ATG Universal Temperature Compensator

Bulletin SS01037 Issue/Rev. 0.3 (4/18)

Smith Meter® Temperature Compensator

A characteristic of all liquids is that a change in volume occurs with a change in temperature. This thermal coefficient of expansion varies with each liquid. The measurement of most liquids is based on net volume, defined as volume at a referenced base temperature (60°F) for the petroleum industry in the U.S.A. for example. When metering liquids, the temperature is usually other than the base temperature and can also vary during the measurement. The difference between gross metered volume and net volume will depend on the coefficient of expansion of the liquid and the difference between average metered liquid temperature and base temperature.

Meters equipped with the ATG Automatic Temperature Compensator provide net registration. The net registration is based on continuous integration of gross metered volume and temperature regardless of flow rate and temperature changes. It is also based on the coefficient of expansion of the particular metered liquid.

The ATG is designed and manufactured not only as a precision instrument, but also to withstand the ambient conditions of sand, dust, humidity, and temperature extremes normally encountered. The unit can be checked in the laboratory with precision thermometers assuring this type of accuracy in actual field use.

Features

The ATG Temperature Compensator provides a continuous, non-cyclic output as it does not utilize clutches, cams, or ratchets. This continuous output is necessary where prover volumes are relatively small as encountered with mechanical displacement provers and when providing a signal output for certain instruments to avoid “hunting.”

The thermal system temperature bulb is not installed in a thermal well, but is mounted in the meter housing or adaptor so that it is exposed directly to the metered fluid, providing fastest possible response to temperature changes.

Even though directly exposed to the liquid, bulb response is not affected by operating pressure changes. Bellows movement is .002" per degree Fahrenheit bulb temperature change providing a high degree of resolution in converting temperature change to linear motion.

Two types of ATG’s are available. These are termed “Standard” and “LPG.” The standard unit is used for gravity ranges of 0°-110° API and 1.075-.580 specific gravity or coefficient of expansion ranges of .0003-.0011/°F and .005-.0020/°C. The LPG unit is used for specific gravity ranges of .600-.500 or coefficient of expansion ranges of .0010-.0025/°F and .0018-.0045/°C.

The gravity dial provides selection of liquid coefficients of expansion over a wide range. The large circumference of the dial provides a high degree of resolution in selecting the desired basis of correction. External positioning of this dial provides a thermal system adjustment feature assuring maximum accuracy in sensing liquid temperature changes.

The ATG is bidirectional and provides temperature compensated reverse registration in those applications where bidirectional flow and registration is desired. In addition to correcting for temperature changes, the unit also provides the means for adjustment of registration.

Principle of Operation

The ATG consists of four basic subsystems. These are: a thermal system, a gravity selector (coefficient of expansion selector), a primary gear system, and a secondary gear system which includes an infinitely variable roller and disc integrator.

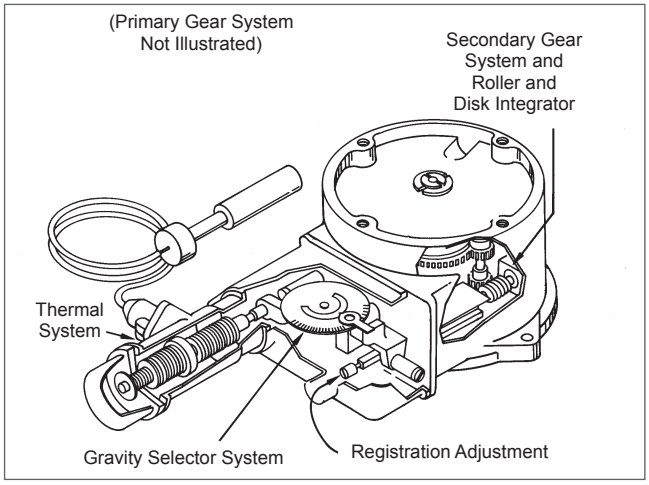

Figure 1

Thermal System

The thermal system consists of the bulb and bellows assembly and the ambient bellows assembly. The bulb is immersed in the metered liquid wherein temperature changes cause a change in volume of the bulb filling liquid. This volume change is transmitted through the capillary tube to the product bellows providing linear movement of the bellows in response to bulb temperature change. Both the product bellows and ambient bellows increase in length with an increase in ambient temperature. Design is such that an increase in ambient bellows length causes a decrease in length of the complete ambient bellows assembly. The ambient bellows assembly then compensates for changes in length of the product bellows, and other components in the unit, due to ambient temperature changes.

