Honeywell

The Series 7020 Dissolved Oxygen Analyzer User's Manual

70-82-25-66

Rev. 3
2/98

TotalPlant

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Revision 3 – 2/98

CE Conformity

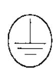
This product is in conformance with the protection requirements of the following European Council Directives: 89/336/EEC, the Electromagnetic Compatibility Directive and 72/23/EEC, the Low Voltage Directive. Conformance of this product with any other "CE Mark" Directive(s) shall not be assumed.

Attention

The emission limits of EN 50082-2 are designed to provide reasonable protection against harmful interference when this equipment is operated in an industrial environment. Operation of this equipment in a residential area may cause harmful interference. This equipment generates, uses, and can radiate radio frequency energy and may cause interference to radio and television reception when the equipment is used closer than 30 m to the antenna(e). In special cases, when highly susceptible apparatus is used in close proximity, the user may have to employ additional mitigating measures to further reduce the electromagnetic emissions of this equipment.

SYMBOL DEFINITIONS

This **CAUTION** symbol on the equipment refers the user to the Product Manual for additional information. This symbol appears next to required information in the manual.



Protective earth terminal. Provided for connection of the protective earth (green or green/yellow) supply system conductor.

WARNING, risk of electric shock. This symbol warns the user of a potential shock hazard where voltages greater than 30 Vrms, 42.4 V peak, or 60 BVdc may be accessible.

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About This Document

Abstract

This manual contains instructions for installation and operation of the Series 7020 Dissolved Oxygen Analyzer.

Revision Notes

The following list provides notes concerning all revisions of this document.

Rev. ID	Date	Notes
0	5/97	This is the initial release of the Honeywell version of the L&N manual part number 278608 Rev. A1. The manual has be reformatted to reflect the Honeywell documentation style and updated to reflect the changes in the product offering. Additions have also been made for CE conformity.
1	7/97	This revision was made to update the Model Selection Guide in Section 2 so it reflects the latest offerings of the Series 7020 Dissolved Oxygen Analyzer.
2	12/97	Changes were made to add information about calibrating Analog Outputs that was missing.
3	2/98	Additions were made to the Wiring CE Units Only - Immunity Compliance section including an additional graphic.

References

Honeywell Documents

The following list identifies all Honeywell documents that may be sources of reference for the material discussed in this publication.

Document Title	ID #
Sampling Considerations for Equilibrium DO Sensors	70-82-58-47

Trademarks

Contacts

The following list identifies important contacts within Honeywell.

Organization	Telephone	Address
Honeywell TAC	1-800-423-9883 Voice	1100 Virginia Drive Fort Washington, PA 19034

Contents

1. INTRODUCTION 1

1.1 Overview 1
- Description of Analyzer 1
- Description of Probe 2
- Theory of Probe Operation 2

1.2 Quick Reference 3
- Do's for the 7021 or 7022 Dissolved Oxygen Analyzer 3
- Don'ts for the 7021 or 7022 Dissolved Oxygen Analyzer 3
- Do's for the 7931 Dissolved Oxygen Probe 3
- Don'ts for the 7931 Dissolved Oxygen Probe 3

2. SPECIFICATIONS AND MODEL SELECTION GUIDE 5

2.1 Specifications 5
- Physical 5
- Power 5
- Environmental 5
- Ranges 5
- Accuracy Statement for the Loop 6
- Standards Compliance 6

2.2 Product Feature Specifications 6
- Operator Interface 6
- Diagnostics 6
- Analog Inputs 6
- Analog Outputs 7
- Discrete Inputs 7
- Discrete Outputs 7
- Default Factory Configuration 8

2.3 Model Selection Guide 9
- Series 7020 Dissolved Oxygen Analyzer 9
- Accessories and Replacement Parts 10
- 7931 Series Probe 12

3. INSTALLATION 13

3.1 General 13
- Unpacking 13
- Inspection 13
- Storage and Shipment 13
- Location 13
- Mounting 13

3.2 Wiring 15

3.2.1 General Wiring Recommendations 15

3.2.2 Power Connections 15
- Safety Grounding 16
- Wiring CE Units Only - Immunity Compliance 16

Noise Suppression 16
3.2.3 Terminal Board Connections 18
General Procedure 19
Special Wiring Considerations - Terminal Boards 21
Special Wiring Considerations - Probe 22
Probe Noise Test 22

4. OPERATION 25

4.1 Overview 25
4.1.1 Button Functions 26
4.1.2 Screen Movement - Arrows 27
4.1.3 Setting Numerical Values 27
4.1.4 Diagnostic Messages 28

4.2 Display Screens 28

4.3 Main Menu 29
4.3.1 On-Line Mode 29
Alarm/Diagnostic Summary 29
Manual Calibration - Units with Software Prior to Version C.3 30
Control Tuning 30
Automatic Cleaning/Calibration 31
Review Program 34
4.3.2 Program Mode 35
Introduction 35
Alarms 35
Relays 38
Analog Outputs 40
Analog Output Programming Procedure CAT features only 42
Analog Output Programming Procedure - DAT features only 42
Control Loop 43
Application Information 45
Auto Calibrate/Clean 47
Auxiliary Input 52
Selecting Dissolved Oxygen or Percent Saturation 54
Configuring Salinity 54
Programming Setup Buttons 55
Password Security 55
Date/Time 57
Auto Ranging (7021-ppb Units Only) 58
4.3.3 Maintenance Mode 59
Contrast Adjust 59
Mains Frequency 59
Manual Calibration - Units with Software Version C.3 or Higher 59
Calibrate Analog Inputs 63
Calibrate Analog Outputs 65
Off-Line Diagnostics 66
Reset Unit 71
Product Information 71

5. DIAGNOSTICS/TROUBLESHOOTING 73

5.1 Diagnostics 73

5.2 Troubleshooting Matrix of Potential Problems and Solutions 74

6. ACCESSORY AND SPARE PARTS KITS 77

APPENDIX A - NOISE TESTING 79

Hints for Reducing Noise 79

APPENDIX B - PROBE AND ANALYZER TESTS 81

Check for probe membrane leakage 81

Check that analyzer is working 81

Check that the analyzer and probe are working together correctly. 82

APPENDIX C - PARAMETERS AFFECTING DISSOLVED OXYGEN MEASUREMENT83

Pressure 83

Temperature 83

Salinity 83

APPENDIX D - DISCUSSION ON CHEMICAL INTERFERENCES ON MEASURED DO CURRENTS 85

Faradaic Currents 85

Residual Currents 85

Electrode Conditioning Currents 85

Charging Currents 85

Faradaic Interferences 85

Sulfite Based Zero Testing 86

APPENDIX E - PERCENT SATURATION READOUT 87

APPENDIX F - LEAK DETECTION IN PPB APPLICATIONS 89

APPENDIX G - PROCEDURE FOR LOW LEVEL PPB DISSOLVED OXYGEN TESTING 91

Overview 91

Equipment Needed 91

Oxygen Measurement Procedure 91

To Calculate True Value 92

Example Calculation 92

APPENDIX H - OUTPUT AUTO RANGING (PPB ONLY) 93

APPENDIX I - SUMMARY OF CAL, CLEAN, AND HOLD 95

Cleanings 95

Calibrations 95
Holds..96

APPENDIX J- AUTOMATIC CALIBRATION IN PURE WATER.................................. 97

APPENDIX K - AUTOMATIC CLEANING AND CALIBRATION IN WASTEWATER.. 99

Tables

Table 3-1 Recommended Minimum Wire Sizes ____ 15
Table 3-2 Definitions of DO Analyzer Inputs and Outputs ____ 23
Table 4-1 Main Menu Quickview ____ 25
Table 6-2 Dissolved Oxygen Solubility vs. Temperature ____ 87

Figures

Figure 1-1 Series 7020 Dissolved Oxygen Analyzer ____ 1
Figure 3-1 Mounting and Dimensions ____ 14
Figure 3-2 Noise Suppression for Optional Mechanical Relay Outputs Card ____ 17
Figure 3-3 Noise Suppression for Optional AC Relay (triac) Outputs Card ____ 17
Figure 3-4 AC Power Terminals ____ 18
Figure 3-5 View Inside Front Bezel ____ 20
Figure 3-6 Standard Label for all Terminal Block Safety Covers ____ 21
Figure 4-1 Series 7020 DO Analyzer Front Panel ____ 26
Figure 4-2 Display of Probe Bias Test Done in Air ____ 68
Figure H-6-1 Output Auto Ranging Connections ____ 93

1. Introduction

1.1 Overview

Description of Analyzer

The Honeywell Series 7020 Dissolved Oxygen Analyzer, Figure 1-1, when used with a separately ordered 7931 probe, accurately measures the concentration of dissolved oxygen in water. The line-powered Analyzer energizes the probe and receives dissolved oxygen and temperature signals from it. The Analyzer provides for automatic or manual calibration with ambient temperature and atmospheric pressure compensation.

Applications include boiler water, process water and wastewater monitoring and control, with many unique features for enhanced performance and ease of operation in each type of installation. Factory configuration of the particular analyzer model and selected options for either ppb measurements in pure water or ppm measurements in process and waste waters allow immediate startups for most installations, requiring only calibration of the probe. Additional features may be enabled at any time, provided any required hardware options (additional output signals and/or relays) have been specified.

For boiler water measurements that span several orders of magnitude in dissolved oxygen concentration, the auto-ranging capability of the display and output signal allows tracking startup conditions. When the three optional relays are specified, they may be used as range indicators for the analog output signal.

Automatic cleaning and/or calibration can be initiated by internal clock, by external contact closure or by front panel push-button. Alarm and diagnostic histories can be retained in memory for periodic review and validation purposes.

The Honeywell Series 7020 Dissolved Oxygen Analyzer can provide complete PID control capability with an option of three simultaneous analog output signals for dissolved oxygen, temperature and CAT (Current Adjusting Type) control. On-off and DAT (Duration-Adjusting Type or time-proportioned) control are also available with relay outputs. Control can be switched between automatic and manual either at the analyzer or by closing a remote contact. An auxiliary input may be used to: (1) correct dissolved oxygen values for salinity, (2) control based on a remote set point, or (3) bias the control output with a flow input.

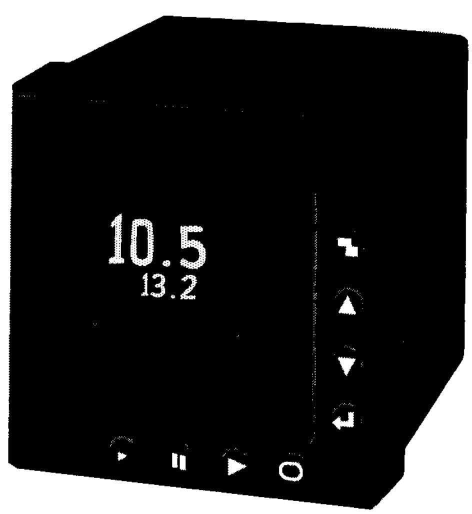


Figure 1-1 Series 7020 Dissolved Oxygen Analyzer

Description of Probe

The probe is housed in a high quality impact resistant PVC or stainless steel casing. One end has a 1" NPT male thread for mounting and a side exit is provided for the cable. The sensor extends from the housing and is covered by a removable cage which allows sample entry while preventing physical damage.

The probe has a permanent electrolyte which is sealed at the rear with an expansion chamber to compensate for pressure changes. The sensor assembly is permanently potted into the housing requiring no field replacement. Operational service consists of an occasional wash to remove any large deposits at the sensor end. This can usually be accomplished without removing the protective cage. If the protective cage is removed for washing, additional care must be exercised as the cage supplies the support for one end of the sensor assembly. As the dissolved oxygen reading is virtually independent of inert fouling, it is usually not necessary to clean the probe, only to remove large accumulations of extraneous matter.

ATTENTION

Extreme caution must be exercised whenever the protective cage or flow-through adapters are removed or installed on a probe. The sensor's membrane may be damaged if these parts are not handled carefully.

For flow-through probe application, usually associated with low D.O. clean liquids, the end protective cage is replaced by a solid end with a ¼" pipe fitting. The probe is supplied with an exit fitting near the top and the liquid travels through the unit after flowing across the sensor.

Physically, the sensor consists of three electrodes and a thermistor for temperature compensation. Two multiple electrodes are interspaced on a supporting substrate and covered with an electrolyte; these electrodes are connected as anode and cathode. The third or reference electrode is mounted in the center of the electrode support and is also in contact with the electrolyte. The anode and cathode perform oxygen generation and reduction functions while the reference electrode maintains the correct electro-chemical potential.

Theory of Probe Operation

When the probe is placed into the sample stream, oxygen diffuses through the membrane and is reduced at the cathode while an equal amount of oxygen is generated at the anode. The diffusion continues until the oxygen partial pressure on both sides of the membrane is equal and a balance exists. The electrical circuitry is arranged such that the current necessary to maintain this equilibrium is converted to read out the dissolved oxygen concentration in the solution.

The reactions are as follows:

At cathode: $0_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

At anode: $0_2 + 4H^+ + 4e^- \leftarrow 2H_2O$

ATTENTION

No oxygen or acid is consumed,
No water is produced,
No net reaction.

1.2 Quick Reference

Do's for the 7021 or 7022 Dissolved Oxygen Analyzer

1. **Do** connect the ground wire on the power line (mains) to the instrument earth ground.
2. **Do** check the key parameters on the Display screen before performing an air calibration for the first time. The parameters should be within the following ranges:
   - Pressure: 760 ±40 mmHg
   - Salinity: 0.0 if not being used
   - Temperature should be a stable reading
3. **Do** run a Probe Bias Test while the probe is still in the air to determine if the probe is operating correctly. Do this test after the first air calibration. Display should look like Figure 4-2.
4. **Do** keep the 5 conduit holes on the under side of the analyzer plugged at all times to ensure the integrity of the NEMA 4X rating.
5. **Do** make sure that the set screws on the front bezel panel are securely tightened to ensure integrity of the NEMA 4X rating.

Don'ts for the 7021 or 7022 Dissolved Oxygen Analyzer

1. **Don't** perform a probe bias test while the probe is in ppb process water.
2. **Don't** perform an air calibration while the probe is in either the ppm or ppb process water.
3. **Don't** perform a sample calibration when the Dissolved Oxygen reading is in the 0.0 - 2.0 ppb range.
4. **Don't** measure the dissolved oxygen in gas streams or air streams. This product measures dissolved oxygen in water.

Do's for the 7931 Dissolved Oxygen Probe

1. **Do** put an o-ring on a new probe before it goes into a ppb application. This avoids leaks.
2. **Do** pull the probe's stopper out when submersing a probe in a ppm application. If you want to run the cable outside the conduit:
   - Guide the probe's cable into the notched curved portion of the probe.
   - Replace the stopper on the probe.
3. **Do** put the probe in process water for at least 24 hours before performing an air calibration for the first time.
4. **Do** connect the probe leads according to the manufacturing recommendations in the manual.

Don'ts for the 7931 Dissolved Oxygen Probe

1. **Don't** remove the silicon membrane on the probe. This probe does not require any internal probe maintenance therefore the membrane should never be removed.
2. **Don't** zero test the 7931 probe in sodium meta or bi-sulfite. Follow the manual's recommendation covered in Appendix G.
3. **Don't** store or operate probe in below freezing temperatures as it may damage the membrane.
4. **Don't** perform air calibration in below 0°C temperatures.

2. Specifications and Model Selection Guide

2.1 Specifications

Physical

Dimensions:	5.67 x 6.67 x 7.59" (144 x 144 x 192.8 mm)
Mounting:	Panel mounting cutout 5.433 x 5.433" +0.039" (138 x 138 mm +1.0 mm), for 0.08-0.75 inch (2-19 mm) thickness, standard. Wall and 1-2 inch NPT pipe mounting hardware supplied with MTG option.
Weight:	6 lb. (2.7 kg)
Enclosure:	Low-copper aluminum alloy case with polyester finish; impact resistant polycarbonate front panel assembly and window; rated NEMA 4X, IP65 with proper conduit, plugs and fittings. Five 0.886 inch (22.5 mm) conduit holes.

Power

Universal:	85-265 VAC; 50/60 Hz; 18VA
Memory Retention:	Configuration and calibration data stored permanently in non-volatile memory.
Fuse Rating:	1 amp/250V Fast Acting Type. Operator Non-replaceable

Environmental

Temperature Limits:

Operating, normal:	14 to 130°F (-10 to 55°C)
Operating, extreme:	-4 to 140°F (-20 to 60°C)*
Storage:	14 to 158°F (-10 to 70°C)
Transit:	-22 to 158°F (-30 to 70°C)

*At these temperatures, the unit will display slightly degraded accuracy and display performance.

Relative Humidity Limits:	10-90%, non-condensing, 10-100% with sealed cable entry to case.
Vibration:	SAMA PMC 31.1, Condition 2, field mount 5-15 Hz, 2mm displacement 15-15- Hz, 1 g acceleration 150-200 Hz, 0.5 g acceleration

Ranges

Measurement Ranges:

DO (7021):	any range from 0.0 ppb to 25,000 ppb, with autoranging of display and output
DO (7022):	any range within 0.00 to 25.00 ppm
Process Temperature:	32-140°F (0-60°C) normal.
Atmospheric Pressure:	500-800 mmHg with internal sensor, for calibration

Auxiliary Input Scaling Range (one of the following):

Flow:	any range within 0-100,000 engineering units
Remote setpoint:	same as dissolved oxygen measurement range

Salinity:	0-40.0 ppt (parts per thousand) as sodium chloride (0-68 mS/cm conductivity)
Sensitivity of Analyzer:	ppm measurements: ±0.2 ppm (at calibration conditions, after stabilization) ppb measurements: ±1% of reading or 0.1 ppb, whichever is greater (at calibration conditions, after stabilization)

Accuracy Statement for the Loop

ppm measurements:	±0.2 ppm (at calibration conditions, after stabilization)
ppb measurem0ents:	±5% of reading or 2 ppb, whichever is greater (at calibration conditions, after stabilization)

Standards Compliance

These products are designed and manufactured to be in conformity with applicable U.S. and European (CE) standards for intended instrument locations. The following standards and specifications are met or exceeded:

Case:	NEMA 4X, IP55
Flame retardance, all materials:	UL94-V0, -V1, or -V2
Max Altitude:	2000 m
Pollution Degree:	2
Installation Category:	II
Compliances:	CE for EMC and Low Voltage directives

2.2 Product Feature Specifications

Operator Interface

Display:	Back-lit dot matrix liquid crystal display with up to 6 lines of text, 1 second update time
Front Panel:	Pushbutton: 8 sealed elastomeric buttons
Security:	Two levels, for configuration and operation

Diagnostics

Probe:	calibration, signal level, temperature, compensator integrity, power, AC noise.
Analyzer:	full circuit card and memory tests, clock.

Analog Inputs

Probe:	Honeywell 7931-series, with integral temperature compensator.
Pressure:	Internal sensor for atmospheric pressure compensation during air calibration.
Auxiliary Input (4-20 mA, 250 ohm load), configurable for one of the following:	Process flow for feedforward control Remote setpoint for cascade control Salinity compensation for online correction of brackish water measurements

---

ATTENTION

Auxiliary Inputs must be isolated from ground.

Analog Outputs

One current output standard, two additional current outputs are supplied as an option. All are isolated and may be field assigned to dissolved oxygen, temperature and/or CAT control output.

Signal:	0-20 or 4-20 mA, front panel selectable
Maximum Load:	800 ohms
Resolution:	0.025%
Isolation:	200 V peak (input/output)

ATTENTION

The optional Dual Current card must be chosen to execute control because the control output, whether CAT or DAT, must be from Analog Output 3 (AO3).

Discrete Inputs

Two inputs from external dry (no external voltage) contacts to control initiation of probe cleaning or calibration sequence and for remote manual control action.

Discrete Outputs

Two or, optionally, five dry (no internal power applied) relay contacts are field-assignable for alarms with adjustable deadband and delay, DAT control, auto range identification, or automatic cleaning/calibration.

Two Mechanical Relays, Standard

Type: Form C, SPDT
Max Switching Current: 14/5 (NO/NC) Amps, 120 VAC resistive
Max Switching Voltage: 265 VAC
Max Switching Power: 200W, DC; 2000 VA, AC
Max Carrying Current: 2A, 250 VAC; 5A, 120 VAC; 2A, 24 VDC

Three Additional Mechanical Relays, Option

Type: 2 Form C, SPDT; 1 Form A, SPST
Max Switching Voltage: 220 VDC, 250 VAC
Max Switching Power: 60W, DC; 125 VA, AC, resistive

Three Solid State AC Relays (optically isolated triacs), Option

Type: Form A, SPST
Max Current: 2A
Voltage Range: 12-280 VAC
Minimum Current: 20mA

Default Factory Configuration

Function	Assignment	
	7022 ppm Analyzer	**7021 ppb Analyzer**
Relay 1	Alarm 1 - Low, 0 ppm DO	Alarm 1 - High, 20,000 ppb DO
Relay 2	Alarm 2 - Low, 0 ppm DO	Alarm 2 - High, 20,000 ppb DO
Optional Relays:		
Relay 3	Alarm 3 - Low, 0 ppm DO	Auto-range indication
Relay 4	Alarm 4 - Low, 0 ppm DO	Auto-range indication
Relay 5	Alarm 5 - Low, 0 ppm DO	Auto-range indication
mA Output 1	0-20 ppm DO	0-20 ppb DO; with option 3 additional relays, auto-range 0-20, 200, 2000, 20000 ppb
Optional mA Output 2	0-50°C temperature	0-50°C temperature
Optional mA Output 3	CAT control output, reverse acting	CAT control output, direct acting
Auto Cal/Clean - off		
	All alarms:	All alarms:
	0.1 ppm deadband, 2 sec delay	0.1 ppb deadband, 2 sec delay
Hold Output	**30 min**	**30 min**

2.3 Model Selection Guide

Series 7020 Dissolved Oxygen Analyzer

Key Number	I	II	III
_ _ _ _ _ _	- _ _	- _ _ _ _ _	- _ _

KEY NUMBER - MEASUREMENTS

Description		CE-Compliant	Selection	Availability			
Parts per Billion (ppb)	(Note 1)	No	070210	•	•	•	•
		Yes	07021C	•	•	•	•
Parts per Million (ppm)		No	070220	•	•	•	•
		Yes	07022C	•	•	•	•

TABLE I - Additional Alarm Relay and Current Outputs

Additional Relays	None		0 _	•	•	•	•
	Three SPST AC Solid State (Triac)	(Note 2)	A _	•	•	•	•
	Three SPDT Mechanical	(Note 2)	M _	•	•	•	•
Additional Current Outputs	None		_ 0	•	•	•	•
	Two, 0-20 or 4-20 mA	(Note 3)	_ 2	•	•	•	•
				•	•	•	•

TABLE II - OPTIONS

User's Manual	English		E _ _ _ _	•	•	•	•
Pipe Mounting Kit	None		_ 0 _ _ _	•	•	•	•
	Pipe Mounting Kit		_ 1 _ _ _	•	•	•	•
Tagging	None		_ _ 0 _ _	•	•	•	•
	Linen	(Note 4)	_ _ L _ _	•	•	•	•
	Stainless Steel	(Note 4)	_ _ S _ _	•	•	•	•
Future			_ _ _ 0 _	•	•	•	•
Future			_ _ _ _ 0	•	•	•	•

TABLE III

Factory use only		00	•	•	•	•

Notes:

1. Auto-Ranging is only available on ppb measurements.
2. Number of relays required for following features:
   One relay for Auto Calibration only
   Two relays for Auto Clean only
   Two relays for both Auto Clean/Auto Calibration
   Three relays for Auto Ranging Identification (Table I = M_ only).
3. Additional Current Outputs needed for CAT Control and/or Temperature Outputs.
4. Customer must supply Tagging Information:
   Up to 3 lines allowed. (22 characters for each line)

