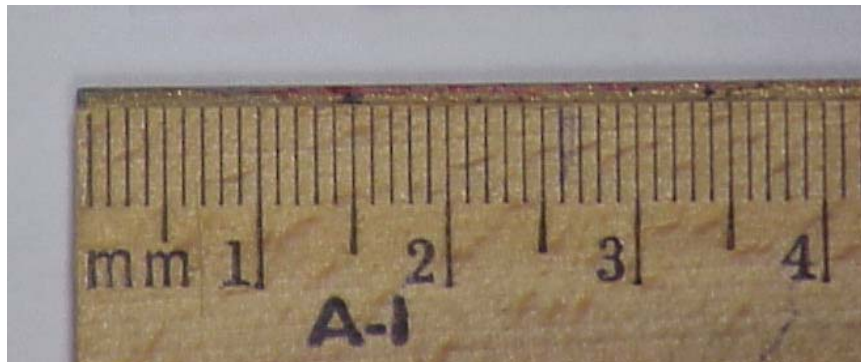


# Instrument Uncertainties

- **Resolution** is the *smallest physically indicated* division that an instrument displays or is marked. This implicitly sets the accuracy of the instrument.



- The **zero-order uncertainty of an instrument**,  $u_0$ , is arbitrarily set equal to  $\frac{1}{2}$  its resolution. It is the smallest uncertainty that an instrument can have.

$$u_{0,\text{ruler}} =$$

# Instrument Uncertainties

- *Design-stage uncertainty* considers other instrument uncertainties in addition to  $u_0$ .
- The instrument uncertainty is the RSS (root-sum-square) of the elemental instrument uncertainties,  $e_I$ 's, where

# Typical Instrument Errors

- Typical instrument errors include:

1. hysteresis:

$$\tilde{e}_H = \left( \frac{e_{H,max}}{FSO} \right) = \left( \frac{|y_{up} - y_{down}|_{max}}{FSO} \right) \quad (9.28)$$

2. linearity:

$$\tilde{e}_L = \left( \frac{e_{L,max}}{FSO} \right) = \left( \frac{|y - y_L|_{max}}{FSO} \right) \quad (9.29)$$

3. sensitivity:

$$\tilde{e}_K = \left( \frac{e_{K,max}}{FSO} \right) = \left( \frac{|y - y_{nom}|_{max}}{FSO} \right) \quad (9.30)$$

4. zero-shift:

$$\tilde{e}_Z = \left( \frac{e_{Z,max}}{FSO} \right) = \left( \frac{|y_{shift} - y_{nom}|_{max}}{FSO} \right) \quad (9.31)$$

5. repeatability:

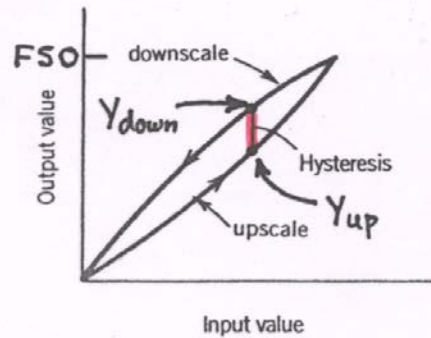
$$\tilde{e}_R = \left( \frac{2S_x}{FSO} \right) \quad (9.32)$$

6. stability:

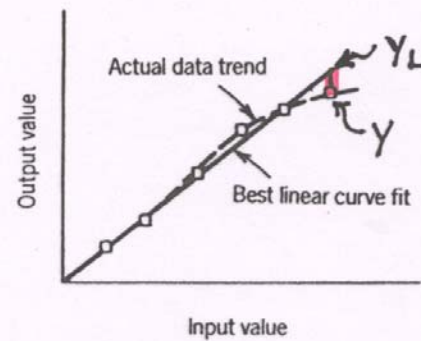
$$\tilde{e}_S = \left( \frac{e_{S,max} \cdot \Delta t}{FSO} \right) \quad (9.33)$$

7. thermal-drift:

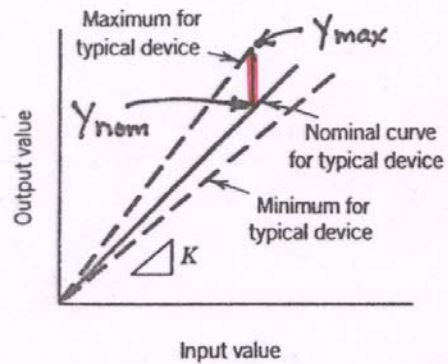
$$\tilde{e}_T = \left( \frac{e_{T,max}}{FSO} \right) \quad (9.34)$$