Gravity Selector

The gravity selector system provides for selection of temperature compensation based on the coefficient of expansion of the particular metered liquid. It consists of a linkages assembly with a movable pivot point to proportionately increase or decrease the effective thermal system movement based on a given selection. Effective thermal system movement is strictly dependent on temperature change and is independent of the metered liquid's coefficient of expansion. Position of the pivot point is indicated on a graduated dial in terms of API Gravity and API Group, specific gravity, or coefficient of expansion. However, for more accurate compensation, the ATG should be recalibrated following a change of the gravity selector setting.

Gear System

The gear system of the ATG consists of primary, secondary, and planetary gear subsystems. The output of the primary gear train is 13% greater than the input in the standard ATG and 31% greater in the LPG-ATG. Correction is accomplished by subtracting. The secondary gear train subtracts revolutions from the ATG output shaft through the planetary gear system. The rate of this subtraction (percent change) is determined by the ratio position of the roller on the disc.

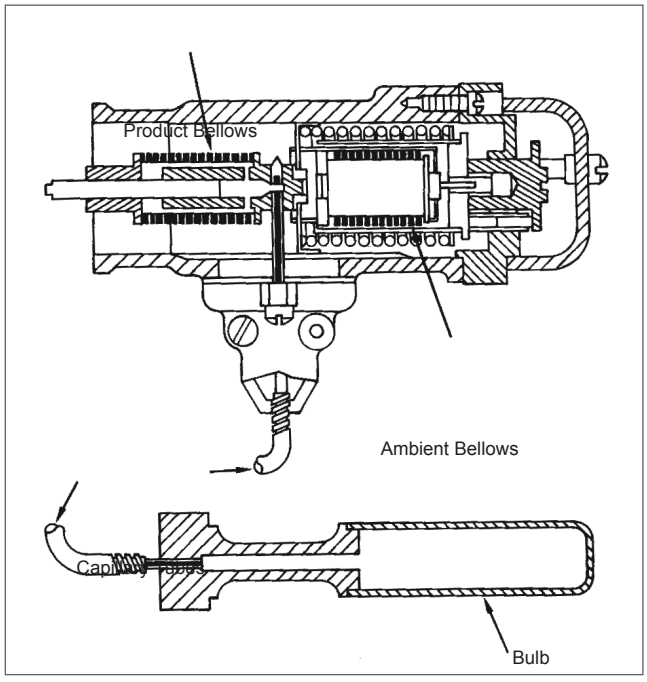

Figure 2 – Thermal System

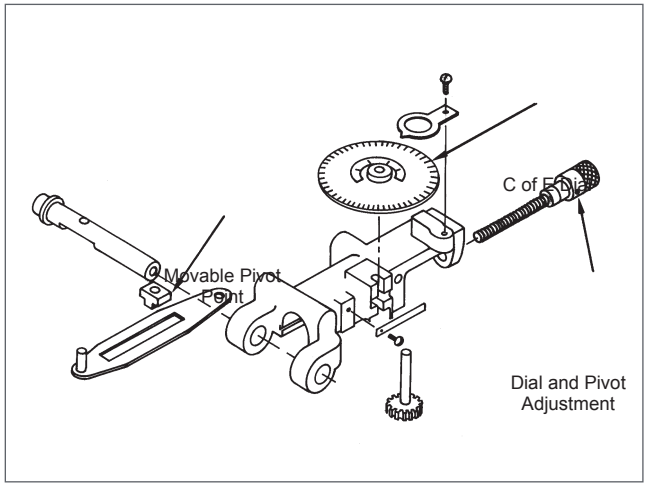

Figure 3 – Gravity Selector

The roller and disc integrator is a variable speed transmission device which automatically combines the effects of thermal linear motion (produced by the thermal and gravity selector systems) and gross meter revolutions. It is part of the secondary gear train and determines the amount of subtraction from the primary gear train.

Position of the roller on the disc is controlled by product temperature through the thermal and gravity selector systems. Disc rate is fixed in direct proportion to gross metered volume. A reduction in product temperature moves the roller toward the center of the disc resulting in fewer roller revolutions. Fewer revolutions of the roller result in a reduction of the amount of subtraction from the primary gear train, producing higher net registration. Increasing liquid temperatures, of course, have an opposite effect since the roller is moved toward the outer edge of the disc, increasing roller revolutions per disc revolution. Subtraction through the planetary system is greater resulting in lower net registration.

The roller and disc integrator serves as a control element, thus, the primary gear train carries the majority of the accessory torque load.

