

# Solartron density transducers for hydrocarbon and process applications

IP7003

## Gas density and gas specific gravity

- ▶ High accuracy and resolution
- ▶ Continuous measurement
- ▶ Fast response
- ▶ Intrinsically safe
- ▶ Long term stability
- ▶ Custody transfer approved

Solartron Mobrey's gas density and gas specific gravity transducers are designed to meet the requirements of gas metering stations for custody transfer, fiscal metering, quality analysis and energy management.

## Liquid density

- ▶ Continuous high accuracy measurement
- ▶ Custody transfer approved
- ▶ 316L, Hastelloy and Ni-span C versions
- ▶ Insertion and by-pass models available
- ▶ Entrained gas option

High accuracy, repeatability and stability are the hallmarks of Solartron Mobrey's field proven liquid density transducers. These densitometers are the industry standard for high accuracy applications

## Advanced density system

- ▶ Direct analog and digital outputs
- ▶ Modular design
- ▶ Local display
- ▶ Comprehensive calculations
- ▶ Diagnostics
- ▶ Intrinsically safe

The advanced density system is a state of the art on-board electronics package designed to interface with Solartron Mobreys range of tube densitometers.



## On-line liquid density measurement solutions...



The Solartron Mobrey's field proven range of densitometers have been designed to meet the most demanding applications found in modern processing plants. These meters have long been recognised as the **industry standard**.

Where the high accuracy of the 7835 series is not required the 7826/8 Insertion Densitometer provides the ideal solution. This unit can be mounted either in a static tank or in a pipeline.

All Solartron densitometers are available with a choice of flange and material of construction. This allows them to be used in a broad range of process liquids ensuring that Solartron has the answer to your metering and control requirements.

### Corrosive Applications

For corrosive applications where AISI 316L stainless steel is not suitable, the **7846** offers wetted parts in Hastelloy C22.

### Hygienic Applications

Solartron densitometers are widely used in the food industry for the monitoring and control of foodstuffs, for example, milk and yogurt. The 3A-authorized, all stainless steel **7847** with special bellows make it an ideal solution. Various sanitary fittings are available for the transducer.

### Insertion Densitometer

The **7826/8** Insertion Densitometer has been developed for applications requiring liquid density measurement in pipelines or static tanks.

The **7826/8** consists of a tuning fork arrangement with the tines mounted from a flange, which in turn supports the electronics housing. The transducer is available in a range of flange options, including a 3A authorised unit. An integral 4-20mA version, the 7828 is available.

### Fiscal Metering

The **7835** is designed for fiscal metering of crude and refined hydrocarbons and non-corrosive process liquids. This transducer offers the highest accuracy with excellent repeatability under pipeline operating conditions. The vibrating element is manufactured from Ni-Span-C for excellent long term and temperature stability.

### General Process

Suitable for most general process applications, the 7845 is manufactured with all wetted parts in AISI 316L stainless steel. typical applications are:

- ▶ Percentage mass, percentage volume and specific gravity of fluids or fluid/fluid fluid/solid mixes.
- ▶ Caustic soda blending. Concentrated product delivered by road tanker is diluted with water for on-site storage.
- ▶ Energy conservation in whisky distilling. Used to monitor the alcohol content and shut off heat source when the value of the alcohol falls near the cost of the energy consumed.
- ▶ In the sugar industry for controlling degrees Brix.
- ▶ Interface detection.
- ▶ Blending control.

## Principles of operation

All Solartron Mobrey liquid density transducers operate on the same general principle and can be likened to that of a spring mass system. As the product density changes it in turn changes the vibrating mass, which is then detected by a change in the resonant frequency. When a mass on a spring is displaced and released it will oscillate at a natural frequency until it comes to a rest due to viscous damping. An oscillation at the natural frequency may be maintained by supplying a driving force to overcome the effects of damping.

The resonant frequency can be derived as:

$$f = \frac{1}{2\pi} \sqrt{\frac{K}{M}}$$

Where: K is the stiffness. M is the mass of the element ( $M_1$ ) plus the mass of the fluid ( $M_2$ ).