Accessories and Replacement Parts

Description	Parts Included in Kit	Quantity	Kit/Part Number
Accessory Parts			
7931 to 7020 Series Adapter Plate			046874
Operator Manual			70-82-25-66
Miscellaneous Parts	Screws, 4-40 x 1.75" front panel hold down	2	51198075-501
	O-ring for front panel & screw retention	4	
	Gasket, front bezel	1	
	Pivot arm linkage set for front panel assembly	1	
	Washer to mount standoff & ground nuts	4	
	Lock washer to mount standoff & ground nuts	4	
	Ground nut, M3	5	
	Flex ribbon cable, at rear	1	
	Ground strip, rear	1	
	Pins, rear cover locating	2	
	Gasket, rear cover	1	
	Screws, rear cover	4	
New/Replacement Kit for Terminal Block Safety Cover	Cover & screw for terminal block safety	1	51198076-501
	Label set for above	1	
	Stand off, accepts safety cover screen	1	
New/Replacement Kit for Terminal Block	Terminal block	1	51198077-501
	Terminal block subplate	1	
New/Replace Kit for Rear Cover	Cover, rear	1	51198078-501
	Gasket rear cover	1	
	Screws, rear cover	4	
	Pins, rear cover locating	2	
New/Replacement Kit for 3 Additional AC SS Relays	3 AC SS relay output cards	1	51204287-501
	Rear terminal block 8 POS	1	
	Terminal block subplate	1	
	Label set	1	
	Assembly, directions	1	
New/Replacement Kit for 3 Additional Mechanical Relays	3 Mechanical, relay output cards	1	51204288-501
	Rear terminal block 8 POS	1	
	Terminal block subplate	1	
	Label set	1	
	Assembly, directions	1	
Bezel Replacement Kit for PPB Units	Display assembly	1	51204289-501
	Pivot arm linkage	1	
	O-ring	4	
	Screws SS four 40 x 1.75	2	
	PPB Prom	1	
	Assembly, directions	1	
Bezel Replacement Kit for PPM Units	Display assembly	1	51204289-502
	Pivot arm linkage	1	
	O-ring	4	
	Screws SS four 40 x 1.75	2	
	PPM Prom	1	
	Assembly, directions	1	

New Replacement Kit for 2 Additional Current Outputs	2 additional current output cards	1	51204290-501
	Rear terminal block 8 POS	1	
	Terminal block subplate	1	
	label set	1	
	Assembly, instructions	1	
Replacement Kit for Power Supply Card	10 W. power supply/relay card	1	51204291-501
	Terminal block	1	
	Terminal block subplate	1	
	Label set	1	
	Assembly, directions	1	
Replacement Kit for Single Current/2 DI Card	Single current/2 DI output card	1	51204292-501
	Terminal block	1	
	Terminal block subplate	1	
	Label set	1	
	Assembly, directions	1	
Replacement Kit for CPU Backplane Card	CPU backplane	1	51204293-501
	Assembly, instructions	1	
New/Replacement Kit for Input Circuit Card	Input circuit card	1	51198079-501
	Rear terminal block 8 POS	1	
	Terminal block subplate	1	
	label set	1	
	Assembly, instructions	1	
Power Line Filter Kit	A fused disconnect switch to terminals to connect AC mains - needed for all CE units	1	079163
	Directions	1	
Withdrawn 7931 Dissolved Oxygen Analyzer Replacement Parts	Replacement current output card	1	445100

7931 Series Probe

Key Number	I	II
_ _ _ _ _	_ _	_, _ _ _ _

KEY NUMBER — **Selection** — **Availability**

Description		Selection	Availability
07931 Dissolved Oxygen Probe	**(Note 1)**	07931	•

TABLE I

Materials of Construction	Connector	Lead Length	Selection	Availability
PVC	Spade Lugs	20 ft	30	•
316 Stainless Steel			40	•
PVC	Quick Disconnect	20 ft	50	•
316 Stainless Steel			60	•
PVC	Spade Lugs	100 ft	70	•

TABLE II - OPTIONS

Tagging	None	0	•
	Linen Customer I.D. Tag Limit to 3 lines, 22 spaces per line	L	•
	Stainless Steel Customer I.D. Tag Limit to 3 lines, 22 spaces per line	S	•

Note 1: When ordering replacement probes for ppb applications, you must order one O-ring Part #31082008 per probe.

3. Installation

3.1 General

Unpacking

Notify the carrier and Honeywell immediately if there is visible damage.

Compare the contents of the Analyzer package with the packing list. Notify Honeywell if there is an equipment shortage. To obtain proper credit and to avoid delays, do not return anything without contacting Honeywell in advance to obtain a return goods authorization.

Inspection

All products are calibrated and tested at the factory prior to shipment. Examine the model number on the unit to verify that it has the correct optional features. See Section 2.3 for information on features associated with model numbers.

Storage and Shipment

The Honeywell Series 7020 Dissolved Oxygen Analyzer is a complex electronic system involving high speed computing components and low level electrical signals. Proper site selection, preparation and installation are vitally important in achieving a trouble-free system.

The following items must be considered before selecting a site for installation:

- Physical mounting and location
- Power line (mains) conditioning
- Grounding for personal safety
- Grounding for noise immunity
- Suppression of noise from electrically connected devices and cables
- Suppression of induced noise from nearby (not connected) sources
- Suppression or shielding from high level radio frequency sources

Location

A suitable physical environment in compliance with Specifications is necessary to insure proper instrument performance. The analyzer meets SAMA PMC 31.1, condition 2 vibration tolerance but must be located in an area free from severe vibrations. Honeywell is not responsible for problems caused by environmental conditions not in compliance.

Allow sufficient space around the instrument for adequate cooling air circulation. If extremely hot or cold objects are nearby, provide radiant heat shielding to ensure that the analyzer stays within its ambient temperature specification.

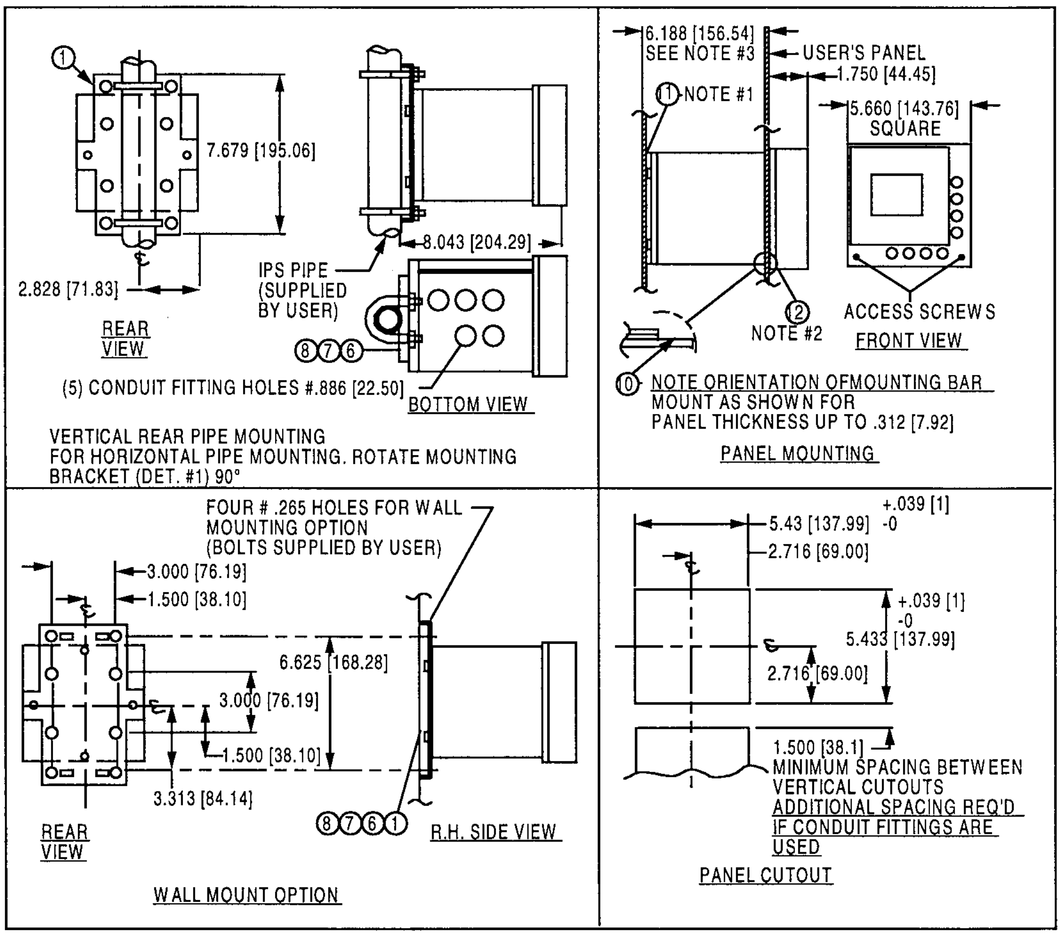
Mounting

Panel mounting is illustrated in Figure 3-1. Provide the panel cutout as shown. The panel may be up to 3/4" (19 mm) thick. It is not necessary to drill holes in the panel. The Analyzer slides into the cutout from the front of the panel to seat against the bezel flange. In back, two mounting bars, which slide in grooves found on the top and bottom of the case, are forced against the panel by screws at the rear. Do not overtighten them. For panels thicker than 0.421" (10.7 mm) the mounting bars must be reversed in their grooves to allow the screws to engage adequately. Where Analyzers are mounted above or below another instrument on a panel, allow at least 1 1/2" (38 mm) between cutouts for vertical door opening and more if conduit fittings are used for wiring to the bottom.

Wall and pipe mounting are also illustrated in Figure 3-1 and require the separate bracket and hardware included as an option in Table II (kit 084711). Pipe mounting may be on either a vertical or horizontal pipe by rotating the mounting bracket 90 degrees.

CAUTION

Pipe mounting is not recommended on a pipe exceeding the specified vibration levels.



DET	QTY	PART NO.	DESCRIPTION
1	1	056347	BRACKET WALL/PIPE MTG.
2	1	304044	"U" BOLT 1" PIPE
3	4	003065	5/16-18 HEX CAP SCREW
4	4	001654	5/16 FLAT WASHER
5	4	301482	K.L.L.W.
6	4	046849	M5X0.8 HEX CAP SCREW
7	4	046850	M5 SPRING LOCK WASHER
8	4	046851	M5FLAT WASHER
9	1	056346	"U" BOLT 2" PIPE
10	2	046849	MOUNTING BAR
11	3	046871	M3X25MM LONG SCREW
12	1	046838	PANEL GASKET (NOTE #2)

NOTES:

1. Do not over tighten fasteners when panel mounting unit.
2. Remove backing from gasket, and adhere gasket to panel before installing unit.
3. Up .250" (6.35mm) may be cutoff from un-notched end of det. 10 to fit into a 6" (152.4mm) deep enclosure.

Figure 3-1 Mounting and Dimensions

3.2 Wiring

CAUTION

- Disconnect mains power before opening case and making wiring connections
- All wiring must be done by qualified technicians and must conform to national or local electrical codes.

3.2.1 General Wiring Recommendations

In general, use stranded copper wire for electrical connections. Keep in mind that the load resistance includes the interconnecting wire.

Twisted signal pairs and shielded cable improve noise immunity if wire routing is questionable. Terminals for shield connections are provided.

Observe all applicable electrical codes when making power connections. Unless electrical codes dictate otherwise, the recommended minimum wire size for connections is give in Table 3-1.

Table 3-1 Recommended Minimum Wire Sizes

AWG	Description
14	Earth ground wire to common power supply
18	Earth ground wire to single unit, 120/240 VAC mains leads. Earth ground wire must have at least the same current carrying capability as mains wire.
20	DC current and voltage field wiring
22	DC current and voltage wiring in control room
24	Dissolved oxygen probe leads, shielded

Specific instructions for all wiring connections are provided in this section.

Dissolved oxygen probes are supplied with integral shielded cables for screw terminal or quick disconnect connection.

CAUTION

- Always disconnect power before opening case and observe correct procedures for handling printed circuit boards and components that can be damaged by electrostatic discharge.
- Always replace all 5 plugs after completion of any wiring to maintain the integrity of the NEMA 4X rating.

3.2.2 Power Connections

The instrument may be connected to a power mains source of 85 to 265 VAC, 50 or 60 Hz with no conversion, change of fuse or special installation requirements. (To set Analyzer for optimum AC noise suppression, a front panel selection of power frequency is made as part of the setup procedure. See Selecting Mains Frequency in Section 4.3.3.)

The power mains should have a neutral (L2) connection with less than 1 V RMS to earth ground. If this cannot be supplied, then provide an isolation transformer between the mains and the instrument, with the secondary (L2) connection earth-grounded.

If power surges or voltage spikes can occur on the mains power, install a surge suppresser. If frequent power interruptions or brownouts can occur, install an uninterruptable power source (UPS).

Safety Grounding

The purpose of safety grounding is to protect against dangerous electrical shock to personnel. A single point ground is recommended. All metal structures, panels, cases, boxes, etc. must be grounded. All grounds must be connected together and fastened to a reliable earth ground with resistance less than 0.1 ohm. If separate ground wire cannot be run from each structure, they can be "daisy-chained" together, if the resistance from the farthest structure to earth ground does not exceed 0.1 ohm.

Always follow local electrical codes for connecting safety ground and power connections.

Wiring CE Units Only - Immunity Compliance

In applications where either the input or output wiring are subject to high level electromagnetic disturbances, double shielded cable with conductive fittings is recommended. The input shield should be terminated at the unit to chassis/earth ground.

Connect the AC mains through a fused disconnect switch to terminals as indicated in the instructions supplied with the Power Line Filter Kit, part #079163. To ensure that the unit meets the immunity levels specified by EMC directive 89/336/EEC, install power line filter kit p/n 079163. Wind three turns of each wire (14 AWG maximum) through the filter core for the two power and protective earth leads as illustrated in Figure 3-4. The wound filter cores shall be located external to the 9782 case within 25 cm.

Noise Suppression

Some amount of electrical noise is present in most locations. The effects of this noise on microprocessor-based instruments can be severe because the circuits are complex and operate at very low power levels. Because high speed interference coupled into digital logic or computing circuits can have the appearance of signals normally found in the system, it is vital that such interference be kept outside the instrument.

Sources of electrical noise include any high voltage or high current devices, especially with AC or switched DC. Noise may be directly coupled as with ground loops, inductively coupled by parallel conductors running near signal or analyzer power leads, or may be coupled by radiation as with radio frequency interference. Appropriate location and/or protection by suppression or shielding must be applied to minimize such noise pick up.

When contacts or outputs are wired with hard contact switches to control an inductive load (such as a motor starter or solenoid), additional transient noise suppression must be provided. A capacitor and a resistor must be installed in parallel with (and preferably close to) the inductive load as shown in the accompanying illustrations. For AC operation, a MOV must be placed across the inductive load. For DC operation, a diode must be placed across the inductive load. See Figures 3-2 and 3-3 for noise suppression connections and recommended component values for each type of device, with Honeywell part numbers indicated.

See Appendix A for a Noise Suppression Test.

ATTENTION

Low Level Inputs (Probe and Auxiliary Inputs) must be kept separated from High Level (110 VAC) wiring (power and relay). Do not Run Low Level wiring in any conduit containing 110 VAC or any other High Level signals or switching circuit wiring.

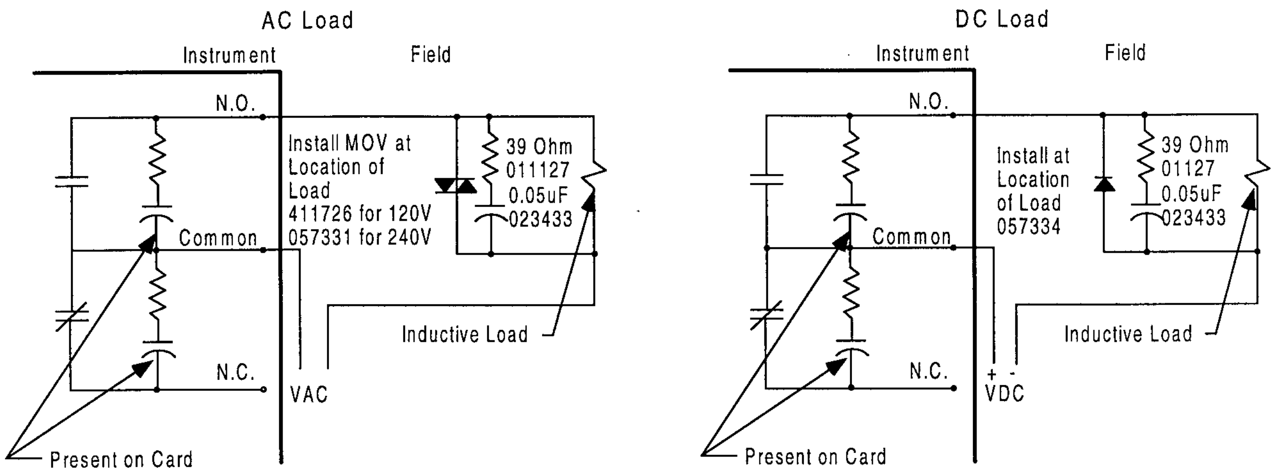


Figure 3-2 Noise Suppression for Optional Mechanical Relay Outputs Card

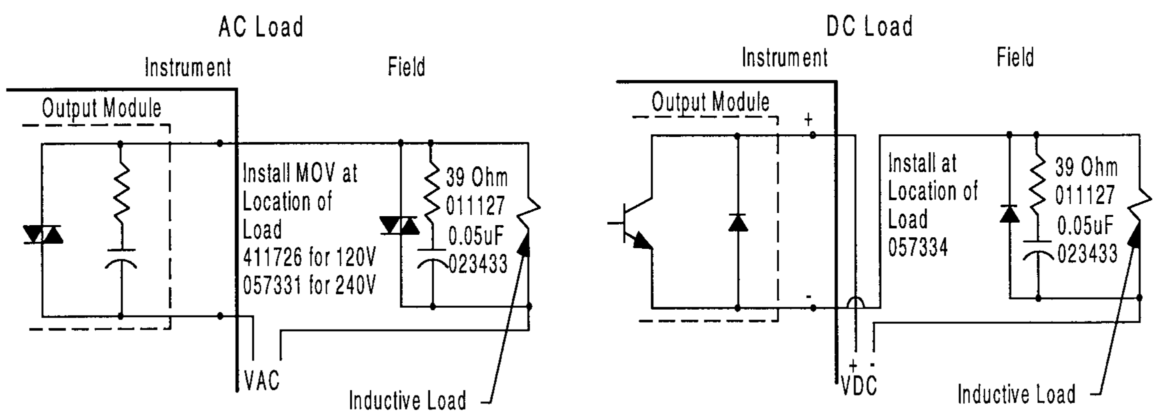


Figure 3-3 Noise Suppression for Optional AC Relay (triac) Outputs Card

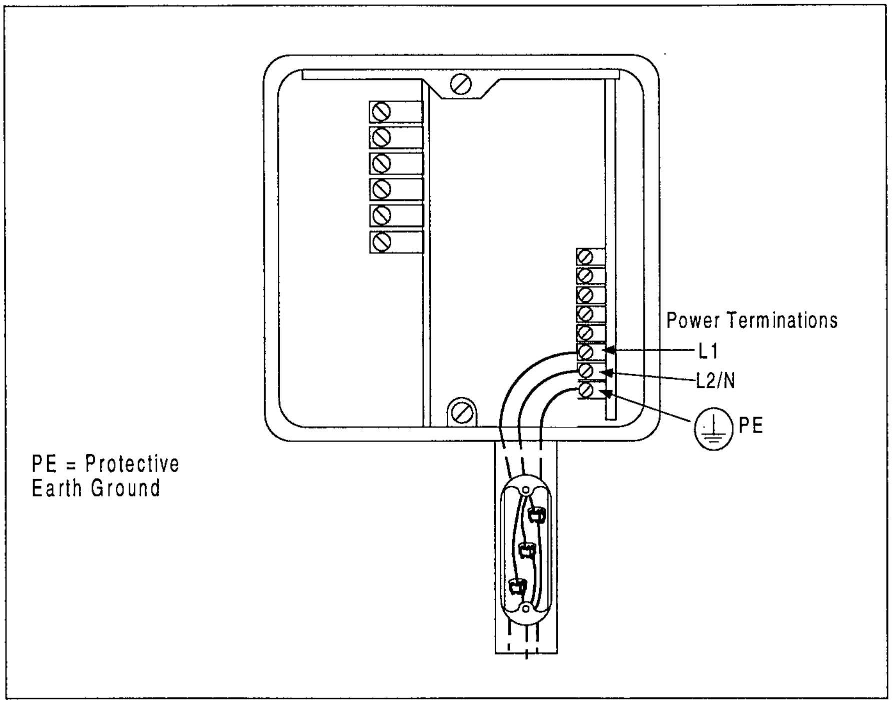


Figure 3-4 AC Power Terminals

3.2.3 Terminal Board Connections

General Procedure

Make all connections at the terminals inside the case as indicated in Table 3-2. The connections to be made are dependent on what options have been selected. To avoid electrical interference with signals, do not run low-level signal leads inside or outside the case in close proximity to or parallel with line voltage leads or other power leads.

To make connections, open the analyzer as follows:

1. Loosen the front panel screws.
2. Pull the panel forward slightly, then lift it up until it latches.
3. Loosen the screw at the top of the terminal board cover, and swing the cover down.
4. Remove the appropriate plug and pull wire through conduit.
5. **To make installation easier,** loosen the screw at the bottom of the terminal board and remove the terminal block from the panel while wiring.
6. Make wiring connections per Table 3-2.
7. Replace the terminal board in the appropriate spot on the panel and tighten the screw.
8. Repeat for each terminal board as needed.
9. Replace the terminal board cover, and tighten the screw.
10. Close the front panel by pushing it down and back to align it. Press in the top edge of the case first, then press in the bottom and tighten the cover screws.