Temperature Range

In addition to covering a wide range of coefficients of expansion, the ATG also covers a wide temperature range. Temperature range limits are determined by two factors: the thermal system and the amount of mechanical correction in the device. The thermal system range is 100°F, 150°F, or 200°F depending on maximum operating temperature (see Characteristics). The total mechanical correction range is 15% for the standard ATG and 30% for the LPG-ATG. Figure 5 illustrates the temperature range for both standard and LPG units. Curves A and A1 define the mechanical correction limits of the standard ATG. B and B1 define the mechanical correction limits of the LPG-ATG. C and C1 define the thermal system limits. A - A1 and B - B1 may be shifted up or down by providing special gearing in the meter or dual head adaptor. C - C1 may be shifted up or down by providing special filling for the thermal system.

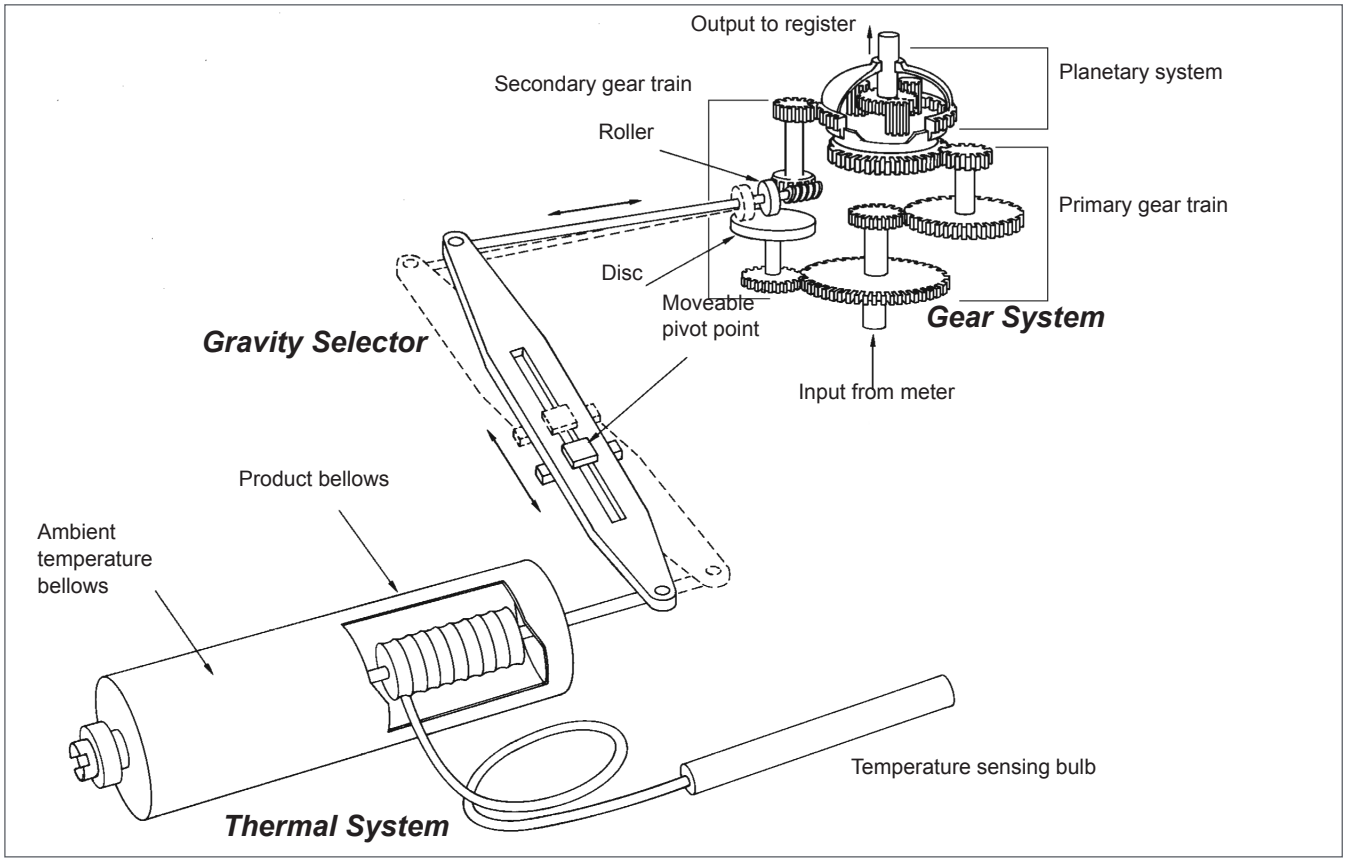

Figure 4 – Gear System

Examples

Number	Product Coefficient of Thermal Expansion	Operating Temperature Range	Special Gearing	Special Bulb Filling
1	0.00042/°F	150°F to 265°F	Yes	Yes
2	0.00060/°F	50°F to 170°F	No	Yes
3	0.00170/°F	-30°F to 70°F	Yes	Yes

