Application Description
AG/265_101-EN

Level Measurement on Closed Containers Using Pressure Transmitters

Instrumentation Solutions

- Level measurement of all kinds of storage liquids
- Level determination according to proven and established procedure
- Adaptation to the usually existing container connections, with or without pressure seal
- Highly precise measurements, independent of foaming

ABB Instrumentation

1 General description and introduction

The right choice of the measured value acquisition and the transmitter as well as detailed knowledge of all measuring system properties, plus the knowledge of process requirements and individual operating conditions, are the foundation for an economical production.

Transmitters are usually located close to the process which is why, under given conditions, they have to provide to the process control level precise and reliable information concerning the current process status or concerning the liquid level.

2 Problem

Possible requirements and operational conditions to the entire measuring system result not only from process specifications, but also from the mechanical design of the plant, from the product properties, from the environmental conditions, and from the corresponding safety requirements.

Such requirements may include:
- Process parameters such as measuring range, measuring accuracy, measuring dynamics, sensitivity, reproducibility, drift, etc.
- Corrosion resistance, contamination, temperature, static pressure
- Geometry, accessibility, shock, humidity, temperature, dust, radiation
- Operation, maintenance, replaceability, training of personnel
- Ex protection, material certificates, mechanical strength

In addition to the correct selection of the transmitter to be used, the correct installation is of special importance. It is furthermore indispensable to have in-depth knowledge of the calculation of the transmitter settings.

3 Level measurement on containers under pressure

Instrumentation
Liquid storage containers are often blanketed by pressurized gas.

Blanketing using inert gas is used for the storage of materials in case these could react with components of the air, oxygen or humidity.

Nitrogen (N) is normally used as inert gas. An inert container atmosphere not only provides quality assurance, but it also reduces the danger of explosions. For containers blanketed with inert gas, pressure monitoring therefore is of major importance.

Fig. 3-1: Steel-based liquid storage containers

Differential pressure transmitters, such as the ABB type 265DS, should be used for this type of level measurement. Differential pressure is used here to make sure the superimposed gas pressure is not reflected in the measurement.

In the selected setup, the gas pressure acts on the liquid and at the same time, via the connected differential pressure pipe, on the other side of the differential pressure transmitter. As the gas pressure thus “presses“ on both sides simultaneously, it cancels each other out, leaving only the real container level for measurement.

The output current signal of the transmitter is therefore proportional to the level of the storage container.

Depending on local conditions you have to make sure that no precipitate accumulates in the pressure compensation pipe (Fig. 3-2 right pipe, connected to top of container), which would distort the result of the level measurement. In case an accumulation of precipitate has to be expected, a precipitate collector / dirt trap with a valve should be connected to the compensation side of the differential pressure transmitter, as shown in Fig. 3-2, which can be used to drain the precipitate from time to time.

For container pressure monitoring, the ABB pressure transmitter type 265GS can be connected in the upper “gas area“ of the storage container.

