Tag Nos. - E12-N008A, B

Seismic Qualification Analysis for Differential Pressure Unit, ITT Barton Model 224

I. Purpose

Evaluate pressure integrity of differential pressure unit when subjected to combined operating and seismic loading.

II. Differential Pressure Unit Environment

Design Loads (Reference 1)

Temperature = 500°F

Pressure = 500 psig

Seismic Loads

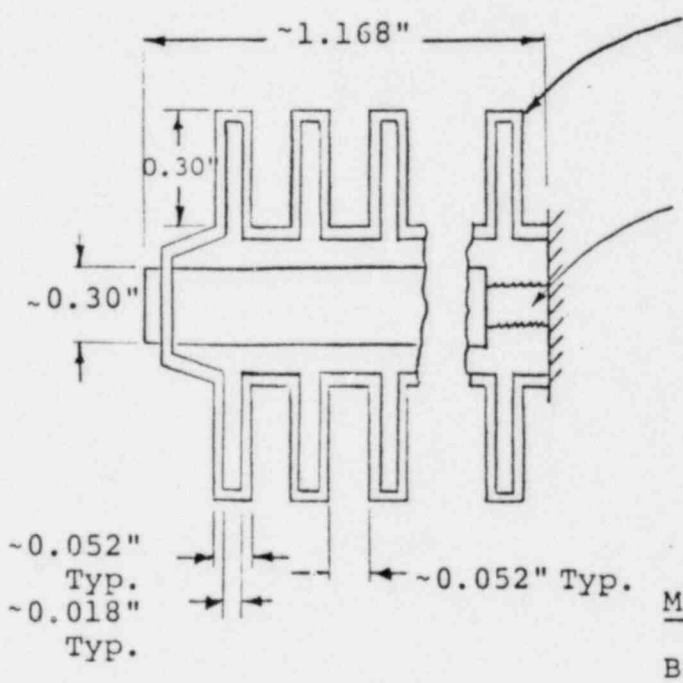
Maximum allowable g - level will be calculated.

III. Method of Analysis

The most critical component affecting the pressure integrity of the unit is the bellows. The maximum allowable g-level for both horizontal and vertical directions is evaluated. The remaining horizontal load is applied axially on the bellows. The g-level equivalent to one psig is computed to show that any g-loads due to seismic events are negligible compared to the working pressure of differential pressure unit (500 psig, Reference 1).

Dimensions are scaled from References 2 and 3.

IV. Bellows Geometry ($1\frac{5}{8}$" O.D.)

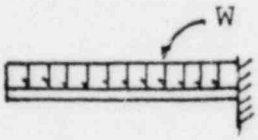


Material Properties:

Beryllium Copper (Reference 4)
S_m = 40,000 psi
E^m = $17(10)^6$ psi
P = 0.297 lb/cu in
SA-479 TYP 316L (worst case, Reference 5)
S_m = 14,400 psi
E^m = $27.7\ (10)^6$ psi
P = 0.286 lb/cu in

V. Maximum g-level Calculation

Bellows and shaft are modeled as a distributed mass cantilevel. The g-level is calculated by assuming all bending occurs either about the shaft solely or the bellows solely.



$$W = W_s + W_B$$

$$W_s = \frac{.286\ (.30)^2\ \pi}{4} = 0.0202 \text{ lb/in}$$

$$W_B = \left[\frac{\pi(1.625^2 - .993^2)}{4\ (1.168)}\ \frac{2}{6} + \frac{\pi 1.625(0.016)}{1.168}\ \frac{1}{6} + \frac{\pi(.993)(.016)}{1.168}\ \frac{3}{6}\right](.297) = 0.120 \text{ lb/in}$$

$$S_m = \frac{Mc}{I} + \tau$$

Where $M = g_s\ \frac{w\ \ell^2}{2}$

S_m = 14,400 psi (shaft)
= 40,000 psi (bellows)

$$\frac{c}{I} = \frac{4}{\pi(.075)^3} = 3018 \quad \text{(shaft)}$$

$$\frac{c}{I} = \frac{4}{\pi}\left[\frac{.5125}{\pi(.5125)^4 - (.4965)^4}\right] = 79.4 \text{ (bellows)}$$

ℓ = 1.168 in

g_s = seismic coef.