Note: *These charts are based on correction to reference (base) temperatures of 60°F or 15°C. To determine mechanical correction for other base temperatures, shift the temperature scale so that the desired base temperature coincides with the present 60°F or 15°C.*

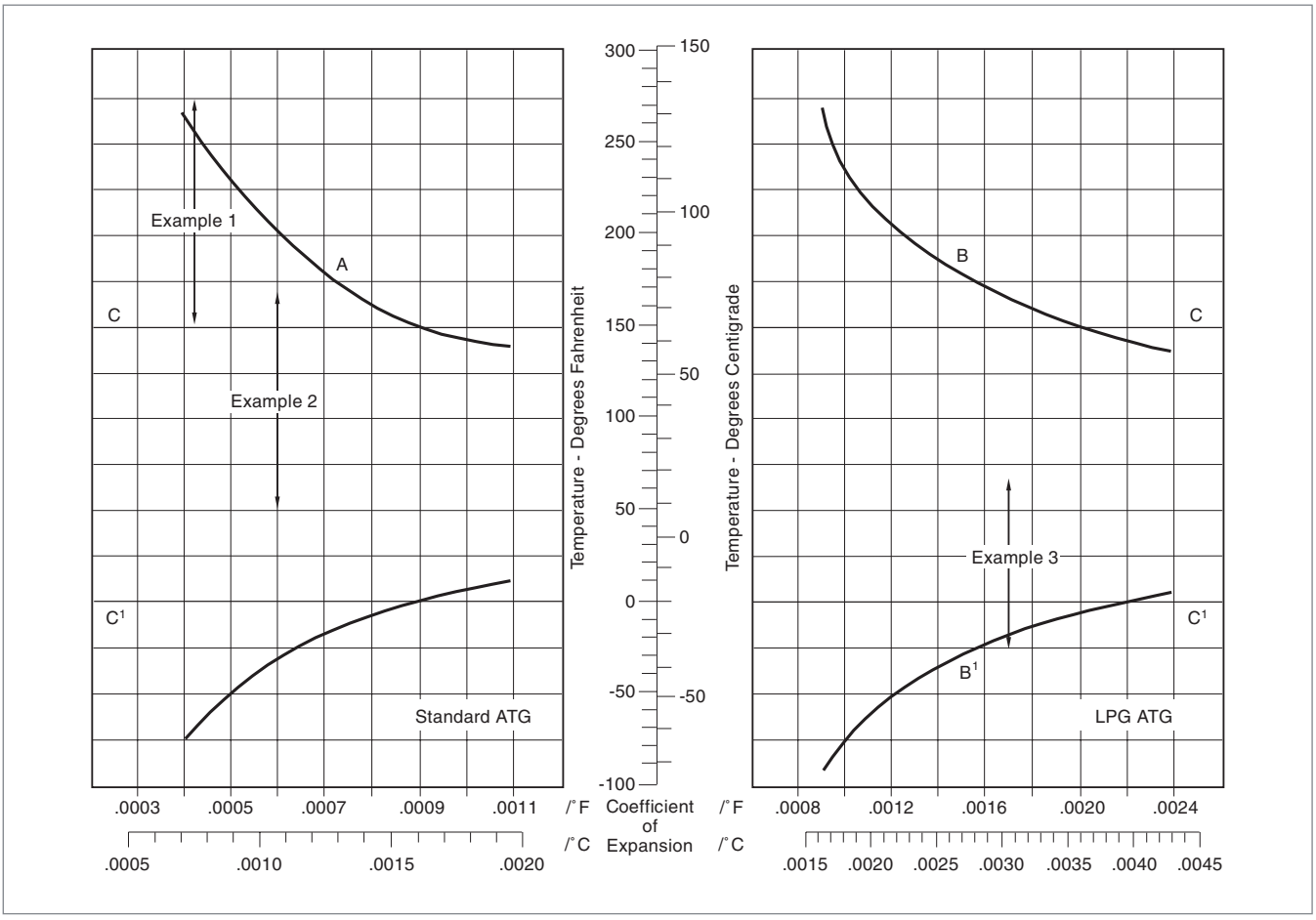

Figure 5

	Standard ATG	LPG-ATG
Correction Range	0-110° API gravity, 1.075-.580 specific gravity at 60/60°F or 15/15°C, .0003-.0011/°F or .005-.0020/°C coefficient of expansion	.600-.500 specific gravity at 60/60°F or 15/15°C, .0010-.0025/°F or .0018-.0045/°C coefficient of expansion
Temperature Range	See Figure 5	
Thermal Systems	Standard: 0°F to 150°F (-15°C to 65°C) range Specials: -50°F to 100°F, 50°F to 200°F, 125°F to 225°F, 175°F to 275°F, 175°F to 375°F, 225°F to 425°F, 275°F to 475°F, 325°F to 525°F	
Ambient Temperature Range	-30°F to 130°F (-35°C to 55°C)	
Linearity	±1°F/100°F (±.5°C/50°C) (See Figure 10)	
Hysterisis	Less than .25°F (.15°C)	
Time Constant	50 seconds (to effect 2/3 response to step ΔT)	
Registration Adjustment	One revolution of adjustment screw equals 0.6%, CW decreases registration	One revolution of adjustment screw equals 1.2%, CW decreases registration

When an ATG is ordered as part of a meter assembly, it is only necessary to specify minimum, maximum, and normal operating temperatures and the basis of correction (specific gravity at 60°F or 15°C, API Gravity at 60°F or API Group for petroleum liquids, and coefficient of expansion for non-petroleum liquids). Meters ordered with LPG meter trim and ATG will automatically be supplied with LPG-ATG. If the unit is to be adapted to a meter in the field, specify the model and serial numbers of the meter in addition to operating conditions.

Assembly 518866-001 (ATG with ventilated extension should be used for temperatures above 200°F [95°C]).

If the ATG is to be mounted above a set-stop counter or on a stepper-motor driven by a turbine meter, specify Series 519141 and whether 26, 42, or 52 inch capillary length is desired.

