Theory of operation

RONAN Non-Contact DENSITY Measuring SYSTEM

The Ronan non-contact density measuring system uses low level gamma radiation to measure the density of a process material in a pipe or vessel.

Principles of Operation A low level gamma source emits an energy beam through the pipe and its process material on the surface of the detector. The amount of radiation transmitted is inversely related to the density or mass of the material present. The output of the radiation detector is calibrated to provide a zero and full-scale reading corresponding to the low and high values of the property being measure. Thus, a continuous measurement is made without contacting the process. Outputs can be defined in specific gravity, density, percent solids or percent acid.

Slurry Density and Solids Content When the main purpose of a *density* gage is for *% solids* measurement, it is important to know whether it is a *solution* or *mixture.* The difference in *mixture* or *solution* is defined as:

Solutions

$$D_T = \frac{1}{K_S} \quad (D_T - D_L) \quad \frac{D_S}{(D_S - \propto D_L)}$$

Where:

- $\propto$ = Solubility factor
- K_S = Mass fraction of solids
- D_T = Total slurry density
- D_L = Liquid carrier density
- D_S = Solids density

Mixtures

$$D_T = \frac{1}{K_S} \quad (D_T - D_L) \quad \frac{D_S}{(D_S - D_L)}$$

Note that for the same slurry density, D_T, the difference between the solids mass fraction for solutions and the solids mass fraction for mixtures is given by:

$$K_S = \frac{(D_S - D_L)}{(D_S - \propto D_L)} K_S$$

Radiation Absorption Theory The equation for radiation absorption for the Ronan density gages depends upon the pipe internal diameter, the solids density, and the chemistry of the solids. It also depends upon whether the liquid is water or brine. Most slurries are *water slurries.*

Water and solids do not have the same absorption characteristics. Water contains 11% hydrogen and has higher absorption coefficients than metallic ores. Hydrocarbon products may have higher radiation absorptivity than water. The absorption coefficient is related to the Z/A ratio (molecular charge/weight).

The radiation absorption curve is defined by:

$R = R_o \cdot e\text{-}\mu_T t D_T$ Where:

- R_o = Radiation received at detector for an empty pipe (D_T=o)
- t = Pipe internal diameter
- D_T = Slurry density
- μ_T = Absorption coefficient of the slurry

For the water slurry: $\mu_T = K_S\mu_S + (1\text{-}K_S)\,\mu_W$ Where:

- μ_S = Absorption coefficient of solids alone
- μ_W = Absorption coefficient of water

For most materials; $\mu_S = 0.91\mu_W$

Therefore, equation becomes: $\mu_T = (1\text{-}0.09K_S)\,\mu_W$

Performance Specifications

- Repeatability: ± 1% of recommended minimum span
- Accuracy: ± 1% of recommended minimum span with adequate side-stream sampling
- Electronic Drift: 0.1% Maximum
- Minimum Recommended Spans

Advantages

- Noncontact measurement. The sensor does not touch vessel or contents. No effect on material measured.
- Adaptive. Easy to install, mounts to existing pipe.
- On stream – continuous. Replaces time consuming side stream sampling.
- High repeatability, reliability and stability. Measurement precision to 200ppm or 0.02% resulting from improved sensor and electronics technology.
- Ruggedized for industrial environments.
- Low maintenance.
- Accuracy. Comparable to side stream sampling.
- Measurement not affected by process flow, viscosity or temperature.

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Some process conditions may introduce difficulties for the Ronan density gage.

Air Inclusion. The Ronan density gauge detects the total density of all materials including any air bubbles. If the measurement is to include the amount of air or gas in a fixed density material (such as, aerated food products), the sensor will measure this accurately. In cases where only the solution or slurry densities are to be measured, care should be taken to eliminate air bubbles at the measurement point. (locating the gauge at the inlet of a pump will eliminate air inclusion due to leaky seal or cavitation.)

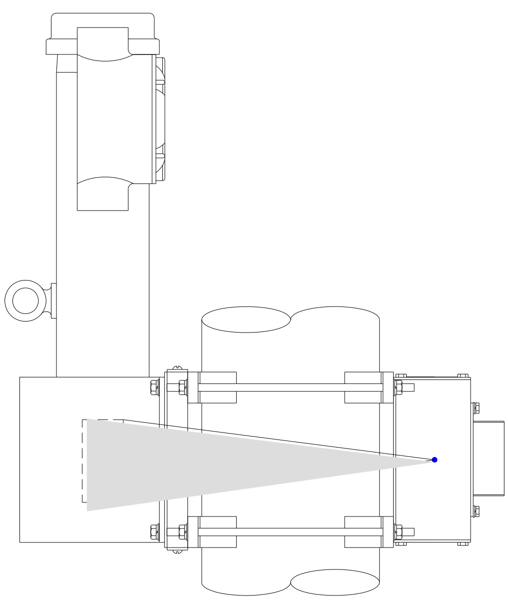
Wall Buildup. The Ronan density gauge will detect changing product wall buildup. Locating the sensor on high velocity or turbulent flow lines will normally reduce this problem. If buildup is evident, a provision may be made for flushing residue by placing the sensor on a by-pass. Using glass, teflon or other lining may also eliminate the problem.

Wall Wear. Changes in wall thickness may cause a measurement offset since the density of the pipe materials is usually greater than the measured product. Using corrosion or abrasion resistant material will help. System referencing will eliminate this effect.

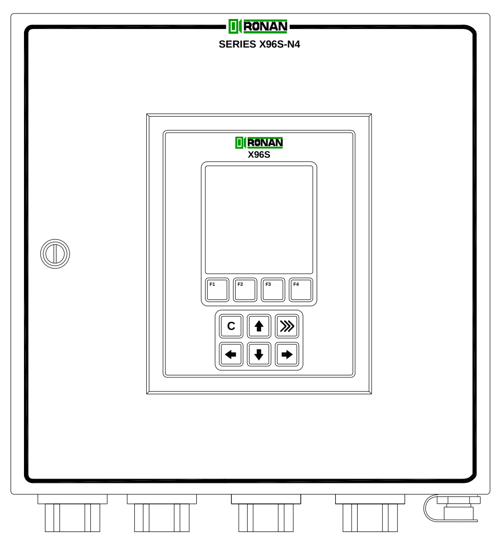
Stratification. Under certain conditions, slurries flowing in horizontal or inclined pipes may tend to settle out. To eliminate this possibility, the sensor should be mounted on a vertical pipe where the flow is upward. If this is not possible, the centerline of the sensor should be mounted on a vertical line through the pipe.

Line Vibration. If vibration changes the measurement enough to affect gauge operation, welding the pipe saddle to the line can usually eliminate the problem.

Hot Pipes. When the pipe temperature exceeds 300º F, insulation should be provided to prevent detector overheating. When insulation is used, care must be taken to maintain rigid geometry; the sensor must not move with respect to the pipe.



Ronan Low Level Density Gauge



X96S Microprocessor

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