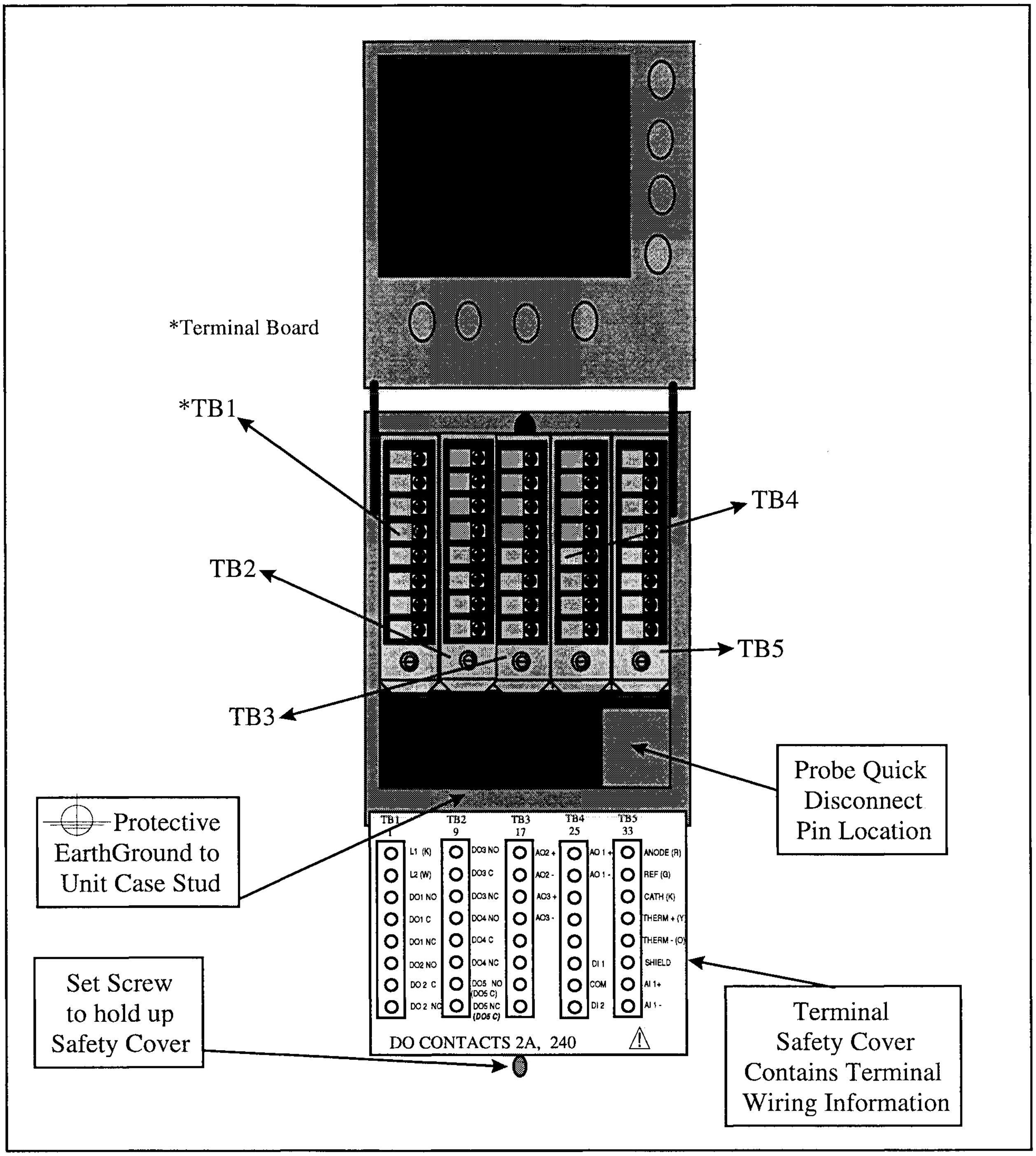


Figure 3-5 View Inside Front Bezel

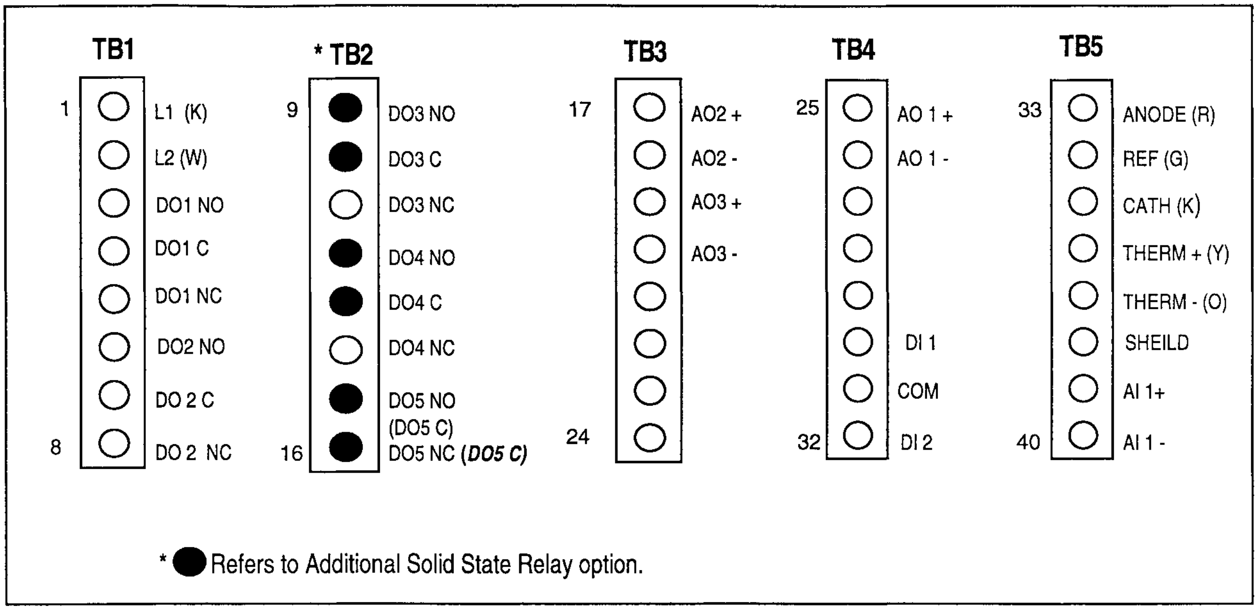


Figure 3-6 Standard Label for all Terminal Block Safety Covers

Terminal Board Legend

R = Red
G = Green
K = Black
Y = Yellow
O = Orange
W = White

Special Wiring Considerations - Terminal Boards

Terminal boards provided are based on the options specified for the particular Analyzer.

All discrete outputs are dry contacts-unpowered. Power must be provided and wired in series if needed for the installation. It is recommended that a power on-off switch be included in the discrete output circuit to enable removal of output power while the Analyzer and input devices remain operational.

ATTENTION

1. When discrete outputs are wired to inductive loads such as motor starters or solenoid valves, additional transient noise suppression must be provided.
2. Mechanical relays are protected by RC (resistance-capacitance) arc suppression circuits wired across their contacts. When powered with AC, leakage through these circuits is often sufficient to activate very small loads such as neon bulbs, continuity testers, PLC logic circuits, etc. If this AC voltage cannot be tolerated, install a suitable load resistance in parallel with the small load.
3. Solid state AC relays or triacs have a minimum current requirement of 20 mA to switch reliably. If a load is used which allows less than 20 mA to flow, then install a suitable resistance (approximately 5000 ohms, 5 watts, for 120 VAC) in parallel with the load.

Special Wiring Considerations - Probe

To connect the DO probe to the Analyzer:

1. Loosen the screw terminal block retaining screw, and remove the block to facilitate connecting the leads.
2. Connect a dissolved oxygen probe with spade lugs to Terminal Board 5, terminals 33-38.
3. If the terminal block is left in place during wiring, take care to connect the probe leads sequentially in the order: Shield, red, green, black, yellow, orange, since probe damage may result otherwise.
4. Disconnect in the reverse order.
5. Connect the shields of both cables together but do not earth ground them.
6. For a dissolved oxygen probe with plug, connect it to the receptacle beneath the right-most terminal board.
7. Separate probe leads from AC wiring.
8. Run power and auxiliary control and/or alarm wiring in conduit to prevent moisture entry into the Analyzer. Conduit openings are provided for this purpose. If conduit is not used, use appropriate cable grips, seals or caulking to maintain enclosure rating.

Probe Noise Test

To assure maximum probe life, there must be negligible voltage pickup on the probe leads. Because this equipment is often installed near electrical noise sources, minimize electrical noise sources by following the procedure found in Appendix A.

Table 3-2 Definitions of DO Analyzer Inputs and Outputs

Terminal Board	Card Type Description	Function	Terminal Board Connections	Notes
TB1	Standard:			
	• Power	Line Power	L1(K) -1 L2(W) - 2	Mains Connections If CE Unit - use Power line Filter Kit part#079163
	• Relay 1	Alarms, Control, or Automatic Clean/Calibration	DO1 - 3, 4, 5	Discrete outputs per Specifications
	• Relay 2		DO2 - 6, 7, 8	
TB2	Optional:			Discrete outputs per Specifications
	• 3 additional Mechanica l Relays	Auto Ranging to recorder, Alarms, Control, or automatic Clean /Calibration	DO3 - 9, 10, 11 DO4 - 12, 13, 14 DO5 - 15, 16, 12	Terminal 16 is DO5 NC and DO4 NO is internally jumpered to DO5 common (no terminal) for use with the auto ranging indication feature.
	OR • 3 additional AC SS Relays		DO3 - 9.10 DO4 - 12, 13 DO5 - 15, 16, 12	To use DO4 and DO5 for other purposes, remove the internal jumper per directions. Most commonly used in power utilities.
TB3	Optional:			
	• Dual Current Outputs	Temperature Measurement	AO2+ - 17 AO2- - 18	Used for an additional measurement output. Maximum load of 800 ohms.
		Control Output	AO3+ - 19 AO3- - 20	Always used as the Control output. Maximum load of 800 ohms.
TB4	Standard:			
	• Single Current Output	DO Output to recorder or DCS	AO1 -	Maximum load of 800 ohms
	• 2 Discrete Inputs	Remote Auto Clean/Calibration	DI 1 -	Can be used to initiate automatic cleaning and/or calibration, as field configured. If used, it requires that a remote dry contact be closed for two seconds to initiate the clean/cal cycle. The contact must open before the sequence is complete to prevent initiating another clean/cal cycle. To determine which function will be initiated by closing DI 1, review Section 4; the end of the discussion describing Programming Automatic Calibration/Automatic cleaning.
		Remote Manual	DI 2 -	Can be used to force control into manual with a remote dry contact. When the contact is closed, control is in manual. When the contact is open, control is in automatic (unless manual operation is selected from the Analyzer front panel.)
TB5	Standard:			
	• Probe Input Card	DO Probe Input	Anode - 33 (R) Reference - 34 (G) Cathode - 35 (K) Therm+ - (Y) Therm- - (O)	For probe with spade lug termination, connection sequence is shield, then top to bottom. Disconnect in reverse order. Probe damage may occur otherwise.
	• Auxiliary Input	Remote Flow Input , Salinity, or Remote Setpoint	AI1+ - 39 AI1– - 40	Accepts a 4-20 mA signal which passes through an internal load resistence of 250 ohms.
Unit Case		Protective Earth Terminal	Case Stud	Connect Earth Ground to stud at bottom of case (Figure 3-4).

4. Operation

4.1 Overview

The front panel is used to view the information stored in the Analyzer. To access operator information, i.e., Dissolved Oxygen Concentration, Temperature, Salinity or Pressure; the Display screen is used. The Display screen is invoked by pressing the Display button (Y).

To access engineering and maintenance information and functions, the Main Menu screen is used. The Main Menu screen is invoked by pressing the Menu Button (≡). From the Main Menu select from three modes of operation. (See Table 4-1.) Each of these modes is used to access a specific subset of screens. Each of these modes and their respective screens are discussed later in this section.

Table 4-1 Main Menu Quickview

ONLINE	PROGRAM	MAINT (Maintenance)
ALARM/DIAG SUMMARY ALARM SUMMARY ALARM HISTORY DIAG SUMMARY AIR CAL CURR DEL DIAGS CONTROL TUNING GAIN RESET RATE TREND TIME TUNING TREND SETPOINT AUTO CLEAN/AUTO CAL DO CLEAN DO CAL REVIEW PROGRAM ALARMS RELAYS ANALOG OUTPUTS CONTROL LOOPS AUTO CAL/AUTO CLEAN SETUP BUTTONS AUXILIARY INPUTS SET CLOCK AUTO RANGE SELECT DO OR %SAT CONFIGURE SALINITY	ALARMS RELAYS ANALOG OUTPUTS CONTROL LOOPS AUTO CAL/AUTO CLEAN SET UP BUTTONS LOCK/UNLOCK SECURITY AUXILIARY INPUT SET CLOCK AUTO RANGE SELECT DO OR %SAL CONFIGURE SALINITY	CONTRAST ADJUST MAINS FREQ MANUAL CALIBRATION AIR CALIBRATION SAMPLE CALIBRATION ZERO CALIBRATON PRESSURE CALIBRATION CALIBRATE AI CALIBRATE AO OFF LINE DIAGS PROBE BIAS TEST RELAY TEST OUTPUT TEST INPUT STATUS RESET UNIT INFORMATION SOFTWARE REVISION PART NUMBER COPYRIGHT DATE

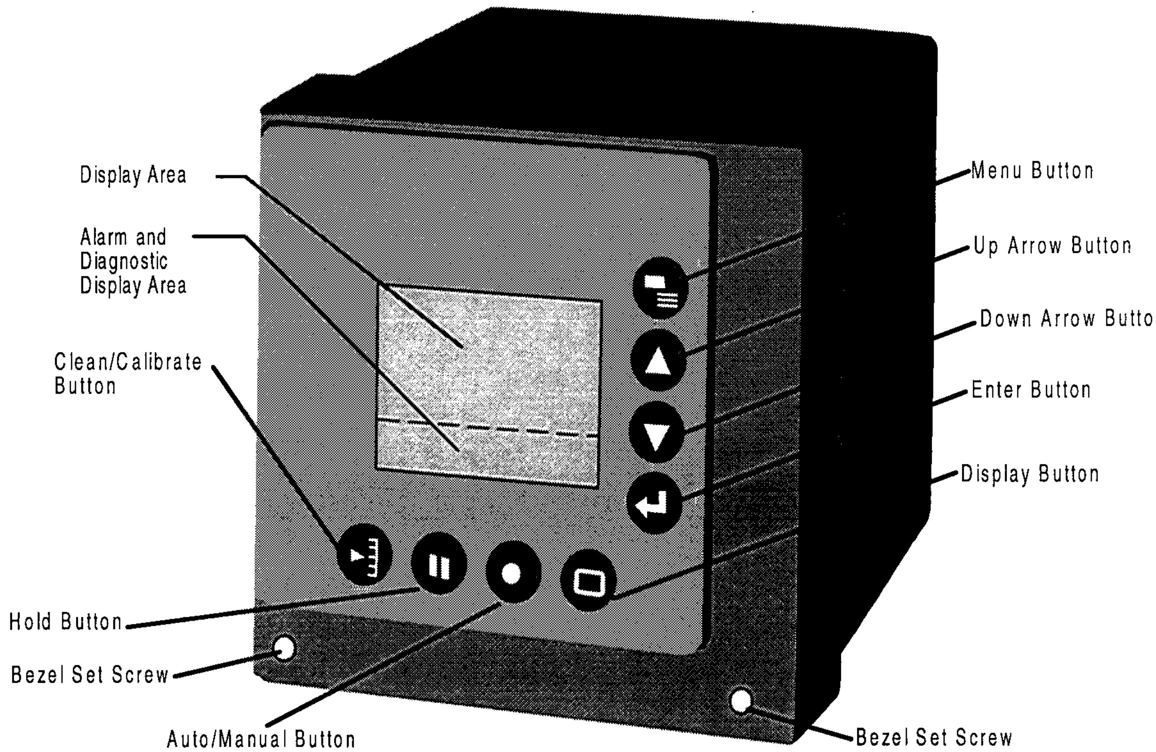


Figure 4-1 Series 7020 DO Analyzer Front Panel

4.1.1 Button Functions

As called out in Figure 4-1:

Menu Button is used initially to enter the menu structure. Subsequent depression of this button steps up one level in menu structure.

UP Arrow is used to move the selection box up, scrolls up through a list of selections and increases the value of the digits being set.

DOWN Arrow is used to move the selection box down, scrolls down through a list of selections and selects the next digit in a number being set.

Enter Button is used to select a menu item or to store a value or setting.

Display Button is used to restore the unit to the on-line mode and display. Subsequent depressions of this button will cycle through the on-line displays.

AUTO/MAN Button is used to select the control mode when control is used.

Hold Button is used to hold alarms conditions and output signals.

CAL Button is used to initiate automatic probe calibration or cleaning, if configured.

Bezel Screws provide NEMA 4X rating and access to Analyzer wiring

4.1.2 Screen Movement - Arrows

No matter what mode or operation the analyzer is in, the present dissolved oxygen concentration and other variables are displayed instantly by pressing the Display button. Pressing the Display button also moves the analyzer into the ONLINE mode, no matter which mode it was in.

The ONLINE mode is selected by pressing the Display button and then pressing the Menu button. The MAIN MENU - ONLINE screen is displayed. A box is around SET MODE. The down arrow, ↓, in the upper right corner of the screen indicates that the list of selections below MAIN MENU - ONLINE is longer than the 4 items displayed on the screen.

MAIN MENU - ONLINE ↓
SET MODE ONLINE
ALARM/DIAG SUMMARY
MANUAL CALIBRATION
CONTROL TUNING

Press the Down Arrow button 4 times. This moves the box to the previously unseen choice of AUTOCLEAN/AUTOCAL.

MAIN MENU - ONLINE ↕
ALARM/DIAG SUMMARY
MANUAL CALIBRATION
CONTROL TUNING
AUTOCLEAN/AUTOCAL

The indication in the upper right corner is now the up/down arrow, ↕, indicating that there are items both above and below those displayed on the screen. Press the Down Arrow once more. The selection box is at the bottom around REVIEW PROGRAM. The up arrow ↑ indicates that this is the last item on this list and that there are more above.

MAIN MENU - ONLINE ↑
MANUAL CALIBRATION
CONTROL TUNING
AUTOCLEAN/AUTOCAL
REVIEW PROGRAM

4.1.3 Setting Numerical Values

Numerical values are set in one of three ways depending on whether the value is a configured value, a selected value or a "ramped-set" value.

Configured values include alarm set points, analog input limits, etc. Entering a new number is accomplished by pressing the Up Arrow to scroll through digits 0-9 for each place and the Down Arrow to move the flashing digit one place to the right. Pressing the Down Arrow eventually "wraps around" to the most significant place again. Besides numerals 0-9 in the most significant place, a minus sign may also be selected where needed.

Selected values are generally those involving time such as minutes, hours and days of the month where only certain values are available. To set a desired selected value, box the number and press the Down Arrow to decrease or the Up Arrow to increase the value and "enter button" when the desired value is boxed. To see examples, refer to Program Mode - SET CLOCK.

The only **Ramped** values are the set point and the control output shown on the ON-LINE- OPERATE LOOP screen. Pressing the Up Arrow increases the output value and pressing the Down Arrow decreases it. Furthermore, holding the button longer causes the rate of change of the value to change more quickly. To slow down the rate of change, release and press the button again.

The three types of values may be distinguished as follows:

1. A **Configured** value has a flashing digit and pressing the Down Arrow shifts the flashing to the right.
2. A **Selected** value has no flashing digit and no decimal place and pressing the Down Arrow decreases the value displayed.
3. A **Ramped** value has no flashing digit, but does have a decimal place and holding the Up Arrow or Down Arrow produces an increasingly rapid change in value.

4.1.4 Diagnostic Messages

These messages can be displayed at any time in the Alarm and Diagnostic Display area which is found at the bottom of the Analyzer screen. (See Figure 4-1) They are not dependent on any specific mode or function. See Section 5.0 Troubleshooting, for more information on diagnostics.

4.2 Display Screens

To view display screens, push the Display button (Y). Pushing the Display button repeatedly scrolls through screens which show the current status of dissolved oxygen concentration, temperature, pressure, salinity, control output percentage. Several screens show the dissolved oxygen concentration in numerals large enough to be read 12 feet away including one display with brilliant backlighting.

While most the of display screens provide information only, the OPERATE LOOP screen allows the setpoint to be adjusted while in automatic control or the control output to be adjusted while in manual control.

To adjust setpoint:

Depress the Display button until the Operate Loop screen is displayed.

Press the AUTO/MAN button, if necessary, to place the analyzer into automatic control. This is indicated by AUTO in the lower right corner of the OPERATE LOOP screen and the fact that the value to the right of SP is boxed.

```
OPERATE LOOP
PV          3.39
SP         [4.00]
OUT        33.3
DEV       -0.41 AUTO
```

To adjust output:

Press the AUTO/MAN button, if necessary, to place the analyzer into manual control. This is indicated by MAN in the lower right corner of the screen and the value to the right of OUT is boxed.

```
OPERATE LOOP
PV          3.39
SP          4.00
OUT       [3.33]
DEV       -0.41 MAN
```

Pressing the Down Arrow button lowers the % output and pressing the Up Arrow button raises it.

Programming the control loop is described in Section 4.1.2 and tuning the loop later in this Section.

Press the Menu button to go to the MAIN MENU - ON LINE SCREEN.

MAIN MENU - ONLINE ↓
SET MODE ONLINE
ALARM/DIAG SUMMARY
MANUAL CALIBRATION
CONTROL TUNING

SET MODE - ONLINE indicates that the analyzer is in the ONLINE mode.

4.3 Main Menu

ATTENTION

If the Display button is pressed during the programming of the unit and the new values have not yet been stored, a screen headed PRESS ENTER TO SAVE is displayed. If the old value should be retained, press the Display button again. If the new value should be saved, press the Enter button first and then the Display button.

4.3.1 On-Line Mode

Alarm/Diagnostic Summary

From the MAIN MENU - ONLINE screen, press the Down Arrow and Enter buttons to display the ALARM/DIAG SUMMARY screen with ALARM SUMMARY boxed.

ALARM/DIAG SUMMARY ↓
ALARM SUMMARY
ALARM HISTORY
DIAG SUMMARY
AIR CAL CURR 93.657

The following screens can be viewed from the ALARM/DIAG SUMMARY screen.

1. **Alarm Summary** - To review a summary of present alarms, press the Enter button. To return to the ALARM/DIAG SUMMARY screen, press the Menu button.
2. **Alarm History** - To review a history of alarms, press the Down Arrow button to move the box to ALARM HISTORY and press the Enter button. To return to the ALARM/DIAG SUMMARY screen, press the Menu button.
3. **Diagnostic Summary** - To review a list of all diagnostic messages since the last time DELETE DIAGS was pressed, press the Down Arrow button until DIAG SUMMARY is boxed and press the Enter button. To return to the ALARM/DIAG SUMMARY screen, press the Menu button.

The AIR CAL CURR value is the probe current at the end of the last air calibration in microamps. It is displayed in the ALARM/DIAG SUMMARY screen for convenience in checking the performance of the probe.

To delete the present list of diagnostic messages, press the Down Arrow button to box DELETE DIAGS and press the Enter button.

Messages indicating the most recent alarm or diagnostic condition are also shown in a bright band near the bottom of the screen. An explanation of these messages is given in Table 4-1.

Manual Calibration - Units with Software Prior to Version C.3

For units with software versions prior to C.3, the Manual Calibration function is found under the On-line Mode Menu. Units with software versions C.3 and higher can find the Manual Calibration function under the Maintenance Mode.

The detailed explanation of the Manual Calibration function can be found in Section 4.3.3, Maintenance Mode.

Control Tuning

Control Tuning allows the operator to change the control set point and the PID parameters gain, reset and rate without going into the PROGRAM mode. To facilitate tuning, a time-configurable display trend of the dissolved oxygen concentration vs. time is available.

Procedure for Control Tuning

1. From the MAIN MENU - ONLINE screen, press the Down Arrow button until CONTROL TUNING is boxed.
2. Press the Enter button to display the CONTROL TUNING screen.

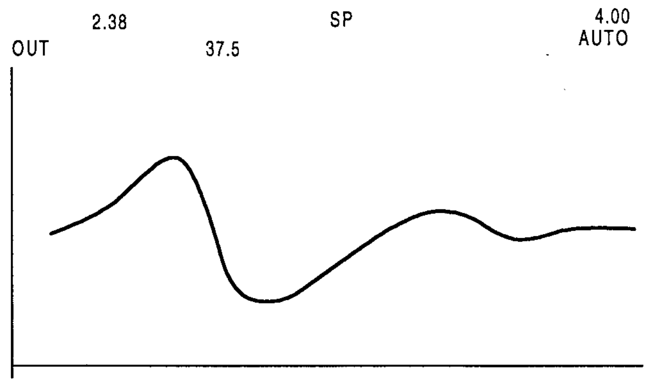
CONTROL TUNING	↓
GAIN	2.0
RESET	1.000
RATE	0.50
TREND TIME	0.5

3. To adjust Gain, Reset or Rate, press the Down Arrow button, as necessary, to box the desired control parameter.
4. Pressing the Enter Button selects that parameter.
5. Adjust the value as described in Section 4.1.3, Setting Numerical Values.
6. Press the Enter button to indicate acceptance of the value.

To observe the dissolved oxygen concentration as a function of time follow the procedure listed below.

1. From the CONTROL TUNING screen, press the Down Arrow button to box TREND TIME.
2. Press the Enter Button.
3. Press the Down or Up Arrow button to set the desired span in minutes of the trend to be displayed. The minimum trend time is two minutes.
4. Press the Enter Button.
5. Press the Down Arrow button to box TUNING TREND.
6. Press the Enter Button to start the trend.

Displayed is a plot of the process variable dissolved oxygen concentration as a function of time with the full width of the plot corresponding to the span configured in TREND MINUTE. Trend time span may be adjusted from 2 to 59 minutes. A typical tuning trend screen looks like:



The span of the abscissa (horizontal axis) is set by the TREND MINUTE setting. The ordinate range (vertical axis representing the dissolved oxygen concentration) is zero to 20,000 for PPB units and zero to 20 ppm for PPM units.

Besides the trend, other information is provided at the top of the screen:

- The 2.38 in the upper left is the present dissolved oxygen concentration
- SP 4.00 indicates that the setpoint (rather than remote setpoint, RS) value is 4.00
- OUT 37.5 indicates that the control output is at 37.5% of maximum
- AUTO indicates that the controller is in automatic (rather than manual, MAN).

To set the control setpoint:

1. From the CONTROL TUNING screen, press the Up Arrow button to box SETPOINT.
2. Press the Enter Button.
3. Adjust the value as described in Section 4.1, Numerical Values.
4. Press the Enter Button.