If K and  $M_1$  are all constant then:

$$\text{Hence } \rho = K_0 + \frac{K_2}{f^2}$$

$$\rho = K_0 + K_2 \tau^2$$

The equation is further enhanced by the addition of a  $K_1$  term to improve linearity and therefore the final equation becomes:

$$\rho = K_0 + K_1 \tau + K_2 \tau^2$$

### Calibration

Solartron transducers undergo rigorous factory calibration on three fluids: air, oil and a high density fluid (non CFC). Initially the units are pressure tested to 1.5 times the operating pressure. With oil the rig is first varied in temperature to determine the temperature coefficient of the transducer and then varied in pressure to determine the pressure coefficient.

To ensure that the production units are accurately calibrated to a high integrity the calibration rigs have two integral transfer standards. The density readings from these standards must agree within certain limits, thus ensuring that the rig has stabilised. Once stabilisation is achieved readings of periodic time from each of the production units can be taken on oil and the high density fluid. From these results and with results from an air calibration, the final calibration of the transducer is calculated.

The transfer standard transducers are calibrated in an in-house United Kingdom Accreditation Service (UKAS) approved laboratory on three fluids. The density of each calibration liquid is determined by displacement methods to an uncertainty of 50ppm. A number of meters from each batch are overchecked in this laboratory to verify the accuracy of the calibration.

The factory calibration datum is 20°C and 1 bar absolute. When operating at other conditions it is necessary to increase the uncertainty of measurement. The overall accuracy is the RMS error of the below error sources. For example at 40°C and 30 bar, 7835 accuracy = +/-0.25 Kg/m<sup>3</sup>, 7845 = +/-1.07Kg/m<sup>3</sup>.

Error sources	7835	7845
Primary standard	0.05Kg/m <sup>3</sup>	0.05Kg/m <sup>3</sup>
Transfer standard	0.1Kg/m <sup>3</sup>	0.1Kg/m <sup>3</sup>
Instrument accuracy (at calibration conditions)	0.15Kg/m <sup>3</sup>	0.35Kg/m <sup>3</sup>
Temperature coefficient	+/-0.005Kg/m <sup>3</sup> /°C	+/-0.05
Pressure effect	+/-0.006Kg/m <sup>3</sup> /bar	+/-0.006



## Advanced density system



The Advanced Density System (ADS) is a state of the art electronics package designed to interface with the Solartron Mobrey 7835/45/46/47 range of tube densitometers.

Located in the head of the transducer the ADS has been designed as a modular system which allows additional functionality to be added as required. The transducer can be interfaced DIRECTLY to a DCS, PID controller or other plant processing equipment via the digital communications link or via the 4-20mA outputs. In the majority of cases there is no need for additional electronics, since most standard calculations are performed within the unit thus providing a very cost effective solution.

The transducer leaves the factory with all calibration factors and initial configuration stored in EPROM on the meter. This means that from initial power up the transducer provides an accurate output of line density and temperature, without the need for extensive programming. The only additional configuration which may be required is the optimisation of the outputs to suit the particular application.

### Measurement and calculated data

All Solartron Mobrey liquid density transducers measure two prime parameters, line density and temperature.

From these two prime measurements the ADS can perform a number of calculations, for example:

- ▶ Referred density (matrix & API)
- ▶ °API
- ▶ % Volume
- ▶ °Baume
- ▶ % Mass
- ▶ °Brix
- ▶ Specific gravity

### Outputs

The base board provides four separate outputs:

- ▶ Two 4-20mA outputs, which can be configured to output any measured or calculated data.
- ▶ One pulse output which provides either tube resonant frequency or an alarm status.
- ▶ One RS485 digital communications link normally for use with the remote display.

The RS232/RS485 and the HART board provide additional digital communications capabilities. If desired the HART board can be used purely as a third 4-20mA output.

### Baseboard

The baseboard is the heart of the system, utilising a high performance low power microcontroller to:

- ▶ Perform the complex calculations previously performed in a separate flow computer or signal converter.
- ▶ Store all the transducer's calibration data, significantly reducing the level of customer programming.