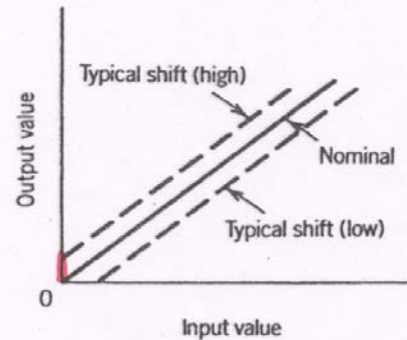
(a) Hysteresis error



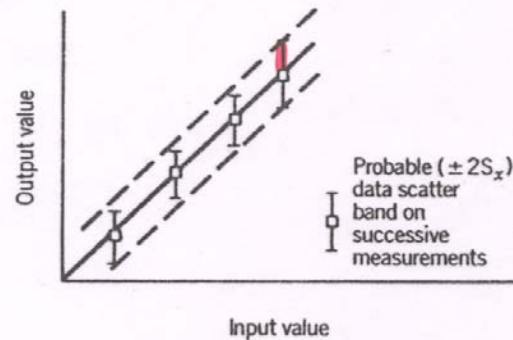
(b) Linearity error



(c) Sensitivity error



(d) Zero shift (null) error



(e) Repeatability error

The Dwyer logo is a stylized, italicized wordmark in white, set against a dark, horizontally-oriented oval background. This oval is centered within a larger, light gray rectangular field.

## DURABLOCK® SOLID PLASTIC STATIONARY GAGE

Dwyer solid plastic stationary gages—or draft gages—are offered in inclined and vertical (well-type) styles for highly accurate laboratory or general industrial service, for measurement of low range gas and air pressures, positive, negative or differential.

To assure the accuracy required in instruments of this type, all machining of bores and wells is to the highest standards of precision backed by Dwyer's years of experience in the fabrication of acrylic instruments.

### Design and Service Features

- **1" Thick Acrylic Plastic Body** is a solid block, virtually unbreakable, stable and free of the danger of distortion.
- **Drilled Bores Accurate To  $\pm .0002$ "** is stable, free of bends or crooks, will never require recalibration because of distortion.
- **Selected Gage Oil** with high wetability characteristics forms a consistent, well shaped meniscus for most accurate reading.
- **Adjustable Reflective Polished Aluminum Scales** with thumbscrew locking for easy zeroing.
- **Parallax-Free Reading** for maximum accuracy and consistency is achieved by simply aligning the meniscus with its image reflected in the scale.
- **Over-Pressure Safety Traps** prevent loss of fluid due to over range pressures or surges in pressure. (Not required on No. 215.)
- **Leveling Adjustment** for inclined style gages is achieved by simply loosening a locking thumb screw on the side or bottom of the gage, adjusting with reference to the integral sensitive ground glass bubble level and retightening.
- **Heavy Gauge Steel Mounting Panels** are gray hammerloid finished.

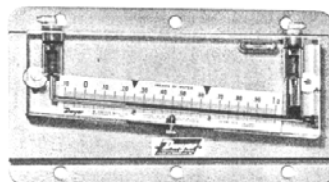


Fig. 6-1. No. 200.5 solid plastic inclined style stationary gage with .10-0-1.0" W.C. range.

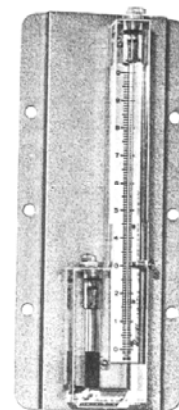


Fig. 6-2. No. 310 solid plastic vertical style stationary gage with 0-10" W.C. range.

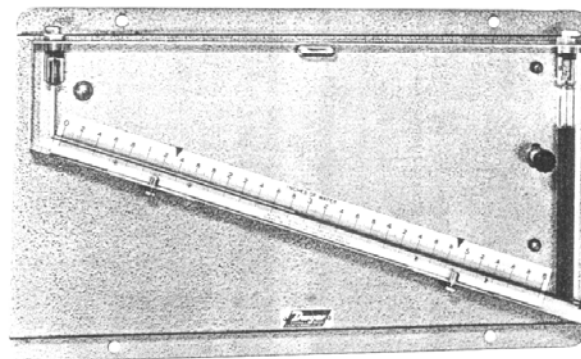


Fig. 6-3. No. 246 solid plastic inclined style stationary gage with 0-6" W.C. range.

