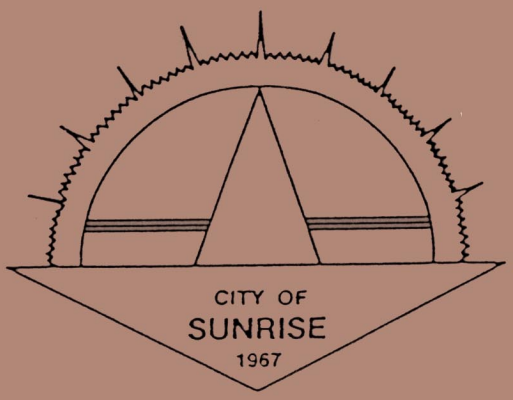
CITY OF SUNRISE
WASTEWATER TREATMENT PLANT No. 3

INJECTION AND MONITORING WELLS OPERATION AND MAINTENANCE MANUAL



Prepared By

CH2M HILL

TAMPA, FLORIDA

FC15805.A2

APRIL 1985

CITY OF SUNRISE

WASTEWATER TREATMENT PLANT NO. 3

INJECTION AND MONITORING WELLS

OPERATION AND MAINTENANCE MANUAL

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Tampa, Florida

April 1985

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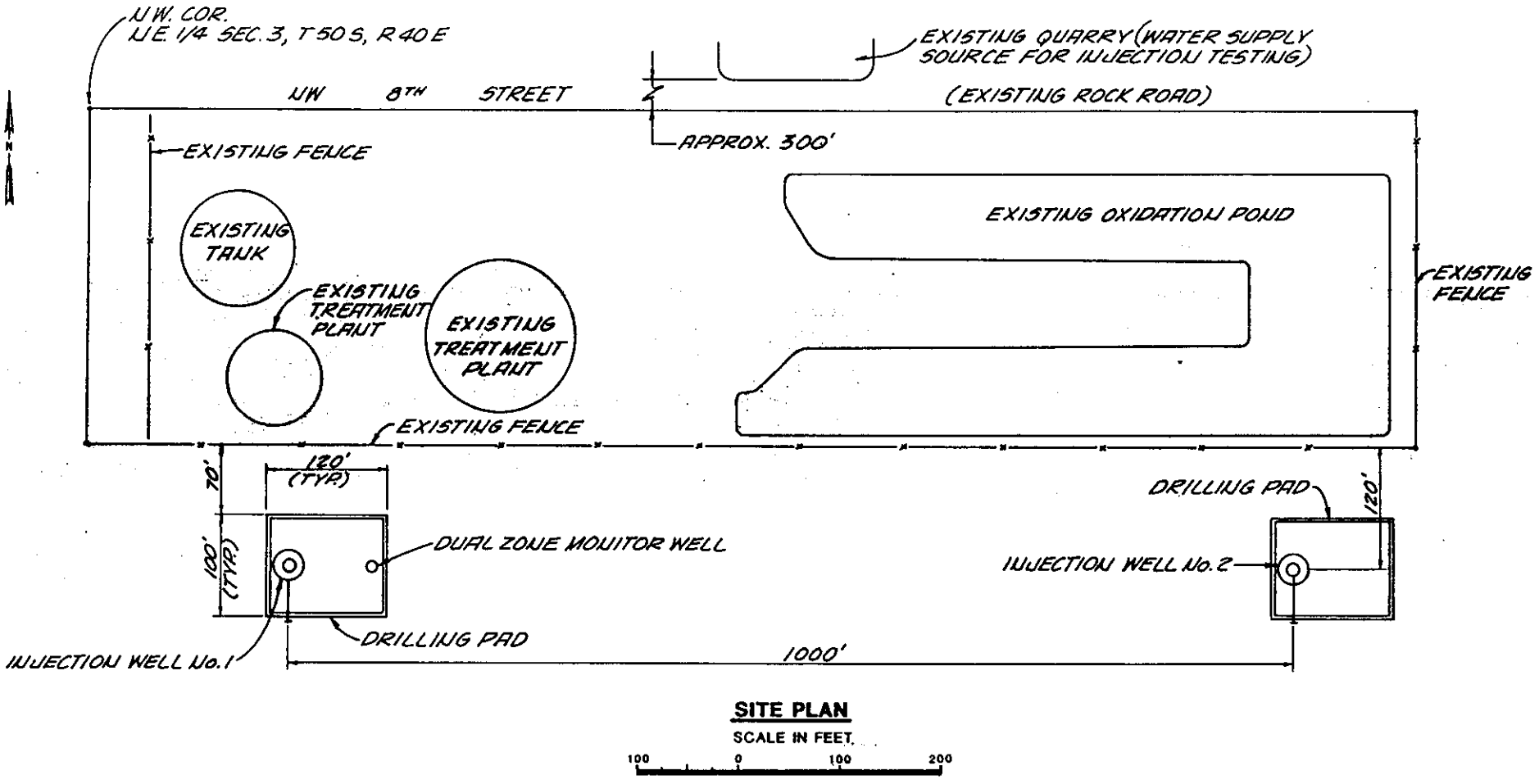
Section 1
INJECTION AND MONITORING WELLS DESCRIPTION

INJECTION WELLS

Two injection wells and one dual zone monitoring well are located at the Sunrise Wastewater Treatment Plant (WWTP) No. 3. Figure 1-1 shows the layout of the injection and monitoring wells at the site. The injection and monitoring wells were constructed under Florida Department of Environmental Regulation Permit No. UD06-66797 and in accordance with Florida Administrative Code, Chapter 17-28.

The injection wells are designed to protect the Biscayne and upper Floridan aquifers from possible contamination by the injected effluent. The casing setting depths are established in accordance with the particular subsurface characteristics of the geologic formations present at this site. At Sunrise, four concentric steel casings were used in construction of the injection wells; 54", 44", 34", and 24" and are shown in Figure 1-2. The injection well heads are shown on Figure 1-3. The Biscayne aquifer, southeast Florida's principal source of potable fresh water, is protected by the four casings which are fully cemented from the bottom to land surface. The brackish water in the upper Floridan aquifer is protected by two of the cemented casings (34" and 24") and confining beds between this aquifer and the injection zone. The confining bed, a very low permeability zone, is approximately 1200 to 1400-feet thick and extends down to the top of the injection zone. At Sunrise, the injection zone, also known as the "boulder zone", extends from approximately 2800 to 3100 feet at IW-1 and from 3050 to 3150 feet at IW-2. The water quality of the boulder zone is similar to that of seawater with total dissolved solids (TDS) concentration approximately 33,000 milligrams per liter (mg/l).



SUNRISE WWTP No.3–INJECTION AND MONITOR WELLS FIGURE 1.1

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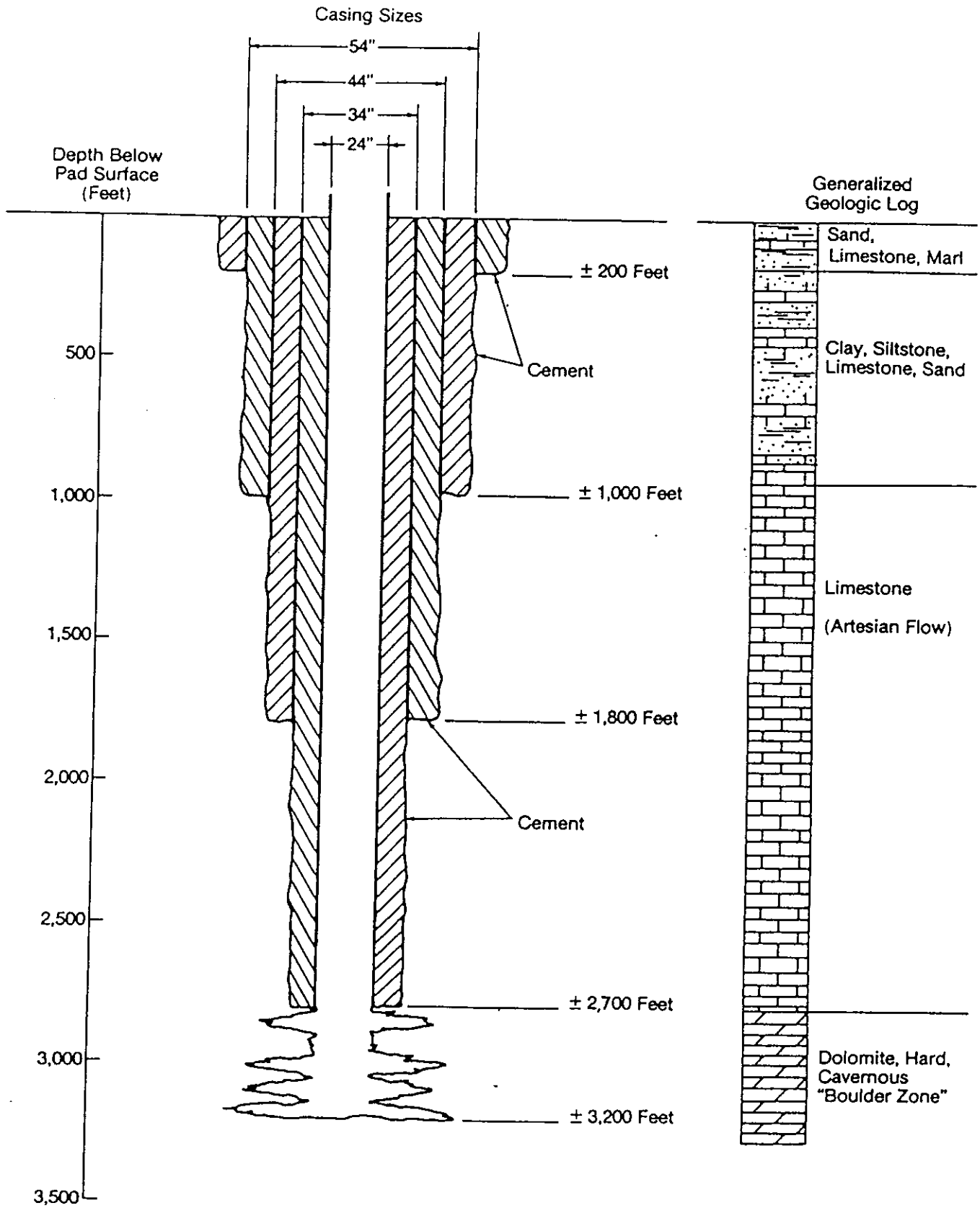

FIGURE 1-2

GENERALIZED INJECTION WELL CONSTRUCTION DIAGRAM FOR THE CITY OF SUNRISE WWTP No. 3

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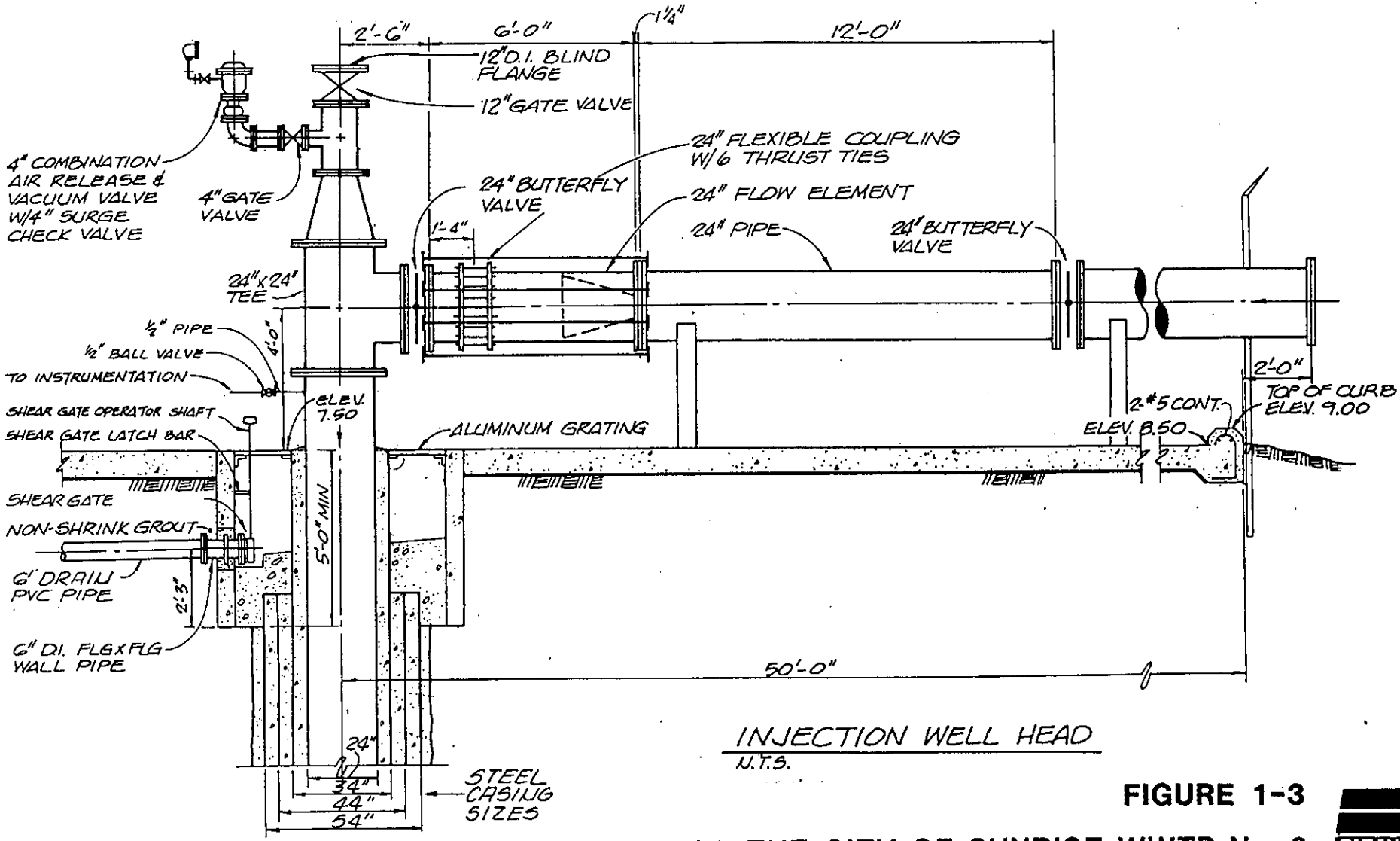

INJECTION WELL HEAD
N.T.S.

FIGURE 1-3

TYPICAL INJECTION WELL HEAD FOR THE CITY OF SUNRISE WWTP No. 3

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The data collected during the drilling and testing of the wells and a detailed summary of their construction are contained in the engineering report, Drilling and Testing of the City of Sunrise Injection and Monitor Wells, dated April 1985, prepared by CH2M HILL.

MONITORING WELL

A dual-zone monitor well was constructed into two aquifer zones in the Floridan aquifer to monitor for any upward migration of the injected effluent. Figures 1-4 and 1-5 show the construction diagram of the dual-zone monitor well and the monitoring wellhead, respectively. The upper aquifer zone (Zone 2) of the well is monitored through the annulus between the 16-inch and 6-inch casings from 1015 feet to 1108 feet in an interval of hard fossiliferous limestone and calcareously cemented grainstone. This zone has an artesian head of approximately 36 feet above pad level and flows approximately 75 gpm through the 2-inch valve on the 16-inch casing.

The lower monitor zone (Zone 1) is the open hole below the 6-inch casing extending from 1600 to 1650 feet in an interval of fossiliferous limestone and calcareously cemented grainstone. The artesian head of the lower zone is approximately 32-feet above pad level and flows approximately 3 gpm through a 1/2-inch line run to the influent wetwell of the treatment plant.