Automatic Cleaning/Calibration

This section describes the autoclean/autocal functions that can be performed in the ONLINE mode. These functions also include reviewing status and manually initiating a cleaning or calibration based on selections made in the PROGRAM mode. Factory settings have automatic cleaning and calibration turned off. When turned on, with relay(s) assigned, the internal clock and timers activate external devices such as solenoid valves or drive units that direct a cleaning stream or expose the probe to air on a set schedule. The user must design the arrangement of all external devices to meet the application needs. See Appendices A4 and A5 for suggested approaches. See Section 4 for programming these operations and assigning relay(s).

The procedure for manual initiation of cleaning and calibration is as follows:

1. From the MAIN MENU - ONLINE screen, press the Down Arrow button until AUTOCLEAN/AUTOCAL is boxed.
2. Pressing the Enter button displays the AUTOCAL STATUS screen.

```
    AUTOCAL STATUS
CLEAN IN   09 19 10
CAL IN     02 19 10
[DO CLEAN]     DO CAL
```

This example screen shows that the next automatic probe cleaning is in nine days, 19 hours and 10 minutes and that the next automatic calibration is in two days, 19 hours and 10 minutes. A pre-programmed cleaning or Air Calibration may also be initiated from this screen.

To initiate an Air Calibration:

3. Press the Down or Up Arrow button, as necessary, to box DO CAL.
4. Press the Enter Button. A series of screens are displayed.

CAL - START DELAY
MAX REM STEP 59
DO 8.98 PPM (or 8980.0 PPB)
TEMP 20.2 C
PRESS MENU TO ABORT

Where MAX REM STEP counts down for 60 seconds (factory set).

CAL - CALIBRATING
MAX REM STEP 2000
DO 8.98 PPM (or 8980.0 PPB)
TEMP 20.2 C
PRESS MENU TO ABORT

Where MAX REM STEP counts down until the probe current and temperature are stable or until the user-set maximum calibration time is reached.

CAL - WAIT RESUME
MAX REM STEP 59
DO 8.98 PPM (OR 8980.0 PPB)
TEMP 20.2 C
PRESS MENU TO ABORT

Where MAX REM STEP counts down for the user-set resume time.

At the completion of the calibration, the AUTOCAL STATUS screen returns.

AUTOCAL STATUS
CLEAN IN 09 19 7
CAL IN 02 19 7
DO CLEAN DO CAL

Or to initiate a Cleaning:

3. Press the Up or Down Arrow button, as necessary, to box DO CLEAN.
4. Press the Enter Button. The CLEAN - RINSING screen is displayed.

CLEAN - RINSING
MAX REM STEP 15
DO 8.96 PPM (or 8960.2 PPB)
TEMP 20.2 C
PRESS MENU TO ABORT

At the completion of the cleaning, the CLEAN - WAIT RESUME screen appears. At the completion of the programmed resume time, the CLEAN COMPLETE screen shows momentarily and then the screen returns to the AUTOCAL STATUS screen.

The cleaning operation performed is that programmed in PROGRAM MODE - AUTO CAL/AUTO CLEAN.

If HOLD OUTPUTS - YES is selected in programming AUTO CAL/AUTO CLEAN, outputs and alarm conditions will be held during operations initiated from DO CLEAN or DO CAL.

Automatic initiation of cleaning and/or calibration.

The screens observed during the automatic clean/calibration operations depend on the operations that have been programmed (in the PROGRAM mode) to occur automatically. For instance, if both an automatic cleaning and automatic calibration are to be initiated at the end of a period, the following screens are displayed. (If HOLD OUTPUTS - YES is selected in programming, AUTO CAL/AUTO CLEAN, outputs and alarm conditions are held during operations initiated automatically.)

1. As the automatic cleaning is initiated, the CC - RINSING screen is displayed for the programmed cleaning time.

    C/C RINSING
    MAX REM STEP 01
    DO 8.61 PPM (or 8614.0 PPB)
    TEMP 23.2 C
    PRESS MENU TO ABORT

2. This is followed by a factory-set delay of one minute while the C/C START DELAY screen is displayed.

    C/C START DELAY
    MAX REM STEP 01
    DO 8.61 PPM (or 8614.0 PPB)
    TEMP 23.2 C
    PRESS MENU TO ABORT

    In both of these screens, MAX REM STEP is the maximum time remaining to complete the operation, DO is the dissolved oxygen concentration during cleaning, TEMP is temperature and the instruction PRESS MENU TO ABORT allows the operator to terminate this operation manually.

3. After the delay is complete, the C/C-CALIBRATING screen is displayed to confirm that calibration is occurring.

    C/C - CALIBRATING
    MAX REM STEP 1984
    DO 8.61 PPM (or 8614.0 PPB)
    TEMP 23.2 C
    PRESS MENU TO ABORT

    In this screen, the maximum remaining step (MAX REM STEP) is in seconds and starts "counting down" from the 2000 second upper limit for this time. The calibration usually takes a minute or two so the MAX REM STEP value decreases until the Air Calibration has been completed.

4. Then the screen changes to the C/C WAIT RESUME screen and the programmed time before resumption of On-Line operation is "counted down" as the value to the right of MAX REM STEP.

    C/C - WAIT RESUME
    MAX REM STEP 01
    DO 8.61 PPM (or 8614.0 PPB)
    TEMP 23.2 C
    PRESS MENU TO ABORT

5. At the completion of the WAIT (to) RESUME time, a screen headed CC-COMPLETE is displayed for a second and then the display returns to whatever online screen was being displayed before the Automatic Calibration and Cleaning operation was initiated.

    C/C - COMPLETE
    MAX REM STEP 01
    DO 8.61 PPM (or 8614.0 PPB)
    TEMP 23.2 C
    PRESS MENU TO ABORT

ATTENTION

While the analyzer is in either off-line mode (PROGRAM or MAINT), automatic calibration and cleaning are disabled.

Review Program

REVIEW PROGRAM allows the displaying of various values and states that have been configured for Alarms, Relays, Analog Outputs, control Loop, Automatic Calibration and Cleaning, the Calibrate button, the Hold button, Auxiliary Inputs, Clock, Automatic Ranging and DO or % Saturation. These functions are described in detail along with how they are configured in Section 4.3 Program Mode. Explained here is simply how to display values and states that have been configured.

Review Program Procedure:

1. From the MAIN MENU - ONLINE screen, Press the Down Arrow button until REVIEW PROGRAM is boxed.
2. Pressing the Enter button displays the REVIEW PROGRAM screen.

```
 REVIEW PROGRAM  ↓
[SET MODE]      ONLINE
ALARMS
RELAYS
ANALOG OUTPUTS
```

3. Pressing the Down and Up Arrow buttons moves the selection box up and down within the same level of selections.
4. Pressing the Enter button accepts what was highlighted and moves the sequence to the next
5. Pressing the Menu button backs the selection out to the previous level.

Example

1. From the PROGRAM REVIEW screen, press the Down Arrow button to box ALARMS.
2. Press the Enter button. Displayed is the ALARMS screen with ALARM 1 boxed.

```
ALARMS              ↓
[ALARM 1           ]
ALARM 2
ALARM 3
ALARM 4
```

3. If the input to ALARM 1 were programmed to be DIS OXY, dissolved oxygen concentration, pressing the Enter button would display the PROGRAM ALARM 1 screen.

```
PROGRAM ALARM   1 ↓
[TYPE          ]   LOW
INPUT          DIS OXY
SET POINT         1.00
DEADBAND          0.50
```

This screen shows: Alarm 1 has been programmed as a low alarm, its input parameter is DIS OXY, its setpoint is 1.00 (again, ppm DO) and its deadband is 0.50 (ppm DO).

4.3.2 Program Mode

Introduction

Described in this section is how to configure (program) the functions and values observed in the MAIN MENU - ONLINE mode under REVIEW PROGRAM. The order follows Table 4-1.

ATTENTION

Whenever the Analyzer is placed in the PROGRAM mode, output values and alarm conditions that existed just prior to entering the program mode are held until the online mode is restored. Also, no new diagnostic messages appear and periodic Auto Clean/Auto Cal are reset while sequential Auto Clean/Auto Cal are not. If a timed event (Auto Clean/Auto Cal) is scheduled, it is not executed.

There are two paths to the PROGRAM mode.

The first path is to press the Display button and then the Menu button. The MAIN MENU - ONLINE screen is displayed with the box around SET MODE.

Pressing the Enter button boxes ONLINE at the right.

MAIN MENU - ONLINE ↓
SET MODE [ONLINE]
ALARM/DIAG SUMMARY
MANUAL CALIBRATION
CONTROL TUNING

Pressing the Down Arrow button changes the boxed selection from ONLINE to PROGRAM.

MAIN MENU - ONLINE ↓
SET MODE [PROGRAM]
ALARM/DIAG SUMMARY
MANUAL CALIBRATION
CONTROL TUNING

Pressing the Enter button displays the screen MAIN MENU - PROGRAM with the ↓ in the upper line indicating that the list is longer than 4 items and the Analyzer is in the PROGRAM mode.

MAIN MENU - PROGRAM ↓
[SET MODE] PROGRAM
ALARMS
RELAYS
ANALOG OUTPUTS

The alternate path is to keep pressing the Menu button until one of the three MAIN MENU screens is displayed. Once it is displayed with SET MODE highlighted, the desired mode is selected by:

1. Pressing the Enter button
2. Pressing either the Up or Down Arrow button until the desired mode is boxed
3. Pressing the Enter button to select the mode that is highlighted.

Alarms

An alarm is a warning signal presented on the Analyzer display whenever a measured or calculated value exceeds its set limit. This section describes how to program the conditions that cause each of the five available alarms to activate. To activate any external device, it is necessary to program both an alarm and one (or more) of the available relays to be activated by the corresponding alarm.

Alarm Programming Procedure:

1. Get to the MAIN MENU - PROGRAM screen.

   MAIN MENU - PROGRAM ↓
   [SET MODE]   PROGRAM
   ALARMS
   RELAYS
   ANALOG OUTPUTS

2. Press the Down Arrow button to box ALARMS.
3. Press the Enter button to select.
4. The ALARMS screen is displayed with ALARM 1 boxed.

ALARMS ↓
[ALARM 1]
ALARM 2
ALARM 3
ALARM 4

Selecting the Alarm:

Press to box the alarm to be configured and press the Enter button. The PROGRAM ALARM screen appears.

PROGRAM ALARM ↓	
[TYPE]	LOW
INPUT	DIS OXY
SET POINT	2.00
DEADBAND	0.50
DELAY IN SEC	2.0

Selecting Alarms Type:

To select the TYPE of alarm:

1. Press the Enter button.
2. Choices are displayed by pressing either the Up Arrow or the Down Arrow button and include:
   NONE
   HIGH
   LOW
3. When the desired choice is boxed, press the Enter button to select the boxed choice.
4. The screen returns to PROGRAM ALARM with TYPE boxed with the type just selected to the right of the box.

Selecting Alarm Input Parameter:

1. To select the PARAMETER whose value activates the alarm, from the PROGRAM ALARM (number) screen:
2. Press the Down Arrow to box INPUT.
3. Press the Enter button to select.
4. Press the Up Arrow until PARM is boxed.
5. Press the Enter button to select.
6. Displayed is the PROGRAM ALARM # screen with the last-selected input parameter boxed.

PROGRAM ALARM 1 ↓
TYPE LOW
INPUT DIS OXY
SET POINT 2.00
DEADBAND 0.50
DELAY IN SEC 2.0

7. Press the Up Arrow or the Down Arrow button to scroll through the choices of parameters:
   DIS OXY (dissolved oxygen concentration),
   AUTORNG (automatic range) PPB only
   RSP (remote set point)
   FLOW
   PCT SAT (percent saturation)
   CTRL OUT (control output),
   PRESSURE,
   TEMP (temperature) or
   SAL (salinity)

ATTENTION

For PPM Series 7020 Analyzer, autoranging is not available and should not be selected as an input parameter. If AUTORNG is chosen, the Series 7020 will function as if DIS OXY were chosen.

To select dissolved oxygen as the alarm parameter:

Press the Up Arrow or the Down Arrow button until DIS OXY is boxed again and press the Enter button. The only change on the screen is that the box returns to the left around INPUT.

To select one of the other parameters, from the PROGRAM ALARM # screen:

1. Press the Up Arrow or the Down Arrow button to box input
2. Press the Enter button to select.
3. Press the Up Arrow or the Down Arrow button if necessary, to box PARM.
4. Press the Enter button to select.
5. Press the Up Arrow or the Down Arrow button to box the desired parameter.
6. Press the Enter button.

Note that this selection is not stored until the Menu or Display button is pressed. At that time a band appears at the top of the screen saying PRESS ENTER TO SAVE. If the newly programmed selections are to be saved, press the Enter button. If the old values are to be retained, press the Menu or Display button again and the screen changes to the desired one WITHOUT saving the newly entered selections.

Setting Alarm Set Points:

To set an alarm set point:

1. From the PROGRAM ALARM (#) screen press the Up Arrow or the Down Arrow button until SET POINT is boxed.
2. Press the Enter button.
3. The box moves to the right of SET POINT to a number with the most significant digit flashing.

PROGRAM ALARM 1 ↓
TYPE LOW
INPUT DIS OXY
SET POINT 00000.00
DEADBAND 00000.00

The desired set point may be set by following instructions for setting numerical values in the Honeywell Series 7020 analyzer in Section 4.1.2.

Setting Deadband:

To set Deadband;

1. From the PROGRAM ALARM (#) screen, press the Up or the Down Arrow button until DEADBAND is boxed.
2. Press the Enter button.
3. The box moves to the right from DEADBAND to either a number with the first digit flashing or to a flashing OFF.
4. Press the Up Arrow until the number appears and then enter the desired DEADBAND value as described in Section 4.1.2.

Deadband units are those of the Alarm Parameter.

Setting Delay in Seconds:

To set Delay in Seconds:

1. From the PROGRAM ALARM (#) screen, press the Up Arrow or the Down Arrow button until DELAY IN SEC is boxed.
2. Press the Enter button.
3. Entering the desired value is identical to that for entering DEADBAND. See Section 4.1.2.

Relays

A relay opens or closes electrical contacts when activated by a discrete signal such as that from an alarm. The Series 7020 Analyzer contains either two or five relays depending on the options installed. Programming the relays consists of selecting the relay, identifying the input parameter which activates the relay and selecting whether the relay is energized when the input parameter is on or off.

ATTENTION

This section deals with programming relay action from discrete inputs. The relays may also be used to output a DAT control signal. Programming a relay as DAT control output will: 1) override any programming previously made in this programming relays section and 2) make it impossible to program the relay from the program relay screen. That the relay has been dedicated as a DAT output will be revealed by the message:

USED BY AO DAT

when programming the relay is attempted.

ATTENTION

If the optional 3 relays (Relays 3-5) have been dedicated to the Autoranging Option (7021, PPB units only - See Programming Autoranging later in this section) it is possible to rededicate them to some other function, but then the Autoranging option does not function. Also, Relay 5 can not function independently of Relay 4 since terminal 12 (DO4 NO) is hard-wired to DO5 C (which has no terminal connection). See Appendix H.

Relay Programming Procedure:

Go to the MAIN MENU - PROGRAM screen. Press the Down Arrow to box RELAYS and press the Enter button.

The RELAYS screen allows the selection of the relay to be programmed.

RELAYS ↓
RELAY 1
RELAY 2
RELAY 3
RELAY 4

Selecting the Relay:

Press the Down Arrow to box the relay to be programmed and the Enter button to select. Displayed is the PROGRAM RELAY screen.

PROGRAM RELAY 1 .	
INPUT	OFF
ENERGIZE WHEN	ON

Turning the Relay OFF:

From the PROGRAM RELAY screen, press the Enter button. Press the Up Arrow, if necessary, to box OFF and the Enter button to select.

Turn the Relay ON and Select the Relay Parameter:

To select the parameter which activates the relay:

1. From the PROGRAM RELAY screen press the Enter button and the Up Arrow, if necessary, to select PARM
2. Press the Enter button to select.
3. Press the Up or Down Arrow to scroll through the choices.
4. Press the Enter button when the desired choice is displayed.

Choices of Relay Parameters:

PRB OUT (probe out - probe removed from sample)
DIAGNOST (diagnostic)
HOLD ON (hold function active)
ALARM 1-5
RANGE 1-3 (automatic range change)
CLN/CAL (Clean and/or calibrate)

Selecting when to Energize:

Whether to energize the relay when the input parameter is on or off is programmed from the PROGRAM RELAY (#) screen using the following procedure:

1. Press the Down Arrow to box ENERGIZE WHEN.
2. Press the Enter button to select.
3. Press the Up or Down Arrow to cause ON or OFF to be displayed.
4. Press the Enter button to select when the desired one is displayed.
5. After selecting input and when to energize, press either the Menu or Display button.
6. Press the Enter button when the band at the top of the screen says "PRESS ENTER TO SAVE" to save this new configuration of the relay.

Analog Outputs

An analog output is one of the continuously variable, 0 to 20 or 4 to 20 mA current output signals. Its level usually represents the value of control output signal or a measured value such as temperature, pressure or dissolved oxygen concentration. The Analyzer has one analog output standard, and two additional outputs when that option is specified.

Programming the analog outputs consists of selecting an analog output, defining its type (CAT or DAT), the input parameter that it represents, and selections specific to CAT or DAT operation.

For CAT (Current Adjusting Type), selections are:

- Input parameter high and low scaling limits of the parameter in engineering units
- High and low signal output limits (typically 20 mA and either 0 or 4 mA)

For DAT (Duration Adjusting Type or time-proportioned), selections are:

- Input parameter, its high and low limits, impulse time, minimum on and off times
- Assignment of a relay for the DAT output signal

Note that if an attempt is made to program a type that has not been installed in the Analyzer, the following message will appear when the selection is entered: TYPE REQUIRES HARDWARE.

Analog Output Programming Procedure (DAT and CAT)

Go the MAIN MENU - PROGRAM screen. Press the Down Arrow to box ANALOG OUTPUTS and the Enter button to select. The PGM ANALOG OUTPUT screen allows the selection of the analog output to be programmed.

PGM ANALOG OUTPUT
ANALOG OUTPUT 1
ANALOG OUTPUT 2
ANALOG OUTPUT 3

Selecting the Analog Output

Press the Down Arrow to box the analog output to be programmed and the Enter button to select. The PGM ANALOG OUTPUT screen is displayed with AO TYPE boxed. If NONE has previously been selected, that is all that is displayed.

PGM ANALOG OUTPUT 2 ↓
AO TYPE NONE

If CAT or DAT were previously selected, the appropriate menu is displayed with AO TYPE the first item. For instance, for a previously programmed CAT output, the screen would be:

PGM ANALOG OUTPUT 1 ↓	
AO TYPE	CAT
INPUT	DIS OXY
IN HI LIMIT	10.0
IN LO LIMIT	0.0

Selecting Analog Output Type

1. Press the Enter button.
2. Press the Up or Down Arrow to box the desired analog output type.
3. Press the Enter button to select.

Selecting the Input parameter that the Analog Output represents

From the PGM ANALOG OUTPUT (#) screen:

1. Press the Down Arrow to box INPUT.
2. Press the Enter button to select.
3. Press the Up Arrow to box PARM.
4. Press the Enter button to select.
5. Press the Up or Down Arrow to box desired input type.
6. Press the Enter button to select.

Choices for input parameters for analog outputs are:

DIS OXY (dissolved oxygen concentration-fixed range)
AUTORNG (dissolved oxygen concentration - auto range - PPB only)
RSP (remote set point)
FLOW
PCT SAT (percent saturation)
CTRL OUT (control output)
PRESSURE
TEMP (temperature)
SAL (salinity)

ATTENTION

For a PPM Honeywell Series 7020, autoranging is not available and should not be selected as an input parameter. If AUTORNG is chosen, the Honeywell Series 7020 Dissolved Oxygen Analyzer functions as if DIS OXY were chosen.

Setting the Input High Limit

From the PGM ANALOG OUTPUT (#) screen:

1. Press the Down Arrow to box IN HI LIMIT.

2. Press the Enter button to select.
3. Enter the numerical value desired as described in Section 4.1.2. The Input High Limit is the input value that results in the maximum analog output.

Setting the Input Low Limit

From the PGM ANALOG OUTPUT (#) screen:

Press the Down Arrow to box IN LO LIMIT and proceed as in "Selecting the Input High Limit" just above.

Analog Output Programming Procedure CAT features only

Setting the Output High Limit

From the PGM ANALOG OUTPUT (#) screen:

1. Press the Down Arrow to box OUT HI.
2. Press the Enter button to select.
3. See the desired numerical value of the high output limit (usually 20 mA). See Section 4.1.2 (Setting Numerical Values).

Setting the Output Low Limit

From the PGM ANALOG OUTPUT (#) screen:

1. Press the Down Arrow to box OUT LO 0/4MA.
2. Press the Enter button to select.
3. Set the desired numerical value of the low output limit (usually zero or 4 mA). See Section 4.1.2 - Setting Numerical Values.

Analog Output Programming Procedure - DAT features only

Setting the Impulse Time

The impulse time is the cycle time in seconds. The relay turns on once a cycle, with the duration of the ON time proportional to the control output.

From the PGM ANALOG OUTPUT (#) screen;

1. Press the Down Arrow to box IMPULSE TIME.
2. Press the Enter button to select.
3. Set the desired numerical value. See Section 4.1.2 - Setting Numerical Values.

Setting the Minimum ON time

From the PGM ANALOG OUTPUT (#) screen

1. Press the Down Arrow to box MIN ON TIME.
2. Press the Enter button to select.
3. Set the desired numerical value. See Section 4.1.2 - Setting Numerical Values.

Setting the Minimum OFF time

From the PGM ANALOG OUTPUT (#) screen.

1. Press the Down Arrow to box MIN OFF TIME.
2. Press the Enter button to select.
3. Set the desired numerical value. See Section 4.1.2 - Setting Numerical Values.

Selecting the DAT output relay

From the PGM ANALOG OUTPUT (#) screen:

1. Press the Down Arrow to box OUTPUT.
2. Press the Enter button to select.
3. Press the Up or Down Arrow until the desired relay is boxed.
4. Press the Enter button to select.

ATTENTION

Programming a relay as a DAT analog output will: 1) override any selections previously programmed for that relay and 2) make it impossible to program the relay from the program relay screen. (See Programming Relays above.)

Control Loop

The Series 7020 Analyzer/Controller includes a single controller which can use the dissolved oxygen measurement as input and provides a control output signal to a final control device to maintain dissolved oxygen near the setpoint. Programming the controller consists of selecting and setting: its type (PID or ON/OFF), high and low input limits, gain (PID only), reset (PID only), rate (PID only), set point, Hysteresis (ON/OFF only), and control action. The only controllable parameter is dissolved oxygen.

ATTENTION

Optional Dual Current Output card containing two additional current outputs, must be chosen to execute control because the control output, whether CAT or DAT, must be from Analog Output 3 (AO3).

Control Loop Programming Procedure

1. Go to the MAIN MENU - PROGRAM screen.
2. Press the Down Arrow to box CONTROL LOOP.
3. Press the Enter button to select.
4. The PROGRAM LOOP screen is displayed with LOOP TYPE boxed.

PROGRAM LOOP	↓
LOOP TYPE	PID
INPUT HI	10.00
INPUT LO	0.00
GAIN	1.00

Selecting the Control Loop type

From this PROGRAM LOOP screen:

1. Press the Enter button.
2. Press the Up or Down Arrow to box the desired type (ON/OFF or PID).
3. Press the Enter button to select.

Setting the High Limit for Dissolved Oxygen and Range on Tuning Trend Screen

From the PROGRAM LOOP screen:

1. Press the Down Arrow to box INPUT HI.
2. Press the Enter button to select.

3. Enter the numerical value desired as described in Section 4.1.2.

The Input High Limit is the highest dissolved oxygen concentration in the control range. It is also the upper limit on the Tuning Trend Screen. Refer to the section on Control Tuning above.

Setting the Low Limit for Dissolved Oxygen and Zero on Tuning Trend Screen

From the PROGRAM LOOP screen:

Press the Down Arrow to box INPUT LO and proceed as in "Setting High Limit" just above. The Input Low Limit is also the zero value on the Tuning Trend Screen. Refer to Control Tuning above.

