DT303 – Density Transmitter with Profibus PA Technology

1.Introduction

Many industrial processes need continuous density measurement to operate efficiently and guarantee quality and uniformity to the final product. This applies for sugar mills, beer plants, distilleries, dairy products, chemical and petrochemical industries, among others.

Several methods are used to measure the density of liquids, based on different technologies, such as: nuclear meters, refractometers, Coriolis principle, vibrant tuning fork, areometers, laboratory analysis, etc.

On the following items it will be presented the characteristics of a new transmitter for continuous density measurement and liquids concentration directly on the on-going processes.

Item **2.0** will present SMAR DT303 digital density and concentration transmitter , item **2.1** its work principle, item **2.2** ways for installation and mounting, item **2.3** calibration and startup details, item **2.4** operation and maintenance details.

Item **3** makes a comparison between DT303 and other available technologies for density measurement.

Item **4** lists down this transmitter some frequent applications

Item **5** shows the operational blocks diagram and **6**, how to configure it cyclically on the Profibus network.

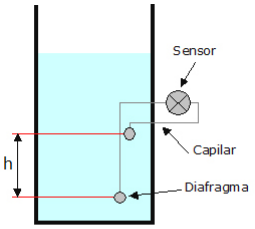
2. Digital Density Transmitter with PROFIBUS PA – DT303 Communication Protocol

The DT303 uses the principle of differential pressure measurement between two separate points on a fixed and known distance to calculate with accuracy the density and concentration of liquids.

2.1. Work principle

The equipment uses a capacitive differential pressure sensor that communicates through capillaries with diaphragms immersed in the process fluid, separated by a fixed distance.

The differential pressure on the capacitive sensor will be directly proportional to the density of the measured liquid (see figure and formulas). This differential pressure is not affected by the liquid variation or the internal tank pressure.



$$DP = h.g.\rho$$

$$\rho = \frac{DP}{h.g}$$

The DT303 density transmitter has a temperature sensor located between the diaphragms to correct and normalize the calculations taking the process temperature into account. Along with the process temperature it is also corrected the distance between the diaphragms and the variation of the filling fluid capillaries volume that transmit the diaphragms pressure to the capacitive sensor.

As the differential pressure sensor is a capacitive type he generates a digital signal. The further process signal is also emitted digitally and the measurement has high stability and accuracy.

The information generated by the sensor along with the process temperature, enables the electronic unit software to perform the density or concentration calculation and sends a digital signal related to the scale selected by the user (ºBrix, ºPlato, ºBaumé, g/cm**3**, etc.).

The same information can be accessed on the local digital indicator or remotely through the Profibus PA protocol.

The DT303 intelligent density transmitters offer an accuracy of ±0,0004 g/cm**3** (± 0,1 ºBrix), and can be used on density measurements from 0,5 b/cm3 to 5g/cm3.

This measuring method is immune to variations on the recipient level and can be used both in open and pressurized tanks. It is only mandatory that both diaphragms be in permanent contact with the process fluid.

Another important advantage is the transmitter robustness, as it does not have movable parts and is not affected by vibration on the plant, unlike density meters based on the oscillation of a sensor.

Moreover, the DT303 has three analog input blocks (AIs) that allow multivariable measurements: density, concentration and temperature.

2.2. Installation and mounting

Since the DT303 is a single and integrated unit, it is very simple to install and needs only one penetration in the recipient - a unique feature that distinguishes it from other systems.

This density transmitter line includes an industrial model with flange mounting (right photo) and a sanitary model connected with a tri-clamp (left photo).

The sanitary model probe that submerges in the process fluid has polished finishing, compliant to standard 3 A to prevent product deposit and the proliferation of bacteria.

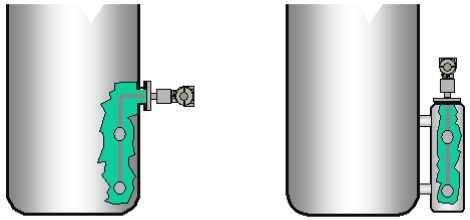
Both models can be mounted on the wall (in tanks) or on top (sampling recipients). As the digital indicator can rotate, the readout will be comfortable in any mounting position.

The DT302 can be mounted without plant shutdown and does not require any special laboratory calibration to start running: just power it and it will start up, as it is factory-calibrated on the user-selected measurement range.

2.2.1. Tank mounting

Generally, the curve model is the best for mounting in tanks. It is mounted on the tank wall, with a flanged or a tri-clamp connection.