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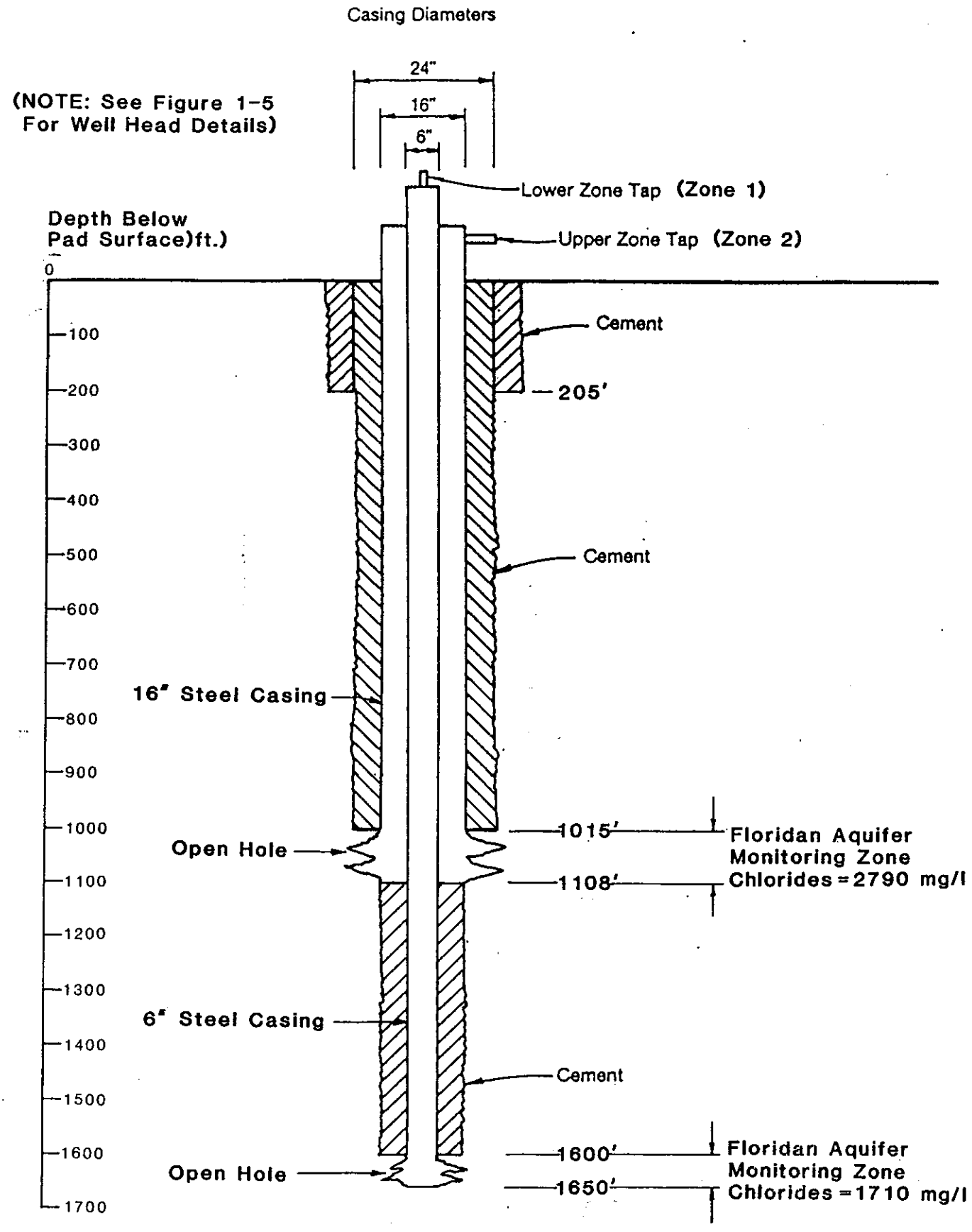

FIGURE 1-4

DUAL ZONE MONITORING WELL DETAIL FOR THE CITY OF SUNRISE WWTP No. 3

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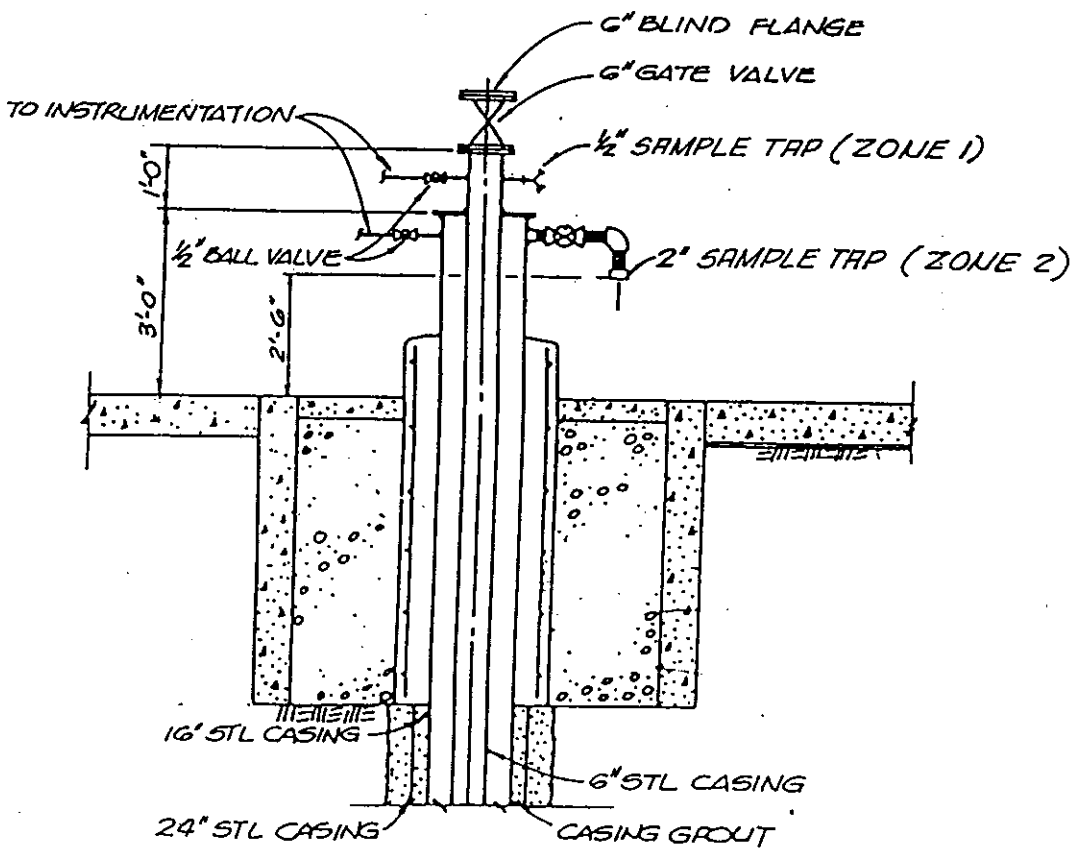

N.T.S.

FIGURE 1-5

DUAL ZONE MONITORING WELL HEAD FOR THE CITY OF SUNRISE WWTP No. 3

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Section 2
INSTRUMENTATION

INJECTION WELL FLOW RATE AND PRESSURE INSTRUMENTS

The effluent flow rate is measured with an insert type venturi, with the flow element located in the injection piping near the injection wellhead. A pressure differential across the venturi is measured by a flow recorder which mechanically converts the pressure differential into an indication of flow rate. A flow indicator, recorder, and totalizer are located in an instrument panel adjacent to each injection wellhead. The Foxboro flow recorder is calibrated to read from 0 to 15 million gallons per day (mgd), and a totalizer on the recorder indicates in total gallons x 1000. The typical injection well instrument panel is shown on Figure 2-1.

The high-pressure signal from the venturi tube is also the injection well head pressure signal and is recorded by a Foxboro pressure recorder calibrated to read from 0 to 220 feet of fresh water column. The pressure recorder is located in the injection well instrument panel on the pad. A 6-inch pressure gauge calibrated to read 0 to 100 psig and 0 to 231 feet of fresh water column is also located in the injection well instrument panel.

Both recorders in the injection well instrument panel are electrically operated and have 7-day, 12-inch circular charts which must be changed weekly. The recorders operate on 120-VAC and 60-Hz power.

DUAL-ZONE MONITORING WELL PRESSURE RECORDERS

Continuous pressure monitoring of each monitoring interval is provided by a Foxboro pressure recorder and a 6-inch

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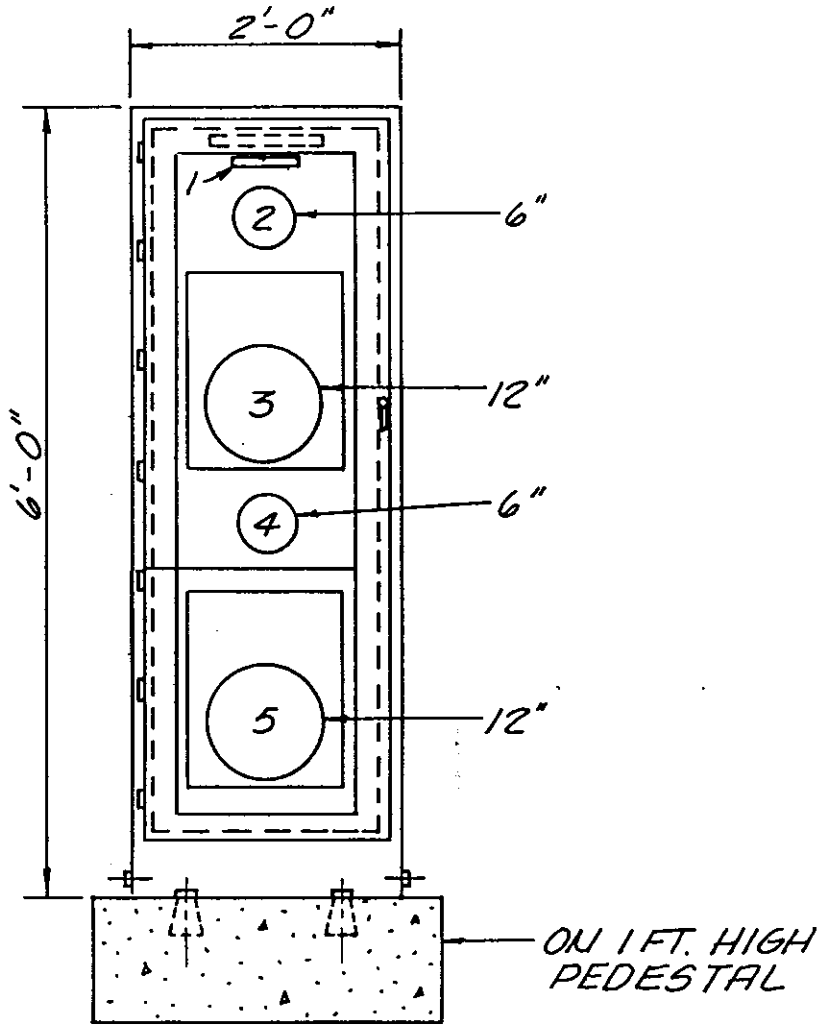

INJECTION WELL PANEL SCHEDULE

ITEM No.	IW-1	IW-2	DESCRIPTION
1	NAMEPLATE	NAMEPLATE	INJECTION WELL
2	PI-1	PI-4	PRESSURE INDICATOR (ROBERTSHAW)
3	PR-1	PR-4	PRESSURE RECORDER (FOXBORO)
4	FI-1	FI-4	FLOW INDICATOR (MID-WEST)
5	FR-1	FR-4	FLOW RECORDER (FOXBORO)

FIGURE 2-1

INJECTION WELL INSTRUMENTATION
FOR THE CITY OF SUNRISE WWTP No. 3

CH2M HILL

pressure gauge mounted together in the instrument panel adjacent to the wellhead. The pressure gauges are calibrated to read 0 to 30 psig and 0 to 70 feet water column. Each pressure recorder is electrically operated and has a 7-day, 12-inch circular chart which must be changed weekly. The recorders operate on 120-VAC and and 60-Hz power. Figure 2-2 shows a diagram of the field installation.

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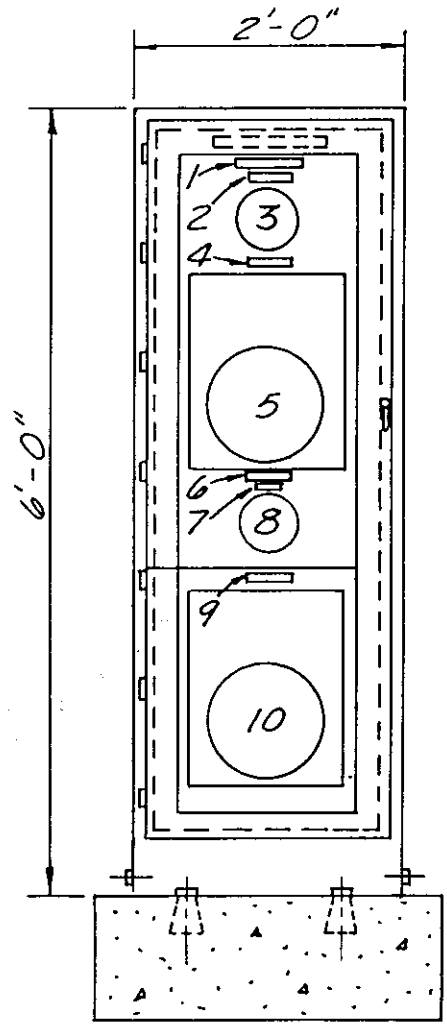

DUAL ZONE MONITORING WELL PANEL SCH.

ITEM No.	TAG No.	DESCRIPTION
1	NAMEPLATE	ZONE-1
2	NAMEPLATE	PI-2
3	PI-2	PRESSURE IND. (ROBERTSHAW)
4	NAMEPLATE	PR-2
5	PR-2	PRESSURE RECORDER (FOXBORO)
6	NAMEPLATE	ZONE-2
7	NAMEPLATE	PI-3
8	PI-3	PRESSURE IND. (ROBERTSHAW)
9	NAMEPLATE	PR-3
10	PR-3	PRESSURE RECORDER (FOXBORO)

FIGURE 2-2

DUAL ZONE MONITOR WELL INSTRUMENT PANEL
FOR THE CITY OF SUNRISE WWTP No. 3

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Section 3

OPERATION, DATA COLLECTION, AND REPORTING

The operating instructions presented in this section are intended to help operators make correct decisions in the field.

Before operating any equipment, the operator must read the equipment supplier's information provided in Appendix C. Specifically, when the operator is having problems with a piece of equipment, he must first call his supervisor and they should decide whether or not they can correct the problem. If they decide they cannot, the equipment supplier or his authorized representative must be contacted.

MONITORING DATA COLLECTION AND REPORTING

Injection system monitoring data are collected to provide a record of system performance and to guide the operator in locating and solving operating problems. This record represents the only direct indication of the injection system performance and serves to substantiate decisions and recommendations. It also provides information required by the Florida DER as stipulated in the operating permit and is crucial in substantiating plant operations and provides necessary information for future system expansion and planning.

A monthly monitoring data summary and a monthly monitoring well water quality forms are contained in Appendix B. Properly filled out, these summaries will serve as the monthly system reports to DER.

The following is a listing of the monitoring data to be collected from the injection system:

Parameter	Equipment or Procedure	Frequency
Injection Flow Rate (mgd)	7-day circular chart recorder in injection well head instrument panel	Continuous
Injection Pressure (feet)	7-day circular chart recorder in injection well head instrument panel	Continuous
Water Quality of Injected Fluid:		
Specific Conductance	Sample at wellhead	Daily
Suspended Solids	Sample at wellhead	Daily
Temperature	Sample at wellhead	Daily
Chlorides	Sample at wellhead	Daily
Pressure in the Upper Monitoring Zone (Zone 2) 1015-1108 ft (feet of water)	7-day circular chart recorder in wellhead panel	Continuous
Pressure in the Lower Monitoring Zone (Zone 1) 1,600-1,650 ft (ft of water)	7-day circular chart recorder in wellhead panel	Continuous
Water Quality of the Two Monitoring Zones:	Sample after flowing zones into lift station via 2-inch line for 1.5 casing volumes	Monthly
Specific Conductance		
Chloride Concentration		
Temperature		
Fecal Coliform		
BOD_5		
Specific Injectivity of Injection Well	Inject @ approximately 5250 gpm; measure pressure	Monthly

MONITORING DATA MONTHLY REPORT

The data for the "Monitoring Data Monthly Report" are to be compiled on a daily basis using data from the influent recorder chart, the injection flow meter recorder chart, the injection pressure recorder chart, and the two monitoring well pressure recorder charts. The effluent water quality is determined from a grab sample at the pump station inlet or the sample tap on the injection wellhead.

It is recommended that the data be compiled at a scheduled time each day, preferably just after taking the recorder readings in the morning.

At the bottom of the form, each column of data is totalized, the maximum and minimum values are entered, and an average value for the month is calculated.

The operator will send the monthly report, with the other treatment plant monthly forms, to the local DER office and to the office of the Broward County Environmental Quality Control Board.

MONTHLY SPECIFIC INJECTIVITY TEST

At the end of every month, a specific injectivity test is to be run on each injection well. This test is run to evaluate the injection capacity of the wells in order to detect any changes over time due to plugging or other flow-restricting conditions.

The test is run as follows:

1. Manually operate one injection pump without throttling and inject water into one well at a time at an approximate flow rate of 5250 gpm.

2. Once the rate is established, measure the injection pressure with the pressure gauge installed on the instrument panel near the injection wellhead.

3. Turn the pump off while carefully watching the injection pressure gauge. After the pressure has stabilized (approximately 5 minutes), record the shut-in pressure or static head on the Monitoring Data Monthly Report specific injectivity test blank.

4. Subtract the shut-in pressure from the injection pressure measured at approximately 5250 gpm (7.56 mgd). Then, convert 7.56 mgd or the actual flow rate to gpm by dividing by 1440 and divide the actual flow rate observed in gpm by this pressure difference. The resulting number, reported as gpm/psig, is the specific injectivity index.

At the completion of the test, open all valves and operate the injection system normally.

MONITORING WELL WATER QUALITY REPORT

Every month water quality samples are to be collected from the two monitoring zones in the monitoring well. These samples are compared to the pre-injection water quality in order to detect any changes caused by migration of injected effluent.

If effluent migration occurs, the quarterly water samples should show a freshening trend from background chloride and specific conductance values.

Table 3-1 is a summary of background water quality in the two monitoring zones prior to the start of injection. Significant deviations from these values should be reported immediately (see "Normal Monitoring Parameters" below).

Table 3-1
Selected Water Quality Parameters
Background Sampling Program[1)]

16" Annulus - 1015' to 1108' (Zone 2)

Parameters	1/21	2/21
Sodium	1,740	1,660
Sulfate	840	860
Chlorides	2,800	2,790
Alkalinity as $CaCO_3$	102	115
pH (Standard Units)	7.85	7.75
Temperature (field-°C)	21.5	23.0
Conductance (µmhos/cm)	9,800	9,320
Total Dissolved Solids	5,700	6,210
Total Organic Carbon	2.09	2.86
Fecal Coliform (colonies/100 ml)	<1	

6" Zone - 1600' to 1650' (Zone 1)	2/19	2/21
Sodium	1,020	990
Sulfate	530	500
Chlorides	1,640	1,710
Alkalinity as $CaCO_3$	105	110
pH (Standard Units)	7.45	7.85
Temperature (field-°C)	23.0	22.5
Conductance (µmhos/cm)	5,820	6,630
Total Dissolved Solids	3,740	3,720
Total Organic Carbon	1.91	2.57
Fecal Coliform (colonies/100 ml)	<1	

1) All concentrations expressed as substance in mg/l unless otherwise indicated.

TPR6/d.7

The monthly water samples are collected as follows:

1. Open both monitoring zone valves (2" and ½") (Figure 1-5) to a flow line into the lift station and verify the flow (i.e., 5 gallon bucket and stopwatch). The pressure in both monitoring pressure recorders will drop significantly.