Setting the Loop Gain (PID only)

From the PROGRAM LOOP screen:

1. Press the Down Arrow until GAIN is boxed.
2. Press the Enter button to select.
3. If OFF is displayed, press the Up Arrow until zero is displayed.
4. Set the desired value as described in Section 4.1.2.
5. To turn Gain off, see below.

Setting the Loop Reset (PID only)

From the PROGRAM LOOP screen:

1. Press the Down Arrow until RESET is boxed.
2. Press the Enter button to select.
3. If OFF is displayed, press the Up Arrow until zero is displayed.
4. Set the desired value as described in Section 4.1.2.
5. To turn Reset off, see below.

Setting the Loop Rate (PID only)

From the PROGRAM LOOP screen:

1. Press the Down Arrow until RATE is boxed.
2. Press the Enter button to select.
3. Set the desired value as described in Section 4.1.2.
4. To turn Rate off, see below.

Setting the Set Point

From the PROGRAM LOOP screen:

1. Press the Down Arrow until SETPOINT is boxed.
2. Press the Enter button to select.
3. Set the desired value as described in Section 4.1.2.
4. To turn the Set Point off, see below.

Setting the Hysteresis (ON/OFF only)

From the PROGRAM LOOP screen:

1. Press the Down Arrow until HYSTERESIS is boxed.

2. Press the Enter button to select.
3. Set the desired value as described in Section 4.1.2.
4. To turn the Hysteresis off, see below.

Turning GAIN, RESET, RATE, SETPOINT or HYSTERESIS off:

To turn GAIN, RESET, RATE, SETPOINT or HYSTERESIS off, from the PROGRAM LOOP screen with the desired function boxed:

1. Press the Enter button to select.
2. Press the Up Arrow to increment the flashing digit until OFF is displayed.
3. Press the Enter button to select.

It is necessary to follow these instructions exactly because once any button other than the Up Arrow is pushed, the OFF selection cannot be made to appear and it is necessary to return to the PROGRAM LOOP screen with the desired function boxed and start over again.

Application Information

Automatic control of dissolved oxygen concentration may be used in applications where a track record of reliable measurement has been achieved. In applications where bio-active membrane fouling, air leaks into ppb samples or other interferences exist, these must be corrected before entrusting the process to automatic operation.

Wastewater Aeration Control Schemes

The on-line control of aeration by dissolved oxygen (DO) can provide significant energy savings. Turning off unnecessary aeration during low organic loading conditions can be done with no detrimental effects so long as control turns it back on when needed.

The DO measurement must be made at a representative location. This may be near the effluent point of the aeration basin or at another point that has thorough mixing. A survey of the basin should be done with a portable DO meter to establish a profile and help find an appropriate location. This should be done with different aerators turned on and off, if that is a part of the anticipated control strategy.

Another possibility is to measure DO continuously at several representative locations in the basin and average or otherwise combine the values to obtain the control parameter. The Series 7020 Analyzer has the capability for a single point of measurement and control. Multiple measurements with control require additional Analyzers, plus signal averaging and separate control which can be provided in a Honeywell Progeny RSX Recorder.

Control System Design

Feedback control systems have the dissolved oxygen measurement downstream of the manipulated variable (aeration rate, deaeration vacuum, oxygen scavenger feedrate, etc.). Regardless of the flow, the dissolved oxygen probe must "see" a representative sample of the process, including any control action. Thus the probe must not be installed downstream of an aeration basin if the flow can go to zero or it could not sense the effect of the aeration under any operating conditions. The probe must be in the aeration basin in this case.

Control Types

On-Off control action provides the basic function of cycling a relay on and off as dissolved oxygen concentration goes below and above setpoint. Small amounts of time delay and/or hysteresis may be programmed to eliminate unwanted response to quickly varying concentration or electrical noise pickup. On-off control provides simple but crude control with an inevitable cycling above and below setpoint.

PID (Proportional, Integral, Derivative) control action provides a throttling or proportioning action based on the amount of deviation of the measured dissolved oxygen from the setpoint, the length of time it has been away from the setpoint and the speed and direction it is moving. It uses settings of Gain, Reset and

Rate for the three tuning parameters. In addition, process flow feedforward control input can supplement the normal PID action.

Proportional action is based on the *amount* of deviation. It produces a control output in direct proportion to the difference between measured dissolved oxygen and the setpoint. The proportional Gain is the change of control output divided by the deviation of dissolved oxygen reading. It sets the basic immediate sensitivity of control action. On the Honeywell analyzer the value is strokes per minute.

Integral or Reset action is based on a combination of the *duration and amount* of deviation from the setpoint . Reset is needed to return the process to the control point when the load changes. It does this by a persistent change of output for the duration of the time a deviation exists. Reset action is defined in terms of how much of the proportional action it reproduces in a minute. The units of reset are repeats/min.

Derivative or Rate action responds to the *speed and direction* of the deviation. It minimizes overshoot by "heading-off" deviations as an operator would do instinctively by observing trends and anticipating their effects. Thus the output is changed by an additional amount in proportion to the rate-of-change in deviation. Rate action stops when the deviation stops changing. Rate settings should always be kept low for stability, usually less than 0.2 minute and is best left at zero where noisy readings are encountered.

Control Action Direction determines the direction in which the control works. For aeration or oxygen injection, attempting to maintain a high level of oxygen with a process which tends to have lower concentrations, reverse action is required; lower DO concentration results in increasing control output. For de-aeration or oxygen scavenger feed where DO levels are to be lowered, direct action is required; higher DO concentration results in increasing control output.

Feedforward Process Flow Input allows use of flowrate to produce an immediate effect on the control output without waiting for dissolved oxygen deviation to develop and for reset action to correct it. Feedforward flow control is a basic multiplying function which approximately doubles the control output when the process flowrate doubles. This multiplication is modified by adding in a small flow bias factor (set 0 to 0.1) which prevents multiplying the control output by zero at zero flow. (Otherwise, the reset action of the controller would "wind up" as it had no effect on control of the process.) The flow input 4-20 mA is converted to a 0-1 multiplier on the control output. This control action is not affected by the full scale flow display value which scales the display only, in desired engineering units.

Loop Type

Trial and error tuning is the most practical and least time-consuming approach in most applications. This requires the user to recognize symptoms of incorrect adjustment. For convenience, the units used in this controller-gain, reset in repeats/min and rate in minutes-each provide greater control action with higher numerical settings. Always allow sufficient time between adjustments for process conditions to stabilize and provide clear results of the last adjustment on the trend screen.

Gain Adjustment

Set Rate to zero and Reset to 0.05 repeats/min. Begin with a Gain setting of 0.5 and gradually increase it until a distinct oscillation occurs when the setpoint is changed by about 5% of its value. The period of oscillation will be several minutes, depending on the system. Note the actual frequency of this cycling. Then reduce the gain just until the cycling stops. (If using DAT control, first observe the control trend operating in manual mode to be able to distinguish any DAT cycling from actual PID control response.)

Rate Adjustment

Leave Gain as set above and Reset at 0.05. Set Rate to 0.05 minutes and change the setpoint by about 5% of its value. If oscillation results and cycle frequency is higher than that noted above for high Gain, the process probably has too much "noise" and cannot take Rate action. In that case set Rate to zero. Otherwise, increase Rate in steps and make similar setpoint changes to reveal any tendency to oscillate. When this does occur, decrease Rate to just stop the oscillation.

Usually Gain can be increased in small steps as Rate action is introduced because of the strong stabilizing action of Rate. If Gain is too high, the cycling frequency will be similar to that observed with Gain by itself, above.

Reset Adjustment

Set Rate to zero. Increase Reset in steps until an oscillation at frequency lower than the Gain cycling is observed when the setpoint is changed by 5% of its value. Then decrease the Reset until the cycling stops. Restore the Rate setting from above. Some fine tuning beyond these values may improve control action. In general, the product of Rate and Reset should be less than 3 for good stability.

Control Action

From the PROGRAM LOOP screen:

1. Press the Down Arrow until CTRL ACTION is boxed.
2. Press the Enter button to select.
3. Press the Up or Down Arrow until the desired action (DIR-direct acting or REV-reverse action) is boxed.
4. Press the Enter button to select.

Direct acting increases control output with increasing dissolved oxygen - appropriate for oxygen scavenger feed, raising deaerator vacuum, etc. **Reverse acting** decreases control output with increasing dissolved oxygen - appropriate for aeration processes, oxygen injection, etc.

Analog Outputs

CAT (Current Adjusting Type) control output provides a continuous 0/4-20 mA output signal proportional to the control action. It is suitable for use with valves and metering pumps designed to provide proportional (throttling) action based on a current signal.

DAT (Duration Adjusting Type) or time proportioning control output provides pulsed relay contact closures with a set cycle period and with the percent “ON” time regulated by the proportional control action. DAT control can improve on simple on-off control if it can be allowed to cycle more quickly than the process-dominated slow response of straight on-off control. DAT output is suitable for any basic on-off valve, blower, aerator, metering pump etc. that can be cycled relatively frequently. DAT control output must be used in conjunction with a large well-mixed volume of water, to provide fairly smooth control response.

The set impulse time in seconds determines the period over which the contacts are cycled. Note that some large blower motors and pumps cannot be cycled frequently. A longer impulse time and minimum on and off times may be specified to protect these. DAT selection is listed under analog outputs since it uses the calculated (essentially analog) output of the PID controller.

Auto Calibrate/Clean

This feature allows the automatic air calibration and/or cleaning of the probe with a pre-programmed frequency. Note that in order to use this Auto Cal/Auto Clean feature, specific relays within the Honeywell Series 7020 Dissolved Oxygen Analyzer Analyzer must be hard-wired to the appropriate end devices (e.g. solenoid valves). See Appendices A-5 and A-6. Programming the feature consists of selecting the desired operation, setting times and durations for the various steps of the selected operation(s), setting a low dissolved oxygen limit to activate cleaning and selecting whether or not to hold outputs during automatic calibration and/or cleaning operations.

Auto Cal/Auto Clean Programming Procedure:

1. Go to the MAIN MENU - PROGRAM screen.
2. Press the Down Arrow to box AUTO CAL/AUTO CLEAN.
3. Press he Enter button to select.
4. The AUTO CAL/AUTO CLEAN screen is displayed with OPERATION boxed.

AUTO CAL/AUTO CLEAN ↓
OPERATION CALS/CLN
OPS/OPERATION 2
SEQUENCE WEEKLY
START DAY SATURDAY

Selecting the Operation(s)

From this AUTO CAL/AUTO CLEAN screen:

1. Press the Enter button to select.
2. Press the Down or Up arrow to box the desired operation.
3. Press the Enter button to select.

Choices for the operation are:

OFF (no automatic operation),
CAL (calibration only),
CLEAN (clean only),
CALS/CLN (calibrations per cleaning) or
CLNS/CAL (cleanings per calibration).

If the operation selected is either CALS/CLN or CLNS/CAL the next item in the menu is OPS/OPERATION. (If OFF, CAL or CLEAN is selected, OPS/OPERATION is not to be displayed.) If calibration is required more frequently than cleaning, then CALS/CLN should be chosen. If cleaning is required more frequently than calibration then CLNS/CAL should be chosen. If calibrations and cleanings require the same frequency then either CALS /CLN or CLNS/CAL may be chosen and the value of 1 selected in OPS/OPERATION.

Setting Operations per Operation (OPS/OPERATIONS)

From the AUTO CAL/AUTO CLEAN screen:

1. Press the Down Arrow to box OPS/OPERATION.
2. Press the Enter button to select.
3. Set the desired operations per operation as described in Section 4.1.2.
4. Press the Enter button to select.

Setting the Frequency with which the Auto Cal/Auto Clean is initiated

There are two ways to set the frequency of operation. In the first, the SEQUENCE of Daily, Weekly or Monthly is selected. In the second, a PERIOD of less than 24 hours may be set.

If SEQUENCE is selected, the time selected (MONTHLY, WEEKLY or DAILY) is the time between most frequent operations. For instance if the selection of MONTHLY were selected, a calibration would be performed each month (on the chosen day and time) but a cleaning would be executed only every other month. Note also that if month days 29, 30 or 31 are chosen, operations are not performed on months without those days. If you want an operation to occur every month, do not select a day higher than 28.

Setting the Sequence

From the AUTO CAL/AUTO CLEAN screen:

1. Press the Down Arrow to box SEQUENCE.
2. Press the Enter button to select.
3. Press the Down or Up Arrow to box the desired selection among: NONE, MONTHLY, WEEKLY or DAILY.
4. Press the Enter button to select. The screen that appears depends on the selection.

If NONE is selected, the AUTO CAL/AUTO CLEAN screen returns with SEQUENCE boxed. The next step should be to set PERIOD HOURS. See below.

If MONTHLY is selected, the AUTO CAL/AUTO CLEAN screen changes to add START DAY (day of the month) and START HOUR. To set the START DAY:

1. Press the Down Arrow to box START DAY.
2. Press the Enter button to select.
3. Press the Up or Down Arrow to box the desired day.
4. Press the Enter button to select.

To set START HOUR:

1. Press the Down Arrow to box START HOUR.
2. Press the Enter button to select.
3. Press the down or Up Arrow to box the desired start hour.
4. Press the Enter button to select.

To set START MIN (minutes), box START MIN and proceed as with START HOUR.

If WEEKLY is selected, the AUTO CAL/AUTO CLEAN screen changes to add START DAY (name of the day of the week) and START HOUR. To set the START DAY, START HOUR and START MINUTE, proceed as with the MONTHLY sequence above.

If DAILY is selected, both the starting time and the period may be programmed. To program one operation per day:

1. Box SEQUENCE and press the Enter button to select.
2. Press the Up or Down Arrow to box DAIL and press the Enter button to select.
3. Press the Down Arrow to box PERIOD HOURS and press the Enter button to select.
4. Press the Up or Down Arrow to box 24 and press the Enter button to select.
5. Press the Down Arrow to box PERIOD MIN and press the Enter button to select.
6. Press the Up or Down Arrow to box 00 and press the Enter button to select.
7. Press the Down Arrow to box START HOUR and press the Enter button to select.
8. Press the Down or Up Arrow to box the desired hour to start the operation and press the Enter button to select.
9. Press the Down Arrow to box START MIN and press the Enter button to select.
10. Press the Down or Up Arrow to select the start minutes and press the Enter button to select.

ATTENTION

If a period other than 24 hours, 0 minutes is chosen, the period selection overrides the "daily" selection.

To program multiple operations per day with a set start time, proceed as above but the period time (PERIOD HOURS plus PERIOD MINUTES) must divide into 24 hours evenly. To program multiple operations per day without selecting a specific start time, follow the directions for Setting the Period.

Note that the period time must be greater than the start time or the message BLOCK PHASE GREATER THAN BLOCK PERIOD appears. If it does, choose either an earlier start time or a longer period such that the period time exceeds the start time.

Setting the Period

This item appears only if NONE or DAILY has been chosen for the SEQUENCE. If DAILY was chosen, see the description of DAILY above. If NONE was chosen:

1. From the AUTO CAL/AUTO CLEAN screen, press the Down Arrow to box PERIOD HOURS.
2. Use the Up Arrow to increase or the Down Arrow to decrease the displayed number of hours.
3. When the desired number of hours between operation is displayed, press the Enter button to select.

PERIOD MIN (minutes) are set in an identical manner except that PERIOD MIN is boxed prior to pressing the Enter button to select. The first operation occurs one period after the period has been entered. If it is desired that the operations occur at set times (not related to when they are programmed) then see Daily - multiple operations/day above.

Setting the Cleaning Time

1. From the AUTO CAL/AUTO CLEAN screen, press the Down Arrow until CLEAN MIN is boxed.
2. Press the Enter button to select.
3. Set the desired value as described in Section 4.1.2.
4. Press the Down Arrow to box CLEAN SEC.
5. Press the Enter button to select.
6. Set the desired value as described in Section 4.1.2.

In many applications, the equilibrium Honeywell Series 7020 Dissolved Oxygen Analyzer probe does not require cleaning. However, if a layer thick enough to affect probe response time or an oxygen-consuming organism layer deposits on the probe, its removal with some regularity may be required. The user should determine the minimum cleaning time required to remove it and set CLEAN MIN to that value.

It is possible to program a cleaning time even if the operation selected is CAL only. Programming this "unused" cleaning time can allow the manual initiation of a cleaning from the ONLINE - AUTOCAL STATUS screen. Refer to AUTO CLEAN/AUTO CAL in the ONLINE Section 4.3 above.

Setting the Resume Time

The Resume Time is the time that the probe is exposed to the sample after calibration or cleaning have been completed, but before the HOLD function is disabled and automatic control based on measured dissolved oxygen concentration is enabled. To program the Resume Time parameter:

1. From the AUTO CAL/AUTO CLEAN screen, press the Down Arrow until RESUME MIN is boxed.
2. Press the Enter button to select.
3. Set the desired value as described in Section 4.1.2. The minimum Resume Time is one minute.

ATTENTION

Note that for ppm applications such as wastewater treatment, the probe generally reads the correct sample value within 2 or 3 minutes of restoring it to the sample after a calibration or cleaning cycle. However, it can take as much as an hour for oxygen concentration to reach a low ppb value. Therefore the Resume Time chosen should be experimentally confirmed by measuring the time-to-final value in the specific probe location.

Setting the maximum time allowed for calibration

This is the user-selected maximum allowable time for air calibration.

1. From the AUTO CAL/AUTO CLEAN screen, press the Down Arrow until MAX CAL MIN (maximum calibration time in minutes) is boxed.
2. Press the Enter button to select.

3. Set the desired value as described in Section 4.1.2.

The purpose of setting MAX CAL MIN is to keep the analyzer from continuing an air calibration for a time longer than the user wants the probe to be out of the process. If this user-selected time is reached before calibration is complete, the next step in the cycle is initiated (typically restoring the probe to the sample), the existing calibration is retained and the diagnostic message REQUEST FAIL flashes across the bottom of the screen. MAX CAL MIN may be set to 5 to 120 minutes. The actual maximum time allowed for an air calibration exceeds this by at least 30 seconds while temperature stability is confirmed. The MAX CAL MIN programmed will apply to Manual Air Calibration, too.

Setting the DO limit that causes a cleaning cycle to be Initiated (PPM Units - Model 2022 only)

1. From the AUTO CAL/AUTO CLEAN screen, press the down Arrow until CLEAN LIM PPM is boxed.
2. Press the Enter button to select.
3. Set the desired value as described in Section 4.1.2.

The signal from the dissolved oxygen probe can decrease for two reasons:

- The dissolved oxygen concentration decreases.
- An oxygen-consuming layer builds up on the probe.

The purpose of this feature is to clean the probe once when the apparent dissolved oxygen concentration decreases below a user-selected value and indicate whether this cleaning did, in fact, restore the probe signal to a value corresponding to a concentration higher than the CLEAN LIM DO value.

When the dissolved oxygen falls below the programmed CLEAN LIM PPM value, a probe cleaning is initiated and the CLEAN - RINSING screen appears.

```
CLEAN - RINSING
MAX REM STEP       22
DO             0.2 PPM
TEMP            22.3 C
PRESS MENU TO ABORT
D PROBE OUTPUT LOW
```

The OUTPUT LOW diagnostic message shows that the cleaning was initiated because of a low probe signal. When the cleaning is complete, the WAIT RESUME screen appears for the programmed resume time.

```
CLEAN - WAIT RESUME
MAX REM STEP       27
DO             1.4 PPM
TEMP            22.4 C
PRESS MENU TO ABORT
D PROBE OUTPUT LOW
```

At the end of the resume time a screen headed CLEAN COMPLETE appears momentarily and then the screen displayed just prior to the initiation of the cleaning operation appears. If the cleaning did not restore the DO concentration to a value greater than the programmed CLEAN LIM PPM, the diagnostic display AUTO CLEAN FAIL appears in a band at the bottom of the screen.

Setting the hold outputs

1. From the AUTO CAL/AUTO CLEAN screen, press the Down Arrow until HOLD OUTPUTS is boxed.
2. Press the Enter button to select.
3. Press the Down or Up Arrow to box either YES or NO.
4. Press the Enter button to select.

If YES is chosen, the analog outputs, alarm states and control output will remain constant at the values that they had when the calibration or cleaning was initiated. If NO is chosen, the alarms states are held, but the analog outputs track their input parameters and control continues to function during the calibration and cleaning operations.

Discrete Input 1 (DI1) is described in Section 3, Installation.

Closing DI1 initiates the NEXT SCHEDULED user-programmed Automatic Calibration/Automatic Cleaning operation. Note that if either CALS/CLN or CLNS/CAL have been selected under AUTO CAL/AUTO CLEAN and OPS/OPERATION is not 1, closing DI1 may result in:

- An automatic calibration or
- An automatic cleaning or
- Both

This depends on what has been programmed into AUTO CAL/AUTO CLEAN and where in the cycle of OPS/OPERATION the Series 7020 happens to be.

Thus, if either CALS/CLN or CLNS/CAL was selected in AUTO CAL/AUTO CLEAN with an OPS/OPERATION value unequal to 1, care must be taken that when DI1 is closed, the desired operation is initiated. The HOLD feature as described under Setting the Hold Outputs, just above.

Auxiliary Input

The Honeywell Series 7020 Dissolved Oxygen Analyzer can accept one auxiliary input. The auxiliary input can be programmed to represent:

- Salinity
- Remote Set Point (RSP) (in units of ppm dissolved oxygen)
- Flow

In each case, the input is 4-20 mA corresponding to (1)0-40 ppt salinity, (2) dissolved oxygen with the range of 0-20,000 ppb for PPB units and 0-20 ppm for PPM units or (3) 0-100% of a flowmeter output, respectively.

Auxiliary Input Programming Procedure

1. Go the MAIN MENU - PROGRAM screen.
2. Press the Down Arrow to box AUXILIARY INPUTS.
3. Press the Enter button to select.
4. The AUXILIARY INPUTS screen is displayed with AUX IN boxed and one of the choices shown at the right.

   . AUXILIARY INPUT .
   [AUX IN] SAL

5. To turn AUX IN off, press the Enter button.
6. Press the Up or Down Arrow to box OFF
7. Press the Enter button to select.

To configure the auxiliary input as salinity:

1. From the AUXILIARY INPUT screen, press the Enter button.
2. Press the Up or Down Arrow to box SAL.
3. Press the Enter button to select.

A 4-20 mA input corresponding to 0-40 ppt salinity should be connected to the auxiliary input terminals 39 (+) and 40 (-).

To configure the auxiliary input as flow:

1. From the AUXILIARY INPUT screen, press the Enter button.
2. Press the Down or Up Arrow to box FLOW.
3. Press the Enter button to select.
4. Displayed is the AUXILIARY INPUT - FLOW screen.

. AUXILIARY INPUT .	
AUX IN	FLOW
FLOW BIAS	0.05
FLOW MAX	100.0

To adjust the flow bias (See Appendix A-? - Feedforward Process Flow Input):

1. Press the Down Arrow to box FLOW BIAS
2. Press the Enter button to select.
3. Adjust to desired value (between 0 and 0.1) as described in Section 4.1.2.
4. Press the Enter button to select.

To adjust the maximum flow (that will correspond to 20 mA):

1. Press the Down Arrow to box FLOW MAX.
2. Press the Enter button to select.
3. Adjust to desired value (between 0 and 9999999.00) as described in Section 4.1.2.
4. Press the Enter button to select.

A 4-20 mA input corresponding to 0-100% of the flow maximum should be connected to the auxiliary input terminals 39 (+) and 40 (-).

To configure the auxiliary input as a remote setpoint:

1. From the AUXILIARY INPUT screen, press the Enter button.
2. Press the Down or Up Arrow to box RSP .
3. Press the Enter button to select.

A 4-20 mA input corresponding to the control range of dissolved oxygen (the value entered in PROGRAM LOOP - INPUT HI, above) should be connected to the auxiliary input terminals 39 (+) and 40 (-).

ATTENTION

If no input is connected to the auxiliary input terminals and AUX IN is programmed to be FLOW, SAL or RSP, a diagnostic AUX IN LO is seen and the value of the AUXIN parameter defaults to 100% FLOW, the programmed salinity constant (see CONFIGURE SALINITY below) or local setpoint, respectively.

Selecting Dissolved Oxygen or Percent Saturation

This feature allows percent saturation, rather than dissolved oxygen concentration, to be displayed in most screens revealed when the Display button is pushed.

