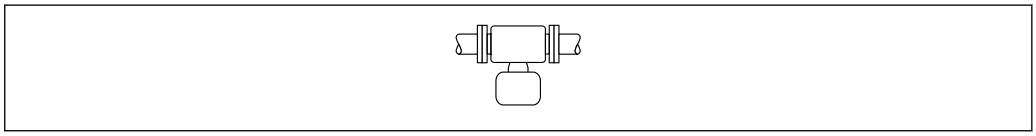
- Do not use in conjunction with the **inlet run correction** function.
- Take the specified inlet runs into account.
- Do not use in conjunction with a flow conditioner.

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 → 6.

3.1 Orientation

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



A0015590

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.

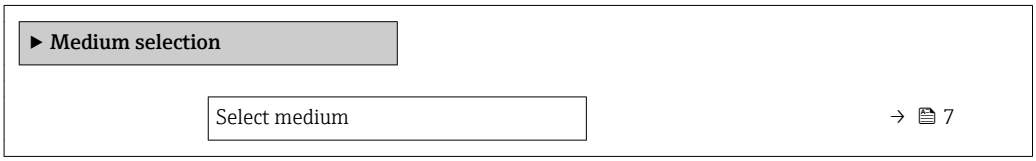
Perform the following to configure the measuring device:

1. Set the medium → 7.
2. Set the process pressure → 8.
3. Activate pressure compensation → 9.

3.2.1 Setting the medium

1. Call up the **Medium selection** wizard.
2. In the **Select medium** parameter (→ 7), select the **Steam** option.

Navigation
"Setup" menu → Medium selection



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 (→ 8) 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 → 9.

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 (→ 9), 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) This factory setting enables backward compatibility for existing measuring points fitted with the previous Prowirl 73 model.

3.2.3 Activating pressure compensation

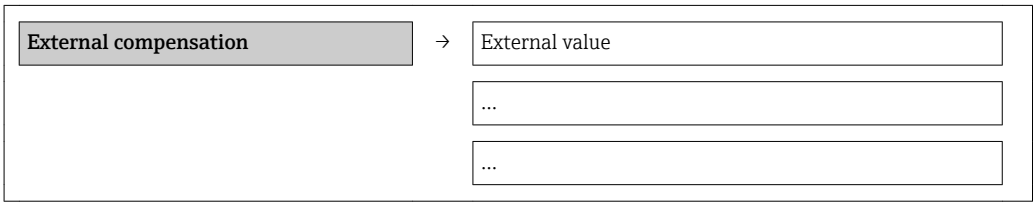
For measuring devices with integrated temperature measurement only [4]:

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 (→ 9), select the **Pressure** option.

Navigation
"Setup" menu → Advanced setup → External compensation



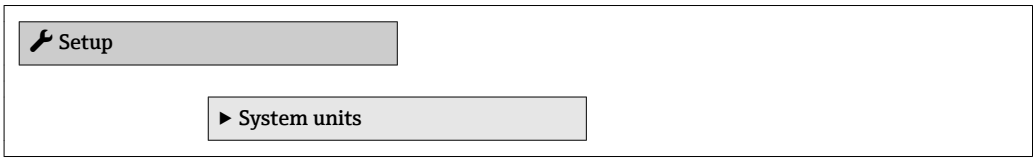
Parameter overview with brief description

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

External pressure transmitter

- If using measuring devices with PROFIBUS PA and an external pressure transmitter to read in the pressure:
  Set the Pascal unit in the **Pressure unit** parameter.

Navigation
"Setup" menu → System units



4) option CA, CB, CC

Parameter overview with brief description

Parameter	Prerequisite	Description	Selection	Factory setting
Pressure unit	With order code for "Sensor version": option "Mass (integrated temperature measurement)"	Select process pressure unit. *Result* The unit is taken from: ▪ 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 % → 11
- Correction of the volume flow, mass flow and energy flow → 12

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 → Advanced setup → External compensation → Steam quality

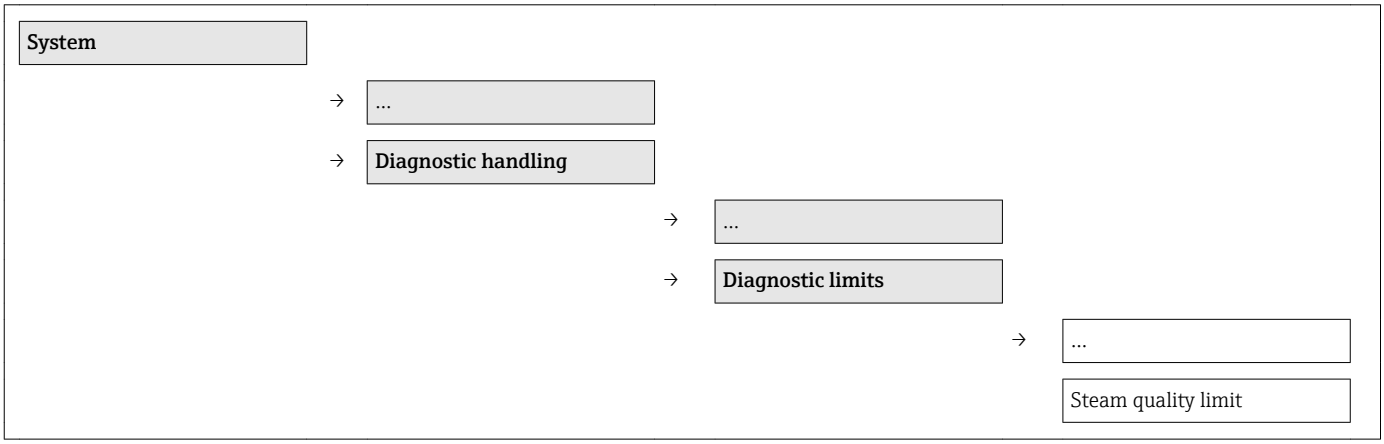
1. Call up the **Diagnostic limits** submenu.
2. In the **Steam quality limit** parameter (→ 12), enter a value from 80 to 100 %.