2. Allow the two zones to flow approximately 1.5 casing volumes as determined by flow rate. The monitoring zone volumes are as follows:

   Zone 2 (Upper zone annulus; 1015' to 1108')
   --1 casing volume
   casing volume = 8,500 gal
   1.5 x casing volume = 12,800 gals
   at 75 gpm = 2 hrs, 50 mins

   Zone 1 (Lower zone 6-inch casing; 1600' to 1650')
   --1 casing volume
   casing volume = 2200 gal
   1.5 x casing volume = 3400 gals
   at 3 gpm = 18 hrs, 53 mins

3. Measure temperature; collect two sample bottles from each zone after letting well flow for the prescribed time and label appropriately. (Include on label the zone sampled, the date, the time, and location.)

4. Close valves and check to ensure that monitoring pressures at adjacent panel return to pre-sampling levels.

5. Have the water in one of the two bottles from each zone analyzed for the required parameters. Keep the other bottle in the refrigerator for 3 months for a check up if necessary.

The results of the analyses should be reported on the Monitoring Well Water Quality Report and sent to the local DER office with the regular monthly report and to the Office of the Broward County Environmental Quality Control Board.

NORMAL MONITORING PARAMETERS

Table 3-2 shows the monitoring parameters and values to be expected when the injection system is operating normally. If the actual values measured for any of the monitoring parameters vary from the normal range, immediate steps should be taken to confirm the anomaly and if so confirmed to report it to DER. Monthly and quarterly monitoring reports should be reviewed for any subtle change or trend in any of the monitoring parameters.

Table 3-2 also lists corrective actions for the most common causes of abnormal values. If the operator cannot identify the problem, a qualified professional must be contacted.

Table 3.2
INJECTION SYSTEM MONITORING PROGRAM
NORMAL VALUES AND TROUBLESHOOTING CHART

Parameter	Normal Range of Values	Suggested Corrective Action if Abnormal Monitoring Values are Encountered[a]
Injection Flow Rate (flow recorder)	0 to 15 mgd (million gallons per day)	1. Check injection pressure for abnormal values. 2. Check water level in pump sump. 3. Check flow path for closed or obstructed valves or fittings. 4. Check and clear clogged pressure line to sender. 5. Check and calibrate flow recorder malfunction. 6. Notify plant operations manager. 7. Remove pump from service. 8. Inspect bowls for obstruction or wear. 9. Inspect shaft, bearings, and motor for wear or damage.
Injection Pressure (pressure recorder)	IW-1 Static: 56 Ft. Pumped: 60 to 93 Ft. IW-2 Static: 60 Ft. Pumped: 65 to 102 Ft.	1. Look for leak in injection line or in check valves. 2. Check gauage at wellhead. 3. Repair and calibrate pressure recorder. 4. Pumpstation malfunction: see items 1-10 above. 5. Inspect and repair plugged or damaged injection well. 6. Notify plant operations manager.
Upper Monitoring Zone Pressure (pressure recorder - Zone 2) Lower Monitoring Zone Pressure (pressure recorder - Zone 1)	36 ft of water (msl) 32 ft of water (msl)	1. Check bleed valve; close if necessary. 2. Check and clear clogged pressure line to recorder. 3. Check pressure recorder malfunction; repair and calibrate. 4. Water quality change; see Monitoring Zone Water Quality, Items 1 and 2 below. 5. Notify plant operations manager.
Upper Monitoring Zone Water Quality (Zone 2) (monthly water sample)	Chloride (mg/l): 2,700-3,100 Specific Conductance µmhos/cm: 9,000-11,000	1. Resample to verify laboratory values. 2. Notify plant operations manager of possible effluent migration into monitoring zones.
Lower Monitoring Zone Water Quality (Zone 2) (monthly water sample)	Chloride (mg/l): 1,600-1,800 Specific Conductance (µmhos/cm): 5,000-7,000	
Injected Fluid Water Quality (daily water sample)	Specific Conductance (µmhos/cm): 500-1,500 Suspended Solids (mg/l): 0-20	1. Check process control and correct as necessary.

[a]Corrective actions not necessarily in appropriate sequence for all conditions.

Section 4
MAINTENANCE

INSTRUMENTATION AND CONTROL MAINTENANCE

These maintenance instructions are general. Maintenance of individual pieces of equipment should be performed specifically in accordance with the recommendations of the manufacturer. Table 4-1 lists the manufacturers and installation companies used for the instrument panels. Operating procedures and ambient conditions of dirt and vibration may dictate maintenance schedules different from those recommended herein.

Modern I&C equipment requires little maintenance if it is in the proper environment. It must be kept clean and dry. The equipment is chosen and designed to withstand ambient temperature and dampness and needs only to be kept clean by periodic maintenance.

Every 3 months, open the instruments and/or withdraw them from their cases; inspect the instruments, and clean with a soft brush. Those instruments which have moving parts should be lightly lubricated in accordance with the instructions of the manufacturer. Do not over-lubricate. Check for interferences between moving parts. Fill ink reservoirs on recorders or change felt tip pens. Look for sources of unusual heat, sound, or odors.

Check the calibration annually on instruments and gauges. If possible, they should be calibrated in-place, using the piping, wiring, and fluids of the processes, calibrating a whole sub-system at once. This method is cheapest and most reliable because it does not require removing the instrument, and it avoids errors such as bad connections and leaks on reinstallation. The disadvantages are that it may disrupt the process, and it may be difficult to obtain

Table 4-1
MAJOR INJECTION SYSTEM EQUIPMENT SUPPLIERS

Equipment Items	Service Representative
Injection and Monitor Well Instrument Panel Installation	C. C. Control Corp. 7231 Southern Boulevard, Unit C-1 West Palm Beach, Florida 33413 V. A. (Butch) Lanford 305/684-3547
Monitoring Well Pressure Recorders	The Foxboro Company 1851 Executive Center Drive Jacksonville, Florida 32207 H. C. Craig 904/398-1545
Pressure Indicators	Robertshaw Acragage (Rep.) System Components Corporation P. O. Box 207 Cocoa Beach, Florida 32931 Robert Shaw - Manufacturers Rep. 305/783-1002
Flow Indicators	Mid West Instrument P. O. Box 939 Troy, Michigan 48099 313/585-0900

sufficient accuracy and range. Pressure gauges should be calibrated and checked anually by connecting to a pressure header with a bleed valve and a pressure valve connected to an air tank. Use a gauge of known accuracy and recent calibration for a reference.

Operating personnel should keep records of the work they do rather than rely on memory to know when to perform each maintenance function. Maintenance files should be provided and used. A sample form is shown in Appendix B.

The following are checklists of maintenance items required at various operating intervals.

Daily Operation

1. All instrumentation should be visually checked on a daily basis, i.e., pens are writing, charts are dry, gauge needles are free, etc.

Monthly Operation

1. Operate all valves. Valves should be fully opened and closed.

2. Review and check alarm system, if applicable.

3. Perform all scheduled maintenance.

4. Run specific injectivity test and collect monitor well water quality sample as described in Section 3.

Yearly Operation

1. Inspect all electrical items for proper operation and condition (a qualified electrician should do this work). Perform any necessary maintenance.

2. Review monthly and quarterly monitoring reports and look for any subtle change or trend in any of the monitoring parameters.

APPENDIX A

City of Sunrise WWTP No. 3
Injection and Monitor Well Design Criteria

APPENDIX A
CITY OF SUNRISE
INJECTION AND MONITORING WELL SYSTEM DESIGN CRITERIA

INJECTION WELL

Injected Flow	
Measured	Flow Element 0 - 15 mgd
Recorded	Foxboro
Velocity	8 feet per second at 15 mgd
Injected Pressure	
Measured	6.0-inch gauge and flow element
Recorded	Foxboro 0 to 220 feet.

Casings	IW-1	IW-2
	54 in/215 ft	54 in/214 ft
	44 in/1035 ft	44 in/865 ft
	34 in/1791 ft1	34 in/1797 ft
	24 in/2700 ft	24 in/2720 ft
	Open/3200 ft	Open/3200 ft

MONITORING WELLS

Number	One well with two zones
Casings, Floridan Well	24 in/204 ft 16 in/1015 ft 6 in/1600 ft Upper Zone Open/1015-1108 Lower Zone Open/1600-1650
Pressure, Upper & Lower Zones	
Pressure indicators	(2) Robertshaw - Acragage 0-30 psi 0-70 ft/H_2O
Pressure Recorder	(2) Foxboro 0-70 ft of water

1Refer to the engineering report: "Drilling and Testing of the City of Sunrise Injection and Monitoring Wells, April, 1985" for an anomaly in the 34" casing (collapse of 34" casing).

APPENDIX B

Maintenance and Monitoring Data Forms

SAMPLE FORM 1

CITY OF SUNRISE WWTP No.3

Deep Injection And Monitoring Well System

MONITORING DATA MONTHLY REPORT
Month _____ 19____
Compiled By _____

Day of Month	Injection Well No. 1							Injection Well No. 2							Collected By	Remarks
	Totalizer Reading (mgd)	Total Flow (mgd)	Minimum Flow (gpm)	Maximum Flow (gpm)	Minimum Operating Pressure (psig)	Maximum Operating Pressure (psig)	Average Pressure (psig)	Totalizer Reading (mgd)	Total Flow (mgd)	Minimum Flow (gpm)	Maximum Flow (gpm)	Minimum Operating Pressure (psig)	Maximum Operating Pressure (psig)	Average Pressure (psig)		
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
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26																
27																
28																
29																
30																
31																
TOTAL																
MAXIMUM																
MINIMUM																
AVERAGE																

SPECIFIC INJECTIVITY Date _____ 19____ By _____

Injection Rate (gpm)	Total Pressure (psig)	–	Shut-In Pressure (psig)	=	Specific Pressure (psig)	Specific Injectivity Index (gpm/Specific Pressure psig)
2800	_____	–	_____	=	_____	_____ gpm/psig

SAMPLE FORM 2

CITY OF SUNRISE WWTP No.3

Deep Injection And Monitoring Well System

MONITORING DATA MONTHLY REPORT
Month _____ 19____
Compiled By _____

Day of Month	Monitoring Well		Injected Effluent					Remarks
	Zone 2 (Upper Zone) Head (ft. msl) [a]	Zone 1 (Lower Zone) Head (ft. msl) [a]	Suspended Solids (mg/l)	Specific Conductance (umhos/cm)	Chlorides (mg/l)	Temp. (° c.)	Collected By	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
TOTAL								
MAXIMUM								
MINIMUM								
AVERAGE								

Zone 2 [a] Upper Zone: Chart Reading + _____ = ft. msl

Zone 1 [a] Lower Zone: Chart Reading + _____ = ft. msl

SAMPLE FORM 3

CITY OF SUNRISE WWTP No. 3
Deep Injection And Monitoring Well System

MONITORING WELL WATER QUALITY
Report for ____ Quarter,19 ____

Parameter	Months of Quarter 1	2	3
Date of Sampling			
Monitoring Well Annulus (Zone 2) Upper Zone			
Temperature °F			
Specific Conductance (umhos/cm)			
Chloride (mg/1)			
Fecal Coliform (colonies/100ml)			
BOD_5 (mg/l)			
Monitoring Well Lower Zone (Zone 1) (6" Casing)			
Temperature °F			
Specific Conductance (umhos/cm)			
Chloride (mg/l)			
Fecal Coliform (colonies/100ml)			
BOD_5 (mg/l)			

Remarks: _____

_____

_____

_____

_____

Submitted by _____ Date _____

Submitted by _____ Date _____

Submitted by _____ Date _____

GNR115

Sample Form 4
SAMPLE EQUIPMENT RECORD CARD

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

Preventive Maintenance Program	Equipemnt Record Number _____

EQUIPMENT DESCRIPTION		ELECTRICAL OR MECHANICAL DATA
Name		Size
Serial No.		Model
Vendor		Type
Vendor Address		
Vender Req.	Phone	
Initial Cost	Date	

WORK TO BE DONE	FREQUENCY	TIME

DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED

GNR115

Sample Form 5
MAINTENANCE FILE CARD

EQUIPMENT _____

SERIAL NO. _____ MAKE _____

TYPE _____ STYLE _____

R.P.M. _____ PHASE _____

SIZE _____

LOCAL REPR. _____

ADDRESS _____

PHONE NO. _____

_____

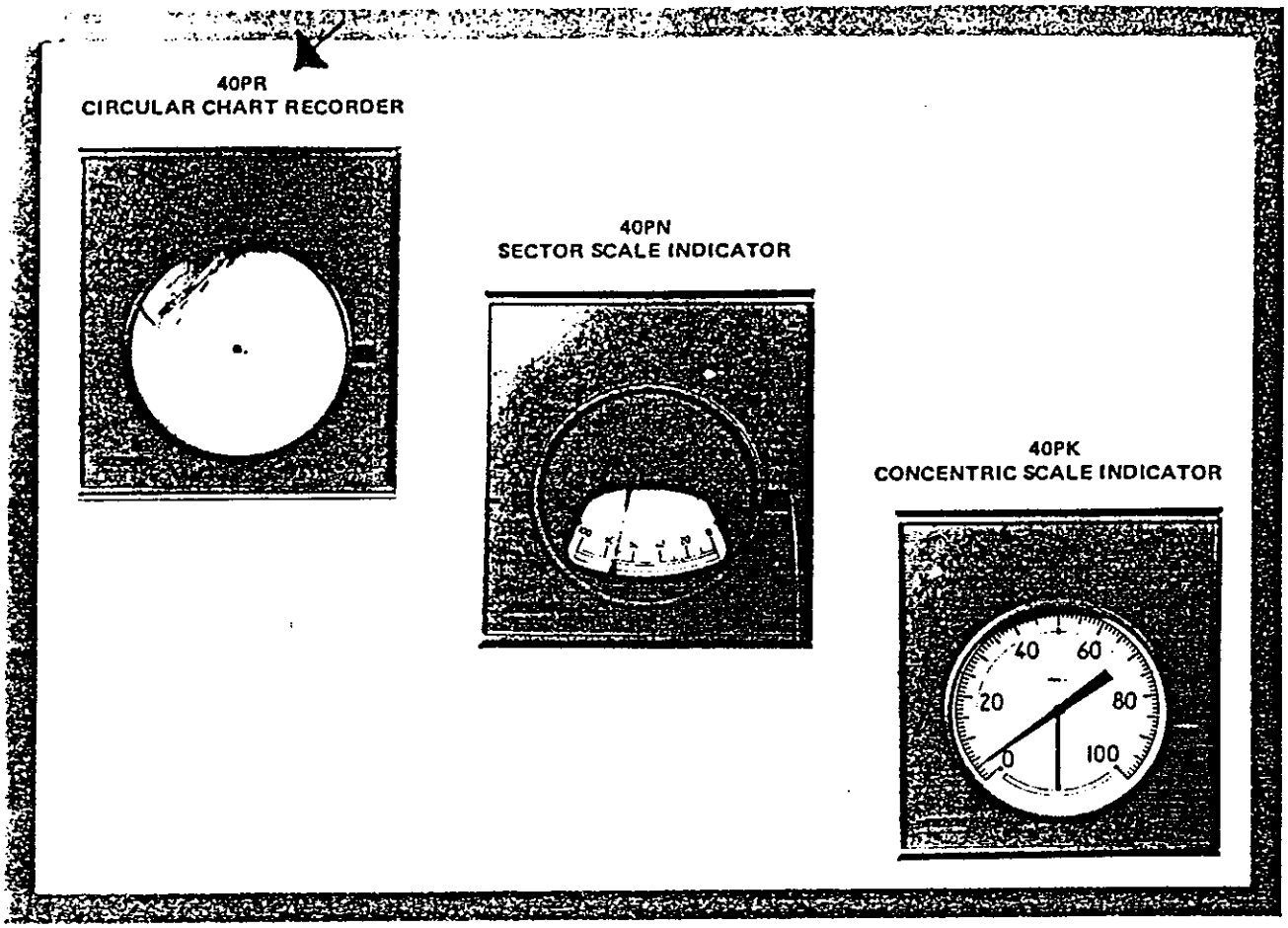
SCHEDULE _____

WORK PERFORMED	DATE	OPT. INT.
PARTS _____		
COMMENTS _____		

GNR115

APPENDIX C

Manufacturer's Literature
(Instrumentation)



40P RECORDERS AND INDICATORS FOR ELECTRONIC INPUTS

These instruments are used wherever accurate chart records or precision indications of electronic input signals are required for efficient process management. They use the simple and dependable Electronic Servo Element for signal-to-motion conversion.

ELECTRONIC SERVO ELEMENT

The Electronic Servo Element accepts electronic inputs from resistance temperature detectors (RTD's), thermocouples (TC's), other sources of dc millivolts, or dc milliamperes, and provides an output shaft position suitable for driving indicator pointers, recorder pens, or other mechanically actuated devices. The element consists of two modules which require only an appropriate electronic input signal and ac power. A servo drive module contains the feedback potentiometer and drive motor. An electronics module contains a regulated power supply, and the input signal conditioning and servo motor control electronics which are mounted on range and servo printed wiring assemblies (PWA's).

Servo Drive Module All internal components are enclosed within a completely sealed aluminum housing. Motor position feedback is provided by a wiper assembly and a conductive plastic element which provides infinite resolution and long life. While slidewire maintenance should not normally be necessary, access to the element for inspection or cleaning is easily accomplished by removing two screws. The torque output of the motor is sufficient to drive any available attachment and provides rapid speed of response. The motor assembly features a minimum of moving parts (no brushes or gears) which results in simple, trouble-free operation.