V. Maxumum g-level Calculation (Continued)

$$\tau = \frac{P}{A} = \frac{g_s W\ell}{A}$$

$A_{shaft} = 0.0177\ in^2$

$A_{bellows} = 0.0507\ in^2$

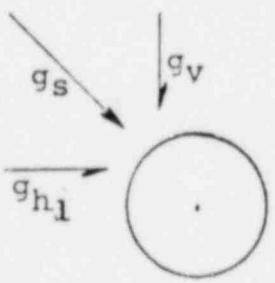
$$\therefore\ g_s = S_m \left[\frac{W\ell}{A} + \frac{W\ell^2 c}{2I} \right]^{-1}$$

$$g_s = 14{,}400 \left[\frac{(.1402)(1.168)}{.0177} + \frac{(.1402)(1.168)^2(3018)}{2} \right]^{-1}$$

$g_s = 48$ (shaft)

$$g_s = 40{,}000 \left[\frac{(.1402)(1.168)}{.0507} + \frac{(.1402)(1.168)^2(79.4)}{2} \right]^{-1}$$

$g_s = 3696$ bellows



LOAD ORIENTATION

$\therefore$ The bellows will withstand a minimum of 48 g's in the radial direction as shown.

V. Maximum G-level Calculation (continued)

G-loads in the remaining axial direction can be considered negligible, using the following rationale:

The g-level equivalent to 1 psig is

$$g = \frac{1 \text{ lb}}{\text{sq in}} \quad \frac{1.625^2 \, \pi \text{ sq in}}{4} \quad \frac{1}{1.168(.1402) \text{ lb}}$$

$$= 12.66$$

This g-level of 12.66g corresponds to 0.2% of the working pressure. This indicates that g-loads applied axially to the bellows can be considered negligible.

VI. Natural Frequency

The frequency calculation will be made assuming both the mass of the bellows and the shaft flex about either the shaft or the bellows. This is a conservative approach. The actual frequency will be ~~between~~ greater than the two calculated below, per Ref 6.

$$f = \frac{22.4}{2\pi} \sqrt{\frac{EIg}{W \ell^4}}$$

$$f_{shaft} = \frac{22.4}{2\pi} \sqrt{\frac{27.7(10)^6 \quad 2.48(10^{-5})}{0.1402 \quad (1.168)^4}}$$

$$= 183.1 \text{ Hz}$$

$$f_{bellows} = \frac{22.4}{2\pi} \sqrt{\frac{17(10)^6 \quad 6.45(10^{-3})}{0.1402 \quad (1.168)^4}}$$

$$= 2312 \text{ Hz}$$

Note that during operation the bellows will be immersed in demineralized water and that a fill liquid is inside the bellows. The liquid lowers the frequency by effectively adding to the mass. Conservatively assuming that the effect is to increase the mass by a factor of 200 the frequency would be $f = 2312/\sqrt{200} = 163$ Hz. - Still rigid

VII. Conclusion

The differential pressure unit bellows and shaft were judged to be the most critical components affecting pressure integrity when the device is subjected to seismic disturbances. Natural frequency calculations showed the unit to be sufficiently rigid to be well beyond the amplification range of normal nuclear piping systems. Maximum allowable g-levels were calculated resulting in levels well above expected peak values. In conclusion, the differential pressure unit will maintain pressure integrity under the most extreme seismic conditions.