# RANGES AND DIMENSIONS

Suitable for total pressures up to 100 psig, temperatures up to 150°F.

Accuracy  $\pm 2\%$  of full scale (1% on models 215, 244, 246 only)

## INCLINED TYPE

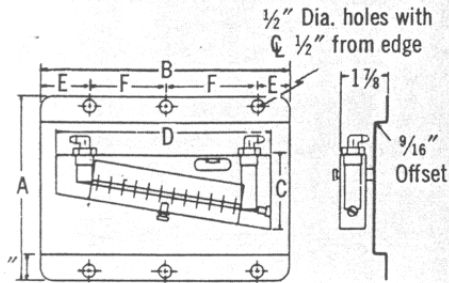


Fig. 7-1.

Model No.	Range Inches Of Water	Minor Scale Div.	Scale Length Inches	Dimensions, Inches						Weight lbs.-oz.
				A	B	C	D	E	F	
200	.10-0-1.0	.02	5½	7	10	4⅛	8½	2	3	2-14
200.5	.10-0-1.0	.01	8¾	7	13	3⅛	11⅜	2	4½	3-11
201	.05-0-.50	.01	5½	7	10	3⅛	8¼	2	3	2-12
202	.20-0-2.0	.02	8¾	9	13	5½	11⅞	2	4½	4-5
202.5	.20-0-2.0	.01	8¾	9	13	5⅞	12	2	4½	4-7
209	.20-0-3.0	.02	8¾	9	13	7	11¼	2	4½	4-11
215	.05-0-.25	.005	6	7	10	3⅛	9½	2	3	2-14
244	0-4	.02	13¾	11	16½	8⅞	15⅞	4	8½	9-11
246	0-6	.02	20	13½	23	11	22	4	15	13-14

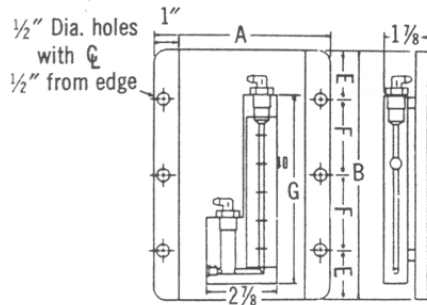


Fig. 7-2.

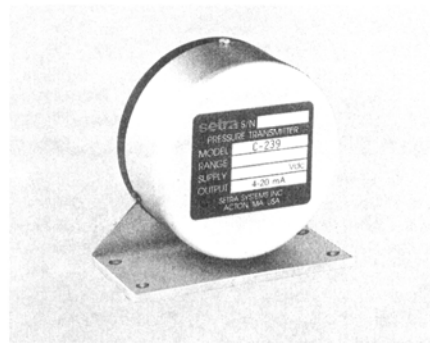
## VERTICAL OR WELL-TYPE

Model No.	Range Inches Of Water	Minor Scale Div.	Scale Length Inches	Dimensions, Inches					Weight lbs.-oz.
				A	B	E	F	G	
300	0-4	.10	4½	7	10	2	3	8¼	2-5
306	0-6	.10	7¾	7	16	4	4	10⅞	3-3
308	0-8	.10	9	7	16	4	4	13⅛	3-7
310	0-10	.10	11⅞	7	16	4	4	15¼	3-10

**Setra Systems, Inc.**  
**PRESSURE TRANSDUCERS  
 AND TRANSMITTERS**

**Model 239/C239  
 LOW RANGE PRESSURE**

Differential Pressure: 0 -  $\pm$  0.25 in. WC to 0-10 psid  
 (Reference pressure: dry non-corrosive gases)

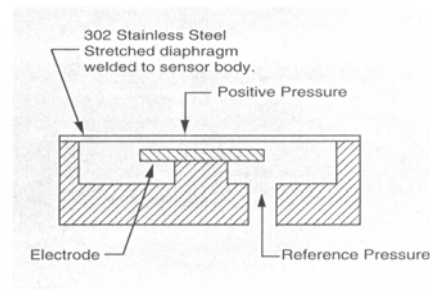


**Applications**

- HVAC Control
- Leak Detection
- Environmental Testing
- Medical Instrumentation
- Energy Management
- Clean Rooms

**Features**

- $\pm$  0.14% FS Accuracy
- Fast Warm-up
- Low Thermal Effect
- Fast Response, <10 milliseconds
- Withstands high overpressure



**Operation**

Setra Model 239 pressure transducers and Model C-239 pressure transmitters are specifically designed for high accuracy measurement of low pressures.