FOXBORO®

SECTION 2

FLOW RECORDER

(DIRECT PROCESS CONNECTED)

2 - REQUIRED

MODEL:	FOXBORO 40PR-RYE1F-DE-B24ED
DISPLAY:	CIRCULAR CHART RECORDING, 12 INCH
CHART DRIVE:	118V AC 60 HZ 7 DAY ROTATION
PEN TYPE:	FIBER TIP DISPOSABLE PEN - RED
ELEMENT:	A) DIFF PRESS RANGE: 117.75" OF WATER B) TYPE: 37/DE-B C) MATERIAL #316 S.S.
OPTIONAL FEATURES:	A) FLOW INTEGRATOR CONTROL SYSTEM WITH INTERNAL 8-DIGIT COUNTER TYPE 24ED (COUNTER VALVE: GAL X 1000)
SUPPLIES:	A) 1-BOX CHARTS EACH RECORDER (PACKAGED 100 PER BOX) B) 6 FIBRE TIP PENS EA. RECORDER
FLOW RANGE:	0-15 MGD
CHART/SCALE:	0-15 SQ RT
TAG:	FIQR-1 & FIQR-4

Electronics Module The electronics module has been designed to provide radio frequency interference (RFI) protection by the use of RFI filters. It is Foxboro self-certified, and Factory Mutual (FM) and CSA certified for use in ordinary locations and Class I, Groups A, B, C, and D, Division 2 hazardous locations. Over 150 calibrated standard ranges are available for measuring between −100 and +500°C or between −50 and +900°F for RTD's; between −200 and +1700°C or between −350 and +2500°F for TC's; between −15 and +100 mV for other millivolt sources; and between 4 and 20 mA or 10 and 50 mA for standard milliampere ranges. The circuits are designed so that response is not affected by a widely varying source impedance. The range of the electronics module may be changed by field replacement of either the range PWA or individual components. The range PWA may be replaced without soldering or the use of special tools.

WIDE VARIETY OF CONFIGURATIONS

All of these instruments either record on a circular chart or indicate on a sector or concentric scale. The recorders are available with up to four pens. The sector scale indicator is available with one or two pointers, while the concentric scale indicator can accommodate one pointer.

FUNCTIONAL BENEFITS OVER FILLED THERMAL SYSTEMS

The use of TC sensors permits measurement of higher temperatures than filled thermal systems, and RTD's provide narrower spans. Instrument calibration can be conveniently performed using a resistance substitution for RTD calibrations, and a millivolt source for TC measurement instruments. The use of filled thermal systems is restricted by the maximum allowable capillary length. Considerably greater distances can be achieved between the measurement and the 40P Recorder or Indicator with the Electronic Servo Element.

WEATHERPROOF CONSTRUCTION

A glass-fiber reinforced case with gasketed door provides exceptional protection against many hostile environments. This construction provides the dust protection defined by IEC IP 53 and the raintight protection of NEMA Type 3.

VERSATILE MOUNTING

These instruments may be mounted in a panel, on a flat surface, or on a continuous vertical pipe.

OPERATING CONDITIONS

Influence	Reference Operating Conditions	Normal Operating Condition Limits	Operative Limits
Ambient Temperature	25 ±2°C (77 ±3°F)	−30 and +60°C (−20 and +140°F)	−30 and +60°C (−20 and +140°F)
Relative Humidity	50 ±10%	5 and 95%	5 and 95%
Supply Voltage	120 ±1 V ac 220 ±2 V ac 240 ±2 V ac	Rated +10, −15%	Rated +10, −15%
Supply Frequency	50 ±3.0 Hz or 60 ±3.0 Hz	47 and 63 Hz	47 and 63 Hz
Vibration[a]	—	0.25 mm (0.01 in) double amplitude from 5 to 25 Hz	0.25 mm (0.01 in) double amplitude from 5 to 25 Hz

[a]Servo element only

PERFORMANCE SPECIFICATIONS
(Under Reference Operating Conditions)

Accuracy ... ±0.5% of span

Repeatability ... 0.25% of span

Hysteresis ... 0.30% of span

Dead Band ... 0.1% of span

Speed of Response 3 seconds for a 90% step change in the input.

Supply Voltage Effect Maximum error will be 0.25% of span for a +10 to −15% supply voltage change

Supply Frequency Effect Maximum error will be less

Vibration Effect Zero shift due to vibration is less than 3.0% of span at frequencies from 5 to 25 Hz with double amplitudes up to 0.25 mm (0.01 in). When vibration stops, the instrument will return to within 0.25% of its original calibration.

Shock Effect When subjected to mechanical shocks to the instrument enclosure which produces accelerations of 1000 m/s² (100 "g") at the servo drive module, momentary shifts of the output will be not more than 1%, and will return to within 0.25% of original reading within five seconds

FUNCTIONAL SPECIFICATIONS

Electronic Servo Element

Servo Motor Direct drive dc torque motor with sufficient torque to drive all available options.

Power Consumption 10 VA maximum, 8.5 W maximum.

Resistance Converter

Output Linear with equivalent temperature.

Maximum Lead Length 2300 m (7500 ft) (1.00 mm^2 or 18 AWG conductor) (50 Ω maximum per conductor).

Lead Wire Effect Error per 30 m (100 ft) for a 1% mismatch in lead resistance. Assuming 0.64 Ω per 30 m (100 ft) of 1.00 mm^2 or 18 AWG conductor.

Span Error Less than 0.1% of span.

Zero Error ±0.2°C (±0.4°F) can be compensated for, by readjustment of linkages.

Millivolt or Milliampere Converter

Output Linear with millivolt or milliampere input.

Burnout Indication Upscale or downscale action on open-circuit condition. Field selectable using a soldered jumper. For TC's only.

Indicator Pointer Concentric scale indicators have a black pointer and single sector scale indicators have an orange pointer. Dual sector scale indicators have one orange and one black pointer.

Indicator Scales Black markings on white background. Refer to Chart and Dial Catalog 600 for available ranges.

Sector The effective length is 175 mm (6.8 in).

Concentric The effective length is 595 mm (23.4 in).

Recorder Electrical Chart Drive The standard speed is one revolution per 24 hours for nominal 120 V ac, 60 Hz power. Refer to Optional Features section for chart drive options.

Recorder Pens Specify using Model Code

Box-Type For 1-, 2-, 3-, or 4-pen instruments.

Capillary-Type For 1-, 2-, 3-, or 4-pen instruments. Front loading with 0.1 US fl. oz. (3 cm^3) capacity disposable cartridge.

Fiber Tip-Type For 1-, 2-, 3-, or 4-pen instruments. Disposable ink cartridge with integral fiber-tip pen. Minimum of 150 m (500 ft) ink line at a nominal 25 mm/s (1 in/s) speed.

V-Type For 1- or 2-pen instruments only. Provides a recorded fine line of 0.25 mm (0.010 in) width.

Recorder Expendable Accessories

Charts and Inking Systems 100 HUMITEX nominal 300 mm (12 in) circular charts, with nominal 100 mm (4 in) calibrated scale, and the specified inking systems are provided with each instrument.

Cardboard Nameplate A cardboard nameplate is provided for displaying the chart factor.

Temperature Sensors Platinum RTD, DIN 43760 calibration is used with resistance converter. Base metal TC Types T, J, E, and K, and Noble metal TC Types R, S, and B, and other millivolt signals are used with the millivolt converter. See Table 1 for the range and span limits for nonstandard ranges. See Measurement Range Code Table on Page 5 for standard ranges.

Table 1. Sensor Range and Span Limits[a]

Parameter	Platinum RTD		Thermocouple[b][c] and Other Millivolt	Milliampere[b]
	Temperature Measurement	Temperature Difference Measurement		
Range Limits	-200 and +650°C -325 and +1200°F	-200 and +650°C -325 and +1200°F	-15 and +100 mV	4 and 20 or 10 and 50 mA
Span Limits	20 and 555°C 40 and 1000°F	15 and 165°C 25 and 300°F	5 and 100 mV	16 or 40 mA

[a] Refer to table on Page 5 for standard ranges offered.

[b] Includes both temperature and temperature difference measurements.

[c] Range and span limits for TC's are shown in millivolts only, rather than °C and °F. This simplifies listing TC temperature range and span limits which vary with wire size, TC type, and TC construction.

Model Code

40P = Rectangular Polyester Case

Function
R = Circular Chart Recorder
N = Sector Scale Indicator
K = Concentric Scale Indicator

Internal Mechanism
-R = Standard Recorder (40PR)
-N = Standard Sector Scale Indicator (40PN)
-K = Standard Concentric Scale Indicator (40PK)
-E = Recorder or Indicator with Type 70 Contacts

Mounting
F = Flush
P = Pipe
S = Surface

Scale or Chart Drive
E = Electrical Chart Drive, 24-hour rotation, 120 V ac, 60 Hz (40PR)
N = Sector Scale (40PN)
K = Concentric Scale (40PK)

Pens or Pointers
1 = One Pen (40PR) or one pointer (40PN or 40PK)
2 = Two Pens (40PR) or two pointers (40PN only)
3 = Three Pens (40PR)
4 = Four Pens (40PR)

Pen or Scale Type
V = V-Type Pen (40PR with one or two pens only)
B = Box-Type Pen (40PR)
C = Capillary Type Pen (40PR)
F = Fiber Tip Disposable Pen (40PR)
S = Single Range Scale (40PN)
D = Dual Range Scale (40PN)
X = Pen Type per AS Reference

+E = Electronic Servo Element
(Show complete code for each element selected)

Power Supply
S = 120 V ac
N = 220 V ac
P = 240 V ac

Measurement—Sensor Type
T = IEC/ISA Type T (Cu-CuNi) TC
C = DIN 43710-77 (Cu-CuNi) TC
J = IEC/ISA Type J (Fe-CuNi) TC
D = DIN 43710-77 (Fe-CuNi) TC
E = IEC/ISA Type E (NiCr-CuNi) TC
K = IEC/ISA Type K (NiCr-NiAl) TC (DIN 43710-77)
R = IEC/ISA Type R (Pt13Rh-Pt) TC
S = IEC/ISA Type S (Pt10Rh-Pt) TC (DIN 43710-77)
B = IEC/ISA Type B (Pt30Rh-Pt6Rh) TC
M = dc mV
A = dc mA
Q = Platinum RTD, 100-ohm DIN Resistance
X = Nonstandard (including Temperature Difference)

Measurement Range
XX = Select from Measurement Range Code Table on Page 5

Range Units
C = Degree Celsius
F = Degree Fahrenheit
M = Millivolts
A = Milliamperes

Burnout Feature (TC's only)
U = Upscale Action—Forward Range (TC only)
D = Downscale Action—Forward Range (TC only)
N = None—Forward Range (RTD, mV, and mA only)
R = Upscale Action—Reverse Range (TC only)
S = Downscale Action—Reverse Range (TC only)
T = None—Reverse Range (RTD, mV, and mA only)

Example: 40PR-4EBV+EST15FD+EST26FD 40PN-NSN1S+ESP37FN

Measurement Range Code Table—Standard (Consult Foxboro for Ranges not shown)

Range Code	Measurement Range	Range Units—Available with Measurement/Sensor Type Code															
		mV	mA	°C							°F						
01	0 to 5	M															
02	0 to 10	M															
03	0 to 20	M															
04	0 to 30									Q							
05	0 to 50	M								Q							Q
06	-50 to +50									Q							Q
07	-100 to +50				J*												
08	0 to 75	M								Q							
09	-20 to +80				J*												
10	0 to 100	M			J					Q							Q
11	-100 to 0									Q							
12	-200 to +100				J*	E											
13	-100 to +100					E						J*	E				
14	50 to 100									Q							
15	-20 to +120																Q
16	—																
17	-25 to +125			T													
18	0 to 150				J					Q							Q
19	-50 to +150				J*	E											
20	50 to 150																Q
21	4 to 20		A														
22	10 to 50		A														
23	0 to 200			T	J		K			Q		J					Q
24	-100 to +200					E						J*	E				
25	100 to 200									Q							Q
26	0 to 250			T	J					Q	T		E				Q
27	-50 to +250			T								J*					
28	50 to 250									Q		J					Q
29	0 to 300				J		K			Q	T	J					Q
30	-350 to +300										T*		E*				
31	100 to 300				J					Q		J					Q
32	0 to 400				J		K			Q	T	J		K			Q
33	100 to 400													K			Q
34	200 to 400				J					Q							Q
35	0 to 500				J		K			Q	T	J		K			Q
36	-150 to +500										T		E				
37	200 to 500						K										Q
38	300 to 500				J												
39	0 to 600						K				T	J					Q
40	—																
41	200 to 600											J					
42	300 to 600				J						T						
43	0 to 700				J												Q
44	200 to 700				J							J					
45	0 to 750				J		K							K			
46	0 to 800							R				J					Q
47	100 to 800											J		K			
48	300 to 800						K					J		K			
49	0 to 900											J					Q
50	500 to 900						K					J					
51	700 to 900						K					J					
52	0 to 1000						K		S			J		K			
53	500 to 1000								S			J		K			
54	0 to 1200											J		K			
55	200 to 1200											J		K			
56	400 to 1200											J		K			
57	0 to 1300							R									
58	—																
59	800 to 1400							R									
60	900 to 1400								S								
61	0 to 1500							R*				J*					
62	500 to 1500											J*		K			
63	0 to 1600													K			
64	1100 to 1600								S*			J*					
65	1200 to 1600													K			
66	500 to 1700							R*						K			
67	0 to 1800											J*		K			
68	0 to 2000													K			
69	1000 to 2000											J*			R		
70	1200 to 2000														R		
71	0 to 2400													K*			
72	1200 to 2400													K*			
73	0 to 2500													K*			
74	1000 to 2500													K*	R		
75	1500 to 2500													K*		S	
76	1700 to 2500															S	
XX	Nonstandard (including temperature difference)																

*These ranges exceed the U.S.A. recommended temperature limits for protected wire type TC's for the largest wire sizes shown. Consult ANSI publication MC 96.1, ASTM SPECIAL TECHNICAL PUBLICATION (STP) 470A, or SPECIFIC vendor TC application data for guidance as to the maximum working temperature of the TC assembly selected.

PHYSICAL SPECIFICATIONS

Enclosure The case and door are glass-fiber reinforced polyester moldings, compounded for superior corrosion resistance. The door has a shatterproof glass window The overall construction provides the dust protection defined by IEC IP 53 and the raintight protection of NEMA Type 3.

Mounting Standard mounting is flush in a panel up to 16 mm (0.6 in) thick or on a surface. A kit of parts is available for vertical mounting on a DN 50 or 2 in diameter pipe.

Color Case is gray, door is textured blue vinyl paint.

Flammability Rating The case and door meet Type V-0 of UL 94*.

Blow-out Plug Located in the bottom of the case.

Electrical Connections Two nominal 22 mm (0.9 in) diameter holes are provided for a nominal 20 mm (CEE 23), PG16, or 1/2 in conduit fitting, one each for power and measurement.

Data Label Aluminum data label fastened to inside of door with pressure sensitive adhesive. Includes space for customer tag data up to a maximum of 90 characters and spaces. For additional space, see optional Customer Tag.

Approximate Mass 12 to 18 kg (25 to 40 lb), depending on options.

OPTIONAL FEATURES

40M Rectangular Metal Enclosure These instruments are also available in the standard Foxboro 40M rectangular metal enclosure. This enclosure consists of a durable die-cast aluminum case and door with corrosion-resistant vinyl finish. A gasketed door with glass window and cam-latch protects the interior from an excess of fumes, dust, and moisture. All electrical connections are located in the bottom of the case. The enclosure can be either flush- or surface-mounted, or yoke-mounted on a DN 50 or 2 in diameter vertical pipe stub. Refer to PSS 3-1A1 A for the specifications and numerous options available with the 40M enclosure. Selectable by specifying the recorder or indicator Model Number, and substituting 40M for 40P

Transmitter dc Power Supply For 4 to 20 and 10 to 50 mA input instruments only Mounted within the 40P or 40M enclosures. Provides dc power to power the milliampere source or the external loop. AS (Auxiliary Specifications) Reference is LPS

Voltage Divider Module Provided for voltage inputs with spans from 0.1 V dc to 42 V dc. The voltage divider attenuates the input voltage to a millivolt signal Voltage divider modules are offered as follows

Voltage Divider Module Code	Attenuation	Measurement Spans Between (V dc)
2AX + VE	100:1	1 and 10
2AX + VF	10:1	0.1 and 1

Note For measurement spans between 10 and 42 V dc, refer to Foxboro for availability of voltage divider module

Type 70 Electric Contacts A variety of contact systems is available to provide a wide range of switching functions to actuate external control or alarm circuits. General Purpose electrical classification only. Select internal mechanism code -E (Refer to Foxboro for options)

24E Series Electric Integrator The 24E is an electromechanical device which provides a continuous totalization of measurement of a variable rate. It is offered for both square-root and uniform calibration. It is suitable for use in ordinary locations and Class I, Groups C and D, Division 2 hazardous locations. Specify 24E and either square-root or uniform calibration.

Flush Door Lock With 2 keys. AS Reference is FDL.

Inlet Purge Restrictor Connection tapped for 1/4 NPT fittings. AS Reference is IPR.

Alternative Color Any standard Foxboro color per GS 5-1D1 A or color reference provided by the user. Textured finish only. Designate Color.

Nameplate Laminated plastic nameplates 38 x 76 mm (1.5 x 3 in) with white characters on a black background. Maximum of 5 lines with 28 characters or spaces 3 mm (0.13 in) high, or 24 characters or spaces 4 mm (0.16 in) high, per line. AS Reference is N/P.

Internal Illumination An incandescent lamp is available for operation from a nominal 120 or 240 V ac power source, as specified. General Purpose electrical classification only. AS Reference is II-I.

Recorder Chart Drives Electrical, single speed, one revolution in 30 seconds; 1,2,4,6,7.5,12,15,24,30, or 96 minutes; 1,2,3,4,6,8, or 12 hours; or 2,3,4, or 7 days; 120 or 220/240 V ac, 50 or 60 Hz. (Refer to Foxboro for others.)

Customer Tag Stainless steel tag wired to instrument for customer tag data that doesn't fit on data label. There can be a maximum of 10 lines of data with 40 characters and spaces per line. Tag is wired to instrument if AS Reference MTS is specified, or fastened with drive screws if AS Reference SCT is specified.