There are several variations in the ATG which affect interchangeability. When ordering replacement or standby units, use the following chart to determine correct assembly number.

Standard ATG	**LPG-ATG**				
Input Coupling	**Capillary Length**	**96% Input[1]**	**100% Input[2]**	**96% Input[1]**	**100% Input[2]**
(A)	42 inches 52 inches 26 inches	516727-001 516727-003 516727-005	519141-001 519141-003 519141-005	516727-021 516727-023 516727-025	519141-021 519141-023 519141-025
(B)	42 inches 52 inches 26 inches	516727-002 516727-004 516727-006		516727-022 516727-024 516727-026	

(A)S and T meter models, E3-S1 through H8-S1, dual-head adaptor with ATG, ventilated extension with ATG, ATG mounted on set-stop counter or large numeral counter.

(B) W, D, and M meter models, B-170 through 875, C2-S1 (C2-S1 through S7), S7 through H8-S3, S5, S6, and S7, J10-S1, S3, S5, S6, and S7 through M16-S1, S3, and S5.

1 96% input for all ATG's supplied as part of meter assembly, dual-head adaptor with ATG, and ventilated extension with ATG.

2 100% input for all ATG's mounted on set-stop counter, large numeral counter, or turbine meter stepper motor.

Installation

ATG units are normally supplied as part of a meter assembly or dual-head adaptor (where both gross and net registration are desired). Within the limits of the capillary tube length, they may be installed remotely or as a part of the meter accessory stack on ventilated extensions for hot oil applications or between set-stop counter and counter-printer if presetting on a gross basis and registration or ticket printing on a net basis is desired. (Series 519141 ATG units necessary for this application.)

If the ATG is located remote from the meter proper or if used with a turbine meter stepper-motor, an accessory temperature well (Figure 6) is available for welding into the piping system. When the remote temperature well kit is used, it is desirable to locate the ATG and well such that the minimum length capillary tube can be utilized. Standard capillary lengths are 26, 42, and 52 inches.

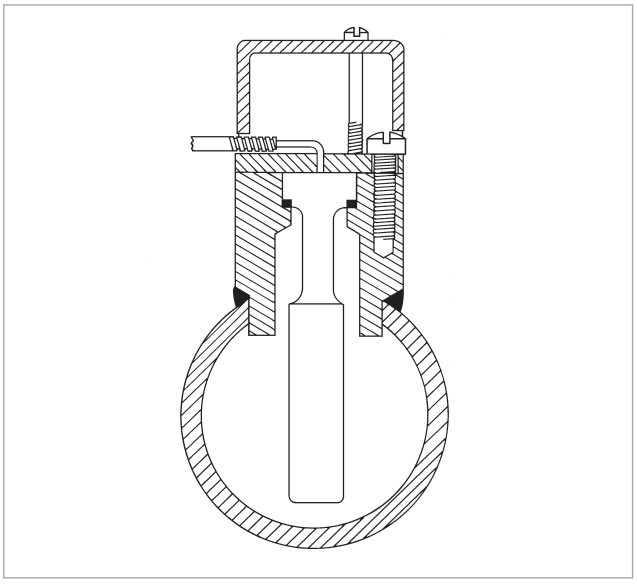

Figure 6 – Thermal Well

X-Dimension (Inches)