References

1. GE PPD 145C3156, "LEVEL TRANSMITTER", Rev. 7, 10/5/77

2. ITT Barton DWG 0224.0904.3, "OUTLINE DIM MODEL 224 1 5/8 O.D. BELLOWS UNIT ASSEMBLY", Rev. 9, 1/5/79

3. ITT Barton Product/Bulletin 224-5-10, "MODEL 224 -- DIFFERENTIAL UNIT", Copyright 1981

4. Metals Handbook, 8th Edition, Volume 1, "PROPERTIES AND SELECTION OF METALS", Page 1038, July 1967

5. ASME Boiler and Pressure Vessel Code, 1980, Section III, Division 1, Appendix I, Table I - 1.2

6. Roark, "FORMULAS FOR STRESS AND STRAIN", Fifth Edition, 1975

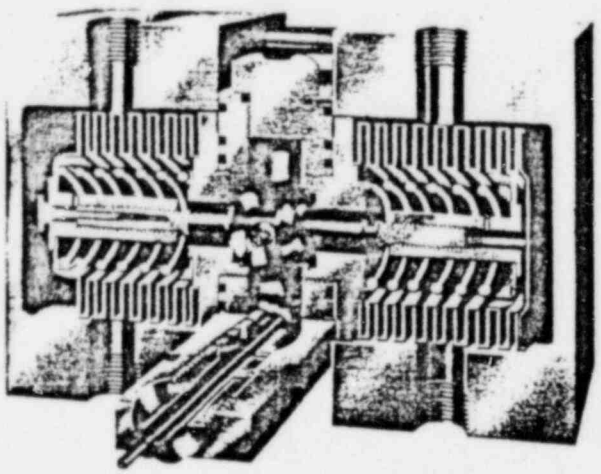
PRODUCT/BULLETIN 227-5

Model 227 Indicator

LIQUID LEVEL - DIFFERENTIAL PRESSURE - FLOW RATE

PRODUCT DESCRIPTION

The Model 227 is a differential pressure indicator equipped with a six-inch dial and is actuated by a Model 224 Rupture-Proof Differential Pressure Unit.



Model 224 Differential Pressure Unit Cutaway

Model 227 Differential Pressure Indicator

An indicating pointer traverses a 270° arc over an extended scale length of 13-1/2" to provide ease of reading differential pressure, flow or liquid level. The ability of this instrument to maintain accurate calibration, even when subjected to high overrange pressures, makes many formerly difficult applications routine. It is ideally suited to use when minimum weight and space are critical considerations and maximum readability is imperative. This versatile instrument is applied as a device for measuring liquified gases and is used extensively for measuring flow and differential pressure in refineries and petrochemical plants. Other typical uses of the Model 227 are the measurement of pressure drop across jet fuel filter separators, aircraft component testing and jet engine test benches.

THE ACTUATING UNIT

The indicator is actuated by dual, rupture-proof bellows with integral temperature compensation. The bellows are liquid-filled and will withstand repeated overranges equal to the working pressure of the instrument housing without causing a calibration change. Motion transmission is made by a hermetically sealed torque tube; thus eliminating friction, leakage, and the need for lubrication.

For complete information, request Bulletin 224. Installation data and technical assistance for standard or special applications available upon request.

CASE

The 6" case is fabricated from die-cast aluminum and is finished with a weather-resistant black epoxy resin paint. The cover glass is secured in the bezel with an elastomer ring, reducing the possibility of accidental glass breakage. The ring also acts as a seal between the bezel and the case. This insures a moisture, fume and dust-free atmosphere for the indicating mechanism.

INDICATING MECHANISM

The indicating mechanism of the Model 227 consists of a precision-made, jewelled, rotary movement. It multiplies rotation of the torque tube shaft through a gear and pinion to the indicating pointer. The indicating pointer traverses a 270° arc, providing excellent readability. The movement has micrometer screws for convenient zero and range adjustments. Zero and range adjustments may be made without removing the scale plate or the pointer. The rotary movement and the pointer are fully protected from overrange in either direction.