The concentration of oxygen dissolved in water (or other liquid) may be described by either "dissolved oxygen (DO) concentration" or be percent saturation. The units for DO are either parts per million - PPM (equivalent to milligrams per liter) or parts per billion - PPB (equivalent to micrograms per liter). The units of saturation are percent where 100% saturation is equivalent to the concentration of oxygen dissolved in air-saturated water. For instance, at 25°C and one atmosphere pressure, 8.3 ppm = 100% saturation. Although the ppm and ppb concentration units are the most frequently used units by far, % saturation may be appropriate for non-aqueous liquids like vegetable oil.

ATTENTION

When % SAT is chosen, the DO value in PPM or PPB is still displayed in most screens including the OPERATE LOOP screen and those for: Calibration, Tuning Trend, Programming Alarm Set Points and CLEAN LIM PPM in Autocal/Autoclean. See Appendix A-7.

Procedure for selecting dissolved oxygen concentration units:

1. Go the MAIN MENU- - PROGRAM screen.
2. Press the Down Arrow to box SELECT DO OR % SAT
3. Press the Enter button to select.
4. Displayed is the SELECT DO or % SAT screen with SELECTION boxed.

   SELECT DO OR % SAT
   [SELECTION] DO

5. Press the Enter button to box DO or press the Up or Down Arrow button to change the DO to SAT.
6. When the correct selection is boxed, press the Enter button to select.

Configuring Salinity

Whether or not salinity is chosen as the auxiliary input, a salinity constant may be set for two purposes:

- To allow a constant salinity correction to dissolved oxygen values where the auxiliary input is OFF, FLOW or RSP
- To serve as the default value for salinity if the AUX IN connection is opened.
-

Procedure for Setting a Salinity Constant:

1. Go the MAIN MENU - PROGRAM screen.
2. Press the Down Arrow to box SELECT CONFIGURE SALINITY
3. Press the Enter button to select.
4. Displayed is the CONFIGURE SALINITY screen with CONSTANT boxed.

CONFIGURE SALINITY
CONSTANT 0.0

5. Press the Enter button,
6. Set the desired salinity value (from 0-40 ppt) as described in Section 4.1.2.
7. Press the Enter button to select.

Programming Setup Buttons

The Calibrate and Hold buttons are user-programmable. Pressing the Calibrate button initiates a user-selected calibration operation. Pressing the Hold buttons holds control outputs and alarms conditions until either:

- The Hold button is pressed again or
- The programmed HOLD TIMEOUT time is exceeded.

Button Set Up Procedure:

1. Go the MAIN MENU - PROGRAM screen.
2. Press the Down Arrow to box SET UP BUTTONS
3. Press the Enter button.
4. The SET UP BUTTONS screen is displayed with CAL BUTTON boxed.

SET UP BUTTONS
CAL BUTTON AIR
HOLD TIMEOUT 3

Selecting the Calibrate button function:

Pressing the Enter button and the Up and Down Arrows scrolls through the choices of the calibration types that can be initiated by pressing the Calibrate button: IGNORE, CLEAN, CAL, OR CLEAN+CAL. Pressing the Enter button with the desired selection boxed causes the initiation of the operation whenever the Calibrate button is pushed.

- If IGNORE is selected, pushing the Calibrate button results in no action.
- If CLEAN is chosen, executed is the cleaning programmed in AUTO CAL/AUTO CLEAN.
- If CAL is chosen, executed is the calibration programmed in AUTO CAL/AUTO CLEAN.
- If CLEAN + CAL is chosen, executed is the cleaning and calibration programmed in AUTO CAL/AUTO CLEAN.

Setting the HOLD TIMEOUT time

1. From the SET UP BUTTONS screen, press the Down Arrow to box HOLD TIMEOUT.
2. Press the Enter button to select.
3. Set the desired hold timeout time in minutes as described in Table 4-4.

Password Security

It is possible to program the Series 7020 analyzer such that parts of its functions can be executed only by entering a user-set security code. There are two levels of security. If security is enabled, entering the Program or Maintenance modes requires the three-digit Master Code, if programmed. If security is enabled, calibrating analog inputs or analog outputs requires the three-digit calibration code, if programmed. Either level of security will be disabled by programming the value 000 for the code.

If Security is not enabled, all screens and functions are available to the operator.

If Security is enabled and a Master Code (unequal to 0) has been programmed, this code must be entered to exit the On-Line mode and enter either the Program or Maintenance mode. The On-Line mode only is accessible without the Master Code. The Master Code is also required to reset the unit - see under Section 4.5 Maintenance, below.

If Security is enabled and a Calibration code (unequal to 0) has been programmed, this code must be entered to execute the calibration of either analog inputs or analog outputs. See Section 4.5 Maintenance, below. Note that the codes required to enter the Maintenance Mode actions are available under the Program Security screen and serve mainly to make an operator think twice before performing these operations which may require subsequent recalibration or restarting time AUTO CAL/AUTO CLEAN functions. Some users may find it convenient to make the two codes identical.

Security Programming Procedure

1. Go the MAIN MENU - PROGRAM screen.
2. Press the Down Arrow to box LOCK/UNLOCK SECURITY.
3. Press the Enter button to select.
4. The PGM SECURITY screen is displayed with ENABLE SECURITY boxed.

```
PGM SECURITY
[ENABLE SECURITY]      NO
MASTER CODE     0
CALIB CODE      0
```

5. To enable security, press the Enter button.
6. Press the Up or Down Arrow to display YES.
7. Press the Enter button to select.

To set a MASTER CODE, which secures the off-line modes (PROGRAM and MAINTENANCE):

1. From the PGM SECURITY screen, press the Down Arrow to box MASTER CODE.
2. Press the Enter button to select.
3. Set the desired numerical code as described in Section 4.1.2.
4. Press the Enter button to select.

To set a CALIB CODE, which secures the analog input and output calibrations in the MAINTENANCE mode:

1. From the PGM SECURITY screen, press the Down Arrow to box CALIB CODE.
2. Press the Enter button to select.
3. Set the desired numerical code as described in Section 4.1.2.
4. Press the Enter button to select.

With Security enabled, each time an attempt is made to enter the protected screens, the SECURITY ACTIVE screen is displayed.

```
SECURITY ACTIVE
ENTER CODE
[000  ]
FOR ACCESS
```

To gain access, set the appropriate user-configured security code and press the Enter button to select.

To disable security or change the code, follow the above Security Programming Procedure and enter desired selections and/or code. Selecting NO for ENABLE SECURITY disables both levels of security. Either level may be disabled while enabling the other by programming 000 for the code for the level to be disabled.

Bypassing Security

If security has been enabled and the code is unavailable, it is possible with the following procedure to [1] bypass security and [2] discover what the user-configured codes are.

Procedure of bypassing security without knowing the security code.

If access to a secure area of the Series 7020 screens is attempted, the SECURITY ACTIVE screen will appear:

SECURITY ACTIVE

ENTER CODE

000

FOR ACCESS

Enter the number 783 and press the Display (not the Enter)button. Displayed is the SECURITY ACTIVE screen with the user-configured codes shown. If desired, record this code and then press the Enter button to gain access to the secure area.

Date/Time

This section describes how to set the internal clock upon which all timed functions are based.

Clock Setting Procedure

1. Go the MAIN MENU - PROGRAM screen.
2. Press the Down Arrow to box SET CLOCK.
3. Press the Enter button to select.
4. The SET CLOCK screen is displayed with HOURS boxed.

SET CLOCK	↓
HOURS	19
MINUTES	58
MONTH	JUL
DAY	5

5. To set the hours, press the Enter button.
6. Use the Up or Down Arrow to box the correct hours.
7. Press the Enter button to select.

To set the minutes:

1. From the SET CLOCK screen, press the Down Arrow to box MINUTES.
2. Press the Enter button to select.
3. Press the Up or Down Arrow to box the correct minutes.
4. Press the Enter button to select.

MONTH, DAY, YEAR, and DATE FORM are set similarly:

1. From the SET CLOCK screen, press the Up or Down Arrow to box the function that is to be set.

2. Press the Enter button to select.
3. Press the Up or Down Arrow to box the desired value or selection.
4. Press the Enter button to select.

Auto Ranging (7021-ppb Units Only)

The Series 7020 analyzer may be programmed to change the range represented by the analog output. This feature allows a recorder to provide a useful trace of dissolved oxygen concentration over the whole range of the ppb analyzer (low ppb to air saturation values). This section describes programming autoranging. The optional three mechanical relays, are required to allow autoranging to function and the three relays must be dedicated to autoranging as described in Appendix H - Output Autoranging.

Programming Autoranging Procedure

1. Go to the MAIN MENU - PROGRAM screen.
2. Press the Down Arrow to box AUTO RANGE.
3. Press the Enter button to select.
4. The AUTO RANGE screen is displayed with RANGE 0 HI boxed.

AUTO RANGE	
RANGE 0 HI	20.00
RANGE 1 HI	200.00
RANGE 2 HI	2000.00
RANGE 3 HI	20000.00

The values shown in the screen are the factory-set default values. To change the high value for a range:

1. Press the Down Arrow to box the range to be reprogrammed.
2. Press the Enter button to select.
3. Set the new value as described in Section 4.1.2.

To facilitate the connections to the dedicated relays, it is strongly advised that RANGE 0 be programmed to be the lowest range, RANGE 1 to be the next highest, etc.

Once the Autorange feature has been programmed, it is necessary to assure that the dedicated optional relays are programmed to operate correctly with autoranging. To do so, return to the RELAYS screen and program them as follows:

PROGRAM	RELAY 3
INPUT	RANGE 1
ENERGIZE WHEN	ON

PROGRAM	RELAY 4
INPUT	RANGE 2
ENERGIZE WHEN	ON

PROGRAM	RELAY 5
INPUT	RANGE 3
ENERGIZE WHEN	ON

(RANGE 0, the lowest range, is selected when all three relays are off.)

4.3.3 Maintenance Mode

ATTENTION

Whenever the Analyzer is placed in the maintenance mode, output values and alarm conditions that existed just prior to entering the maintenance mode are held until the ONLINE mode is reentered.

Contrast Adjust

To change the screen CONTRAST ADJUST:

1. From the MAIN MENU - MAINT screen, press the Down Arrow to box CONTRAST ADJUST.
2. Press the Enter button to select.
3. Press the Up or Down Arrow button to adjust for desired display contrast.
4. Press the Enter button to select.
5. The MAIN MENU - MAINT screen remains with CONTRAST ADJUST boxed. but with the new contrast being displayed.

Mains Frequency

This selection allows the choice of Mains (Line Power) frequency. No adjustment is required for Mains (Line) voltage over the range 85-265 VAC.

Procedure for Selecting Mains Frequency:

1. Go to the MAIN MENU - MAINT screen.
2. From the MAIN MENU - MAINT screen, press the Down Arrow to box MAINS FREQ.
3. Press the Enter button to select.
4. The MAIN MENU - MAINT screen remains, but a frequency value (either 50 Hz or 60 Hz is boxed to the right of MAINS FREQ).

MAIN MENU - MAINT ↓
SET MODE MAINT
CONTRAST ADJUST
OFF LINE DIAGS
MAINS FREQ [50 HZ]

5. Press the Down or Up Arrow to box the desired frequency selection.
6. Press the Enter button to select.
7. The box moves to the left around MAINS FREQ.
8. To complete the change in frequency, press the Down Arrow to box RESET UNIT.
9. Press the Enter button to select. (It is necessary to reset the unit after a change in Mains Frequency.)

Manual Calibration - Units with Software Version C.3 or Higher

To access the MANUAL CALIBRATION screen and initiate one of the calibrations displayed, follow one of the procedures listed below. The procedure to be followed is dependent on the version of the PROM installed in the analyzer.

For PROM Versions Prior to C.3

1. From the MAIN MENU - ONLINE screen, press the Down Arrow button until MANUAL CALIBRATION is boxed.

2. Pressing the Enter Button reveals the types of manual calibration available: AIR CALIBRATION, SAMPLE CALIBRATION, ZERO CALIBRATION (7021 PPB units only) and PRESSURE CALIBRATION.
3. Press the Down Arrow button until the calibration desired is highlighted.
4. Press the Enter button to select.

For PROM Versions C.3 or Greater

1. From the Maintenance Menu, press the Down Arrow button until MANUAL CALIBRATION is boxed.
2. Pressing the Enter Button reveals the types of manual calibration available: AIR CALIBRATION, SAMPLE CALIBRATION, ZERO CALIBRATION (7021 PPB units only) and PRESSURE CALIBRATION.
3. Press the Down Arrow button until the calibration desired is highlighted.
4. Press the Enter button to select.

If removing the probe from the sample for calibration, (air and zero calibration) press the Hold button to maintain outputs and alarms in their current condition. A bright diagnostic band (HOLD ACTIVE) appears across the bottom of all screens. For instance, if the Hold button was pushed just prior to initiating air calibration, the AIR CAL IN PROGRESS screen would be displayed with HOLD ACTIVE shown at the bottom of the screen.

For Prom Versions Prior to C.3

AIR CAL IN PROGRESS
DO 8.77 PPM (or 8774.02 PPB)
TEMP 20.9 C
PRESS MENU TO ABORT
HOLD ACTIVE

For Prom Versions C.3 or Greater

AIR CAL IN PROGRESS

"CAL MODE"

HOLD ACTIVE

Hold may be deactivated at any time by pressing the Hold button a second time. Alternatively, the Hold times out after the set time period. The factory setting is 30 minutes. The time-out setting can be set from 1 to 120 minutes, from the MAIN MENU - PROGRAM mode.

Air Calibration -

This is the simplest and most commonly used method of calibration.

ATTENTION

If "Initial Installation", power probe and analyzer for 24 hours before first air calibration.

1. Assure that the probe has been powered for at least one hour.
2. Press the Hold button, if required.
3. Expose the probe to air (or air-saturated water) until the temperature reading stabilizes.
4. Select MANUAL CALIBRATION from the Maintenance Menu. AIR CALIBRATION is boxed.

MANUAL CALIBRATION
AIR CALIBRATION
SAMPLE CALIBRATION
ZERO CALIBRATION
PRESSURE CALIBRATION

5. Press the Enter button. Displayed is a screen with the heading AIR CAL IN PROGRESS.

For Prom Versions Prior to C.3

AIR CAL IN PROGRESS
DO 8.77 PPM (OR 8774.02 PPB)
TEMP 20.9 C
PRESS MENU TO ABORT

For Prom Versions C.3 or Greater

AIR CAL IN PROGRESS

"CAL MODE"

PRESS MENU TO ABORT

This screen remains until the Air Calibration is complete. At that time the previous screen is displayed indicating that the air calibration has been completed.

Air Calibration is not completed until both the probe temperature and the probe signal are stable. If the probe has just been removed from a sample low in dissolved oxygen or with temperature significantly different from the air temperature, it takes longer to reach stability than if the probe were already near ambient conditions when calibration was initiated. If the drift during calibration is too great, a screen appears showing:

CALIBRATION FAILED

PRESS ENTER TO RESUME

If this happens, try again by pushing the Enter button as directed, and then pushing the Enter button again to repeat the air calibration. If the second try gives the CALIBRATION FAILED message, consult Section 5, Troubleshooting.

6. When air calibration is complete, return the probe to the process and, if the Hold button was pressed in step 2, press Hold again to terminate the hold function.

Sample Calibration -

Sample calibration allows a calibration based on a known dissolved oxygen concentration. It is similar to air calibration except that the known DO value may be entered. Assuming an accurate reference is available, use the sample calibration method rather than air calibration if any of the following conditions apply:

- The air is below freezing (32°F, 0°C), or hot (above 104°F, 40°C) or very dry (below 20% relative humidity).
- The probe is mounted such that it is much easier to measure the concentration of the DO in the water independently than to expose the probe to air. Such mounting is not recommended but is sometimes necessary.
- The measurement interruption for air calibration cannot be tolerated.

Sample calibration is usually executed by leaving the probe in the measured sample and adjusting the analyzer to agree with the sample dissolved oxygen measured with a properly calibrated portable dissolved oxygen meter whose probe is held very close to the probe of the analyzer. Alternatively, the probe may be removed from the measured sample and placed in a sample of known dissolved oxygen concentration.

Sample Calibration Procedure:

1. Power the probe for at least 1 hour. (Power for 24 hours if initial installation.)
2. Press the Hold button, if required.
3. Immerse the probe in the sample of known DO concentration, and wait until the DO reading is steady.
4. From the MAIN MENU - ONLINE screen, press the Down Arrow button twice to box MANUAL CALIBRATION.
5. Press the Enter button to select the MANUAL CALIBRATION screen.
6. Press the Down Arrow button to box SAMPLE CALIBRATION.
7. Press the Enter button. The following screen is displayed with the first digit of the DO value flashing.

   GRAB SAMPLE CAL .
   DO 6.31009 (or 6310.09 if PPB)
   PRESS ENTER TO SAVE
   PRESS MENU TO ABORT

8. If the flashing first digit of the boxed number is not equal to the first digit of the known sample DO, press the UP Arrow button until the correct first digit is displayed.
9. Press the Down Arrow button to accept the first digit and move to the second digit which is now flashing.
10. Press the Up Arrow button to scroll to the correct second digit and press the Down Arrow button to accept it and move to the third digit, etc.
11. When the value displayed equals the known sample DO concentration, press the Enter button. The display returns to the MANUAL CALIBRATION screen and the sample calibration is complete. See Section 4.1, Numerical Values for a general description of setting values in the analyzer.
12. When sample calibration is complete, return the probe to the measured sample and, if the Hold button was pressed in step 2, press Hold again to release the hold function.

Zero Calibration - (7021 - PPB units only)

Zero calibration is available only on ppb Analyzers and allows adjustment of only ±3 ppb. The need for more adjustment than that may indicate an inadequate zero standard, air leakage into the sample or interference from extremely high levels of oxygen scavengers.

CAUTION

Do not perform zero calibration unless absolutely necessary and a zero standard is available which is extremely close to zero-well below 1 ppb. In general, zero calibration is not needed. The error associated with omitting zero calibration is generally less than ±1 ppb while the error caused by calibrating with an inaccurate zero standard may be as much as 3-4 ppb.

Zero Calibration Procedure:

1. Power the probe for at least one hour.
2. Press the Hold button, if required.

3. Place the probe in the zero-dissolved-oxygen standard and wait until the display (or recorded output) indicates a steady reading. This typically takes several hours and the final reading is on the order of 0 to 1.0 ppb.
4. From the MAIN MENU - ONLINE screen, press the Down Arrow button twice to select MANUAL CALIBRATION.
5. Press the Enter Button. This displays the MANUAL CALIBRATION screen.
6. Press the Down Arrow button to box ZERO CALIBRATION.
7. Press the Enter button.
8. Displayed is a screen with the heading ZERO CAL IN PROGRESS. This screen remains until the Zero Calibration is complete.

```
ZERO CAL IN PROGRESS .
 DO            0.04 PPB
 TEMP          21.5 C
PRESS MENU TO ABORT
```

9. When zero calibration is complete (as indicated by the return of the MANUAL CALIBRATION screen), return the probe to the measured sample.
10. If the Hold button was pressed in step 2, press the Hold button again to release the hold function.

Pressure Calibration

The concentration of oxygen dissolved in air-saturated water depends on the air pressure. This dependence is automatically compensated for during air calibration using a pressure sensor built into the Analyzer. The purpose of the pressure calibration is to calibrate that pressure sensor. However, this sensor has been factory calibrated and should not require re-calibration.

Pressure Calibration Procedure:

1. Determine the true ambient atmospheric pressure, such as from a calibrated pressure transmitter or a mercury barometer. Absolute barometric pressure is required - not the "relative" pressure normally reported by the weather bureau.
2. From the MAIN MENU - ONLINE screen, press the Down Arrow button twice to select MANUAL CALIBRATION.
3. Press the Enter button to make the selection.
4. Press the Down Arrow button to box PRESSURE CALIBRATION.
5. Press the Enter button to make selection.
6. Adjust the value of mmHg digit-by-digit, as described under Sample Calibration above, until the displayed pressure in mmHg agrees with the known pressure.
7. Press the Enter button to indicate completion of the adjustment to the value.
8. The MANUAL CALIBRATION screen returns indicating completion of the pressure calibration.

Calibrate Analog Inputs

CAUTION

These calibrations are performed at the factory with NIST-traceable precision test equipment. Recalibration is unnecessary unless some problem has been detected or if components have been replaced.

The purpose of this calibration procedure is to allow calibration of the analog to digital converter (ADC) and the dissolved oxygen input ranges against external standards. Equipment required includes a 5.0000

(0.02% or better) DC voltage source and either a precision direct current source or a precision voltage source with precision resistors such that direct currents of 350, 35, 3.5 and 0.35 microamps (0.01% or better) may be connected to the analyzer.

Calibrating the ADC consists of applying 5 volts between Unit Pins 39 (+) and 40 (-), performing the ADC MAX calibration and then shorting Unit Pin 39 to Unit Pin 40 and performing the ADC ZERO calibration. Calibrating the DO ranges consists of introducing 350, 35, 3.5 and 0.35 microamps to Unit Pins 35 (+) and 38 (-), performing the MAX CAL calibration for each input, respectively, and then introducing zero microamps to Unit Pins 35 and 38 and performing the zero calibration for each range, respectively.

CAUTION

If these calibration procedures are performed with inappropriate inputs, or for instance, the max cals are initiated with no input, serious errors can be anticipated in all results subsequently reported. Proper performance may be restored only by performing these calibrations with accurate standards.

If both calibrations are to be done, it is convenient prior to the actual calibration to:

1. Disconnect main power to the analyzer.
2. Remove TB 5.
3. Disconnect any leads to TB5.
4. Connect short leads to TB5 Unit Pins 35, 38, 39 and 40.
5. Plug TB5 back into the analyzer.
6. Restore main power to the analyzer.

If ADC calibration only is to be performed, in Step 4 above, connect short leads to TB5 Unit Pins 39 and 40 only.

If DO input ranges only are to be calibrated, in Step 4 above, connect short leads to TB5 Unit Pins 35 and 38 only.

Procedure for Calibrating the ADC:

1. With 5.0000 volts between Unit Pin 39 (+) and Unit Pin 40 (-), from the MAIN MENU - MAINT screen, press the Down Arrow to box CALIBRATE AI and hit the Enter key. (If the SECURITY ACTIVE screen appears, enter the CALIB CODE and press the Enter key.)
2. The CALIBRATE AI screen is displayed with CALADC ZERO boxed.

   CALIBRATE AI ↓
   CAL ADC ZERO
   CAL .35 UA ZERO
   CAL 3.5 UA ZERO
   CAL 35 UA ZERO

3. Press the Down Arrow five times to box CAL ADC MAX.
4. Press the Enter key.
5. A screen displaying "CALIBRATION IN PROGRESS" is displayed momentarily and then the screen returns to the CALIBRATE AI screen and the ADC MAX calibration is complete.
6. To calibrate ADC zero:
7. Remove the 5V source and connect Unit Pin 39 directly to Unit Pin 40.
8. From the CALIBRATE AI screen, press the Up Arrow to box CAL ADC ZERO.
9. Press the Enter key.

10. A screen displaying "CALIBRATE IN PROGRESS" is displayed momentarily and then the screen returns to the CALIBRATE AI screen and the ADC ZERO calibration is complete.

Procedure for Calibrating DO Input Ranges:

1. From the MAIN MENU - MAINT screen, press the Down Arrow to box CALIBRATE AI and press the Enter key.
2. The CALIBRATE AI screen is displayed with CAL ADC ZERO boxed.