*Underwriters Laboratory Recognized Standard for Flammability of Plastic Materials UL 94

PRODUCT SAFETY SPECIFICATIONS

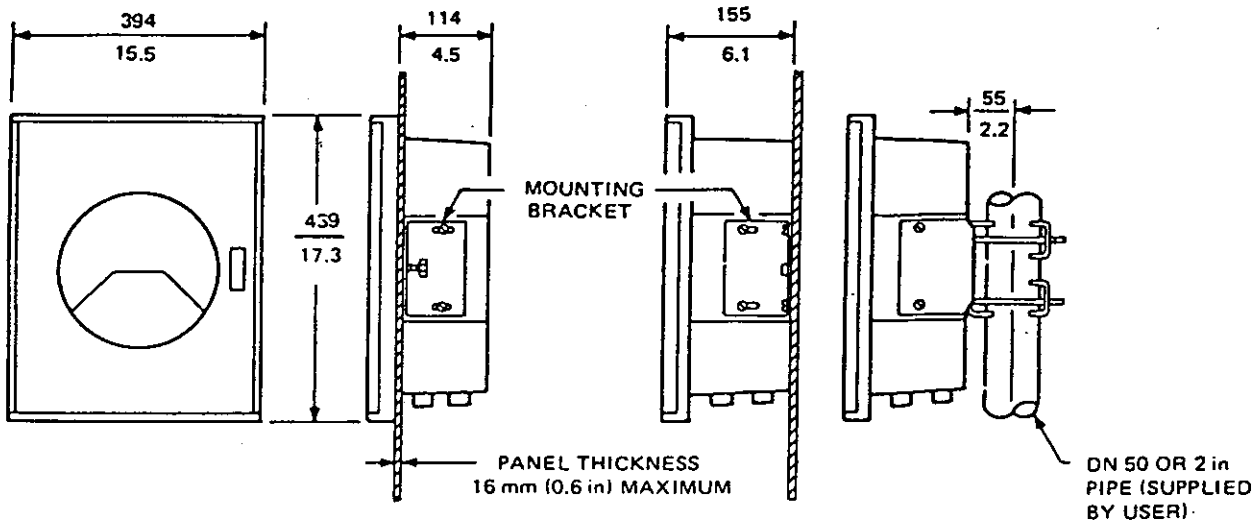
These instruments have been designed to meet the requirements of the Occupational Safety and Health Administration (OSHA). When properly installed, they are Foxboro self-certified, and FM and CSA certified for use in ordinary locations, and for Class I, Groups A, B, C, and D, Division 2 hazardous locations (without internal illumination or Type 70 contact options).

ORDERING INSTRUCTIONS

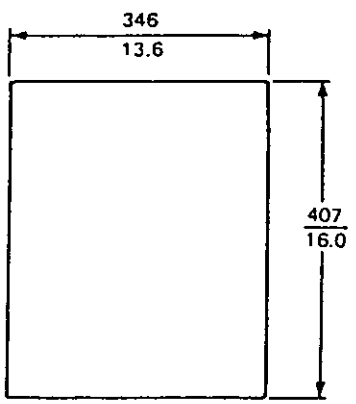
1. Model Number
2. Type of Pen(s)
3. Optional Features
4. Tag and Application

DIMENSIONS—NOMINAL

mm / in



FLUSH MOUNTING SURFACE MOUNTING PIPE MOUNTING



PANEL CUTOUT

NOTE

FOR HORIZONTAL MULTIPLE PANEL MOUNTING, A MINIMUM DISTANCE OF 445 mm (17.5 in) FROM CENTER LINE TO CENTER LINE IS REQUIRED.

— GENERAL DESCRIPTION and PRINCIPLE OF OPERATION —
TYPE 37 DIAPHRAGM METER

General

The Type 37 Diaphragm Meter is used to measure flow, liquid level, or differential pressure. It performs the functions of a float type manometer, but requires no mercury.

The following standard ranges are available: 20 inches, 50 inches, 100 inches, and 200 inches of water differential, with a maximum static pressure rating of 2,000 pounds per square inch.

Other full scale ranges may be produced by adjusting the standard range springs and multiplication lever. For example, a 100-inch range instrument may in this way be converted to a 50-inch range instrument.

Compound ranges are also easily produced by adjustment of standard range springs and proper zero setting. Compound ranges with range shift up to 50 percent are available. For example, with a 100-inch range spring, compound ranges between 0-100 inches and 50-0-50 inches are available.

Either rectangular (UR-13C) or circular (UC-12) case design may be provided, the UC-12 case permitting measurement of one supplementary variable, and the UR-13C design permitting measurement of two supplementary variables.

The meter is temperature compensated for all differential ranges. However, it should not be exposed to temperatures above 230 F or below −30 F.

Other features include an adjustable damping device permitting damping of flow disturbances and pulsations, pressure chamber covers and body constructed of either carbon steel or 316 stainless steel, and range springs made of Ni-Span C, which has a very low thermal expansion rating.

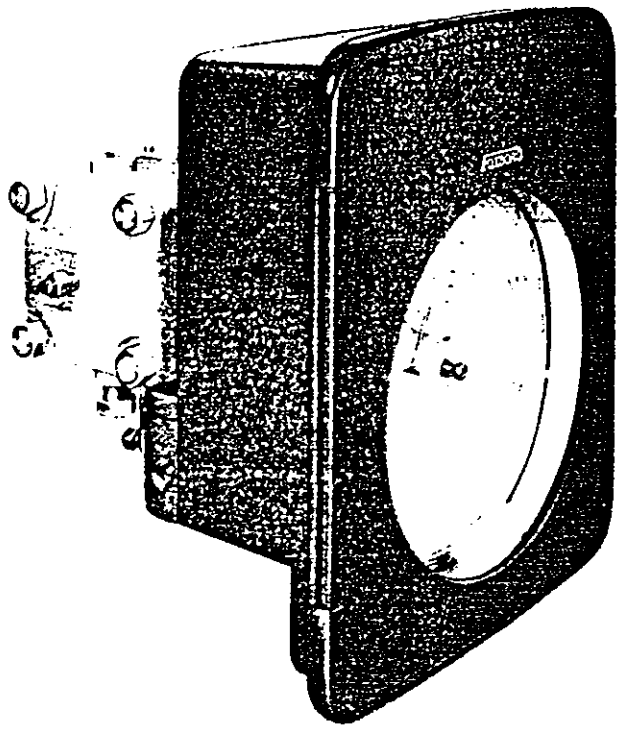


Fig. B3287

The differential range of the instrument is stamped on the data plate on top of the meter body. The data plate also identifies the high and low pressure chambers.

Principle of Operation (Refer to Fig. B3288)

The Type 37 Meter consists of a liquid-filled system, a high pressure chamber and a low pressure chamber, a range spring assembly, and a drive lever assembly to transfer motion of the diaphragms to a pen or pointer.

There are two diaphragms, one in each meter chamber. The high pressure chamber diaphragm (7) is the compensating diaphragm, and the low pressure chamber diaphragm (2) is the range diaphragm. Both diaphragms, the passage between them, and the body area to the bellows seal (5) on the drive lever, are liquid filled.

When a differential pressure across the primary device causes a difference in pressures in the high and low chambers, the higher pressure compresses the compensating diaphragm (7) so that some fill liquid flows from it into the range diaphragm (2). The range diaphragm expands, exerting a pressure against the opposing range springs (3). The particular characteristic of these springs determines the instrument range. Since the range diaphragm (2) is directly connected by Elgiloy flexure strips to the drive lever assembly (4), the linear motion of the range diaphragm moves the inner end of the drive lever. The drive lever is pivoted by Elgiloy flexures outside the bellows seal (5); therefore, the outer end of the drive lever moves in proportion to the inner end, and this movement, proportional to changes in differential pressure, is transmitted to a pen or pointer.

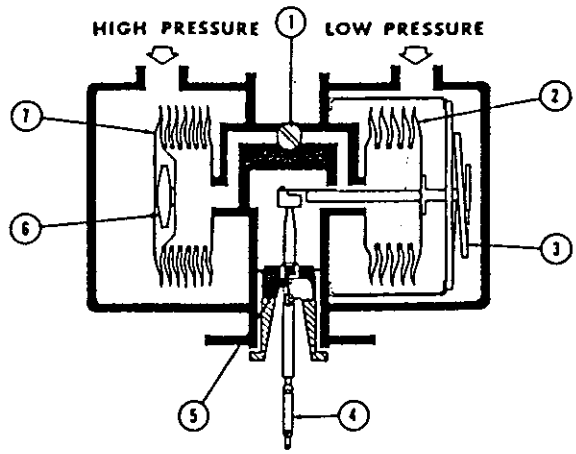


Fig. B3288

A bimetallic Temperature Compensator (6), inside the compensating diaphragm (7), automatically adjusts the capacity of the diaphragm assembly to the changing volume of the fill liquid resulting from any change in ambient temperatures. Zero setting of the meter will not be affected by changes in ambient temperature.

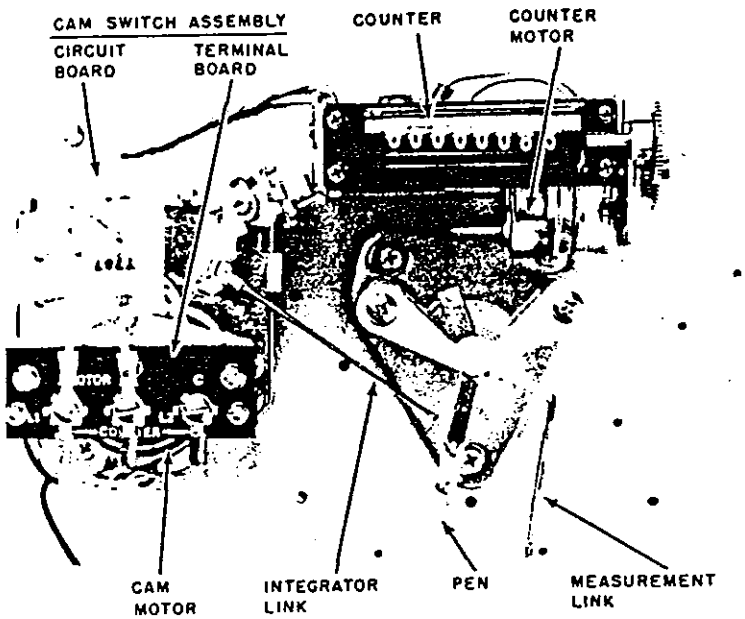
Damping occurs when the area of the passage between the two diaphragms is restricted by adjustment of the damping screw (1).

Instruction

MI
6-211
October 1975

— TYPE 24E INTEGRATOR, STYLE D —

Installation and Operation



Type 24E Integrator is an electro-mechanical device that totalizes a variable measurement (usually flow) over a period of time. The measurement is transmitted to the integrator by a link from a pen movement or from a receiver bellows.

The integrator consists of a cam-switch assembly and a counter assembly. The cam switch energizes the counter motor circuit for a time interval that is proportional to the measurement. Thus the counter continuously indicates the integrated value of the measurement.

If the measurement signal varies uniformly with the flow, the cam is heart-shaped; if the measurement signal varies with the square of the flow, the cam is approximately oval-shaped.

The integrator is usually used in conjunction with a recorder. The counter can be located either adjacent to the cam-switch within the recorder case, or outside the recorder case. More than one counter assembly can be wired in parallel (with a suitable relay) for duplicate totalized readings.

Standard Specifications

Voltage:	120 or 240 V ac ±10%, 50 or 60 Hz, as specified
Temperature Limits:	-40 to +60°C (-40 to +140°F)
Output:	5 to 48.8 counts/min., depending on gears
Integrating Range:	10 to 100% of scale
Power Consumption:	Cam switch with counter load - 20 VA max.
	Cam switch with relay load - 10 VA max.
Electrical Classification:	Class I, Groups C and D, Division 2 locations
Accuracy:	±0.5% of full scale, relative to pen position. Cam speed varies directly with frequency.

FOXBORO

Principle of Operation

The link connecting the pen movement with the integrator, moves a linkage on the cam-switch assembly. Therefore for every value of measurement there is a corresponding position of this linkage.

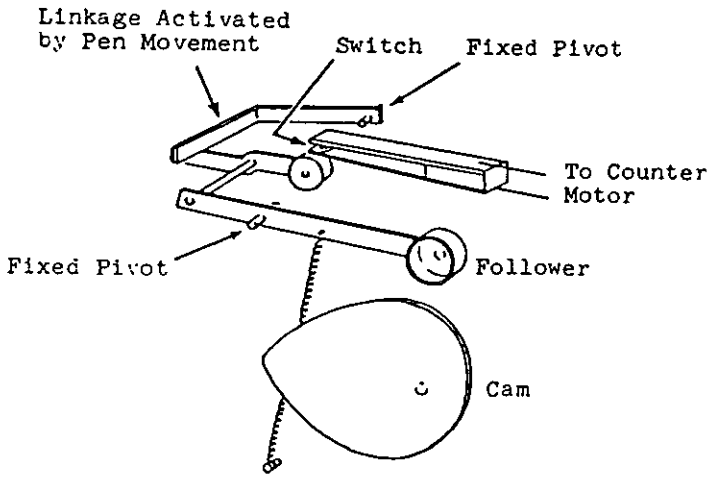
The path of the motion of this linkage is the same as that of the end of the follower of a cam. This cam is turned by a synchronous motor at 5 rpm. The linkage is so arranged that, depending on both the measurement and the location of the follower on the cam, an increasing measurement will cause the linkage to contact the follower and lift it off the cam. (A decreasing measurement will tend to move the linkage away from the follower.) At the same time, whenever the linkage contacts the follower, a switch is closed; and when the contact is broken, the switch is opened.

The shape of the cam is such that with the measurement at a given percent of scale, the follower will be lifted off the cam by the linkage for that same percent of the time of one revolution of the cam (12 sec.). For example, if the measurement were at 60% of scale, the follower would be lifted off the cam for 60% of 12 seconds, and the switch would be closed for this same period.*

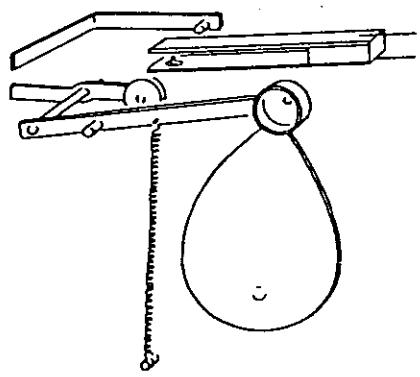
When the switch is closed, the gate circuit to a triac allows voltage to be applied to another synchronous motor which turns a mechanical counter. When the switch is opened, the voltage is interrupted and the motor stops turning; a brake rectifier in the counter assembly applies a dc voltage to the motor to prevent coasting.

***Actual design of cam-switch assembly is such that when measurement is at 100% of scale, switch is not closed 100% of time, but is interrupted for 1/21 of the 12-second cycle. Therefore, at maximum flow, counter operates for only (20/21)(12 seconds) = 11.43 seconds. The gears in the counter assembly compensate for this condition and counter reading is correct. If integrator is used with a time-contact unit, an allowance should be made for this factor.**

CAM-SWITCH DETAILS



Cam Follower Lifted Off Cam; Switch CLOSED



Cam Follower Riding On Cam: Switch OPEN

NOTE: Illustrated is square-root cam (oval-shaped).

SECTION 5

PRESSURE RECORDER

(DIRECT PROCESS CONNECTED)

2 - REQ'D

MODEL:	FOXBORO 40PR - RFEIF-PB-BA
DISPLAY:	CIRCULAR CHART RECORDING, 12 INCH
CHART DRIVE:	118V AC 60 HZ 7 DAY ROTATION
PEN TYPE:	FIBER TIP DISPOSABLE PEN - RED
ELEMENT:	PRESSURE RANGE: 0-220 FT. MATERIAL: #316 S.S. TYPE: SPIRAL
SUPPLIES:	A) 1-BOX CHARTS EACH RECORDER (PACKAGED 100 PER BOX) B) 6-FIBRE TIP PENS EA. RECORDER
MEASUREMENT RANGE:	0-220 FT
CHART/SCALE:	0-220
TAG:	PR-1 & PR-4

SECTION 3

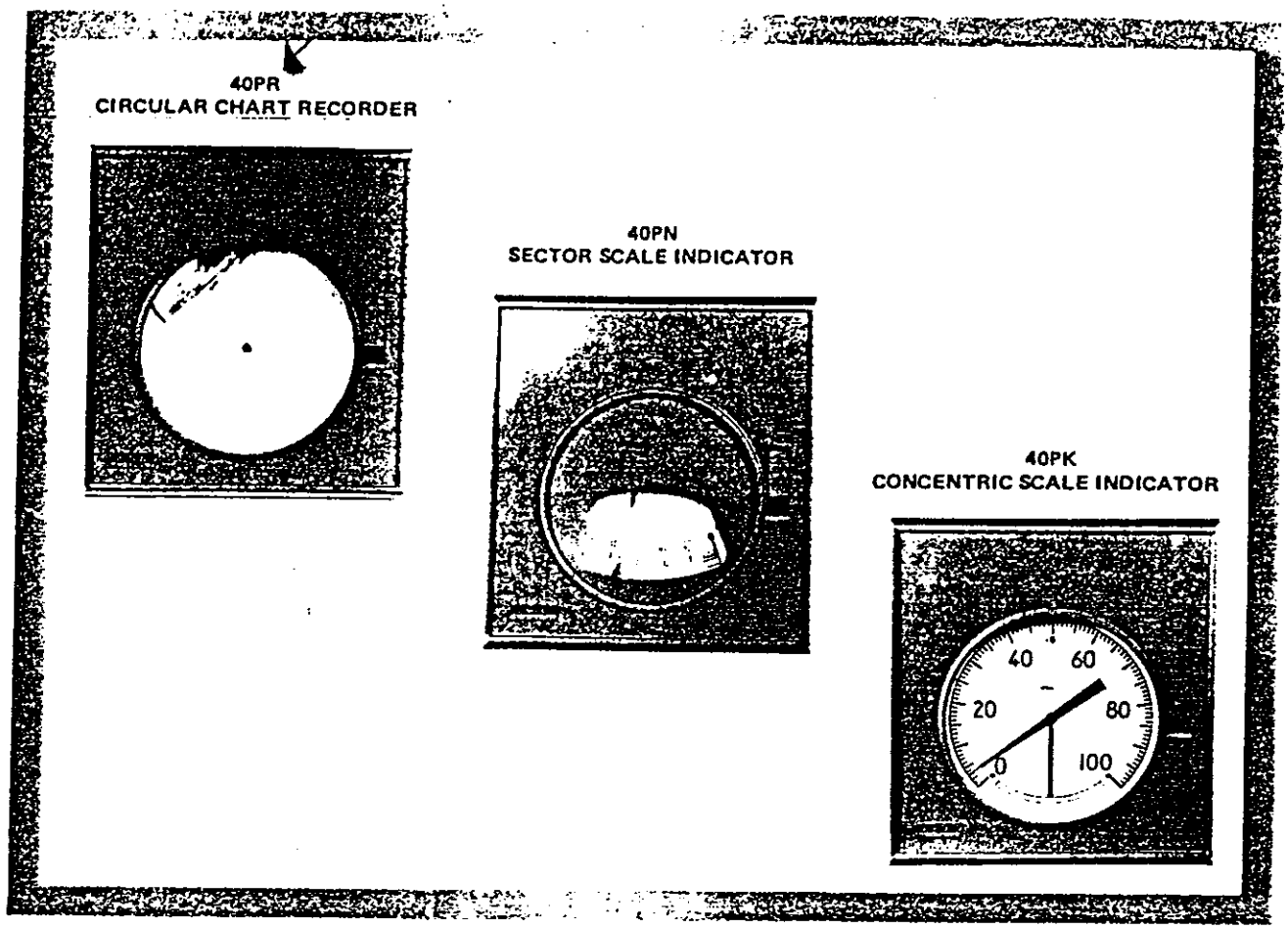
PRESSURE RECORDER

(DIRECT PROCESS CONNECTED)

2 - REQ'D

MODEL:	FOXBORO 40PR - RFEIF
DISPLAY:	CIRCULAR CHART RECORDING, 12 INCH
CHART DRIVE:	118V AC 60 HZ 7 DAY ROTATION
PEN TYPE:	FIBER TIP DISPOSABLE PEN - RED
ELEMENT:	PRESSURE RANGE: FT. MATERIAL: #316 S.S. TYPE: SPIRAL
SUPPLIES:	A) 1-BOX CHARTS EACH RECORDER (PACKAGED 100 PER BOX) B) 6-FIBRE TIP PENS EA. RECORDER
MEASUREMENT RANGE:	FT
CHART/SCALE:	
TAG:	PR-2 & PR-3

NOTE: ENGINEER TO ADVISE RANGES AS PER SPECIFICATIONS.