SCALES

The indicating scale is graduated uniformly for measurement of differential pressure or liquid level. Square root scales are available for direct reading of flow rate and special scales can be furnished for indicating the quantity of liquid in tanks.

GENERAL SPECIFICATIONS

	Meter Body	Available Differential Pressure Ranges				Pressure Connections	
		Stainless Steel Bellows		Beryllium Copper Bellows			
SWP-psi	Housing Material	1-5/8" O.D.	3/4" O.D.	1-5/8" O.D.	3/4" O.D.	Top	Bottom
500	Forged Brass (ASTM-B124 #2)			0-30" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/4" NPT	1/4" NPT
500	Stainless Steel (316)	0-30" w.c. to 0-55 psi	0-60 psi to 0-600 psi	0-30" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/4" NPT	1/4" NPT
1,000	Brass (Fed. Spec. QQ-B-637 Comp. 2)			0-60" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/8" NPT 1/4" NPT	1/8" NPT 1/4" NPT
1,000	Copper Nickel (70-30) MIL-C-15726			0-60" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	MS16142-4	MS16142-4
1,500	Cold Rolled Steel (C1018) Stainless Steel (316)	0-60" w.c. to 0-55 psi	0-60 psi to 0-600 psi	0-60" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/4" NPT	1/4" NPT
3,000	Cold Rolled Steel (C1018) Stainless Steel (316)	0-60" w.c. to 0-55 psi	0-60 psi to 0-600 psi	0-60" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/2" NPT	1/4" NPT
6,000	Cold Rolled Steel (C1018) Stainless Steel (316)	0-70" w.c. to 0-55 psi	0-60 psi to 0-600 psi	0-70" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/2" NPT 9/16"-18UNF-2B	1/4" NPT 9/16"-18UNF-2B
10,000	Alloy Steel (4140)	0-100" w.c. to 0-55 psi	0-60 psi to 0-600 psi	0-100" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	9/16"-18UNF-2B	9/16"-18UNF-2B
Net Volume in cu. in.	L.P. Head	1.66	2.51	1.66	2.51		
	H.P. Head	1.55	2.42	1.55	2.42		
Displacement in cu. in. for full scale travel		.14	.03	.14	.03		

NOTES: Zero center or split ranges are available on special order. For example, a 0-60" w.c. range may be ordered 30-0-30" w.c. or 15-0-45" w.c. Absolute pressure ranges are available from 100" w.c. to 600 psi.

Other sizes and types of connections (welding stubs, MS, A.N.D., etc.) are available upon request.

Special bellows and housing materials can be made available such as Monel, Inconel 625 and Hastelloy-C upon request.

Outline dimensional drawings are available upon request.

PERFORMANCE SPECIFICATIONS

Accuracy: Ranges from 0-30" w.c. to 0-200 psi . . . . . ± 1/2% of full scale differential pressure
Ranges from 0-200 psi to 0-400 psi . . . . . ± 3/4% of full scale differential pressure

Temperature Limits . . . . . -60°F to +200°F

ORDERING INFORMATION

Housing pressure rating (SWP)
Housing material
Bellows material
Material contacting bellows
Differential pressure range
Type of scale (square root, uniform)
Scale graduations
Mounting (pipe, wall, flush panel)

YOUR LOCAL REPRESENTATIVE

PROCESS INSTRUMENTS AND CONTROLS
900 S. Turnbull Canyon Road, P.O. Box 1882
City of Industry, California 91749
Telephone (213) 961-2547 Telex: 67-7475

HC15M [illegible] U.S.A.