   CALIBRATE AI ↓
   CAL ADC ZERO
   CAL .35 UA ZERO
   CAL 3.5 UA ZERO
   CAL 35 UA ZERO

3. Press the Down Arrow nine times to box CAL 350 UA MAX.
4. Introduce 350 UA to Unit Pins 35 (+) and 38 (-). Press the Enter key.
5. A screen displaying "CALIBRATE IN PROGRESS" is displayed for a few seconds and then the screen returns to the CALIBRATE AI screen and the 350 UA MAX calibration is complete.
6. Press the Up Arrow once to box CAL 35 UA MAX, change the 350 UA input to 35 UA and press the Enter key to complete the 35 UA MAX calibration.
7. Press the Up Arrow to box CAL 3.5 UA MAX, change the 35 UA input to 3.5 UA and press the Enter key to complete the 3.5 UA MAX calibration.
8. Press the Up Arrow to box CAL 3.5 UA MAX, change the 3.5 UA input to 0.35 UA and press the Enter key to complete the 0.35 UA MAX calibration.
9. Disconnect the current source from Unit Pins 35 and 38.
10. Press the Up Arrow five times to box CAL .35 UA ZERO and press the Enter key. A screen displaying "CALIBRATE IN PROGRESS" is displayed momentarily and then the screen returns to the CALIBRATE AI screen and the CAL .35 UA ZERO is complete.
11. Press the Down Arrow to box CAL 3.5 UA ZERO and press Enter to complete the 3.5 UA ZERO calibration.
12. Press the Down Arrow to box CAL 35 UA ZERO and Enter to complete the 35 UA ZERO calibration.
13. Press the Down Arrow to box CAL 350 UA ZERO and Enter to complete the 350 UA ZERO calibration.

This completes the calibration of Analog Inputs.

Calibrate Analog Outputs

The purpose of this test is to check the accuracy of the analog outputs and adjust the output values if necessary. Required is a current or voltage meter and resistor with an overall system resolution of 0.025%. If a voltage meter is used, a 250 ohm resistor must be placed across the output terminals to provide the needed 1-5 drop for the calibration.

WARNING

This procedure should be performed by a qualified electrical technician.

Procedure for Calibrating Analog Outputs

1. Open the front bezel of the 7020 Analyzer and connect the voltmeter across the analog output leads being calibrated.

2. Turn power on.
3. For each analog output to be checked, first go to the ONLINE mode, by pressing the Display and Menu button.
4. Press the Down Arrow to box REVIEW PROGRAM and press Enter to select.
5. Press the Down Arrow to box ANALOG OUTPUTS and press Enter to select.
6. Press the Down Arrow, if necessary, to box the analog output to be checked and press Enter to select.
7. Displayed is the PGM ANALOG OUTPUT # screen with AO TYPE boxed.

   PGM ANALOG OUTPUT 1
   AO TYPE CAT (or DAT)
   INPUT 8.5
   IN HI LIMIT 20.0
   IN LO LIMIT 0.0

8. Press the Down Arrow five times to reveal the output limits:

   PGM ANALOG OUTPUT 1 ↓
   IN HI LIMIT 20.0
   IN LO LIMIT 4.0
   OUT HI 20.0
   OUT LO 0/4 MA 4.0

9. Confirm that the displayed output limits (OUT HI and OUT LO 0/4 MA) are the limits that you want to test. If they are not, then go to the Program Mode - Analog Outputs and change them to the desired values.
10. Now return to the MAINT mode and press the Down Arrow to box CALIBRATE AO and press Enter to select.
11. Displayed is the CALIBRATE AO screen with AO 1 ZERO boxed.

    CALIBRATE AO ↓
    AO 1 ZERO
    AO 1 SPAN
    AO 2 ZERO
    AO 2 SPAN

12. Press the Down Arrow, if necessary, to box the desired output limit and press Enter to select. If, for instance, you selected AO 1 ZERO, the ZERO CALIBRATE AO 1 screen would appear.

    ZERO CALIBRATE AO1
    PRESS UP DOWN

    POSITION OFF

13. If necessary, press the Down or Up Arrow to make the output agree with its stated value, for instance, 4.0 mA as measured by the current meter.
14. Proceed to check and, if necessary, calibrate the zero and span for each analog output.

Off-Line Diagnostics

Off Line Diagnostics include the Probe Bias Test, the Relay Test, the Output Test and Input Status. The function of each is described, followed by the procedure for performing each.

Procedure for Performing Off Line Diagnostics

From the MAIN MENU - MAINT screen, press the Down Arrow to box OFF LINE DIAGS and press Enter to select.

The OFF LINE DIAGS screen is displayed with PROBE BIAS TEST boxed.

OFF LINE DIAGS .
PROBE BIAS TEST
RELAY TEST
OUTPUT TEST

Probe Bias Test

The dissolved oxygen probe is an electrochemical cell which produces an electric current that is directly proportional to the concentration of oxygen dissolved in the sample in which the probe tip is immersed. (When the probe is in air, the current is identical to that produced when the probe is in air-saturated water.) This current is a direct measurement of oxygen being consumed at one of the probe electrodes. in order to consume the oxygen, it is necessary to apply a negative bias voltage to the electrode where it is to be consumed. Usually, the probe is operated at -0.6V with respect to a reference electrode within the probe. (The minus sign is omitted from the screen as well as from the following discussion.) However, in some applications, the performance of the DO probe can be enhanced by using other bias voltages. The purpose of this test is to evaluate whether the probe bias voltage should be adjusted. Possible interference with probe performance may also be inferred from the Probe Bias Test (PBT).

The result of the PBT is the relative probe current as a function of bias voltage. When the test is initiated, the bias voltage is adjusted down from its original value (usually 0.6V) at 10 mv/sec until 0V is reached. Then the bias voltage is driven up to 1.0 V at 10 mv/sec and finally, it is driven down again until it has returned to the value it had just before the test was initiated. During this voltage sweep, the probe current is monitored and the graph of current as a function of voltage is displayed. If during the test the probe current rises above a factory-set upper limit, the bias voltage is returned to its pre-test value at 10 mv/sec and the test is terminated without completing the full 1.0 volt sweep. (The bias voltage test may also be terminated at any time by pressing the ≡ button.)

Under normal conditions, the completed display shows a graph of current as a function of voltage with the following features: from approximately 0 to 0.2 volts a fairly rapid increase in current is observed; from approximately 0.2 to 0.8 volts, the current exhibits a “flat” region where it is nearly independent of voltage and at some voltage above about 0.8 volts, the current rises quickly.

A typical current-voltage curve is shown below. The Sweep Bias millivoltage (SB) is a voltage from 0 -1V that is applied to perform the test. The Operating Bias millivoltage (OB) is the current position of the cursor on the graph and represents the current bias voltage. The horizontal axis numerals are in hundreds of millivolts.

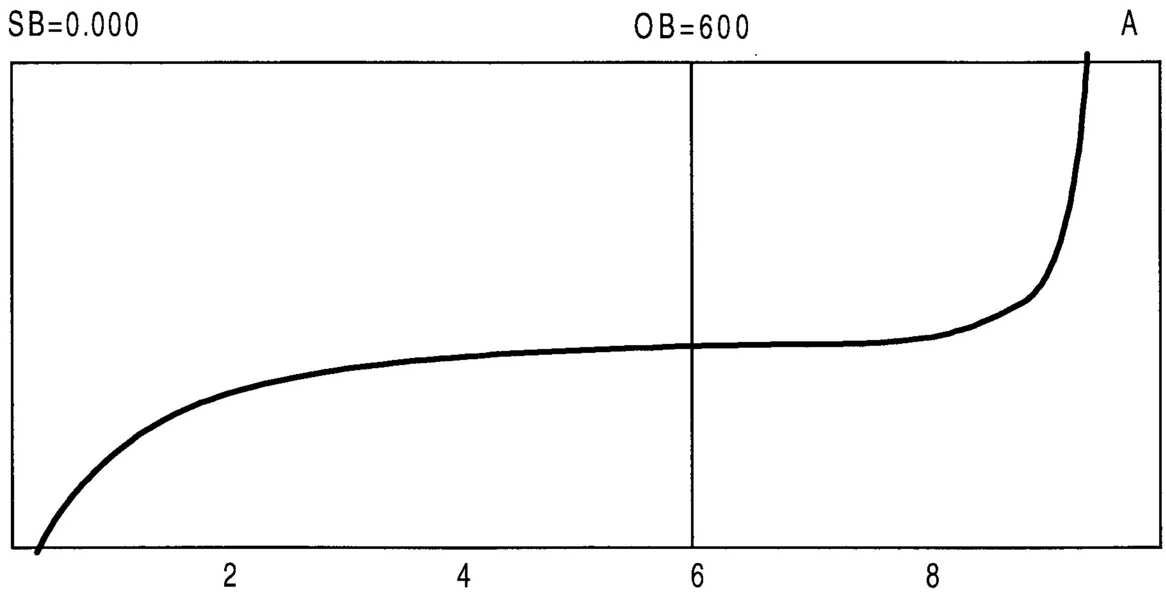


Figure 4-2 Display of Probe Bias Test Done in Air

Note that the curve is quite flat at 0.6V. This means that even rather large changes in the probe current-voltage characteristic does not affect the current (and, thus, probe sensitivity) at 0.6V. In general, the curve formed by decreasing voltage is not identical to that formed by increasing voltage. This hysteresis is a function of the voltage scan rate and may be ignored.

The interpretation of figure shown above is as follows:

As the bias voltage of the oxygen-consuming electrode (relative to an internal reference electrode) is increased, there is an initial increase in current as more and more of the oxygen that approaches the electrode is consumed. However, at about 0.2V, the current stops rising and a flat region, independent of voltage, is observed. It is in this region that all of the oxygen approaching the electrode is consumed. Increasing the voltage cannot increase the current because there is no more oxygen to be consumed. Finally, at a voltage exceeding 0.8 volts, a second process (hydrogen production) begins to occur and the current again rises. To achieve stable results, the probe should be operated within the flat region so that small changes in the probe characteristics result in negligible changes in probe current.

In some industrial wastewater applications, particularly those in petroleum refineries, active gases dissolved in the wastewater can cause this current-voltage characteristic to shift, moving the flat region to other, usually lower, voltages. Also, in some very rare instances, the chemical treatment of boiler water can cause this current-voltage characteristic to shift, moving the flat region to other, usually lower, voltages.

To summarize, the Probe Bias Test automatically varies the probe voltage while displaying the probe current as shown in the figure. At the completion of the test an opportunity to change the bias voltage is provided. Thus, even where significant gaseous contamination might otherwise interfere with the response of the probe to dissolved oxygen, this advanced feature allows the probe to operate.

(If the results of the probe bias test should ever be significantly different from those shown in the figure, Honeywell Service should be consulted.)

Procedure for Performing the Probe Bias Test

1. From the OFF LINE DIAGS screen with PROBE BIAS TEST boxed, press the Enter button to initiate the probe bias test.

2. This displays the current-voltage screen with the "live" relative value of current as a function of the changing voltage.
3. The SB in the upper left corner displays the live (changing) Sweep Bias voltage (in millivolts).
4. The OB indicates the Operating Bias voltage.
5. The R stands for "running" indicating that the test is taking place.
6. The Probe Bias Test may be terminated at any time by pressing the Menu button. The bias voltage is returned to its pre-test value at a rate of 10 mv/sec.

Adjusting the probe bias voltage:

If the probe bias test shows that the vertical line representing the operating voltage does not cross the flat portion of the current-voltage curve as in Figure 4-2, the operating voltage should be adjusted.

Procedure for Adjusting the Probe Bias Voltage

1. At the conclusion of the probe bias test, an A for "adjust" appears in the upper right corner of the screen and the operating probe bias may be adjusted by pressing the Down Arrow to decrease or the Up Arrow to increase the probe bias.
2. The adjusted value is indicated after SB= in the upper left corner of the Probe Bias Test screen and also by the position of the vertical line that crosses the current-voltage curve.
3. When the operator changes the bias and presses the Enter button if Prom version is C.3 or greater, a new screen is displayed:

   NEW BIAS ACCEPTED
   PRESS ENTER
   TO RETURN TO MENU

4. Pressing the Enter button returns the unit to the OFF-LINE DIAGS menu.

To leave the probe bias test without changing the bias:

1. The user presses the Menu button.
2. The COMPLETING BIAS TEST message is displayed for a moment and the operator is returned to the OFF-LINE DIAGS menu.
3. If the scan bias is not equal to the operating bias, the COMPLETING BIAS TEST is displayed until the scan bias value has reached that of the operating bias.

Relay Test

This test allows the relays to be energized and deenergized manually to assure that they are functioning.

Procedure for performing the Relay Test:

1. From the OFF LINE DIAGS screen, press the Down Arrow to box RELAY TEST and press Enter to select.
2. Displayed is the RELAY TEST screen with TEST RELAY 1 boxed.

   RELAY TEST ↓
   [TEST RELAY 1]
   TEST RELAY 2
   TEST RELAY 3
   TEST RELAY 4

3. Press the Down Arrow to select the relay to be tested and press Enter to select.
4. The second RELAY TEST screen with the relay number indicated in the upper right corner and ENERGIZE RELAY boxed is displayed.

RELAY TEST ↓
ENERGIZE RELAY
DEENERGIZE RELAY

5. To energize the relay manually, press Enter.
6. To deenergize the relay, press the Down Arrow to box DEENERGIZE RELAY and press Enter to select.
7. To return to the higher level screens, press the Menu button.

Output Test

This test is performed to check the accuracy of the CAT analog outputs and consists of forcing the analog outputs to pre-selected percentages of its range.

Procedure for performing the Output Test

1. From the OFF LINE DIAGS screen, press the Down Arrow to box OUTPUT TEST and press Enter to select.
2. Displayed is the OUTPUT TEST screen with ANALOG OUTPUT 1 boxed.

. OUTPUT TEST .
ANALOG OUTPUT 1
ANALOG OUTPUT 2
ANALOG OUTPUT 3

3. Press Enter to select.
4. Displayed is the second OUTPUT TEST screen with the number of the selected output in the upper right corner and SET TO 0 PCT boxed.

. OUTPUT TEST 1 .
SET TO 0 PCT
SET TO 25 PCT
SET TO 50 PCT
SET TO 75 PCT

5. To set the output to the desired percentage of its range, press the Down Arrow to box the desired percentage and press Enter to select. Choices of output percentages are: 0, 25, 50, 75 and 100.

Input Status

Input status screen displays the "live" value of discrete inputs and the probe current. Note that this probe current is, in general, different from the probe current for the last air calibration found in the MAIN MENU - ON LINE, ALARM/DIAG SUMMARY.

Procedure for viewing input status:

1. From the OFF LINE DIAGS screen, press the Down Arrow to box INPUT STATUS and press Enter to select.
2. Displayed is the INPUT STATUS screen. A typical screen is:

INPUT STATUS
DI 1 OFF
DI 2 OFF
PROBE CURRENT 94.168

This screen shows that both discrete inputs are OFF and the present (live) probe current is 94.168 micro amps.

Reset Unit

Occasionally a microprocessor based unit "locks up" (ceases to function correctly) as a result of an electrical spike or some other cause. Also, it is necessary to reset the unit after a change has been selected for MAINS FREQUENCY. It is the purpose of RESET UNIT to restore the analyzer to proper functioning after such an occurrence. All programmed information and stored values, alarms, etc., are saved during and after RESET UNIT has been executed.

Procedure for Resetting the Unit:

There are 2 equivalent methods for resetting the unit. Either

1. Press simultaneously the Calibrate and the Menu buttons or
2. From the MAIN MENU - MAINT screen, press the Down Arrow to box RESET UNIT and press Enter to select.

(If the SECURITY ACTIVE screen appears, enter the MASTER CODE and press "enter.") With either method, the Series 7020 screen appears momentarily and then the MAIN MENU - MAINT screen is displayed indicating that the reset is complete.

Product Information

Information about the Series 7020 analyzer, such as the software revision, may be displayed.

Procedure for Displaying Information:

1. From the MAIN MENU - MAINT screen, press the Down Arrow to box MAINS FREQ.
2. Press Enter to select.
3. Displayed is the Series 7020 screen with product information.
4. Press the Menu button to return to the MAIN MENU - MAINT screen.

5. Diagnostics/Troubleshooting

5.1 Diagnostics

Messages	Significance/Corrective Action
BATTERY FAILED	Battery is not accepting a charge. Rechargeable probe battery needs replacement if message persists after a few hours of powering Analyzer.
CLOCK RESET	Clock has lost its setting. Reset time.
HOLD ACTIVE	Alarms and Outputs are being held.
EXTREME PROBE TEMP	Sample temperature is greater than 60°C which may shorten probe life.
HI PRB VOLTAGE	AC voltage detected on probe leads. Perform test in Appendix A.
PRB OUTPUT LOW	Probe probably needs cleaning (DO value less than DO preset value).
HI PROBE CURR	Probe current is out of range for DO measurement. This may be due to a chemical interference, sulfides on the probe membrane or a failed probe. Remove probe and clean with mild soap and water. Rinse probe and return to process. If alarm persists, remove probe from process and perform a Probe Bias Test in air. If the cursor is too far to the right of the horizontal portion of this curve, move the cursor until it is centered on the horizontal portion of the curve. The display should show a good DO value. Clean the probe and return it to the process. If the alarm persists, call Honeywell TAC for further assistance.
AUTO CAL FAIL	Temperature during Auto Calibration did not reach stability, calibration aborted. Instrument uses previous calibration values.
CLEAN PROBE	Auto clean was inadequate; manual probe cleaning required (See Section 4.4 Main Menu-Program, Programming Automatic Calibration/Automatic Clean - Setting one DO limit that causes a cleaning cycle to be initiated [PPM units only].)
THERMISTOR FAIL	Probe temperature compensator is shorted or open. Check wiring and replace probe, if necessary.
TEMP OUT OF SPEC	An air calibration was attempted while ambient temperature was lower than 0°C. Air calibration unable to be done.
HIGH CELL VOLTAGE	Input card failed, it needs to be replaced.
AUX_IN_LOW	An auxiliary input is programmed, but not connected to a 4-20 mA signal. Either connect input to signal or turn off the auxiliary input under Program Mode.

5.2 Troubleshooting Matrix of Potential Problems and Solutions

WARNING

More than one switch may be required to de-energize unit.

Symptom	Possible Problem	Troubleshooting	Solution
DO reading is higher than expected	Leaks in pipe line	Follow Probe and Analytical tests to confirm that neither are the problem. Appendix B.	Inspect all joints in process line. Follow leak detection procedure in Appendix F.
Air Calibration Failed	Too windy	Air Calibration based on stable temperature reading.	Wait until temperature can be more stable or repeat air calibration after both air temperature and DO reading are stable.
The DO reading is higher or lower than expected	The pressure setting may be unintentionally set to an incorrect value.	Do a visual check on the front display of the analyzer. Press the Display button. If the Pressure value is either < or > 760 ±40 mmHg the pressure is incorrect.	Enter the correct barometric pressure.
The DO Reading is lower than expected	The Salinity may unintentionally be turned "ON".	Salinity is used to correct for salt in the process water. If the process water doesn't contain salt and Salinity is selected, the DO reading will be lower than expected. Confirm current Salinity value through visual check on the front Display. Press the Display button. If Salinity is >0.0, and the process doesn't contain salt, the value should be 0.0.	Go to Program Mode. Under Auxiliary Input, change value from Salinity to OFF.
Air Calibration doesn't hold or DO Reading is lower than expected	Auto Air Calibration may unintentionally be turned "ON"	A manual air calibration was done successfully. The unit is displaying the expected DO value while in the process. At some time period later, the process's DO reading is different from the expected reading. A manual air calibration is performed and the unit is again displaying the expected DO value. Again, at some time period later, the DO reading is different from the expected reading by an amount similar to the first "OFF" reading.	Under Program mode, under Auto Clean/Calibrate, turn the Auto Cal "OFF." Perform a manual Air Calibration.
Flashing DO Value 25 ppm or 25,000 ppb	Probe is measuring an O_2 concentration greater than 25 ppm or 25,000 ppb		Do not use probe in this application.
	Air Calibration was done in 15-20 ppm process.		Pull probe out of process and perform air calibration in air.
Flashing DO Value 0 ppm or ppb	A Probe Bias test was performed in a 0-10 ppb application.		Remove probe from process, perform an air calibration and return probe to process.
	A sample calibration was performed in a 0-2 ppb application.		Remove probe from process and perform an air calibration to cancel the sample calibration.
	An air calibration was performed in a low ppb application.		Remove probe from process and perform an air calibration in the air.
	Chemical Interference (ex., Hydrazine in excess of 1,000 ppb)		While analyzer is online, the Hydrazine concentration should be kept to less than 1,000 ppb or flashing may continue.
	Other Chemical Interference's		Consult Honeywell TAC or Application Engineers to determine effect of a Specific Chemical on DO reading.

Symptom	Possible Problem	Troubleshooting	Solution
Probe is connected to unit but unit is display: DO "Flashing 0.0" Temp 0.0 Pressure 0.0	Input card may be bad Salinity input may be turned ON	Confirm that the unit is not working by installing a 2nd probe, if available. The unit should display the exact same incorrect readings with the 2nd probe. If a 2nd probe is not available, perform the following procedure: Put a 5K resistor on pins on TB5 pins 36 and 37. Place a straight wire from TB5 pins 33 and 34. Place a 10K ohm resistor on TB5 pins 34 and 35. If unit is working, you should see a DO value of 7.6 ppm or 76000 ppb and a temperature of 25°C. If you still see 0.0's, the input card is bad.	If unit is under warranty, call Honeywell TAC. If not under warranty, call Honeywell for replacement card.
Reading is higher tan expected	Chemical Interference	Assumption is that the probe is a known working probe. Remove probe from process and perform a Probe Bias test to see if the probe characteristic curve is like the one in the manual. If not, call Honeywell TAC for further instructions	Determine if additional amounts of the following chemicals such as Cl2, O3, H2 N2H4 or SO2 have been recently added to the process. Reduce the amounts of these chemicals and validate that the DO has returned to expected values. Reference Discussion on DO Measurements in Appendix D.
Difficulty seeing the display as it is very dim.	LCD displays are affected by temperature change.		Go to Maintenance Menu, under Adjust Contrast. Adjust screen until you can see display until you can see display clearly.

6. Accessory and Spare Parts Kits

Kit Number	Description	Parts Included in Kit	Quanity
51198075-501	Misc. Parts for All 7020 DO Analyzers	Screws, 4-40 x 1.75" front panel hold down O-ring, for front panel & screw retention Gasket, front bezel Pivot arm linkage set for front panel assembly Washer, to mount standoff & ground nuts Lock washer, to mount standoff & ground nuts Ground nut, M3 Flex ribbon cable, at rear ground strip, rear Pins, rear cover locating Gasket, rear cover Screws, rear cover	2 4 1 1 4 4 5 1 1 2 1 4
51198076-501	New/Replacement Kit for Terminal Block Safety Cover on all 7020 DO Analyzers	Cover & screw, for terminal block safety Label set for above Stand off, accepts safety cover screen	1 1 1
51198077-501	New/Replacement Kit for Terminal Block on all 7020 DO Analyzers	Terminal Block Terminal Block Subplate	1 1
51198078-501	New/Replacement Kit for Rear cover on all 7020 DO Analyzers	Cover, rear Gasket rear cover Screws, rear cover Pins, rear cover locating	1 1 4 2
51204287-501	New/Replacement Kit for 3 Additional AC SS Relays. Available on all 7020 DO Analyzers	3 AC SS Relay Output Card Rear Terminal Block 8 POS Terminal block Subplate Label Set Assembly Directions	1 1 1 1 1
51204288-501	New/Replacement Kit for 3 Additional Mechanical Relays. Available on all 7020 DO Analyzers	3 Mech. Relay Output Card Rear Terminal Block 8 POS Terminal Block Subplate Label Set Assembly Directions	1 1 1 1 1
51204289-501	Bezel Replacement Kit. Available on all 7020 DO Analyzers	Display Assembly Pivot Arm Linkage O-ring Screws SS four 40X1.75 Assembly Directions	1 1 4 2 1
51204290-501	New/Replacement Kit for 2 Additional Current Outputs. Available on all 7020 DO Analyzers	2 Additional Current Outputs Rear Terminal Block 8 POS Terminal Block Subplate Label Set Assembly Directions	1 1 1 1 1
51204291-501	Replacement Kit for Power Supply Card. Available on all 7020 DO Analyzers	10 W. Power Supply/Relay Card Terminal Block Terminal Block Subplate Label Set Assembly Directions	1 1 1 1 1
51204292-501	Replacement Kit for Single Current/2 DI Card. Available on all 7020 DO Analyzers	Single Current/2 DI Output Card Terminal Block Terminal Block Subplate Label Set Assembly Directions	1 1 1 1 1
51204293-501	Replacement Kit for CPU Backplane Card. Available on all 7020 DO Analyzers	CPU Backplane Assembly Instructions	1 1
51198079-501	New/Replacement Kit for Input circuit Card. Available on all 7020 DO Analyzers	Input Circuit Card Rear Terminal Block 8 POS Terminal Block Subplate Label Set Assembly Instructions	1 1 1 1 1
079163	Power Line Filter Kit	A fused disconnect switch to terminals to connect AC mains-needed for all CE units Directions	1 1

Appendix A - Noise Testing

Hints for Reducing Noise

Specifications for proper operation of Honeywell dissolved oxygen (DO) probes demand that the alternating current (AC) voltage signal (noise) between anode and shield connections and cathode and shield connections be less than 1 mV AC.