- ▶ Ensure that the transducer is operating correctly, providing several diagnostic facilities for the service engineer.
  - ▶ Facilitate digital communications with the remote display or other computer systems (e.g. PC, PLC or DCS).
  - ▶ Provide two direct analog outputs.
- The baseboard along with the liquid density transducer provides a complete system for measuring liquid density and temperature. However, if outputs need to be configured in the field or if additional functionality is required then a remote display or option board may be used.

### Remote display/keypad

This unit is intended for either hand held or wall mounted use. It provides a convenient means for displaying calculated data and for configuring or analysing the system setup. The display can be operated up to 100 meters away from the transducer and communicates with the baseboard via an RS485 digital communications link. The display is of an intrinsically safe design and can therefore be mounted in the hazardous area.

### Option boards

Three option boards are available for fitting to the baseboard:

- ▶ Switch board - Providing a low cost means of configuring the system, and offers some flexibility on system functionality.
- ▶ HART board - Providing full HART communications and an additional 4-20mA output and full systems functionality.
- ▶ RS232/RS485 board - Providing additional serial communication capabilities and full system functionality.

## Gas density and SG measurement

Solartron gas density meters have been serving the hydrocarbon industry in custody transfer of natural gas for over two decades. The 7812 gas densitometer is the latest in the range and replaces both the 7810 and 7811 meters.

### 7812 Densitometer

The Solartron 7812 gas density transducer is designed to meet the requirements of custody transfer metering stations by combining high performance with safety. The sensor is designed for insertion mounting into the gas flow path, either directly or in a thermowell pocket, but with the gas sample brought to the instrument via a sample loop. This instrument satisfies the requirements of on-line density measurement as in ISO 5167 and AGA 3.

The pressure retaining parts of the 7812 gas density transducer are manufactured for NACE compatible materials. The transducer is approved by CENELEC for use in all categories of hazardous area.

### Principle of operation

The transducer sensing element consists of a thin-walled metal cylinder, resonating at its natural frequency. The gas flows over both surfaces of the cylinder and the mass of gas in contact with the cylinder depends on the gas density. Since increasing the mass decreases the natural frequency of vibration, the gas density can be determined by measuring the resonant frequency.

### 3098 Specific gravity transducer

The Solartron 3098 Gas Specific Gravity transducer provides a direct on-line measurement of gas specific gravity or normal density for custody transfer, standard volume flow determination, quality analysis and energy management. The 3098 is most frequently applied in deriving standard volume and energy flow measurements of natural gas, where the exceptional accuracy and repeatability are of direct benefit.

### 3098 Principle of operation

The 3098 consists of a vibrating element gas density transducer surrounded by a constant volume reference chamber retaining a fixed quantity of gas known as the reference gas.

The reference gas pressure acts through a separator diaphragm on the pressure control valve chamber so that the gas pressure on both sides of the diaphragm is equal. Temperature equalisation is achieved by temperature stabiliser coils and a thermal insulation cover.

### The basic theory

The specific gravity (G) of a gas is the ratio of its molecular weight (M) to that of standard air. However, under set temperature (T) and pressure (P) conditions, with the super-compressibility factors (Z) taken into consideration, specific gravity and relative density are synonymous. The density of the sample gas ( $\rho$ ) by definition is:

$$\rho_1 = \frac{PM_1}{Z_1RT}$$

And since a fixed quantity of reference gas is contained in a constant volume, then:

$$\frac{\rho_2}{M_2} = \frac{P}{Z_2RT} = K$$

Under equalised pressure and temperature:

$$\rho_1 = KM_1 \frac{Z_2}{Z_1} = KM_1$$

Thus the output signal from the density transducer is a measurement of the molecular weight or specific gravity of the sample gas.