Setra's variable capacitance sensors are designed to be simple and reliable. A stainless steel diaphragm and an insulated electrode form a variable capacitor. As pressure increases or decreases the capacitance changes. This capacitance is detected and converted to a linear D.C. electric signal by Setra's unique electronic circuit. Model 239 provides a high level 0-5 volt output and the C-239 provides a 4-20 mA current output. High positive overpressure protection is achieved by the sensor electrode acting as a stop for the diaphragm. The high level output signals, excellent long term stability and fast dynamic response make these transducers and transmitters ideal for a wide range of industrial, laboratory and aerospace applications.

**Full Scale Ranges**

Pressure Range Unidirectional Pressure	Proof Pressure	
	Positive	Negative
0 to 0.5 in. WC	10 PSI	2.5 in. WC
0 to 1 in. WC	10 PSI	5 in. WC
0 to 2.5 in. WC	10 PSI	12.5 in. WC
0 to 5 in. WC	20 PSI	25 in. WC
0 to 15 in. WC	50 PSI	75 in. WC
0 to 30 in. WC	50 PSI	150 in. WC
0 to 5 PSID	75 PSI	25 PSI
0 to 10 PSID	100 PSI	50 PSI
<b>Bidirectional Pressure</b>		
0 to $\pm$ 0.25 in. WC	10 PSI	2.5 in. WC
0 to $\pm$ 0.5 in. WC	10 PSI	5 in. WC
0 to $\pm$ 1 in. WC	10 PSI	12.5 in. WC
0 to $\pm$ 2.5 in. WC	20 PSI	25 in. WC
0 to $\pm$ 7.5 in. WC	50 PSI	75 in. WC
0 to $\pm$ 15 in. WC	50 PSI	150 in. WC
0 to $\pm$ 2.5 PSID	75 PSI	25 PSI
0 to $\pm$ 5 PSID	100 PSI	50 PSI

NOTE: Setra adheres to strict quality standards including MIL-1-45208A and MIL STD 45662A. The calibration of this product is NIST traceable.

U.S. Patent Nos. 3646538; 3975719; and Re 30603  
 Canada Patented (Brevete) 1974, 1975, 1976, 1979, 1980 and 1982

Specifications subject to change without notice.



For 0.5 in. H<sub>2</sub>O full scale (FS):

Accuracy should be the RSS of

Let's check!  
nonlinearity:  
hysteresis:  
nonrepeatability:

→ RSS =  
or in. H<sub>2</sub>O

thermal:  $\pm 1 \% \text{ FS} / 100 ^\circ \text{F}$   
for zero *and* for span  
→ for 10 °F variation:

$u_{\text{thermal}} =$   
 $=$  in. H<sub>2</sub>O

## Model 239/C-239 Specifications

### Pressure Ranges and Media

Unidirectional Differential	0 to 0.5, 1, 2.5, 5, 15, 30 in. WC and 0 to 5, 10 PSID
Bidirectional Differential	0 to $\pm 0.25, 0.5, 1, 2.5, 7.5, 15$ in. WC and 0 to $\pm 2.5, 5$ PSID
Positive Pressure Media	Gases compatible with stainless steel, hard anodized 6061 aluminum, Buna N "O" ring (Stainless steel in place of aluminum on special order.)
Reference Pressure Media	Clean dry air or other gases (Non-corrosive, non-condensable.)
Operable Line Pressure	Vacuum to maximum 250 psig
Line Pressure Effect	2%/100 PSI
Proof Pressure	Listed on front page
Internal Volumes	Positive port 0.03 cu. in.; Reference port 0.1 cu. in.