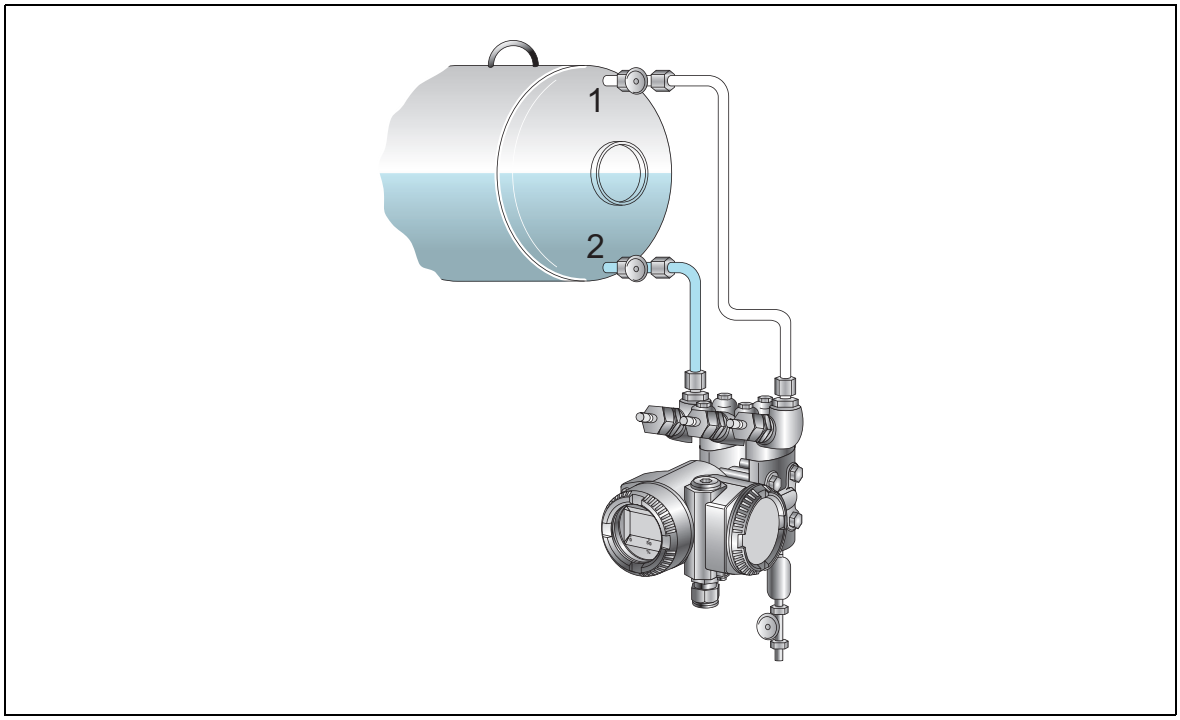

Fig. 3-2: Setup for level measurement on storage container

1 Gas (inert gas)
2 Liquid

When storing liquids that are hazardous to water, observe the regulations for systems used for storing, filling and handling substances that are hazardous to water (German abbrev. VAwS).

The storage of inflammable liquids has been prescribed in the regulation on inflammable liquids (German abbrev. VbF BGBl. 240/1991) and must also be observed.

Calculation of setting value

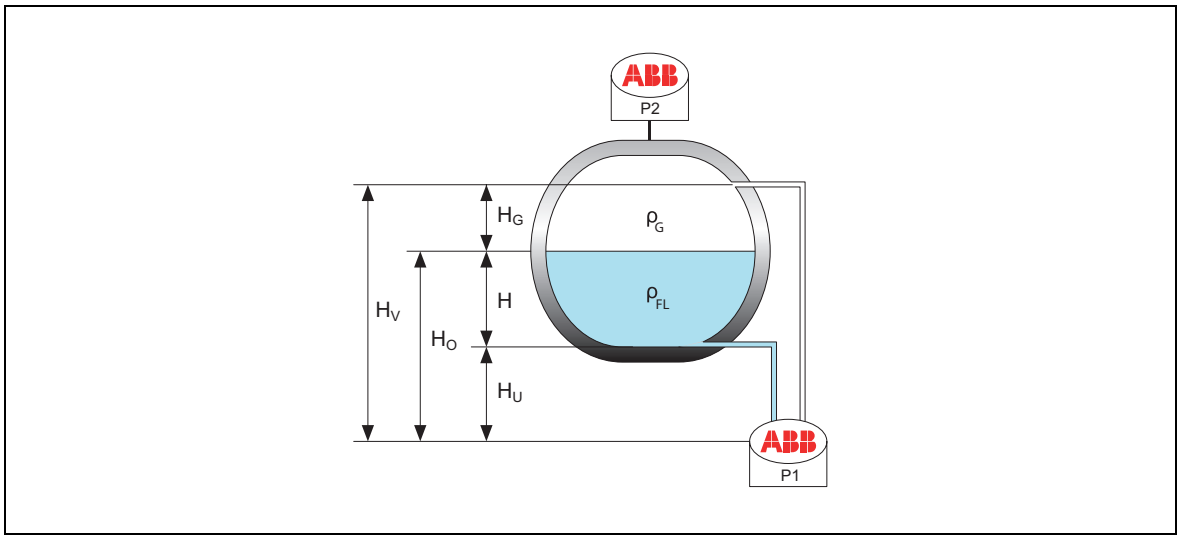

Fig. 3-1: Schematic diagram for level measurement in storage container

Given:

H	= 1.40 m	
H_O	= 2.70 m	
H_U	= 1.30 m	
H_V	= 3.90 m	
ρ_{FL}	= 930 kg/m³	(density of stored liquid)
ρ_G	= 1.25 kg/m³	(density of gas (N) above the stored liquid)
ρ_V	= 1.25 kg/m³	(density compensation side = density gas)
g	= 9,81 m/s²	(gravitational acceleration)
H	= 0 ... 1,40 m	(liquid level monitoring)

Required:

Start of measurement	P_U (at lower level H_U)
End of measurement	P_O (at upper level H_O)

Calculation:

Start of measurement:	$\Delta P_U = [H_U \times \rho_{FL} \times g + (H_V - H_U) \times \rho_G \times g] - H_V \times \rho_V \times g$
(4 mA)	ΔP_U = 11844 Pa = 118.44 mbar
End of measurement:	$\Delta P_O = [H_O \times \rho_{FL} \times g + (H_V - H_O) \times \rho_G \times g] - H_V \times \rho_V \times g]$
(20 mA)	ΔP_O = 24599 Pa = 245.99 mbar

Possible basic measurement range: 400 mbar => **Measuring span set to**: 118,44 … 245.99 mbar

Fig. 3-2: Example calculation

4 Level measurement on a steam boiler

Instrumentation

Water heats up if thermal energy is applied to water in a container. It boils if even more energy is applied, and then vaporization starts. This physical law is exploited to generate steam with a certain pressure in closed containers. The amount of energy required can be calculated with: Enthalpy of water plus vaporization heat at the respective pressure. The enthalpy is the difference between feed water temperature and boiling temperature multiplied by the specific heat and density.

Steam is required for many industrial applications. These include the chemical and pharmaceutical industry, the food industry for sterilization or heating, or for driving generator turbines in power plants, to name but a few.

All these applications require steam boilers the level of which needs to be measured.

