Technical Notes
NIST Traceable Calibration and Performance Specifications for Target Meter

THEORY OF TARGET METER OPERATION

The Target Meter provides flow measurement by sensing the fluid force acting on the target that is suspended in the flow stream. The following equation describes the operation of the strain gage target flow meter:

$$\textbf{Force} = Cd\ A\ \rho\ (V^2/2g)$$

Where:
Cd = Overall drag coefficient obtained from empirical data
A = Target area
ρ = Fluid density
V = Fluid velocity at the point of measurement
g = Gravity

In a given flow application, the drag coefficient, target area, and gravitational force will be constant. The flow meter actually measures the following:

Fluid density x fluid velocity^2

Flow is equal to the square root of the force acting on the target area. The Model 2010 Transmitter amplifies the output signal, extracts the square root, and produces a linear analog (4-20ma) output with HART communication for the corresponding flow rate.

The transducer that converts the mechanical force (flow) into an electrical signal consists of a strain gage bridge circuit. Four strain gages are attached to a sensing tube. Two of the gages are located on the leading side of flow, and the other two strain gages are located on the trailing side of flow. The strain gages are inter-connected, forming a strain gage bridge circuit. At zero flow (no force on the target), the bridge circuit is balanced, producing zero output.

Flow produces a strain on the sensing tube, compressing the leading side strain gages and tensing the trailing side strain gages. This mechanical change causes the leading and trailing gage resistance values to decrease and increase respectively. The change in resistance of the strain gages offsets the bridge circuit, and produces an electrical output.

The target area size determines the calibration and range of the flow meter. For each Target Meter, the application flow parameters (internal pipe diameter, fluid or media, operating temperature, operating pressure, and the flow range) are required to determine the amount of stress applied to the sensing tube at full-scale flow. The force required at the full scale flow then determines the target size. Proprietary software and algorithms were developed to determine the selection of the sensing tube as well as the target size. The correct selection based on the flow parameters allows the performance of the Target Meter to be accurate within 0.5% of full scale flow or 1.0% of rate, and to be repeatable within 0.15% of the rate of flow.

CALIBRATION

Every Target Meter undergoes a calibration procedure to verify the performance characteristics of the meter. All fluid flow applications can be mathematically converted to a water flow equivalent which represents the same force as the actual fluid application allowing water to be used as the primary calibration media. The following applications all exert the same force on the target, producing the same bridge output:

FLUID	SIZE	FLOW RATE	PSIG	TEMP (F)
Saturated Steam	3”	3460 PPH	120	+350
Air	3”	1080 SCFM	100	+70
Water	3”	100 GPM	75	+45
Liquid Nitrogen	3”	750 PPM	20	-300

For inline meters, the force of the water flow within the NIST traceable flow test stand simulates the actual conditions that the Target Meter will be manufactured to as specified on the application data sheet. For probe meters, NIST traceable weights simulate the actual conditions that the Target Meter will be manufactured to as specified to on the application data sheet.

INLINE TARGET METER

Inline Target Meter undergo a reference calibration with water to determine the actual performance specifications of the particular Target Meter under test. A calibrated flow stand, with NIST traceability to the master load cells, validates the calibration and performance of the meter under test. The flow validation consists of five discrete flow tests with each flow test selectively spaced across the selected flow range. Each flow test approximates to 5%, 25%, 50%, 75% and 100% of the full scale flow for the meter under test. Each meter is tested with water at a corresponding weight of 8.3264 lb/gal and tested under standard temperature and pressure conditions and for a specified period of time. This water flow equivalent replicates the amount of force for the actual fluid application. Data logging software captures the output from both the flow meter under test as well as the master load cell. A comparison is then made between the master load cell and the flow meter under test at each of the five calibration points. Based on the criteria of 0.5% Full Scale Flow or 1.0% of Rate, the determination is made for the accuracy of the meter to be either within specifications or out of specifications.

PROBE TARGET METER

Each Probe Target Meter has a unique Force Factor that measures the meter sensitivity. The Force Factor is the millivolt per volt electrical output of the Target Meter with 1000 grams suspended from the target. Each Probe Target Meter has the full scale electrical output either at one millivolt per volt or two millivolts per volt. The signal output from the bridge circuit is linear to the amount of force that is applied to the transducer. As an example, if the Force Factor is 1.000 mV/V then the full scale output will be at 2.000 mV/V, and this will be confirmed by suspending 2000 grams from the target.

Once the Force Factor is determined for the Target Meter, the meter goes through a five point force test that is selectively spaced across the given flow range. The performance test utilizes NIST traceable weights to replicate the force generated in the process flow stream by the fluid or media. As with the inline meter, each discrete test approximates to 5%, 25%, 50%, 75% and 100% of the full scale flow for the meter under test. A comparison is then made between the calculated real value and the output of the flow meter under test at each of the five calibration points. Based on the criteria of 0.5% Full Scale Flow or 1.0% of Rate, the determination is made for the accuracy of the meter to be either within specifications or out of specifications.

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