ITT BARTON

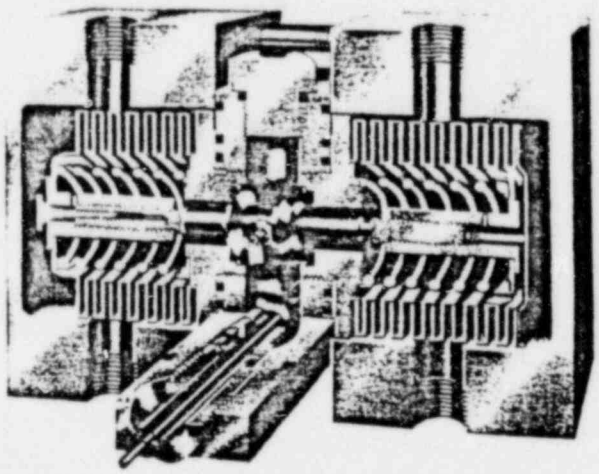
PRODUCT/BULLETIN 224-5-9

Model 224
Differential Pressure Unit

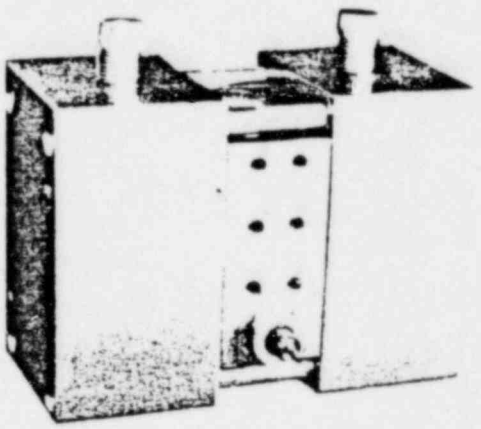
LIQUID LEVEL - DIFFERENTIAL PRESSURE - FLOW RATE

PRODUCT DESCRIPTION

The Model 224 fills an industry need for an instrument capable of measuring differential pressures from 0-30" w.c. to 0-600 psi at safe working pressure ratings from 400 to 10,000 psi. The Model 224 is a lightweight, compact sensor that incorporates the original Barton patented rupture-proof bellows with the unique design and construction features that have made Barton instruments the standard of the industry.



Model 224 Cutaway



Model 224 Differential Pressure Unit

Ease of installation, stability of calibration and minimum maintenance are inherent qualities of this unit. The Model 224 is used to actuate a complete line of Barton indicators, recorders, integrators, transmitters, switches, and controllers. It is also used by other leading instrument manufacturers as the differential pressure measuring element in their equipment.

CONSTRUCTION AND OPERATING PRINCIPLES

The Model 224 is composed of a rupture-proof Bellows Unit Assembly and a pair of pressure housings that enclose opposite sides of the assembly.

The Bellows Unit Assembly consists of a high and low pressure bellows, a center plate, over-range valves, a temperature compensator, a torque tube assembly and range springs. The two flexible metal bellows are mounted on opposite sides of a center plate. The outer ends of the bellows are sealed, and are rigidly connected internally by a stem passing through an annular hole in the center plate. Opposed valves located on the connecting stem are arranged to seal against corresponding valve seats on the center plate at predetermined positions of the stem. The interior of the bellows and center plate are completely filled with a clean, non-corrosive, low freezing point liquid, and will stand repeated overranging, as excessive as the working pressure of the instrument housing, without causing a calibration change.

An additional two free-floating convolutions are attached to the high pressure side of the bellows unit to allow for expansion and contraction of the fill liquid, thus providing positive temperature compensation through a wide range of ambient temperatures.

The torque tube assembly is an integral part of the bellows unit assembly and is employed to transmit motion of the bellows to the exterior of the unit. Its use insures a positive seal requiring no lubrication or maintenance.

The differential pressure range is determined by the force required to move the bellows through their normal travel. In order to provide for the various calibrations necessary, a range spring assembly is incorporated in the Bellows Unit Assembly which accurately balances the differential pressure applied. For units with low ranges in inches of water, most of the balancing force is furnished by the bellows and the torque tube. However, as the differential pressure range is increased, the range springs provide a major share of the balancing force.