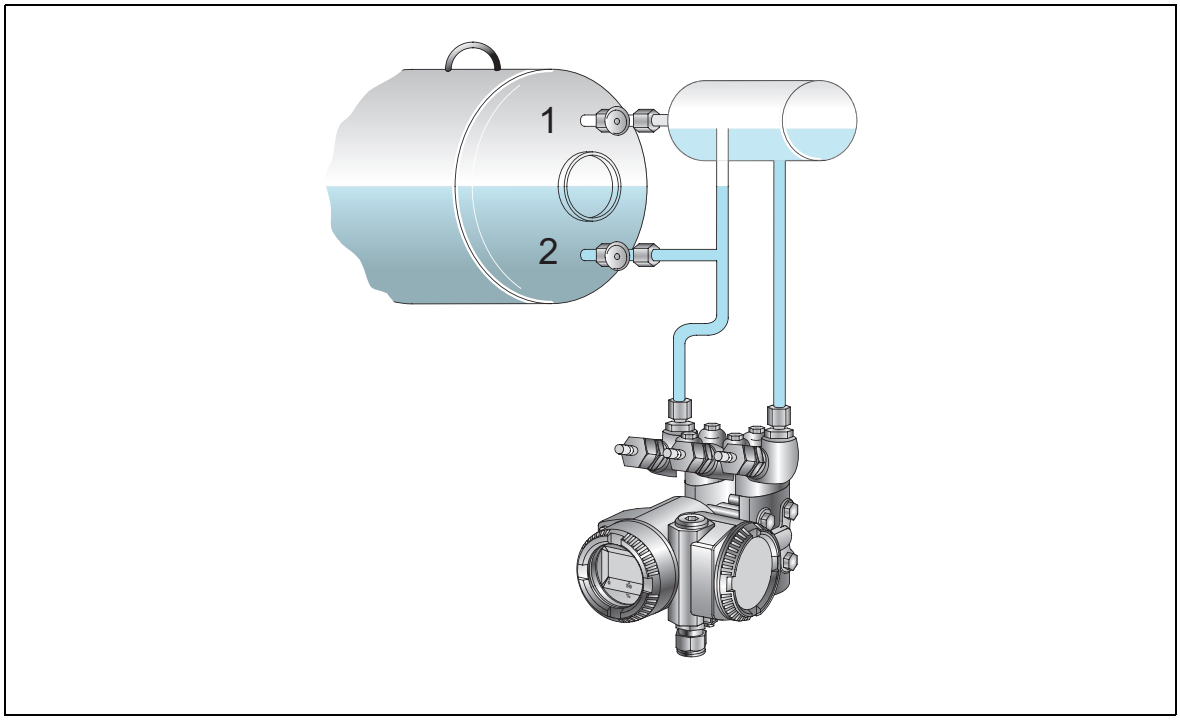

Fig. 4-1: Setup for level measurement on steam boiler

1 Steam
2 Liquid

As steam boilers are under pressure, a differential pressure transmitter, e.g. ABB type 265DS, must be selected here for level measurement to compensate for the excess pressure of the container.

As the steam temperature is usually higher than a transmitter can bear in terms of admissible process temperature, a precaution must be taken to prevent hot steam from penetrating the measuring instrument. In most cases, a precipitate bin /balancing bin is added to the measurement setup.

The balancing bin is used to make sure that the water receiver / water column at the “compensation side/negative side“ of the transmitter always is of constant height. This water receiver is a reliable temperature barrier. In the balancing bin, steam condensates to water and accumulates to a certain level. Excess precipitate will flow back to the container.

Fig. 4-1: Transmitter instrumentation with 5-fold valve combination and blowout pipes for steam measurement

For steam measurement, a 5-fold valve block combination is usually added before the transmitter, i.e. 3-fold valve block with 2 separate blowout valves. This separation of the blowout valves prevents hot steam from getting in contact with the transmitter and damaging it when blowing out the pipes.

Calculation of setting value

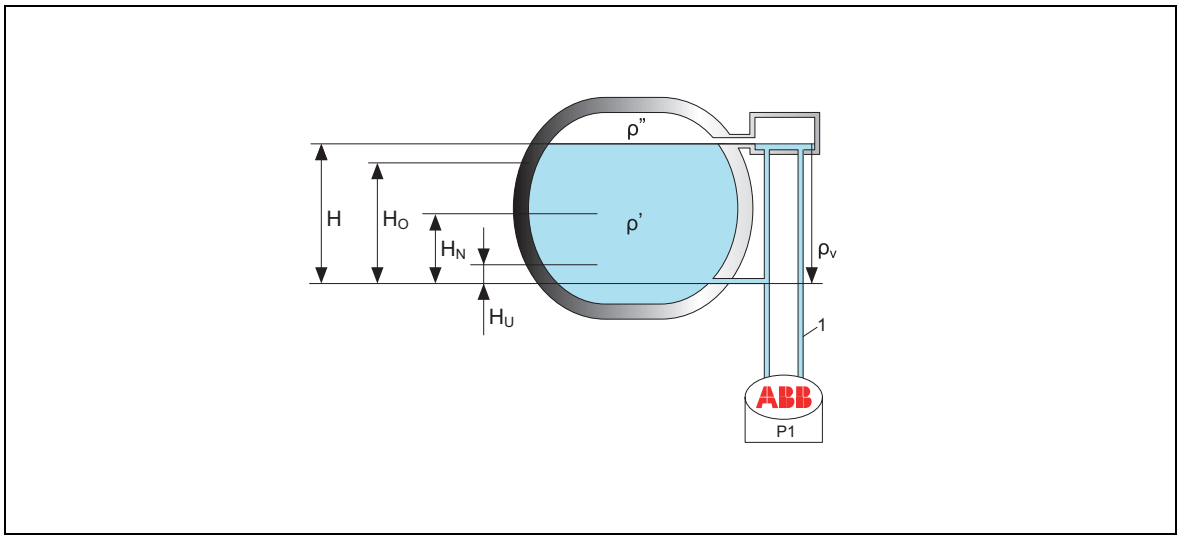

Fig. 4-2: Schematic diagram for level measurement in steam boiler

1 Comparison column

Given:

H	= 0.6 m	
H_O	= 0.5 m	
H_N	= 0.25 m	
H_U	= 0 m	
$H_{N\ (Normal)}$	= -0.25 ... 0 ... +0.25 m	(water level)
P_{abs}	= 75 bar	(operating pressure)
T	= 290.5 °C	(temperature of saturated steam)
t_V	= 50 °C	(temperature of comparison column)
g	= 9.81 m/s²	(gravitational acceleration)
ρ'	= 731.15 kg/m³	(water density from water steam table)
ρ''	= 39.48 kg/m³	(steam density from water steam table)
ρ_V	= 991.3 kg/m³	(density of comparison column from water steam table)

Required:

Start of measurement	ΔP_U (at lower level H_U)
End of measurement	ΔP_O (at higher level H_O)

Calculation:

Start of measurement:	$\Delta P_U = [H \times \rho_V \times g - [H_U \times \rho' \times g + (H - H_U) \times \rho'' \times g]$
(4 mA)	$\Delta P_U =$ 56.02 mbar
End of measurement:	$\Delta P_O = H \times \rho_V \times g - [H_O \times \rho' \times g + (H - H_O) \times \rho'' \times g]$
(20 mA)	$\Delta P_O =$ 22.1 mbar

possible basic measurement range: 60 mbar => **Measuring span to**: 56.02 … 22.1 mbar,
i. e. “falling characteristic curve“

Fig. 4-1: Example calculation

5 Features of the used components

	Instrumentation	
P1		**Transmitter for differential pressure 265DS** • High-performance transmitter for smallest to large measuring ranges • High turndown ratio up to 100:1 • High accuracy of characteristic curve: 0.04% • Flexible configuration options • Protection class IP 67 • Extremely reliable **Communication:** • HART / 4 ... 20 mA, PROFIBUS PA or FOUNDATION Fieldbus **Explosion protection:** • Intrinsically safe according to ATEX, FM • Flameproof enclosure according to ATEX, FM, CSA **Span limits:** • 0.05 ... 10000 kPa
P2		**Transmitter for overpressure 265GS** • High-performance transmitter with a large variety of measuring ranges • High turndown-ratio up to 100:1 • High accuracy of characteristic curve: 0.04% • Flexible configuration options • Protection class IP 67 **Communication:** • HART / 4 ... 20 mA, PROFIBUS PA or FOUNDATION Fieldbus **Explosion protection:** • Intrinsically safe according to ATEX, FM • Flameproof enclosure according to ATEX, FM, CSA **Span limits:** • 0.2 ... 6000 kPa

ABB has Sales & Customer Support expertise in over 100 countries worldwide.

www.abb.com/pressure

Printed in the Fed. Rep. of Germany (03.2008)

3KDE010022R3001

AG/265_101-EN

Germany
ABB Automation Products GmbH
Borsigstr. 2
63755 Alzenau
Tel: +49 551 905 534
Fax: +49 551 905 555

UK
ABB Limited
Oldends Lane
Stonehouse
Gloucestershire, GL10 3TA
Tel: +44 1453 826 661
Fax: +44 1453 829 671

Italy
ABB Sace S.p.A.
Via Statale 113
22016 Lenno (CO)
Tel: +39 0344 58111
Fax: +39 0344 56278

USA
ABB Inc.
Automation Technology Products
125 E. County Line Rd
Warminster PA 18974-4995
Tel: +1 215 674 6000
Fax: +1 215 674 7183

China
ABB (China) Ltd.
35th floor, Raffles City (Office Tower)
268 Xizang Zhong Lu
Shanghai, 200001
Tel: +86 (0) 21 6122 8888
Fax: +86 (0) 21 6122 8892