### Accuracy Data

Accuracy*	$\pm 0.14\% \text{ FS}$ at constant temperature
Non-linearity	$\pm 0.1\% \text{ full range output}$ (best straight line method)
Hysteresis	0.1% FS
Non-repeatability	$\pm 0.02\% \text{ FS}$
Thermal Effects**	30°F to 150°F Zero Shift $< \pm 1\% \text{ FS}/100^\circ \text{F}$ Span Shift $< \pm 1\% \text{ FS}/100^\circ \text{F}$
Acceleration Response	$< 0.0002 \text{ psi/g}$
Volume increase due to FS pressure	$1 \times 10^{-6} \text{ cu. in.}$
Natural Frequency	2000 Hz nominal
Settling Time	$< 100$ milliseconds
Warm-up Shift (typical)	$< \pm 0.1\% \text{ FS total}$

\* Accuracy as RSS non-linearity, hysteresis, and non-repeatability.

\*\* X 2 for 0.5 and  $\pm 0.25$  in. WC ranges.

### Environmental and Dimensional Data

Temperature	0°F to 175°F operating -65°F to 250°F storage
Vibration	2 g from 5 Hz to 500 Hz
Acceleration	10 g maximum
Shock	50 g operating
Pressure Fittings	1/8" -27 NPT internal
Electrical Connection	2-foot multiconductor cable
Weight (approx.)	8 ounces

### Options (239/C239)

Option #602-607	Special Outputs 1 to 5, 1 to 6, 0 to 10, 1 to 10, 0 to 2.5, 0 to 5 VDC
Option #621	Special Excitation, $\pm 24$ VDC
Option #622	Special Excitation, $\pm 15$ VDC
Option #640	Intrinsic Safe Design FM Approved For Class I, II, III, Division 1, Groups A, B, C, D, E, F, G hazardous locations. For standard catalog products without other electrical options or remote controls options.
Option #642-644	Remote Sensitivity, Remote Calibration (Adjustable), Remote Calibration (Fixed).
Option #702	Compensated Temperature, -65°F to 250°F; (double the standard thermal effect specification).
Option #803-810	2 foot (nominal) cable is standard on most transducers and transmitters and all accelerometers. Up to 10 feet of cable can be supplied on your order; please specify cable length when ordering (eg. 805 for 5 ft. cable). Consult factory for cables longer than 10 feet.
Option #860	303SS Pressure Housing.

### Electrical Data

#### Voltage Output (Model 239)

Circuit	4-wire
Excitation	Nominal 24 VDC, 10 milliamperes (0.25 watts), 22 to 30 VDC. Reverse excitation protected. Internal regulation minimizes effect of excitation variation with $< \pm 0.02\% \text{ FS}$ output change. Will operate on 28 VDC aircraft power per MIL-STD-704A and not be damaged by emergency power conditions.

#### Full Scale Output\*\*\*

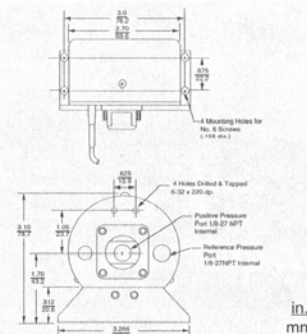
Unidirectional pressure:	0-5 VDC
Bidirectional pressure:	0- $\pm 2.5$ VDC
Factory set to within $\pm 20 \text{ mV}$ (internally adjustable)	
Zero Pressure Output	Factory set to 0 mV, $\pm 20 \text{ mV}$ (externally adjustable)
Output Impedance	$< 10$ ohms
Output Noise	$< 200$ microvolts RMS (in band, 0 Hz to 10 KHz)

\*\*\*Calibrated into 50 Kohm load. Operable into 5000 ohms or greater. Can be attenuated to match your system.

#### Current Output (Model C-239)

Circuit	2-wire
Full Scale Output	20 mA (adjustment range $\pm 1 \text{ mA}$ )
Zero Pressure Output	4 mA (adjustment range $\pm 0.2 \text{ mA}$ )
External Load	0 to 1000 ohms
(Calibrated at factory using a 250 ohm load at 24 VDC.)	
Minimum supply voltage (VDC) = $17 + 0.02 \times$ (Resistance of receiver plus line).	
Maximum supply voltage (VDC) = $42 + 0.004 \times$ (Resistance of receiver plus line).	
Effect of Power Supply Variations	$< 0.003 \text{ mA/volt}$
Output Noise	$< 10$ microamperes RMS (0 Hz to 10 KHz)

### OUTLINE DRAWING



### Ordering Information

Order as Model 239 pressure transducer or Model C239 pressure transmitter. Specify pressure range, desired electrical output, and options.

**setra**