In operation, the bellows move in proportion to the difference in pressure applied across the bellows unit assembly. The linear motion of the bellows, which is picked up by a drive arm, is mechanically transmitted as a rotary motion through the torque tube assembly. Should the bellows be subjected to a pressure difference greater than the differential pressure range of the unit, they will move through their calibrated travel plus a small amount of "over travel" until the valve mounted on the center stem seals against its corresponding valve seat. As the valve closes, it "traps" the fill liquid in the bellows and since the liquid is essentially non-compressible, the bellows are fully supported and cannot be ruptured regardless of the over-pressure applied. Furthermore, since opposed valves are provided, full protection is afforded against an "over-range" in either direction.

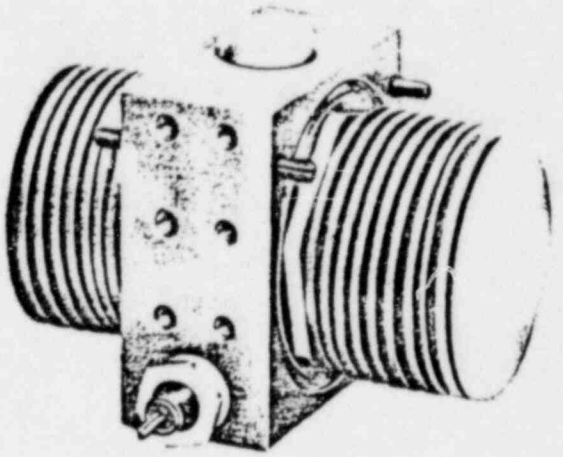
With the exception of the bellows and range springs, all moving parts of the instrument are contained within the sealed system and are continually bathed in clean fill liquid. Consequently, the Model 224 is essentially maintenance-free.

DYNAMIC RESPONSE

The unique design of the Model 224 has resulted in an instrument which features exceptionally fast response time. Very small displacement coupled with low system inertia makes the Model 224 ideally suited for applications where fast response is desirable.

SELF-DRAINING OR VENTING

The high and low pressure housings of the Model 224 are provided with both top and bottom pressure connections. Consequently, the unit is self-venting and self-draining. This feature eliminates the need for seal pots when wet gases are being measured, and similarly, if "slugs" of liquid enter the meter housing while a gas flow is being measured, the liquid will drain from the meter automatically and completely. When used on liquid service and installed according to standard practice, it is self-venting.



1-5/8" Bellows Unit Assembly

TEMPERATURE COMPENSATION

Temperature Compensation is accomplished through the addition of a free-floating bellows which is attached to the high pressure side of the bellows unit to allow for expansion and contraction of the fill liquid, thus providing positive temperature compensation through a wide range of ambient temperatures.

MOUNTING

The Model 224 is supplied with brackets suitable for wall or pipe mounting. The front face of the center plate is provided with tapped holes for use in attaching it to the device to be actuated. An outline dimensional drawing will be furnished upon request.

BELLOWS

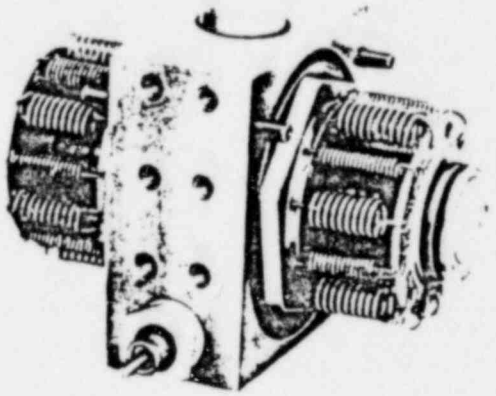
The bellows incorporated in the Model 224 were specifically developed for use in sensing and measuring instruments. This development was necessary to obtain bellows with exacting linearity characteristics as well as long cycle life, free from the effects of work hardening as commonly encountered in the hydraulically formed or mechanically rolled type.