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

5 Technical data

The **Wet Steam Detection** 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**).

Maximum measured error [1]:

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

1) In the event of wet steam in the range of 80 to 100 %steam quality for DN 25 to 100 (1 to 4") and 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

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 → 🖹 15 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

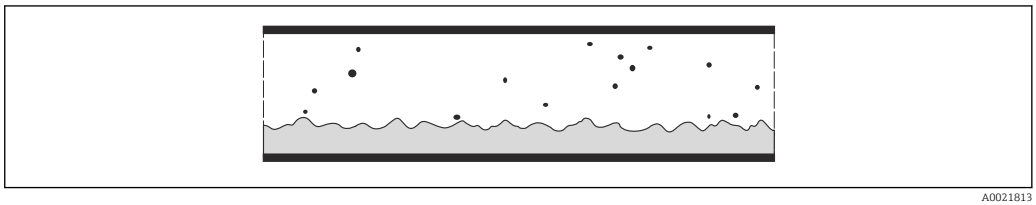
Classifications for two-phase flow (depending on the steam quality, velocity of the primary phase, pressure and temperature):

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).

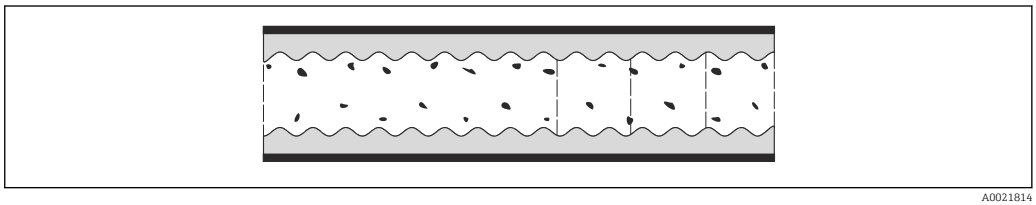


A0021813

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.



A0021814

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.).

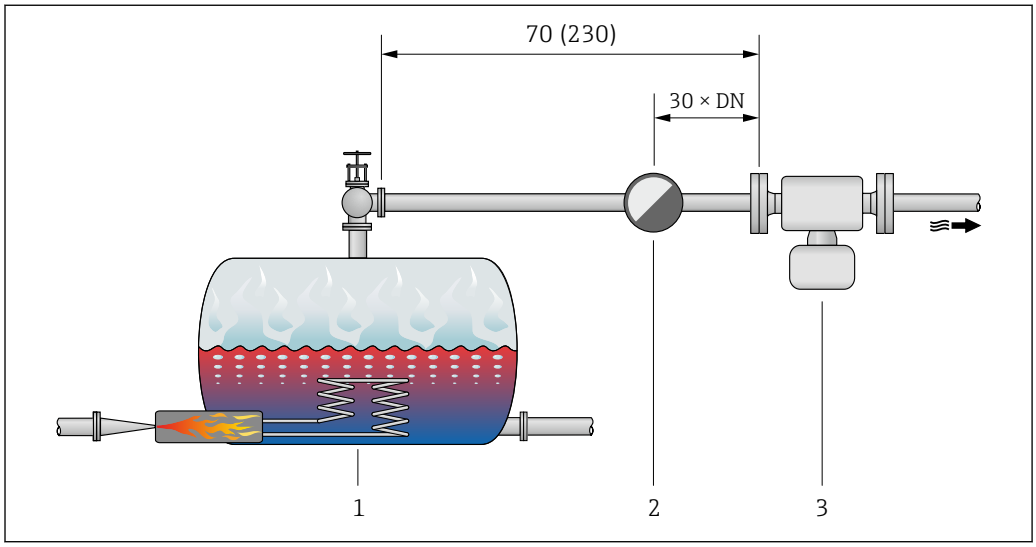
6.6.1 Advantages over conventional processes for determining steam quality

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 F 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 load 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; 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 ES "Wet steam detection"

www.addresses.endress.com

Endress+Hauser

People for Process Automation