Meters supplied with ATG are higher than those with standard calibrators. Distances shown are from center line of flange to top of meter (X) - see figure 7.
For other dimensions, refer to appropriate meter bulletin.

Model	Dimension
S-13	11.2"
K-13	15.0"
S-28	10.7"
W-28	14.6"
D-28	15.1"
M-28	15.1"

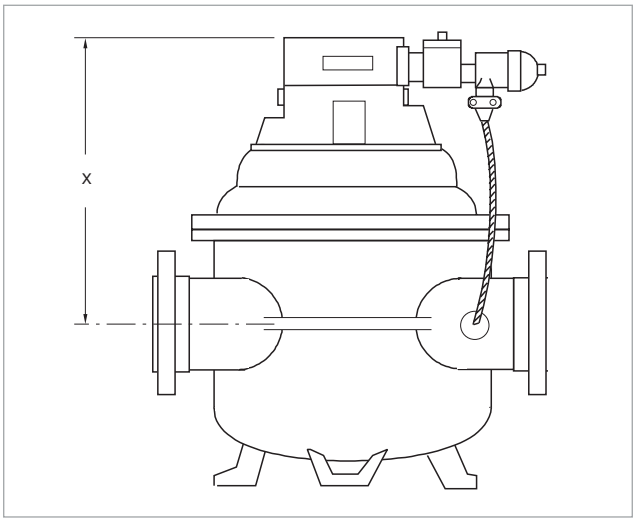

Figure 7 – X-Dimension in inches

Model	S1	S3	S5	S6	S7
C2	15.7"	18.6"	18.6"	17.5"	17.5"
E3	15.4"	16.8"	16.8"	18.9"	20.3"
F4	16.4"	17.9"	17.9"	18.4"	20.3"
G6	17.0"	18.8"	18.8"	20.4"	21.2"
H8	19.6"	21.4"	21.4"	23.3"	24.5"
JB10	24.1"	24.7"	24.7"	24.2"	26.9"
K12	31.0"	30.9"	30.9"	–	–
M16	37.6"	37.6"	37.6"	–	–