Either 316 ELC stainless steel bellows or beryilium copper bellows can be furnished with the Model 224 as indicated in the specifications section of this bulletin.

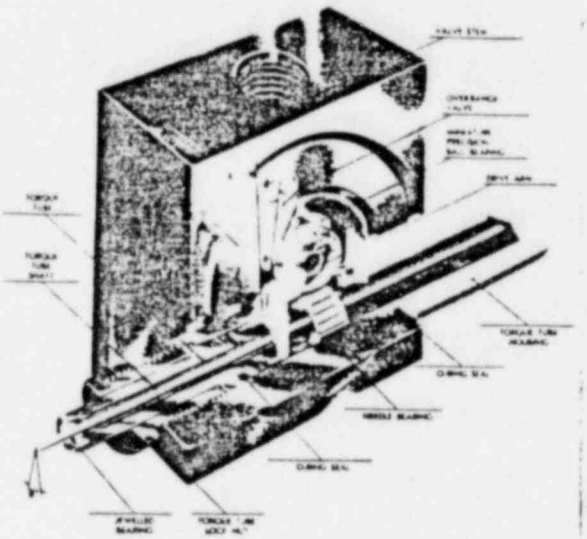
Both types of bellows are manufactured from special mill runs of material. Individual diaphragms are stamped, formed and assembled by highly specialized techniques. The stainless steel bellows are fabricated using advanced seam welding equipment. Beryllium copper bellows are oven-brazed and heat-treated to insure uniformity of spring characteristics.

Several standard bellows fill liquids are available and selection is determined by service. Turbine oil fill is used for general industrial purposes. A mixture of 68% ethylene glycol and 32% water fill is optional.

Other fill liquids are available for special applications upon request.



3/4" Bellows Unit Assembly



Torque Tube

TORQUE TUBE

The Torque Tube Assembly consists of a tube, a shaft, and supporting members. The tube is made from beryllium copper tubing fabricated to exacting standards to insure linearity. The torque tube shaft is made from corrosion-resistant type 416 stainless steel. The outboard end of the tube is sealed to the center plate. The torque tube shaft passes through the center of the tube and is welded to the tube at the inboard end. Movement of the bellows is transmitted to the inboard end of the torque tube, as a rotary response, by means of the drive arm. Because the outer end of the torque tube is sealed to the center plate, it must twist when subjected to torque. The shaft which is freely supported within the tube at its outer end, but rigidly attached to the tube and drive arm at the inner end, rotates through the same angle as the drive arm.

The torque tube assembly is sealed inside the Bellows Unit Assembly and comes in contact only with the fill liquid. This construction permits the use of miniature needle and ball bearings to support and drive the torque tube, thereby assuring a permanent high degree of accuracy and sensitivity. Since the torque tube is installed under a preloaded condition, there is no possibility of backlash as it rotates back and forth through its entire travel.

RANGE SPRINGS

The range springs incorporated in the Model 224 are carefully designed to prevent overstressing and to insure stability of calibration. On units incorporating 1-5/8" bellows, the springs are contained within the bellows and do not come in contact with the measured fluid.

On units incorporating 3/4" bellows, the springs are grouped around the outside of the bellows. The range springs are fabricated from high quality material with composition compatible with the type of bellows material specified, and have an extremely low hysteresis characteristic and exceptional temperature stability.

Other Barton Products:

- Flow Recorders
- Integrating Flow Recorders
- Recording Controllers
- Indicators
- Switches
- Transmitters
- Floco Positive Displacement Meters
- P.D. Meter Accessories
- Orifice Plates and Flanges
- Sulfur Analyzers
- Densitometers
- Turbine Meters

Detailed information concerning any of the products listed above will be furnished upon request.