When the transmitter cannot be installed directly in the tank an external sampling tank can be used (see figures below).



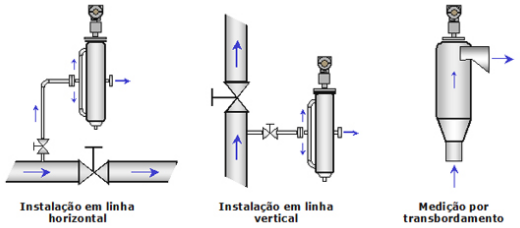
Side mounting

Top mounting

2.2.2. In-line mounting

In processes without recipients or storage tanks for measurements the DT303 can be installed intercalated in a sampling vessel where the process fluid circulates, as shown in the examples below (figures on left and center).

As the sampling vessel has simultaneous inlets on top and bottom, the measurement is not affected by the speed of the fluid circulation.



In-line horizontal installation **In-line vertical installation** **Overflow measurement**

Another mounting alternative is a sampling recipient with overflow discharge getting in through the bottom part and overflowing through the upper part (right figure).

The vessel is dimensioned so that the fixed liquid column that overflows entirely covers the transmitter repeating pressure diaphragms.

2.3. Calibration and startup

The DT303 is factory calibrated at the engineering unit and on the measurement range at user´s request and it begins working just after being installed and activated. In case of needing to be recalibrated or setting new work range it can be locally adjusted with a magnetic screwdriver, or remotely with the SMAR ProfibusView , Siemens Simatic PDM, or any tool based on the FDT/DTM like SMAR AssetView. These procedures can be applied without process halt. As the density and temperature calculation is done in the same unit there is no need for other data besides the density or concentration range that will be used.

A fundamental characteristics in this transmitter is that it does not require laboratory calibration.

The units available for density and concentration measurement are g/cm³, kg/m³, lbm/ft³, ºBrix, ºBaumé, ºPlato, ºAPI, ºINPM, ºGL. In addition, the output unit can be configured in solids percentage and concentration percentage, and one of the following options should be used:

- a polynomium of the 5th degree with configurable coefficient to obtain the correlation between the user unit function and the density;
- a 16-point table with two inputs to carry out a function linearization that relates the user unit with the density.

By enabling any of them, the density and concentration transmitter will measure primarily the density while the local indication and digital output will follow the function loaded in the polynomium or in the table.

2.4. Operation and maintenance

The DT303 density transmitter provides the direct indication in engineering units for the liquid density value, as well as its temperature, both in the local indicator and the digital communication.

This transmitter was designed to process polluted fluids without needing to be filtered. The diaphragm project reduces greatly the deposit of product residues on it, which avoids the equipment periodical cleaning.

The sanitary model was meant to work with CIP cleaning systems, ensuring that all transmitter parts in contact with the process be reached by the CIP system cleaning

fluid.

3. DT303, digital density and concentration transmitter compared to other technologies

The DT303 has multiple advantages over other types of density transmitters. An accuracy of 0,0004 g/cm³ is obtained in comparison to 0,05 – 0,001 g/cm³ of other Technologies, which allows more uniformity and quality to the final product, in addition to additives and energy savings, in many cases. Another big advantage is easy mechanical and electrical installation.

Besides, the DT303 has three Analog Input blocks – AIs, that enables multivariable measurements: density, concentration and temperature.

4. Applications

The DT303 versatility allows the user to utilize the best measuring unit according to the process. The transmitter indications are expressed in density units like: g/cm3, kg/m3 , lbm/ft3 , relative density (@20ºC, @4ºC) or concentration (ºBrix, ºBaumé, ºPlato, ºAPI, ºINPM, ºGL, % of solids, % of concentration).

The exchange of a measurement unit for another does not require recalibrating the transmitter.

Some frequent applications are:

Oil refinaries :

- Vegetable oils,
- Miscela Extraction.

Sugar and ethanol mills:

- Must and honey Brix Degree,
- Syrup Brix Degree, beteen effects ando n the last evaporation stage,
- Decanter mud density,
- Hydrated and anhydrous alcohol
- Lime mil Baumé degree.

Food industries:

- Pre-condensed milk density,
- Starch dilution,
- Heavy water density,
- Honeys, jams, gelatines.

Beverage Industries:

- Beer fermentation Plato Degree
- Beer cookers Plato Degree,
- Sugar cane liquor degree,
- Syrup dilution Brix Degree,
- Fruit juice concentration/dilution,
- Soft drinks, soluble coffee, wine, malt, tequila.