40P RECORDERS AND INDICATORS FOR ELECTRONIC INPUTS

These instruments are used wherever accurate chart records or precision indications of electronic input signals are required for efficient process management. They use the simple and dependable Electronic Servo Element for signal-to-motion conversion.

ELECTRONIC SERVO ELEMENT

The Electronic Servo Element accepts electronic inputs from resistance temperature detectors (RTD's), thermocouples (TC's), other sources of dc millivolts, or dc milliamperes, and provides an output shaft position suitable for driving indicator pointers, recorder pens, or other mechanically actuated devices. The element consists of two modules which require only an appropriate electronic input signal and ac power. A servo drive module contains the feedback potentiometer and drive motor. An electronics module contains a regulated power supply, and the input signal conditioning and servo motor control electronics which are mounted on range and servo printed wiring assemblies (PWA's).

Servo Drive Module All internal components are enclosed within a completely sealed aluminum housing. Motor position feedback is provided by a wiper assembly and a conductive plastic element which provides infinite resolution and long life. While slidewire maintenance should not normally be necessary, access to the element for inspection or cleaning is easily accomplished by removing two screws. The torque output of the motor is sufficient to drive any available attachment and provides rapid speed of response. The motor assembly features a minimum of moving parts (no brushes or gears) which results in simple, trouble-free operation.

FOXBORO®

ectronics Module The electronics module has been designed to provide radio frequency interference (RFI) protection by the use of RFI filters. It is Foxboro self-certified, and Factory Mutual (FM) and CSA certified for use in ordinary locations and Class I, Groups A, B, C, and D, Division 2 hazardous locations. Over 150 calibrated standard ranges are available for measuring; between -100 and +500°C or between -50 and +900°F for RTD's; between -200 and +1700°C or between -350 and +2500°F for TC's; between -15 and +100 mV for other millivolt sources; and between 4 and 20 mA or 10 and 50 mA for standard milliampere ranges. The circuits are designed so that response is not affected by a widely varying source impedance. The range of the electronics module may be changed by field replacement of either the range PWA or individual components. The range PWA may be replaced without soldering or the use of special tools.

WIDE VARIETY OF CONFIGURATIONS

All of these instruments either record on a circular chart or indicate on a sector or concentric scale. The recorders are available with up to four pens. The sector scale indicator is available with one or two pointers, while the concentric scale indicator can accommodate one pointer.

FUNCTIONAL BENEFITS OVER FILLED THERMAL SYSTEMS

The use of TC sensors permits measurement of higher temperatures than filled thermal systems, and RTD's provide narrower spans. Instrument calibration can be conveniently performed using a resistance substitution for RTD calibrations, and a millivolt source for TC measurement instruments. The use of filled thermal systems is restricted by the maximum allowable capillary length. Considerably greater distances can be achieved between the measurement and the 40P Recorder or Indicator with the Electronic Servo Element.

WEATHERPROOF CONSTRUCTION

A glass-fiber reinforced case with gasketed door provides exceptional protection against many hostile environments. This construction provides the dust protection defined by IEC IP 53 and the raintight protection of NEMA Type 3.

VERSATILE MOUNTING

These instruments may be mounted in a panel, on a flat surface, or on a continuous vertical pipe.

OPERATING CONDITIONS

Influence	Reference Operating Conditions	Normal Operating Condition Limits	Operative Limits
Ambient Temperature	25 ±2°C (77 ±3°F)	-30 and +60°C (-20 and +140°F)	-30 and +60°C (-20 and +140°F)
Relative Humidity	50 ±10%	5 and 95%	5 and 95%
Supply Voltage	120 ±1 V ac 220 ±2 V ac 240 ±2 V ac	Rated +10, -15%	Rated +10, -15%
Supply Frequency	50 ±3.0 Hz or 60 ±3.0 Hz	47 and 63 Hz	47 and 63 Hz
Vibration[a]	—	0.25 mm (0.01 in) double amplitude from 5 to 25 Hz	0.25 mm (0.01 in) double amplitude from 5 to 25 Hz

[a]Servo element only.

PERFORMANCE SPECIFICATIONS
(Under Reference Operating Conditions)

Accuracy ..... ±0.5% of span

Repeatability ..... 0.25% of span

Hysteresis ..... 0.30% of span

Dead Band ..... 0.1% of span

Speed of Response 3 seconds for a 90% step change in the input.

Supply Voltage Effect Maximum error will be 0.25% of span for a +10 to -15% supply voltage change.

Supply Frequency Effect Maximum error will be less

Vibration Effect Zero shift due to vibration is less than 3.0% of span at frequencies from 5 to 25 Hz with double amplitudes up to 0.25 mm (0.01 in). When vibration stops, the instrument will return to within 0.25% of its original calibration.

Shock Effect When subjected to mechanical shocks to the instrument enclosure which produces accelerations of 1000 m/s² (100 "g") at the servo drive module, momentary shifts of the output will be not more than 1%, and will return to within 0.25% of original reading within five seconds.

FUNCTIONAL SPECIFICATIONS

Electronic Servo Element

Servo Motor Direct drive dc torque motor with sufficient torque to drive all available options

Power Consumption 10 VA maximum, 8.5 W maximum.

Resistance Converter

Output Linear with equivalent temperature.

Maximum Lead Length 2300 m (7500 ft) (1.00 mm^2 or 18 AWG conductor) (50 Ω maximum per conductor).

Lead Wire Effect Error per 30 m (100 ft) for a 1% mismatch in lead resistance. Assuming 0.64 Ω per 30 m (100 ft) of 1.00 mm^2 or 18 AWG conductor.

Span Error Less than 0.1% of span.

Zero Error ±0.2°C (±0.4°F) can be compensated for, by readjustment of linkages.

Millivolt or Milliampere Converter

Output Linear with millivolt or milliampere input.

Burnout Indication Upscale or downscale action on open-circuit condition. Field selectable using a soldered jumper. For TC's only.

Indicator Pointer Concentric scale indicators have a black pointer and single sector scale indicators have an orange pointer. Dual sector scale indicators have one orange and one black pointer.

Indicator Scales Black markings on white background. Refer to Chart and Dial Catalog 600 for available ranges.

Sector The effective length is 175 mm (6.8 in).

Concentric The effective length is 595 mm (23.4 in).

Recorder Electrical Chart Drive The standard speed is one revolution per 24 hours for nominal 120 V ac, 60 Hz power. Refer to Optional Features section for chart drive options.

Recorder Pens Specify using Model Code

Box-Type For 1-, 2-, 3-, or 4-pen instruments.

Capillary-Type For 1-, 2-, 3-, or 4-pen instruments. Front loading with 0.1 US fl. oz. (3 cm^3) capacity disposable cartridge.

Fiber Tip-Type For 1-, 2-, 3-, or 4-pen instruments. Disposable ink cartridge with integral fiber-tip pen. Minimum of 150 m (500 ft) ink line at a nominal 25 mm/s (1 in/s) speed.

V-Type For 1- or 2-pen instruments only. Provides a recorded fine line of 0.25 mm (0.010 in) width.

Recorder Expendable Accessories

Charts and Inking Systems 100 HUMITEX nominal 300 mm (12 in) circular charts, with nominal 100 mm (4 in) calibrated scale, and the specified inking systems are provided with each instrument.

Cardboard Nameplate A cardboard nameplate is provided for displaying the chart factor.

Temperature Sensors Platinum RTD, DIN 43760 calibration is used with resistance converter. Base metal TC Types T, J, E, and K, and Noble metal TC Types R, S, and B, and other millivolt signals are used with the millivolt converter. See Table 1 for the range and span limits for nonstandard ranges. See Measurement Range Code Table on Page 5 for standard ranges.

Table 1. Sensor Range and Span Limits[a]

Parameter	Platinum RTD		Thermocouple[b][c] and Other Millivolt	Milliampere[b]
	Temperature Measurement	Temperature Difference Measurement		
Range Limits	-200 and +650°C -325 and +1200°F	-200 and +650°C -325 and +1200°F	-15 and +100 mV	4 and 20 or 10 and 50 mA
Span Limits	20 and 555°C 40 and 1000°F	15 and 165°C 25 and 300°F	5 and 100 mV	16 or 40 mA

[a] Refer to table on Page 5 for standard ranges offered

[b] Includes both temperature and temperature difference measurements.

[c] Range and span limits for TC's are shown in millivolts only, rather than °C and °F. This simplifies listing TC temperature range and span limits which vary with wire size, TC type, and TC construction.

Model Code

40P = Rectangular Polyester Case

Function
R = Circular Chart Recorder
N = Sector Scale Indicator
K = Concentric Scale Indicator

Internal Mechanism
-R = Standard Recorder (40PR)
-N = Standard Sector Scale Indicator (40PN)
-K = Standard Concentric Scale Indicator (40PK)
-E = Recorder or Indicator with Type 70 Contacts

Mounting
F = Flush
P = Pipe
S = Surface

Scale or Chart Drive
E = Electrical Chart Drive, 24-hour rotation, 120 V ac, 60 Hz (40PR)
N = Sector Scale (40PN)
K = Concentric Scale (40PK)

Pens or Pointers
1 = One Pen (40PR) or one pointer (40PN or 40PK)
2 = Two Pens (40PR) or two pointers (40PN only)
3 = Three Pens (40PR)
4 = Four Pens (40PR)

Pen or Scale Type
V = V-Type Pen (40PR with one or two pens only)
B = Box-Type Pen (40PR)
C = Capillary Type Pen (40PR)
F = Fiber Tip Disposable Pen (40PR)
S = Single Range Scale (40PN)
D = Dual Range Scale (40PN)
X = Pen Type per AS Reference

+E = Electronic Servo Element
(Show complete code for each element selected)

Power Supply
S = 120 V ac
N = 220 V ac
P = 240 V ac

Measurement—Sensor Type
T = IEC/ISA Type T (Cu-CuNi) TC
C = DIN 43710-77 (Cu-CuNi) TC
J = IEC/ISA Type J (Fe-CuNi) TC
D = DIN 43710-77 (Fe-CuNi) TC
E = IEC/ISA Type E (NiCr-CuNi) TC
K = IEC/ISA Type K (NiCr-NiA1) TC (DIN 43710-77)
R = IEC/ISA Type R (Pt13Rh-Pt) TC
S = IEC/ISA Type S (Pt10Rh-Pt) TC (DIN 43710-77)
B = IEC/ISA Type B (Pt30Rh-Pt6Rh) TC
M = dc mV
A = dc mA
O = Platinum RTD, 100-ohm DIN Resistance
X = Nonstandard (including Temperature Difference)

Measurement Range
XX = Select from Measurement Range Code Table on Page 5

Range Units
C = Degree Celsius
F = Degree Fahrenheit
M = Millivolts
A = Milliamperes

Burnout Feature (TC's only)
U = Upscale Action—Forward Range (TC only)
D = Downscale Action—Forward Range (TC only)
N = None—Forward Range (RTD, mV, and mA only)
R = Upscale Action—Reverse Range (TC only)
S = Downscale Action—Reverse Range (TC only)
T = None—Reverse Range (RTD, mV, and mA only)

Examples: 40PR-BEE2V+EST15FD+EST26FD; 40PN-NSN1S+ESP37FN

Measurement Range Code Table—Standard (Consult Foxboro for Ranges not shown)

Range Code	Measurement Range	Range Units—Available with Measurement/Sensor Type Code			
		mV	mA	°C	°F
[illegible]	[illegible]	M			
[illegible]	[illegible]	M			
[illegible]	[illegible] to 20	M			
[illegible]	[illegible] to 30			O	
[illegible]	[illegible] to 50	M		O	O
06	-50 to +50			O	O
07	-100 to +50			J*	
08	0 to 75	M		O	
09	-20 to +80			J*	
10	0 to 100	M		J O	O
11	-100 to 0			O	
12	-200 to +100			J* E	
13	-100 to +100			E	J* E
14	50 to 100			O	
15	-20 to +120				O
16	—				
17	-25 to +125			T	
18	0 to 150			J O	O
19	-50 to +150			J* E	
20	50 to 150				O
21	4 to 20		A		
22	10 to 50		A		
23	0 to 200			T J K O	J O
24	-100 to +200			E	J* E
25	100 to 200			O	O
26	0 to 250			T J O	T E O
27	-50 to +250			T	J*
28	50 to 250			O	J O
29	0 to 300			J K O	T J O
30	-350 to +300				T* E*
31	100 to 300			J O	J O
32	0 to 400			J K O	T J K O
33	100 to 400				K O
34	200 to 400			J O	O
35	0 to 500			J K O	T J K O
36	-150 to +500				T E
37	200 to 500			K	O
38	300 to 500			J	
39	0 to 600			K	T J O
40	—				
41	200 to 600				J
42	300 to 600			J	T
43	0 to 700			J	O
44	200 to [illegible]			J	J
45	0 to [illegible]			J K	K
46	0 to 800			R	J O
47	100 to 800				J K
48	300 to [illegible]			K	J K
49	0 to [illegible]				J O
50	500 to [illegible]			K	J
[illegible]	700 to [illegible]			K	J
[illegible]	0 to [illegible]			K S	J K
[illegible]	500 to [illegible]			S	J K
[illegible]	0 to [illegible]				J K
[illegible]	300 to [illegible]				J K
56	400 to [illegible]				J K
57	0 to [illegible]			R	
58	—				
59	800 to 1400			R	
60	900 to 1400			S	
[illegible]	0 to [illegible]			R*	J*
62	500 to [illegible]				J* K
63	0 to 1600				K
64	1100 to [illegible]			S*	J*
65	1200 to [illegible]				K
66	500 to [illegible]			R*	K
[illegible]	0 to [illegible]				J* K
[illegible]	[illegible]				K
[illegible]	[illegible]				J* R
[illegible]	[illegible]				R
[illegible]	[illegible]				K*
[illegible]	[illegible]				K*
[illegible]	[illegible]				K*
[illegible]	[illegible]				K* R
[illegible]	[illegible]				K* S
[illegible]	[illegible]				S
XX	[illegible]				

* [illegible] temperature limits for protected wire type TC [illegible] for the largest wire sizes shown. Consult ANSI publication [illegible] ASTM [illegible] TECHNICAL PUBLICATION (STP) 470A [illegible] SPECIFIC vendor TC application data for guidance as to the maximum working [illegible]

PHYSICAL SPECIFICATIONS

Enclosure The case and door are glass-fiber reinforced polyester moldings, compounded for superior corrosion resistance. The door has a shatterproof glass window. The overall construction provides the dust protection defined by IEC IP 53 and the raintight protection of NEMA Type 3.

Mounting Standard mounting is flush in a panel up to 16 mm (0.6 in) thick or on a surface. A kit of parts is available for vertical mounting on a DN 50 or 2 in diameter pipe.

Color Case is gray, door is textured blue vinyl paint.

Flammability Rating The case and door meet Type V-0 of UL 94*.

Blow-out Plug Located in the bottom of the case.

Electrical Connections Two nominal 22 mm (0.9 in) diameter holes are provided for a nominal 20 mm (CEE 23), PG16, or 1/2 in conduit fitting, one each for power and measurement.

Data Label Aluminum data label fastened to inside of door with pressure sensitive adhesive. Includes space for customer tag data up to a maximum of 90 characters and spaces. For additional space, see optional Customer Tag.

Approximate Mass 12 to 18 kg (25 to 40 lb), depending on options.

OPTIONAL FEATURES

40M Rectangular Metal Enclosure These instruments are also available in the standard Foxboro 40M rectangular metal enclosure. This enclosure consists of a durable die-cast aluminum case and door with corrosion-resistant vinyl finish. A gasketed door with glass window and cam-latch protects the interior from an excess of fumes, dust, and moisture. All electrical connections are located in the bottom of the case. The enclosure can be either flush- or surface-mounted, or yoke-mounted on a DN 50 or 2 in diameter vertical pipe stub. Refer to PSS 3-1A1 A for the specifications and numerous options available with the 40M enclosure. Selectable by specifying the recorder or indicator Model Number, and substituting 40M for 40P.