GENERAL SPECIFICATIONS

Meter Body		Available Differential Pressure Ranges				Pressure Connections	
		Stainless Steel Bellows		Beryllium Copper Bellows			
SWP-psi	Housing Material	1-5/8" O.D.	3/4" O.D.	1-5/8" O.D.	3/4" O.D.	Top	Bottom
400	Cast Aluminum	0-30" w.c. to 0-55 psi	0-60 psi to 0-600 psi			1/8" NPT	1/8" NPT
500	Forged Brass (ASTM-B124 #2)			0-30" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/4" NPT	1/4" NPT
500	Stainless Steel (316)	0-30" w.c. to 0-55 psi	0-60 psi to 0-600 psi			1/4" NPT	1/4" NPT
1,000	Brass (Fed. Spec. QQ-B-637 Comp. 2)			0-60" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/8" NPT	1/8" NPT
1,000	Copper Nickel (70-30) MIL-C-15726			0-60" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	MS16142-4	MS16142-4
1,500	Cold Rolled Steel (C1018) *Stainless Steel (316)	0-60" w.c. to 0-55 psi	0-60 psi to 0-600 psi	0-60" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/4" NPT	1/4" NPT
3,000	Cold Rolled Steel (C1018) *Stainless Steel (316)	0-60" w.c. to 0-55 psi	0-60 psi to 0-600 psi	0-60" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/2" NPT	1/4" NPT
6,000	Cold Rolled Steel (C1018) *Stainless Steel (316)	0-70" w.c. to 0-55 psi	0-60 psi to 0-600 psi	0-70" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	1/2" NPT 9/16"-18UNF-2B	1/4" NPT 9/16"-18UNF-2B
10,000	Alloy Steel (4140)	0-100" w.c. to 0-55 psi	0-60 psi to 0-600 psi	0-100" w.c. to 0-24.5 psi	0-25 psi to 0-400 psi	9/16"-18UNF-2B	9/16"-18UNF-2B
Net Volume in cu. in.	L.P. Head	1.66	2.51	1.66	2.51		
	H.P. Head	1.55	2.42	1.55	2.42		
Displacement in cu. in. for full scale travel		.14	.03	.14	.03		

NOTE: Zero center or split ranges are available on special order. For example, a 0-60" w.c. range may be ordered 30-0-30" w.c. or 15-0-45" w.c. Absolute pressure ranges are available from 100" w.c. to 600 psi.

Other sizes and types of connections (welding stubs, MS, A.N.D., etc.) are available upon request.

Special bellows and housing materials can be made available, such as Monel, Inconel 625 and Hastelloy-C upon request.

Outline dimensional drawings are available upon request.

*Available only with stainless steel bellows.

PERFORMANCE SPECIFICATIONS

Torque Tube Rotation (full-scale differential pressure) . . 8 ± 10%

Temperature Limits . . . . . -60° to +200°F

Repeatability . . . . . 0.2% Full Scale

ORDERING INFORMATION

Housing Pressure Rating (SWP)
Housing Material
Differential Pressure Range

Bellows Material
Fluid Contacting Bellows
Mounting (Pipe or Wall)

BARTON
PROCESS INSTRUMENTS AND CONTROLS
900 S. Turnbull Canyon Road, P.O. Box 1882
City of Industry, California 91749
Telephone (213) 961-2547 Telex 67-7475

GI 2.5M Litho USA T

nutech

San Jose, California

Project Grand Gulf Nuclear Station File No.

Owner Mississippi Power and Light Co.

Client Mississippi Power and Light Co.

In a telephone conversation between Victor Lawford of ITT-Barton and R.P. Morton of Nutech, Mr Lawford verified that the Model 227 pressure indicator is actuated by the Model 224 differential pressure unit. The pressure indicator is shown in Barton Product Bulletin 227-5, and the differential pressure unit is shown in Barton Product Bulletins 224-5-9 and 224-5-10.

The telephone conversation took place on 4-15-82 at 3:30 PM and is documented in Nutech file 32.1206.0001.

Revision	-					Page 1
Prepared By/Date	RPM/4-15-82					of 1
Checked By/Date						