Dimensions

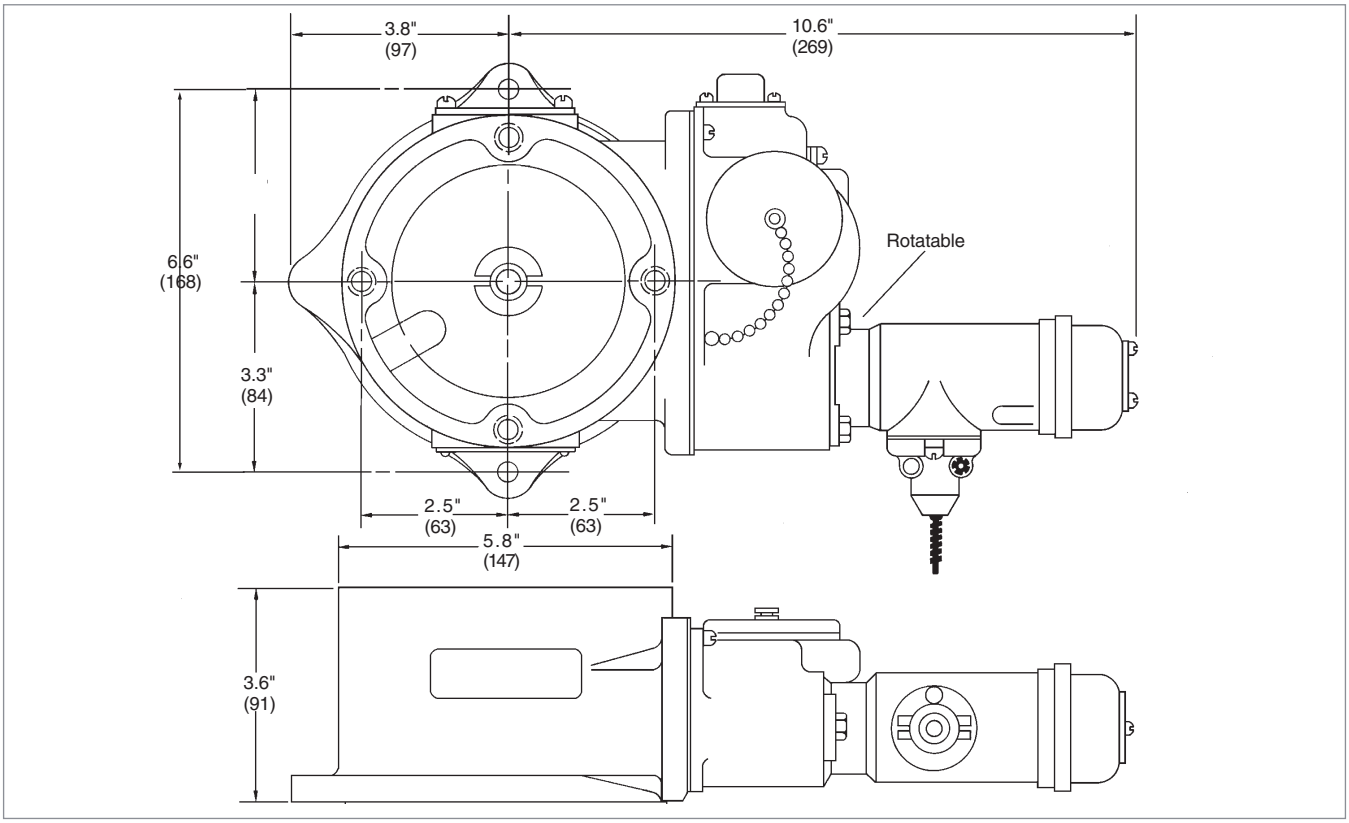

Figure 8

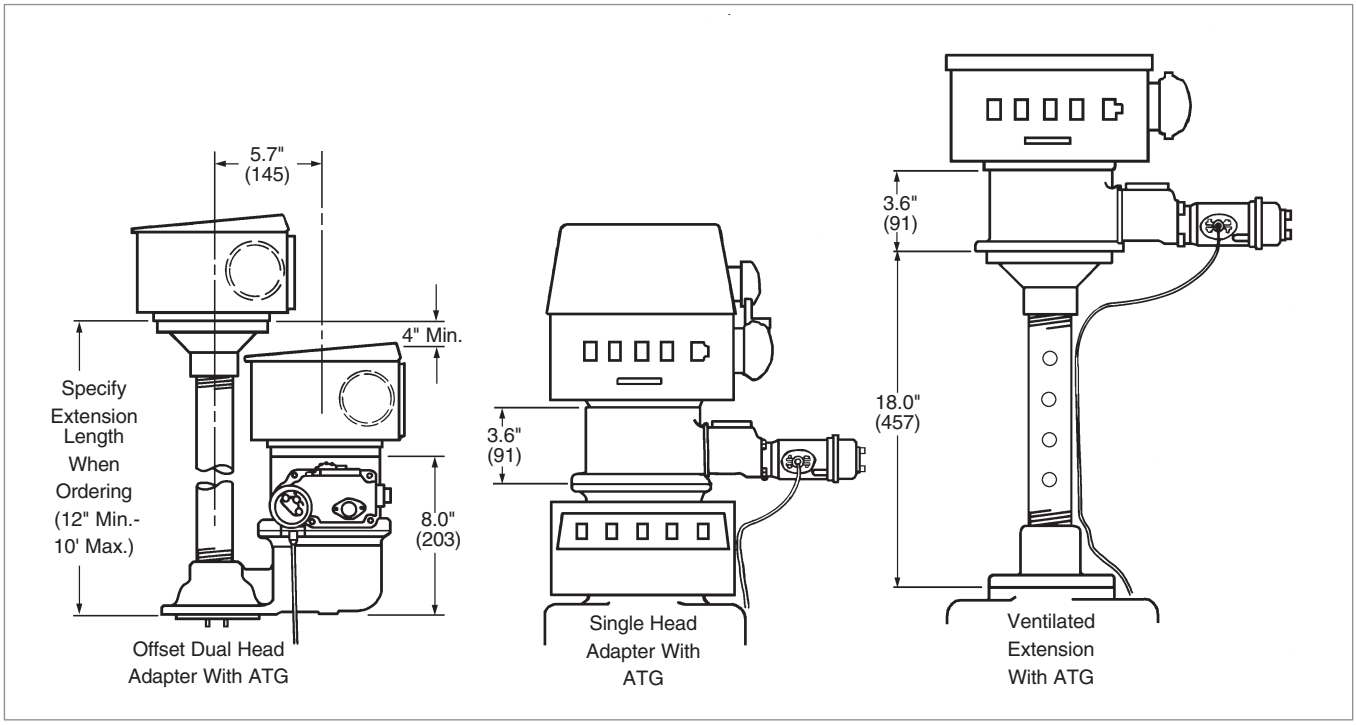

Figure 9

Linearity

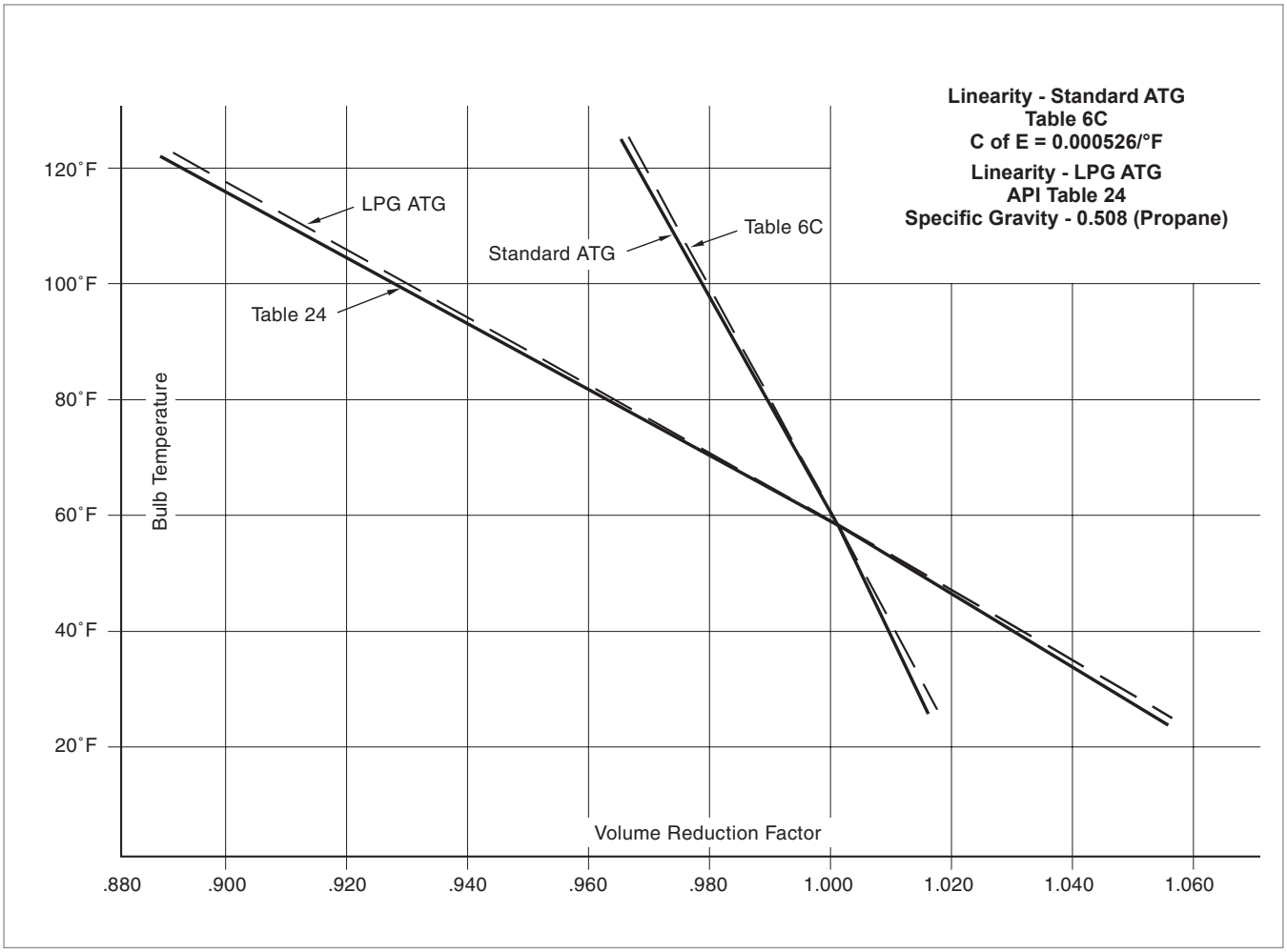

Figure 10

Revisions included in SS01109 Issue/Rev. 0.3 (4/18):
New company branding.

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