Transmitter dc Power Supply For 4 to 20 and 10 to 50 mA input instruments only. Mounted within the 40P or 40M enclosures. Provides dc power to power the milliampere source or the external loop. AS (Auxiliary Specifications) Reference is LPS.

Voltage Divider Module Provided for voltage inputs with spans from 0.1 V dc to 42 V dc. The voltage divider attenuates the input voltage to a millivolt signal. Voltage divider modules are offered as follows:

Voltage Divider Module Code	Attenuation	Measurement Spans Between (V dc)
2AX + VE	100 : 1	1 and 10
2AX + VF	10 : 1	0.1 and 1

Note: For measurement spans between 10 and 42 V dc, refer to Foxboro for availability of voltage divider module.

Type 70 Electric Contacts A variety of contact systems is available to provide a wide range of switching functions to actuate external control or alarm circuits. General Purpose electrical classification only. Select internal mechanism code -E. (Refer to Foxboro for options)

24E Series Electric Integrator The 24E is an electromechanical device which provides a continuous totalization of measurement of a variable rate. It is offered for both square-root and uniform calibration. It is suitable for use in ordinary locations and Class I, Groups C and D, Division 2 hazardous locations. Specify 24E and either square-root or uniform calibration.

Flush Door Lock With 2 keys. AS Reference is FDL.

Inlet Purge Restrictor Connection tapped for 1/4 NPT fittings. AS Reference is IPR.

Alternative Color Any standard Foxboro color per GS 5-1D1 A or color reference provided by the user. Textured finish only. Designate Color.

Nameplate Laminated plastic nameplates 38 x 76 mm (1.5 x 3 in) with white characters on a black background. Maximum of 5 lines with 28 characters or spaces 3 mm (0.13 in) high, or 24 characters or spaces 4 mm (0.16 in) high, per line. AS Reference is N/P.

Internal Illumination An incandescent lamp is available for operation from a nominal 120 or 240 V ac power source, as specified. General Purpose electrical classification only. AS Reference is II-I.

Recorder Chart Drives Electrical, single speed, one revolution in 30 seconds; 1,2,4,6,7.5,12,15,24,30, or 96 minutes; 1,2,3,4,6,8, or 12 hours, or 2,3,4, or 7 days; 120 or 220-240 V ac, 50 or 60 Hz. (Refer to Foxboro for others.)

Customer Tag Stainless steel tag wired to instrument for customer tag data that doesn't fit on data label. There can be a maximum of 10 lines of data with 40 characters and spaces per line. Tag is wired to instrument if AS Reference WTS is specified, or fastened with drive screws if AS Reference SCT is specified.

*Underwriters Laboratory Incorporated Standard for Test Flammability of Plastic Materials - UL 94

PRODUCT SAFETY SPECIFICATIONS

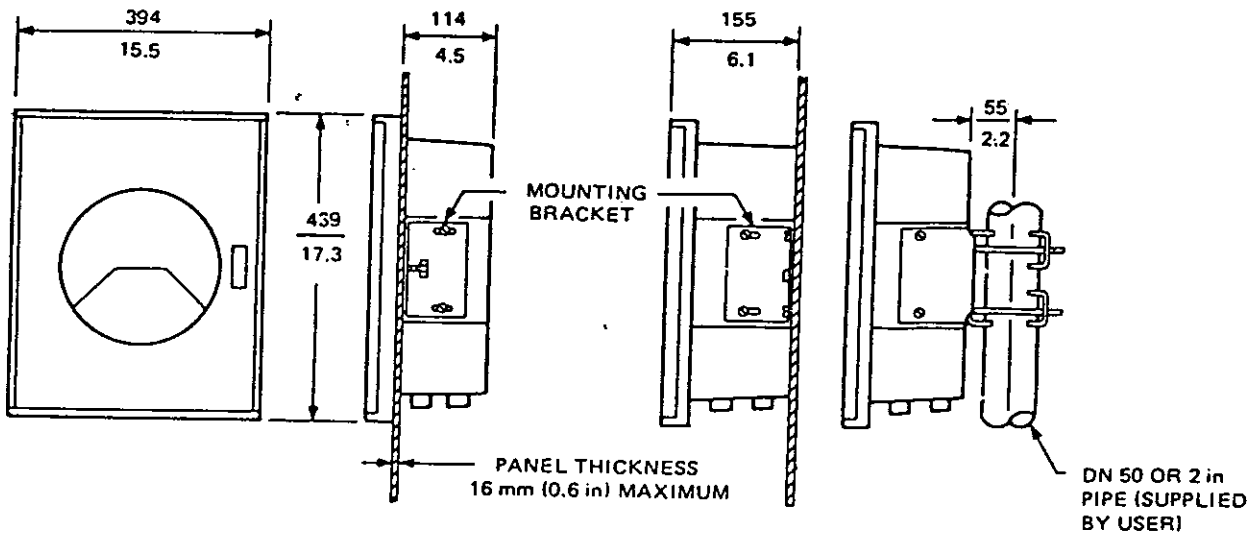
These instruments have been designed to meet the requirements of the Occupational Safety and Health Administration (OSHA). When properly installed, they are Foxboro self-certified, and FM and CSA certified for use in ordinary locations, and for Class I, Groups A, B, C, and D, Division 2 hazardous locations (without internal illumination or Type 70 contact options).

ORDERING INSTRUCTIONS

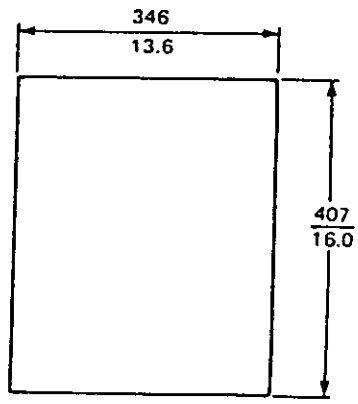
1. Model Number
2. Type of Pen(s)
3. Optional Features
4. Tag and Application

DIMENSIONS—NOMINAL

mm / in



FLUSH MOUNTING SURFACE MOUNTING PIPE MOUNTING



PANEL CUTOUT

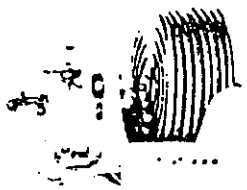
NOTE

FOR HORIZONTAL MULTIPLE PANEL MOUNTING, A MINIMUM DISTANCE OF 445 mm (17.5 in) FROM CENTER LINE TO CENTER LINE IS REQUIRED.

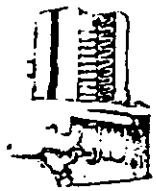
PRESSURE AND RECEIVER ELEMENTS

Effective May 1, 1977
Supersedes December 6, 1976

Measuring Elements for Base Instruments



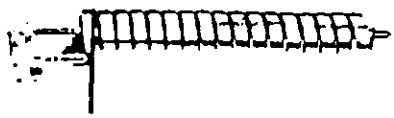
DIAPHRAGM



BELLOWS

SPIRAL

HELICAL



HEAVY DUTY HELICAL

Ordering Instructions – Specify

1. Base instrument from 3-1 if a recorder, indicator, or controller; or from 2A-1H or 2B-1H if a transmitter.
2. Element Code
3. Calibrated Range (Range and torque factor rating information is located in Engineering Section.)
4. Optional Features

Standard Specifications

Pressure and receiver elements are assembled in base instruments. For a particular instrument it is necessary to determine that a measuring element has a sufficient torque to operate the desired components and that all the elements and components can be accomodated in the instrument's case. Refer to Engineering Section for instructions.
Span and Range Limits: Refer to Engineering Section.

Element Connections:

1/4 NPT internal thread for pressure to 14 MPa (2000 psi, 140 bar or kg/cm^2)
1/2 NPT external thread for pressure over 14 MPa (2000 psi, 140 bar or kg/cm^2) to 70 MPa (10 000 psi, 700 bar or kg/cm^2).
9/16-18 AMINCO (a) for pressure over 70 MPa (10 000 psi, 700 bar or kg/cm^2).

Element Code and UNITS OF CURRENCY ADDITION:

Element		Normal Recorder Measurement Ranges (Torque Factor Rating 30)			Element Code
Type	Material	kPa, MPa	inH$_2$O, psi, mmHg, psia	bar or kg/cm^2	
Diaphragm 50 mm (2 in)	Cu-Ni-Mn (60 - 20 - 20)	0 - 6 to 0 - 35 kPa	0 - 25 to 0 - 280 inH$_2$O	0 - 0.06 to 0 - 0.35	PB-DF
Diaphragm 75 mm (3 in)	Cu-Ni-Mn (60 - 20 - 20)	0 - 2 to 0 - 10 kPa	0 - 8 to 0 - 40 inH$_2$O	0 - 0.02 to 0 - 0.10	PB-PF(b)
Bellows	Brass 316 ss (c)	0 - 30 to 0 - 180 kPa 0 - 35 to 0 - 200 kPa	0 - 110 inH$_2$O to 0 - 26 psi 0 - 4.5 to 0 - 29 psi	0 - 0.3 to 0 - 1.8 0 - 0.35 to 0 - 2	PB-CC PB-CA
Receiver	Brass	20 to 100 kPa Other	3 to 15 psi Other	0.2 to 1.0 Other	PC(d) PC(d)
Spiral	Bronze Be-Cu NI-SPAN C (e)	0 - 70 kPa to 0 - 1.4 MPa	0 - 10 to 0 - 200 psi	0 - 0.7 to 0 - 14	PB-BC PB-BB PB-BE
	316 ss K-MONEL(e)	0 - 82 kPa to 0 - 1.4 MPa 0 - 140 kPa to 0 - 1.4 MPa	0 - 12 to 0 - 200 psi 0 - 20 to 0 - 200 psi	0 - 0.8 to 0 - 14 0 - 1.4 to 0 - 14	PB-BA PB-BM
Double Spiral	Bronze	0 - 280 to 0 - 420 kPa	0 - 40 to 0 - 60 psi	0 - 2.8 to 0 - 4.2	PB-MC
Helical	Bronze	0 - 1.4 to 0 - 3.1 MPa	0 - 200 to 0 - 450 psi	0 - 14 to 0 - 31	PB-AC
	Be-Cu NI-SPAN C 316 ss	0 - 1.4 to 0 - 40 MPa	0 - 200 to 0 - 6 000 psi	0 - 14 to 0 - 400	PB-AB PB-AE PB-AA
	K-MONEL	0 - 1.7 to 0 - 14 MPa	0 - 250 to 0 - 2 000 psi	0 - 17 to 0 - 140	PB-AM
Heavy-Duty Helical (f),(g)	316 ss	0 - 0.5 to 0 - 200 MPa 0 - 270 to 0 - 550 MPa	0 - 75 to 0 - 30 000 psi 0 - 40 000 to 0 - 80 000 psi	0 - 5 to 0 - 2000 0 - 2700 to 0 - 5500	PB-GA PB-KA (h)
Absolute Bellows (f)	Bronze 316 ss	0 - 13 to 0 - 270 kPa 0 - 17 to 0 - 240 kPa	0 - 100 mmHg to 0 - 39 psia 0 - 125 mmHg to 0 - 35 psia	0 - 0.13 to 0 - 2.7 0 - 0.17 to 0 - 2.4	PA-CC PA-CA
Absolute Double Spiral	316 ss	0 - 275 to 0 - 700 kPa	0 - 40 to 0 - 100 psia	0 - 2.7 to 0 - 7	PA-MA

(a) Trademark of American Instrument Company for high pressure connection.
(b) PB-PF required for control instruments below 10 kPa (40 inH$_2$O, 0.1 bar or kg/cm^2).
(c) AISI Type 316 stainless steel.
(d) Specify signal range.
(e) Trademark of International Nickel Company.
(f) Replacement element uncalibrated.
(g) Replacement element not recommended. Instrument should be returned to The Foxboro Company.
(h) Not available in the Model 40P

SECTION 4

FLOW INDICATOR

(DIRECT PROCESS CONNECTED)

2 - REQ'D

MODEL:	MID-WEST #105-QE-00-00 DIFFERENTIAL PRESSURE GAGE	
DIAL:	6" DIAMETER	
SCALE:	270	
FLOW RANGE:	0-15 MGD	
ELEMENT:	A) DIFF. PRESS RANGE: B) MATERIAL:	117.75" OF WATER #316 S.S.
TAG:	FI-1 & FI-4	

Southeast Underground Construction, Inc.

APPROVED FOR SUBMITTAL

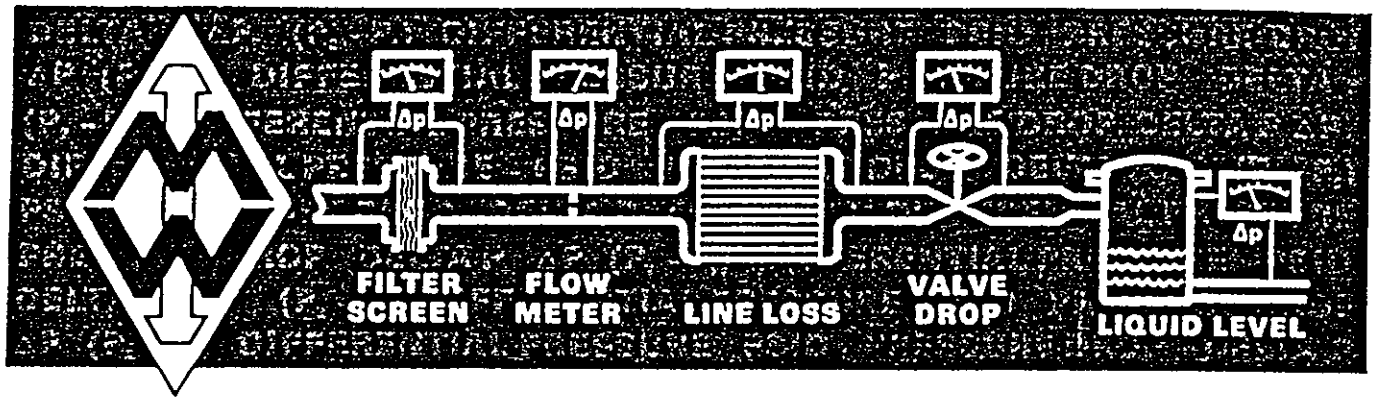
By Phillip Bissell

Date 8-31-84

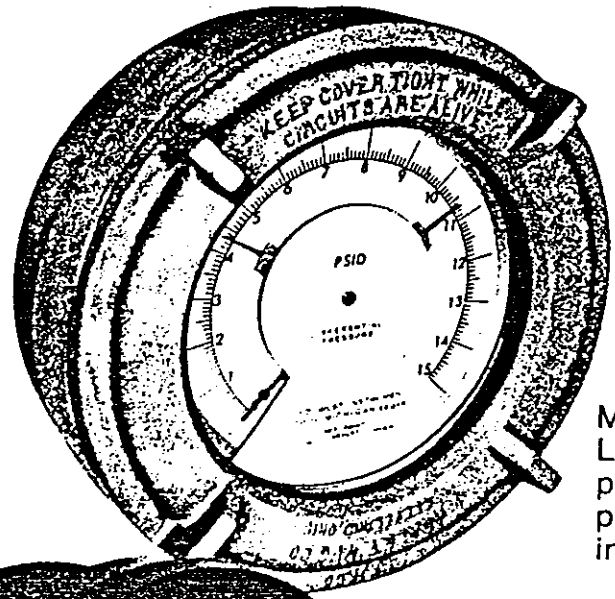
United Steel Erectors, Inc.

APPROVED

CHECKED BY



Differential & Absolute Pressure Indicating and Control Systems



Model 109
with explosion-proof
enclosure

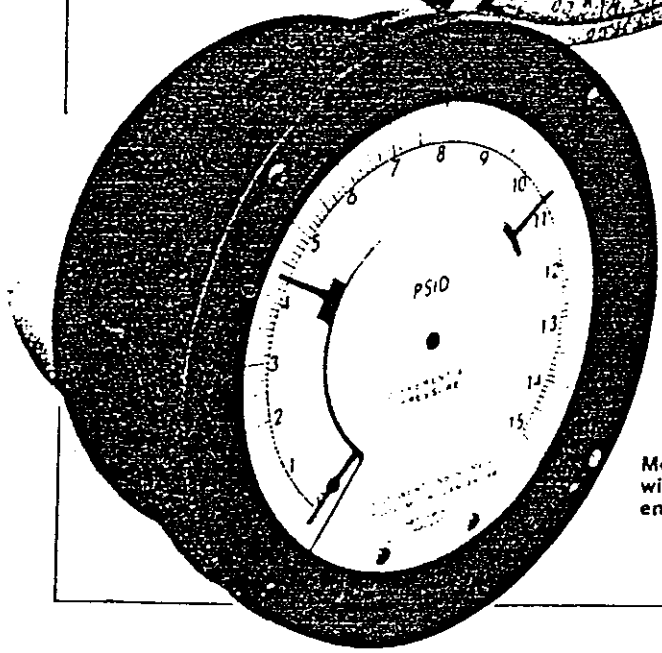
Presenting a new "Freedom"...

For further details refer to Bulletin No. LLC76.

Mid-West Instrument's "Locked Logic" solid-state alarm controls provide "freedom" from moving parts, wear, friction, and decrease in indicated reading accuracy.

The "Locked Logic" system is all solid-state and is available with one or two set pointers, weather-proof or explosion-proof housing, and optional *external* set point adjustment.