Chemical and petrochemical:

- Water/oil interface in treating and separator tanks,
- Crude oil and lubricants density,
- Gas, diesel oil, kerosene, GLP density,
- Gases washing water,
- Acids concentration and dilution,
- Caustic soda concentration,
- Lime Milk dilution.

Pulp and Paper Industry:

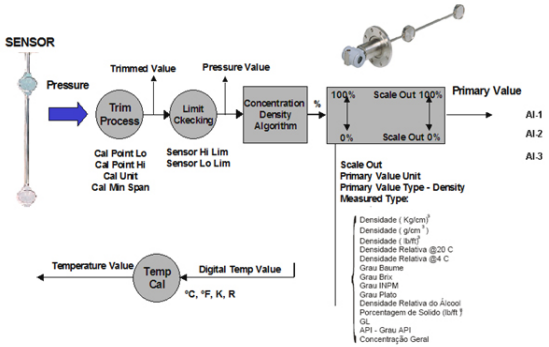
- Green, black, white liqueur concentration,
- Lime mud density,
- Caustic soda concentration,
- Starch dilution,
- Talc, ashes dilution,
- Paint concentration.

Mining and steel industries:

- Orepulp density,
- Fine coal recovery ,
- Flotation cells, scrapers,
- Mud and lixivium extraction,
- Acids dilution,
- Steel plates stripping.

5. Block diagram

The figure below exemplifies the DT303 functional block diagram, according the V3 Profile. The DT303 has an Analog Input block where are cyclically exchanged the density/concentration and temperature values for the Profibus class 1 master.



The DT303 gsd file and DDs can be requested free of cost on the site: www.smar.com.br

Watch the video on the DT303 transmitter at:http://www.smar.com/brasil2/products/dt303.asp

6. How to configure the DT303 cyclically

Both PROFIBUS-DP and PROFIBUS-PA include protocol mechanisms against communication failures and errors, and checks several sources of problems during startup. After power up the field equipment (the slaves) are ready for exchanging data

with the class 1 master, but, to achieve it the master parameterization for that slave must be correct. This information is got through GSD files, which must be one for each device.

The master executes through the commands below the entire initialization process with PROFIBUS-PA equipment:

- Get_Cfg: loads the slave configuration and checks the network configuration;
- Set_Prm: writes in slave parameters and executes parameterization services on the network;
- Set_Cfg: configures the slaves according to the inputs and outputs;
- Get_Cfg: a second command where the master will check the slave configuration.

All these service are based on the information got in the slave GSD files.

The DT303 GSD file brings details on hardware and software revision, bus timing and information on the exchange of cyclical data:

- 1st AI Block: available to configure the concentration units;
- 2nd AI Block: available to configure the density units;
- 3rd AI Block: available to configure the temperature units.

Most PROFIBUS configuration tools use two directories which show the GSD and bitmap files from different manufacturers. GSD and bitmap for SMAR equipment can be ordered via internet at the site: www.smar.com.br.

See next a typical example of the necessary steps to integrate the DT303 equipment on a PA system, one that can be extended to any equipment:

- Copy the DT303 GDS file on the PROFIBUS configurator research directory, normally called GSD.
- Copy the DT303 bitmap file on the PROFIBUS configurator research directory, normally called BMP.
- As long as the master is selected, the following rates can be chosen, when having couplers: 45.45 kbits/s (Siemens), 93.75 kbits/s (P+F) and 12Mbits/s (P+F, SK3). When the link device is IM157, up to 12Mbits/s can be reached.

Add the DT303 with its address specified on the bus.

- Choose a cyclical configuration via parameterization with the GSD file, depending on the application, as seen earlier. For the AI Blocks, the DT303 provides the master with the value of the process variable in 5 bytes, whose four first ones are in floating point format and the fifth byte is the status that shows the information on the measurement quality.
- The watchdog condition also can be activated and after detecting the loss of communication between the slave and the master equipment, the equipment can enter a fail-safe condition.

7. Conclusion

The SMAR DT303 digital density and concentration transmitter for hydrostatic pressure differential insertion that can be used on industrial process monitoring and control provides high precision on real-time feedback on density and concentration of liquids.

References:

- Mecatrônica Atual Magazine, Edition 46, Minimizing Noises in PROFIBUS Installations, César Cassiolato, 2010.

Related links:

- SMAR technical article list at:http://www.smar.com/brasil2/artigostecnicos
- PROFIBUS blog:http://www.smar.com/blog-profibus
- César Cassionato twitter: http://www.twitter.com/cesarcassiolato