## Technical specification

Liquid Density	7826	7835	7845	7846	7847
Wetted parts material	SS 316L Hastelloy C22	NiSpan C	SS 316L	Hastelloy C22	SS 316L
Density accuracy	0.001 g/cc	0.00015* g/cc	0.00035* g/cc	0.00035* g/cc	0.00035* g/cc
Density repeatability	0.0001 g/cc	0.00002 g/cc	0.0001 g/cc	0.0001 g/cc	0.0001 g/cc
Density range	0-3 g/cc	0-3 g/cc	0-3 g/cc	0-3 g/cc	0-3 g/cc
Calibrated density range	0.3-1.1 g/cc	0.3-1.1 g/cc	0.6-1.6 g/cc	0.6-1.6 g/cc	0.6-1.6 g/cc
Operating pressure (max)	207 bar (3000 psi)	150 bar (2175 psi)	100 bar (1450)psi	50 bar (725 psi)	20bar (290 psi)
Pressure coefficient	negligible	+/- 0.000006 g/cc/bar			
Temperature range	-50°C to 160°C (-58°F to 320°F)	-50°C to +110°C (-58°F to +230°F)			
		-50°C to +160°C (-58°F to +320°F) high temp kit			
Density temp. coefficient	+/- 0.0001 g/cc/°C	+/- 0.000005g/cc/°C	+/- 0.00005 g/cc/°C		
Safety approval	EExd IICT4. CSA	EEx ia IIC T6, CSA			
Power supply	24-27VDC, 50mA	16 to 28 VDC at 25mA max			

\* 0.0001 available with additional calibration

Liquid Density	Advanced Density System
Transducer performance	As above
Analog outputs	
Number	2 (+1 with HART option board)
Accuracy	+/- 0.1% of reading plus 0.05% of full scale
Repeatability	+/- 0.025%
Out of range capability	2-22mA on 4-20mA (programmable alarm scale)
Pulse output	Open collector output, alarm status or frequency
Communication options	HART, RS232, RS422, RS485, Modbus
Configuration options	Remote display/keyboard, switchboard, via communications protocol
Calculations	Line density, line temperature, Base density, °API, °Brix, °Baume, % solids, % mass, % volume, specific gravity
Safety approval	EEx ia IIC T4. Class 1, Division 1, Groups B, C, D
EMC approval	Emissions: BS EN 50081-2: 1994 Heavy industrial environment Immunity: BS EN 50082-2: 1995 Heavy industrial environment

Gas Density/ Specific Gravity	7812	3098
Density accuracy	+/- 0.1% reading (Nitrogen) +/- 0.15% reading (Natural Gas)	+/- 0.1%
Density repeatability	+/- 0.01% reading	+/- 0.02%
Density range	0-0.4 g/cc	N/A
Specific gravity range	N/A	unlimited
Operating pressure (max)	250 bar (2625 psi)	Regulator used to set input pressure
Temperature range	-20°C to +85°C (-4°F to +185°F)	-30°C to +50°C (-22°F to +122°F)
Process connection	1/4" NPT (API) female	1/4" compression fitting (6mm) pipe



## Signal Converters

The 795x Series of Signal Converters are designed as easy-to-use units which will process signals from Solartron density or viscosity transducers along with live inputs of temperature and pressure. Calculations within the converter include transducer correction and calculation of line or referred density and viscosity, °API, °Baume, calorific value, Wobbe Index etc.



Model		7950	7951	Option
<b>Mounting:</b>		<b>Wall</b>	<b>Panel</b>	
<b>Inputs</b>	Density:	1	1	
	Temperature (PRT 4-wire):	4	4	
	Analogue (0/4-20mA):	4	4	+4/+6
	Digital/status:	8	8 or 18	
<b>Outputs</b>	Analogue (0/4-20mA):	4	4	+4
	Digital/status:	8	8 or 16	
<b>Comms.</b>	RS232/RS485:	3	3	+2 HART
<b>Calculations</b>	Line and Base density (API or Matrix referral) Derived parameters (%volume, %mass, °Brix, °API, S.G., S.S.U.)			

**Full details of all these products are contained in the brochures listed below:**

Product	Brochure No:
7835 Advanced Densitometer	B1026
7845/46/47 Advanced Densitometer	B1024
Entrained Gas Densitometer	B1018
7826 Densitometer	B1019
Gas Density and Gas Specific Products	B1253
795x Series Flow Computers for Gas Applications	B1248
795x Series Flow Computers for Oil Applications	B1249
795x Signal Converters	B1251

Solartron Mobrey has a worldwide network of distributors in 66 countries:



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