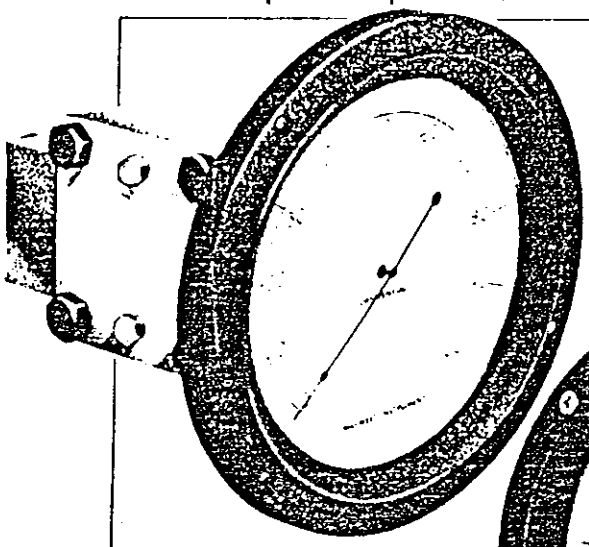
Now available on many Mid-West differential pressure or absolute pressure gauges. Contact your nearest Mid-West representative for full details.



Model 109
with weatherproof
enclosure

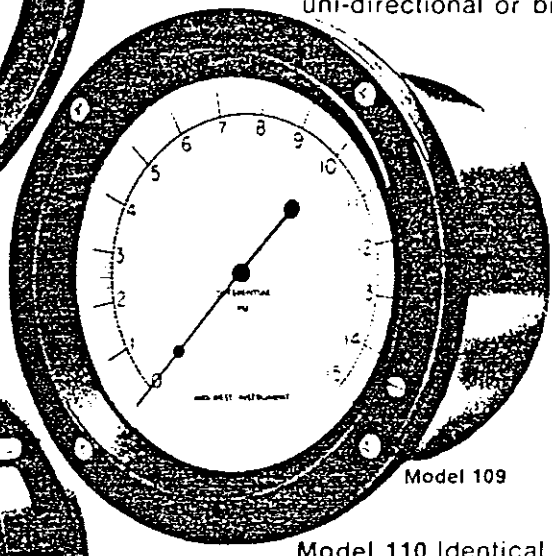
Mid-West
Instrument

Announcing the availability of Mid-West's new "Locked Logic" solid-state alarm-controls for all large dial Mid-West gauges. The "Locked Logic" system is all solid-state with no moving parts, no wear, no friction and *no decrease in indicated reading accuracy.* Available with one or two pointers, weatherproof or explosion-proof housing with optional external set point adjustment.



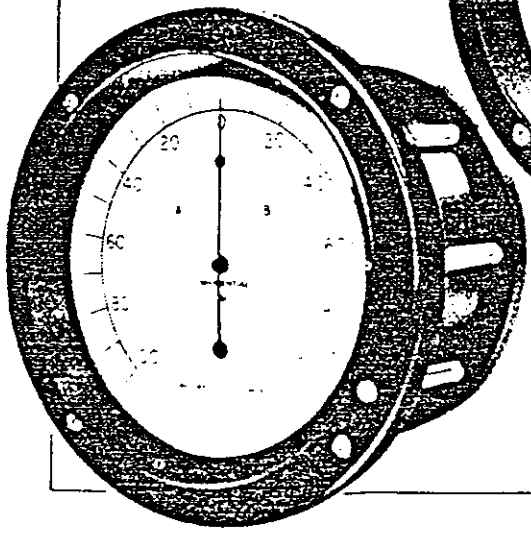
Model 105

Model 105 Featuring a multiple diaphragm and torque tube movement. Available with 1% or ½% full scale accuracy, with dial ranges from 25" H_2O to 300" H_2O and working pressure capability to 6000 p.s.i.g. 4½" or 6" dials, regular or mirrored. Fully protected against overrange. Available in a variety of materials for most services. Also available in uni-directional or bi-directional dial versions.



Model 109

Model 109 Utilizes a single "test gauge" quality bourdon tube, magnetically coupled to the indicating pointer. Available with 1% full scale accuracy, with dial ranges from 10 to 5000 p.s.i.d. and working pressure capability to 6000 p.s.i.g. 4½" or 6" dials, regular or mirrored. Fully protected against overrange. Available in aluminum or stainless steel for most services. Also available in uni-directional or bi-directional dial versions.

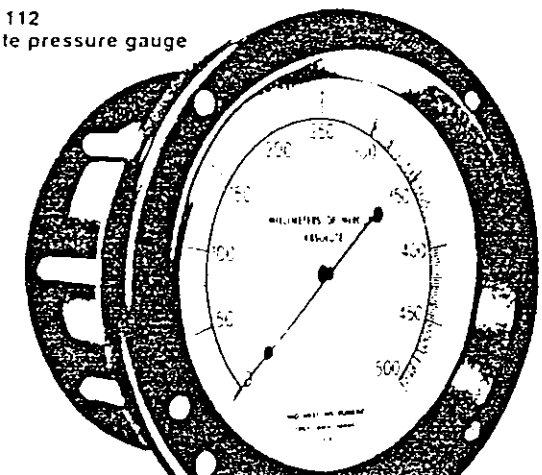


Model 110

Model 110 Identical in design to the above Model 109 except in capsule construction and working pressure capability. The Model 110 offers the precision of the 109 plus the economy of a lower pressure design. Available with pressure capabilities of 750, 1000 and 2000 p.s.i.g. The same options are available as on the Model 109.

Model 112 Absolute Pressure Gauges

Model 112
absolute pressure gauge



- A simple, direct and an accurate way to measure true absolute pressure.
- Fully compensates for barometer changes.

The Model 112 Absolute Pressure Gauge is supplied in 4½" and 6" dial sizes. Pressure ranges are 0-10 p.s.i.a. (0-75 Kilopascals) to 0-1000 psia (0-7000 Kilopascals). Accuracy of 1.0% of full scale is standard, to 0.5% is available when required. Standard construction is aluminum and brass. 316 stainless steel is available when required

SECTION 4

PRESSURE INDICATOR

(DIRECT PROCESS CONNECTED)

2 - REQ'D

MODEL:	ROBERTSHAW #367-B GAGE WITH #67 STYLE CASE
DIAL:	6" DIAMETER
CASE:	FLUSH MTG
RANGE:	DUAL SCALE 0-100 PSI 0-231 FT
ELEMENT:	A) TYPE: BOURDON TUBE B) MATERIAL: PHOSPHOR BRONZE
TAG:	PI-1 & PI-4

SECTION 4

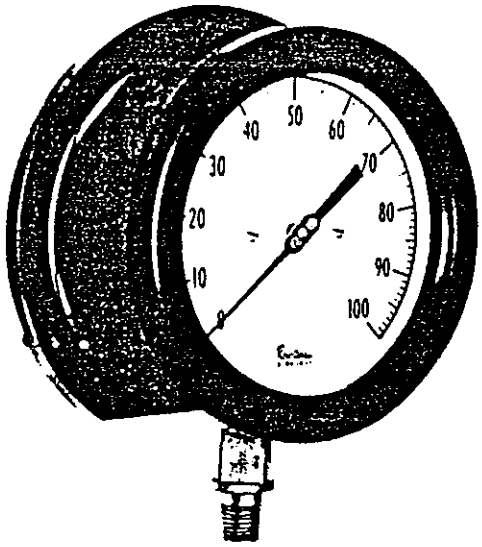
PRESSURE INDICATOR

(DIRECT PROCESS CONNECTED)

2 - REQ'D

MODEL:	ROBERTSHAW #367-B GAGE WITH #67 STYLE CASE.
DIAL:	6" DIAMITER
CASE:	FLUSH MTG
RANGE:	DUAL SCALE 0-PSI 0-FT
ELEMENT:	A) TYPE: BOURDON TUBE B) MATERIAL: PHOSPHOR BRONZE
TAG:	PI-2 & PI-3

NOTE: ENGINEER TO ADVISE RANGES AS PER SPECIFICATIONS.



300 SERIES
PHOSPHOR BRONZE BOURDON TUBE / BERYLLIUM COPPER BOURDON TUBE

ACRAGAGE®
SOLID FRONT GAGES

MOVEMENTS: Add suffix letter to catalog number to designate movement. (B: stainless steel; D: Delrin.) Complete description of movements on page 6.

For ordering information, see page 34.

Catalog No.	Case	Ring	Mounting
313	Aluminum	Screwed	Wall, Flush or Stem
314	Aluminum	Screwed	Stem only
367	Aluminum	Hinged	Flush only
375	Phenol	Polypropylene	Wall or stem

PRESSURE RANGES — PSI

Total Graduations	Figure Intervals	Minor Subdivisions
0 - 15	1	.1
0 - 30	3	.2
0 - 60	5	.5
0 - 100	10	1
0 - 160	20	2
0 - 200	20	2
0 - 250	50	2
0 - 300	30	2
0 - 400	50	5
0 - 600	50	5
0 - 800	100	10
0 - 1000	100	10
0 - 1500	200	20
0 - 2500	500	20
0 - 3000	500	20
0 - 5000	500	50

Also available in equivalent metric ranges.

COMPOUND RANGES (Inches HG. VAC. and PSI)

Total Graduations	Figure Intervals	Minor Subdivisions
30" - 0 - 15	5" & 3	.5" & .2
30" - 0 - 30	10" & 5	1" & .5
30" - 0 - 60	10" & 10	1" & 1
30" - 0 - 100	30" & 10	2" & 1
30" - 0 - 150	30" & 30	5" & 2
30" - 0 - 200	30" & 20	5" & 2
30" - 0 - 300	30" & 50	5" & 2
VACUUM RANGE		
0 - 30" Vac.	3"	.2"

RECOMMENDED APPLICATIONS

For air, oil, water and other pressure media not corrosive to bronze (see pages 10-11). Install siphon when used on steam.

SPECIFICATIONS

Bourdon Tube:
Drawn phosphor bronze, silver-brazed joints; ranges through 1000 psi. Beryllium copper for ranges above 1000 psi.

Case and Ring:
4½" and 6": Available with aluminum case, styles 13, 14 and 67; and Phenol case, style 75. See Catalog No. tabulation, this page, and case descriptions, page 12.

Dial:
Standard: White with black figures.
Optional: Black with white figures.

Socket:
Brass.

Connection:
Pressures up to 1000 psi: 1/4" and 1/2" NPT male.
Pressures over 1000 psi: 1/2" NPT male.

NOTE: Custom connections available.

Pointer:
Acrapointer, balanced adjustable design.

Lens:
Standard: Double-strength glass.
Optional: Safety glass or plastic.

Movements:
Suffix B: Geared stainless steel. Stainless pinion, gear and bushings.
Suffix D: Delrin bushed and heared. Delrin sector and bushings; stainless pinion.

Accuracy:
ANSI B40.1 Grade 2A. ± .5% of span.

Dimensions:
See pages 31-32.

Net Weights:
See page 32.

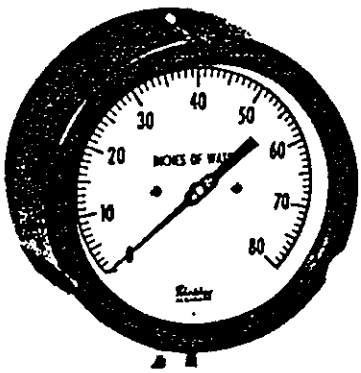
Accessories:
See pages 28-31.

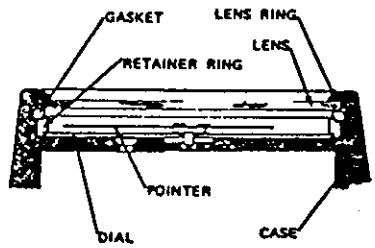
Note:
Gages on this page available with special features shown on pages 7 and 9.

ACRAGAGE CASES

Acragage cases are offered in many styles to fit specific uses and installations. All feature the famous Acragage full-area blowout disc for extra safety. The type 75 case features the polypropylene snap ring that provides a positive, weather-tight seal . . . yet snaps in or out quickly for easy access to the dial.

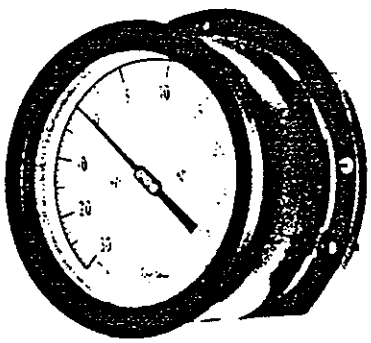
And Acragage, of course, offers famous solid-front safety at standard cost!





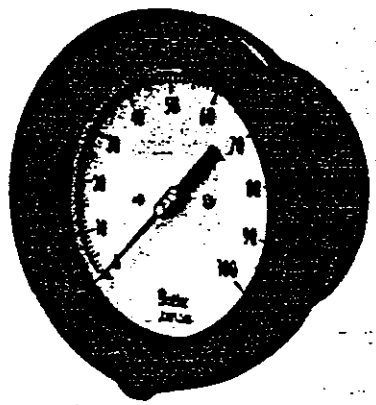
TYPE 75

Solid front phenolic turret case features a positive lens seal and type 316 stainless steel blow-out back. The snap-in polypropylene lens ring allows for temperature and humidity changes. An "O"-ring type gasket beneath the lens provides a positive inner seal. A light reflecting retainer ring between dial and gasket improves dial readability. 4½" size. Back or bottom connections.



TYPE 13, 14

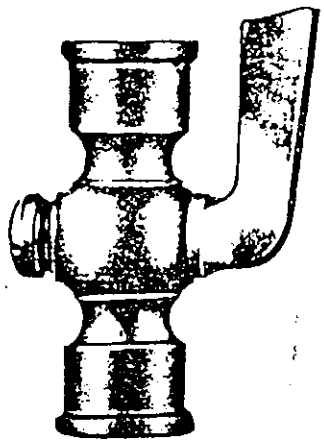
Solid-front case of aluminum alloy, with threaded ring. Has back flange for wall or stem mounting. Black instrument finish. In 4½" and 6" sizes for either back or bottom connection. Type 14 is similar but with back flange removed.



TYPE 67

Solid-front case of aluminum alloy with front flange for flush mounting. Black instrument finish. Steel lens ring held with hinge pin and knurled screw. All with back connection.

Top Mounted Gages — All bottom-connected and back-connected Acragage Gages except Bellows Gages (page 20), Fluid-filled gages (page 19) and Case Style 67 may be converted to top-connected styles by removing and reversing the dial.



GAGE COCKS

Tee Handle Cock (Catalog No. 1301)

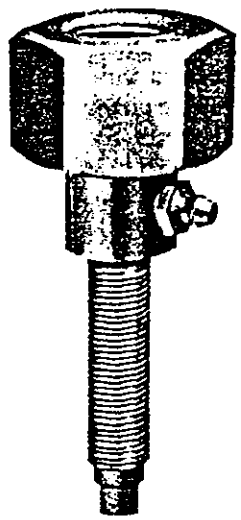
For steam pressures to 150 psi., hydraulic pressures to 300 psi., brass; 1/4" female connection. Weight 3 oz.

Lever Handle Cock (Catalog No. 1303)

For steam pressures to 250 psi., hydraulic pressures to 600 psi., brass;, 1/4" female connection. Weight 4 oz.

EXTRUSION ADAPTER

Rated 10,000 psi@500° F.



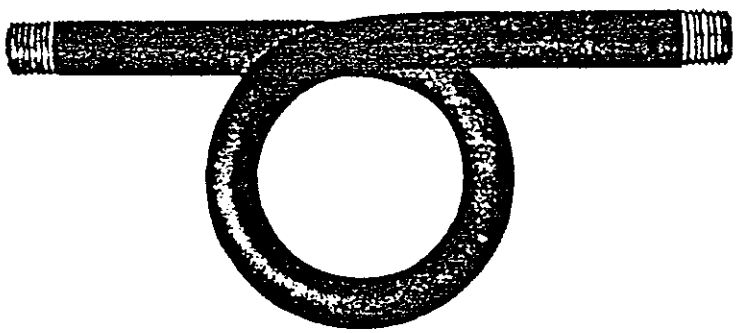
Designed exclusively for plastic extrusion machines, where pressure must be constantly and accurately indicated and contamination of the plastic cannot be tolerated.

The complete adapter assembly — consisting of a gage (with capillary bleeder) and adapter — can be readily mounted on the extruder: die head, barrel extension, or the barrel itself. The capillary bleeder is essential: it assures complete filling of Bourdon tube and adapter with high-vacuum silicone grease.

When necessary, additional silicone grease can easily be introduced into the system through either the capillary bleeder or the hydraulic fitting on the adapter.

Thread sizes: 1/2" NPT female gage connection. 1/2" 20 UNF male extruder connection. Weight 9 oz.

To order adapter *only*, specify Catalog No. 1701A. To order complete plastic extruder gage, specify Adapter 1701A, and add gage description from pages 16-20. Capillary bleeder *must* be specified for effective operation.



SIPHONS

The siphon serves as a protective device for isolating the gage mechanism from high temperature and/or live steam by providing a simplified but effective condensing coil. Sometimes referred to as a "pigtail."

Catalog No.	Size	Material	Capacity	Weight
1201	¼	Iron - 6½" long (Schedule 40)	1000 psi. up to 400° F.	7 oz.
1202	¼	Iron - 8" long (Schedule 40)	1000 psi. up to 400° F.	8 oz.
1203	¼	Iron - Angle (Schedule 40)	1000 psi. up to 400° F.	7 oz.
1204	¼	Brass - 5¾" long (regular)	350 psi. up to 400° F.	8 oz.
1205	¼	Brass - 8" long (regular)	350 psi. up to 400° F.	9 oz.
1208	¼	Extra heavy steel (seamless, Schedule 80)	3000 psi. up to 650° F.	16 oz.
1209	½	Extra heavy steel (seamless, Schedule 80	2500 psi. up to 650° F.	2 lb. 1 oz.
1210	½	Extra heavy steel (seamless, double extra strong)	7500 psi. up to 650° F.	3 lb. 4 oz.
1211	½	Stainless steel (seamless, double extra strong)	5000 psi. up to 650° F.	3 lb. 4 oz.
1212	¼	Stainless steel (seamless, Schedule 40S)	1500 psi. up to 650° F.	12 oz.
1213	½	Stainless steel (seamless, Schedule 40S)	1000 psi. up to 650° F.	1 lb. 10 oz.