While it is the user's responsibility to assure that this specification is met, the following are some hints that have been successful in reducing these signals to the required value in a variety of installations.

1. First eliminate external connections as a source of excess AC noise.
2. After installation of all wiring, use a digital voltmeter to check the following voltages:

Anode - Shield	1.2 to 2.0 VDC depending on oxygen level less than 1 mV AC. In low ppb measurements, this value may be zero.
Cathode - Shield	< 1 mV DC less than 1 mV AC

3. Any readings greater than the limits shown above indicate electrical noise that should be corrected.
4. Systematically remove external connections to the Analyzer, noting if the voltage drops within the acceptable limit.
5. If a noise source is identified, improved shielding, grounding or re-routing of that cable may be required. (In attempting to reduce AC noise, do not ground the shield as this shunt filtering is designed to reduce electromagnetic interferences {EMC}.)
6. If the measured voltages are greater than procedures states, one at a time remove an external connection (ex., isolated outputs and relays) and re-measure the AC signal. If the AC signal has decreased after disconnecting one of these connections, then this was the source of the noise.
7. If the noise remains at a value greater than 1 mV AC after disconnecting all external connections described in step 1, disconnect the shield wire from Terminal 38 and connect it to instrument ground inside the case.
8. If the noise remains at a value greater than 1 mV AC after performing step 2, reconnect the shield wire to Terminal 38 and connect an additional (jumper) wire from ground to the shield connection, Terminal 38.

If these steps fail to reduce the Anode-Shield and Cathode-Shield AC signals to the specified 1mV AC or less, obtain an isolated transformer and power the analyzer from that.

Appendix B - Probe and Analyzer Tests

Before performing an air leak detection, it is necessary to determine that both Probe and Analyzer are working properly.

Assumptions:

- The probe and analyzer should be connected, the analyzer powered-up, and the probe in the process water for at least 24 hours prior to testing.
- No additional configuration should be done.
- The process is as it would be normally. All equipment in the process is online and contributing to the process. This is to ensure that the tester is working in a known environment.

Check for probe membrane leakage

If the probe has membrane leaks, incorrect readings may occur. Follow this procedure to check for probe membrane leakage:

1. Remove probe from analyzer and process.
2. Using either the flow chamber or original protective adapter, screw this piece on the probe. If using the adapter, wrap electrical tape around the adapter to seal the holes.
3. Next, wrap electrical tape around the hole on the side of the probe. The intent is to create a reservoir for the sealed probe.
4. Position probe with the membrane pointing up.
5. Make a solution of Salt water using 2 T. of salt and 8 oz. of water.
6. Fill the probe (via the adapter or flow chamber opening) with the salt water until water is overflowing from the top of the reservoir.
7. If using the adapter or a PVC flow through chamber, place a wire (uncurled paper clip) in adapter or flow through chamber opening such that one end is immersed in the salt water solution. If using a Stainless Steel(SS) flow chamber, you do not need the wire.
8. Using a DVM that can measure Mohms, attach one DVM lead to the paper clip (or touch side of SS flow through chamber) and the other DVM lead to the cathode(black lead). Measure the impedance between the Cathode and the wire(probe side). If the probe has no leakage problem, this resistance will be greater than 1 Mohm go to Step 10. If the reading is in the k ohms or ohms range, there is a leak in the membrane which can cause erratic readings in the probe. Stop any further testing until the probe is replaced.
9. If you are here, it has been confirmed that there are no membrane leaks in the DO probe. Remove the tape and wire from probe and rinse probe with tap water. Go to Steps 9 - 16.

Check that analyzer is working

1. Remove power from analyzer.
2. Disconnect the probe and put the following resistor values on the terminal block of the analyzer:
   - Jumper (bare wire) - TB5 - Anode(33) to Ref(34)
   - 10k resistor - TB5 - Ref(34) to Cathode(35)
   - 5k resistor across thermistor leads TB5 - 36 and 37
3. Turn analyzer back on.

4. If you see a reading of approximately 7.6 ppm or 7600 ppb at 25°C, the analyzer is working correctly.
5. If not, the analyzer maybe the problem. Consult Honeywell TAC for support.

Check that the analyzer and probe are working together correctly.

1. If not already done, connect the probe to the analyzer and power up the analyzer. Put probe in a bucket of water for approx. 1 hour so it can stabilize before proceeding.
2. Expose probe to ambient air for 3-5 minutes or until the temperature is stable.
3. Press the Display key on the Analyzer until the following parameters **DO**, **TEMP**erature, **SAL**inity, and **PRESS**ure are showing on the analyzer's display.
4. Perform a Visual Check on these parameters while the probe is in ambient Air:
5. The Temperature is not flashing and is between 15 - 35 Deg C.
6. DO's Barometric Pressure is approx. 760 mmHg +/- 40 mmHg
7. The Salinity value should be 0.0 PPT. (Indicates that Salinity is turned OFF).
8. If any of the above parameters are incorrect, make the necessary changes to correct them so that they are as stated above.
9. Perform an air calibration.
10. When air calibration is completed, look at the DO value and the Temperature on the Analyzer's display.
11. Confirm that these two parameters are correct by comparing them to values in Table 6.2. If the measured values are not similar to the table, the probe is suspect, call *TAC for assistance.
12. With probe still in air, perform a Probe Bias Test under the Maintenance Menu.
13. When completed, the display should look exactly like Figure 4-2 under Probe Bias Test. If it does, move to Step 16.
14. If the problem is a shift of the curve either to the left or right of the cursor (OB=600), move the cursor so that it is positioned on the flat portion of the curve. At this point, the probe is suspect and should be sent to *TAC for analysis. If the problem is that the cursor is positioned too far to the left or right of the flat portion of the curve, then move the cursor back to the flat portion of the curve where OB= 600.
15. Perform another Air Calibration to correct any changes that occurred during the PBT.
16. If you reached this point, you have both a working probe and analyzer which are calibrated to one another correctly.

Appendix C - Parameters Affecting Dissolved Oxygen Measurement

The actual quantity of oxygen that can be present in solution is governed by the partial pressure of the gas in the atmosphere, the solubility in solution, the temperature and purity of the solution.

Pressure

ADO Progeny Analyzers include an internal pressure sensor and software algorithm that automatically compensates for atmospheric pressure variations during calibration. Pressure variations have a direct effect on the dissolved oxygen concentration during normal measurement so no pressure compensation is applied at that time. The information given below is only for reference to published solubility tables and is not needed for operation of the Analyzer.

The equilibrium concentration of oxygen dissolved in a liquid is directly proportional to the partial pressure of oxygen in the vapor phase with which the solution is in contact. Dry air, which contains 20.9% oxygen, will have an oxygen partial pressure of 159 mmHg if the total pressure is 760 mmHg. Tables of oxygen solubility are normally referenced to this value. An altitude or pressure correction must be made when conditions differ from this level. The correction is made using the following equation:

$S = S' (P - p)/(760 - p)$
where:

S is the solubility at barometric pressure of interest (P)
S' is the solubility at 760 mmHg at a given temperature
P is the barometric pressure
P is the partial pressure of water at the given temperature

Temperature

Honeywell dissolved oxygen probes and analyzers include temperature sensors and an automatic temperature compensation algorithm. The algorithm takes the raw oxygen signal from the probe (which is proportional to the partial pressure of oxygen) and converts it into the actual concentration of oxygen at the measuring temperature. The algorithm is based on the decreasing solubility of oxygen with increasing temperature and on the probe temperature coefficient.

Salinity

The significant effect of dissolved solids on reducing oxygen solubility is well documented. However, the partial pressure of oxygen (raw oxygen probe signal) is the same whether in pure or saline water. Since the actual solubility is reduced, a correction must be made when measuring brackish, sea or other water containing much more than 1 ppt (1000 ppm) of dissolved solids. The ADO Analyzer includes a salinity correction algorithm which uses input from either a fixed value of salinity in ppt (parts-per-thousand) entered from the front panel, or a 4-20 mA input signal from an external conductivity instrument which represents 0-40 ppt salinity as sodium chloride. The input signal should be used in installations where the salinity is high and variable.

The salinity range corresponds to a conductivity range of approximately 0-68 mS/cm for which the conductivity analyzer signal should be scaled. If seawater is the medium and its deviation from pure sodium chloride is taken into account, then a conductivity range of approximately 0-59 mS/cm should be used instead. The Honeywell 7082 Wide Range Conductivity Analyzer and cell are suitable for this measurement.

Suspended and settled solids have negligible effect on solubility, but may affect the transfer rate of oxygen when in excess of 2%.

Appendix D - Discussion on Chemical Interferences on Measured DO Currents

There are four contributors to measured current:

Faradaic Currents

Faradaic currents are those resulting from oxidation or reduction of chemical species. The reduction of oxygen to water, the oxidation of water to oxygen, and the oxidation of hydrogen, hydrazine or sulfur dioxide, are examples of Faradaic currents.

Residual Currents

Residual currents are unwanted Faradaic currents caused by impurities in the probe electrolyte. These impurities are metals (e.g. lead, zinc) in electrolyte reagents which are capable of being reduced at the cathode and give rise to zero offset currents at "zero ppb oxygen".

Electrode Conditioning Currents

The platinum cathode and anode materials are actually made up of conducting platinum oxides. These oxides exist at the molecular level. The actual platinum surface state strongly affects the observed Faradaic currents. Before methods of wire conditioning were established, upwards of 96 hours was needed to allow these conditioning currents to stabilize. Once wire conditioning methods were established, it now takes approximately 24 hours for these conditioning currents to completely stabilize. Electrode conditioning currents occur on first probe power-ups, following power interruptions of more than 1 second (battery back-up is on the probe to prevent this current during a power outage) and following a Probe Bias test.

Charging Currents

The Dissolved Oxygen (DO) probe consists of closely spaced bi-filar platinum windings separated by a high dielectric constant material. This is a description of a capacitor; the capacitance of a DO probe is approximately 150 uF. When the probe is scanned during a Probe Bias Test(PBT) at 10mV/min, a +/- 1.5 uA charging current is observed. This is equivalent to +/- 150 ppb dissolved oxygen.

The purpose of the PBT is to verify the optimum operating range of the current/voltage curve. It further allows one to determine if a reference shift has occurred. Most importantly, it allows one to select to identify a new bias point, if one is needed. To employ this diagnostic, the user should be in air or air saturated water (ppm current is in uA range). A PBT should not be performed in a ppb application (ppb current is in nA range), due to charging and electrode currents being at a maximum value (uA range) during one of these scans. Furthermore, the final current rise during the PBT produces both hydrogen and oxygen gases within the probe. Time is needed before these gases can re-establish equilibrium with the outside sample. Therefore, the PBT should be limited to air level conditions and adequate time should be allowed for probe recovery following a PBT.

Faradaic Interferences

The DO probe responds to oxygen partial pressure as follows:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O \qquad (1)$$

Reaction (1) is a chemical reduction in which dissolved oxygen is reduced to water. This reduction occurs at the working electrode, commonly referred to as the cathode. The equal and opposite (oxidation) reaction occurs at the counter electrode (anode). Any gaseous substance which is permeable through the membrane and is capable of being oxidized or reduced (electroactive) at the working electrode will interfere. Cl_2, O_3, H_2, N_2H_4 and SO_2 are examples of interfering dissolved gases.

$$Cl_2 + 2e^- \rightarrow 2Cl^- \quad (2)$$

$$H_2 \rightarrow 2H^+ + 2e^- \quad (3)$$

Reaction (2) is a reduction and hence a positive interference will be observed; reaction (3) is an oxidation which will result in a negative interference. All amperometric probes are subject to reduction or oxidation interference as shown above. In addition to the direct interference shown in these two equations, the equilibrium probe provides an additional indirect interference. In normal probe operation oxygen is consumed at the working electrode and an equal amount of oxygen is produced at the counter electrode. In a positive interference condition, such as (2) above, chlorine is reduced at the working electrode and an equivalent amount of oxygen is produced at the anode. This oxygen is electroactive, along with the dissolved chlorine and is a contributor to the measured current.

In a negative interference situation as in (3), hydrogen gas is consumed at the working electrode and the opposite reaction, the reduction of water to hydrogen gas occurs at the counter electrode. In this hydrogen interference mode, the probe is both consuming and producing equal amounts of hydrogen, and is operating in a hydrogen detection equilibrium mode.

In cases of electrochemical interference, if the interference is positive, dissolved oxygen will be produced at the counter electrode giving a perceived higher oxygen reading. If the interference is negative, dissolved hydrogen gas will be produced at the counter electrode giving a perceived zero oxygen reading.

Sulfite Based Zero Testing

Often as a quick check to determine if a DO probe can reach 0.0 ppb, the user will immerse the probe in a sulfite based solution. While sulfite is known to be a convenient oxygen scavenger, it's effectiveness depends on factors such as temperature, solution pH and trace impurities. What's worse is that sulfites are produced by bubbling sulfur dioxide gas through caustic solutions. Sulfur dioxide, if present in solution, will diffuse through the probe membrane, react with the alkaline probe electrolyte to form electrolyte sulfites and produce a negative interference by the reaction:

$$SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e^- \quad (4)$$

As opposed to reaction (1), reaction (4) is an oxidation; electrons are on the opposite sides of the equations and hence the measured current for (4) is opposite (interfering) the oxygen reduction signal. The sum of (1) and (4) is the reaction by which sulfites scavenge oxygen, namely:

$$O_2 + 2SO_3^{2-} \rightarrow 2SO_4^{2-} \quad (5)$$

From the above discussion it is apparent that while sulfite oxygen scavenging can be beneficial, the existence of dissolved SO_2 gas is detrimental. To further complicate the situation is the fact that at least 10 different SO_2/Sulfite species exist in solution, and that the equilibrium between these species is slow. The primary parameters that establish equilibrium conditions are total sulfite concentration and pH. Sodium bisulfite ($NaHSO_3$) and sodium meta bisulfite ($Na_2S_2O_5$) are acid sulfite forms; because acidity favors SO_2 formation these materials should be avoided. While sodium sulfite (Na_2SO_3) is the best starting material, before use, an optimum pH of 9-10 should be obtained and divalent metal catalyst should be added to speed up that species equilibrium. Testing was done at the Honeywell Engineering labs, it was impossible to create a consistently optimum solution preparation for zero probe calibration using sulfites.

However, a Honeywell proven low ppb DO test using Nitrogen, another oxygen scavenger, is recommended in Appendix G of this manual.

Appendix E - Percent Saturation Readout

In some special applications, it is desirable to read out in percent saturation rather than concentration. These are usually in non-aqueous solutions where the normal temperature compensation of the Series 7020 Analyzer for the solubility of air/oxygen in water does not apply. The percent saturation readout disables this solubility part of the temperature compensation. The readout is 100% when measuring in air or in a solution saturated with air, regardless of the temperature. Thus an air calibration will always produce approximately a 100% saturation readout. With this readout, salinity should be left at zero since the normal salinity correction also does not apply to non-aqueous media.

When percent saturation readout is selected, the on-line displays read in percent saturation, however, all the dissolved oxygen settings in the Analyzer remain in concentration units (ppm or ppb). Therefore, percent saturation alarms, output, etc. Should be used only if the process temperature is nearly constant. To set alarm points, output limits, etc., it is necessary to convert a percent saturation value to concentration. This is done by multiplying the percent saturation, as a fraction, times the air saturation value at the process temperature to obtain the corresponding concentration setting.

For example, assume it is desired to have an alarm setpoint at 75% saturation while operating at 20°C. The corresponding setpoint is the 0.75 x 9.07 = 6.80 ppm.

Table 6-2 Dissolved Oxygen Solubility vs. Temperature
(From Standard Methods for the Examination of Water and Wastewater)

Sample Temperature (°C)	Solubility (ppm, mg/L)
0	14.60
1	14.19
2	13.81
3	13.44
4	13.09
5	12.75
6	12.43
7	12.12
8	11.83
9	11.55
10	11.27
11	11.01
12	10.76
13	10.52
14	10.29
15	10.07
16	9.85
17	9.65
18	9.45
19	9.26
20	9.07
21	8.90
22	8.72
23	8.56
24	8.40
25	8.24
26	8.09
27	7.95
28	7.81
29	7.67
30	7.54
31	7.41
32	7.28
33	7.16
34	7.05
35	6.93
36	6.82
37	6.71
38	6.61
39	6.51
40	6.41
41	6.31
42	6.22
43	6.13
44	6.04
45	5.95
46	5.86
47	5.78
48	5.70
49	5.62
50	5.54

Appendix F - Leak Detection in PPB Applications

Before performing and air leak detection, it is necessary to determine that both the probe and analyzer are working properly. Refer to Probe and Analyzers tests in Appendix B.

1. First, check to see that the probe contains an O-ring. Per the probe directions, an O-ring must go into a probe that is used in ppb applications. This creates a tight seal between the probe and flow chamber. MAKE SURE THIS O-RING IS IN THE PROBE.
2. Unless already in air, open the probe to air for 30 seconds.
3. Put it back into the process again.
4. Allow the DO to drift down to the 20-30 ppb range. The 20-30 ppb range was chosen because the reading was low enough that the drift was small with respect to the changes observed for various flow rates but high enough that changes could be observed.
5. At this range, vary the flow rate from 10 to 100 ml/min. These low flow rates were selected for two reasons. The first, the tester many only have a 0 - 100 ml/min flow indicator. The other reason, is a leak that exists at this low flow, will cause a change in the DO reading.
6. If the DO value at 10 ml/min exceeds the DO value at 100 ml/min, a leak is present in the sampling line.
7. Fixing the leak may require plastic tubing to be replaced with metal tubing, tape to be put on fittings, and/or fittings at the bottom of the probe to be tighten securely.
8. Now, repeat Steps 2 - 6 until the flow can be changed from >100 ml/min to 10 ml/min with no change in the DO value.

Appendix G - Procedure for Low Level ppb Dissolved Oxygen Testing

Overview

The purpose of this procedure is two-fold. First, using a controlled environment, new probes and/or analyzers can be tested to determine if each is performing correctly before being installed in field. Second, this procedure can be used to re-test the performance of an existing analyzer and/or probe.

You may choose to use this set-up for a zero calibration test. However, a zero calibration test would require, as a minimum, modifications to two of the test parameters. One modification would require a closed loop water system. The sample water must be tapped directly from the customer's process water. The other modification would be the gas. For zero calibration, a high purity nitrogen gas (very expensive) must be piped into the process sample. Since Honeywell can neither control the quality of the gas the customer purchases nor the quality of the process water used, the company will not guarantee the accuracy of the results of a zero calibration done by this modified method.

Equipment Needed

One Tank of Oxygen in Nitrogen gas mixture

One pressure regulator/shutoff valve

Wash bottle - used to add moisture to the sample gas before the gas reaches the probe. (Without addition of moisture, the Nitrogen gas would dry out the probe membrane.)

One Beaker - used to vent the gas sample

One Dissolved Oxygen probe - used to make DO measurement

One Dissolved Oxygen flow through chamber - provide a closed environment

One Honeywell Model 7021 Dissolved Oxygen Analyzer - monitors and displays DO value.

Oxygen Measurement Procedure

1. Connect probe and energize the electronics.
2. Allow probe to sit in tap water for 1 hour.
3. Perform an air calibration per the manual instructions.
4. Set-up equipment as shown in Figure G-1.
5. Immerse probe into sealed flow chamber and connect to wash bottle piping.
6. Set room temperature to 25 °C and sparge water with nitrogen overnight. Reading should be less than 1 ppb.
7. Remove probe from flow chamber and expose to 25 °C air for 2 hours.
8. Perform an air calibration.
9. Return probe to flow chamber and resume nitrogen sparging.
10. When analyzer indicates that DO level is below 20 ppb, change gas to 250 ppm O_2 in nitrogen. Run until equilibrated (4-6 hours). After equalization, note barometric pressure and temperature.

11. Compare reading with calculated value

To Calculate True Value

$$\frac{{}^{*}\text{Air Sat. Value at T °C} \times \text{known gas } O_2 \text{ Value}}{20.9\%} \times \frac{\text{Barometric Pressure}}{760 \text{ mmHg}} = \text{True Value}$$

Example Calculation

At 25 °C using 250 ppm O_2 in N_2 at 770 mm Hg

$$\text{True Value} = \frac{8.24 \times 10^{-6} \times 250 \times 10^{-6}}{20.9 \times 10^{-2}} \times \frac{770}{760} = 9.986 \times 10^{-9} \text{ or } 10 \text{ ppb}$$

* If the temperature of the process water is not at 25°C, use O_2 Solubility Tables in Honeywell Dissolved Oxygen Analyzer Operator Manual and the process water temperature to determine the Air Saturated O_2 value.

Special Requirements:

Note 1: Gas Mixture is Oxygen in Nitrogen - use Gravametric Gases analyzed to +/- 1% of contained gas. Get Certificates of Conformance and Analysis on the purchased gas.

Note 2: Dual Stage, Ultra high purity, high flow pressure regulator - non-corrosive surface. Try to get this from the gas supplier to be consistent with their recommended setup. Example supplier - Scott Model-18 Series.

Note 3: Glass Gas Washing bottles with fritted disc and beaker. Gas bottle should be filled 3/4 with water. Example supplier - Fisher, Cole Palmer

Note 4: Piping around glass wash bottle should be heavy wall flexible plastic. Piping that goes into beaker should be submerged about 1/2" into beaker of water.

Note 5: All other piping should be rigid polypropylene tubing.

Note 6: All calculations are based on 25 Deg C.

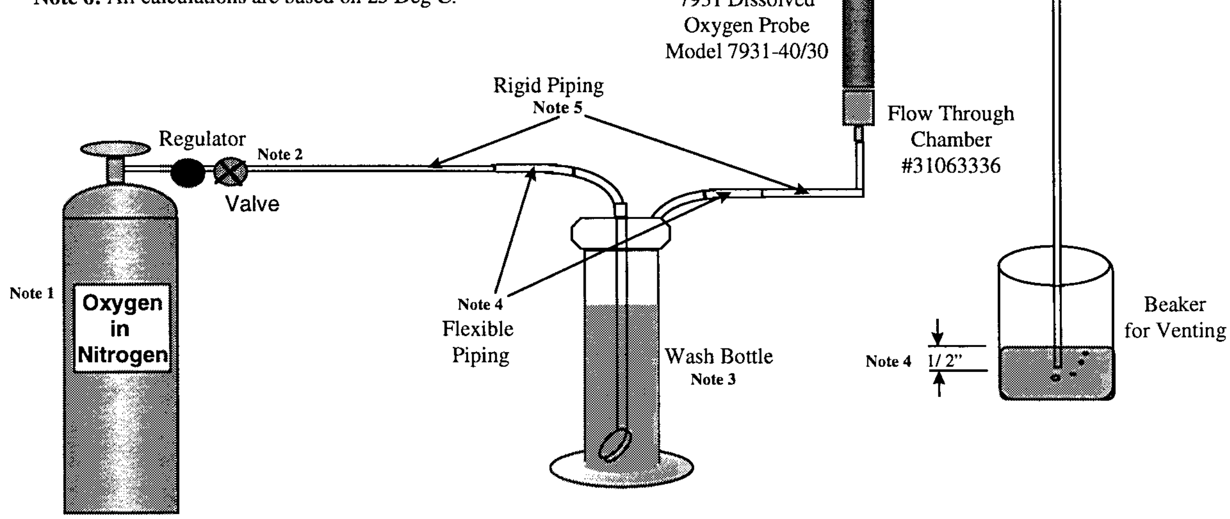


Figure G-1 Suggested ppb Dissolved Oxygen Test Set-up

Appendix H - Output Auto Ranging (PPB Only)

Power plant dissolved oxygen measurements are typically in the low ppb ranges in normal operation. However, during startup or upset conditions, much higher levels of oxygen must be removed from the system. It is necessary to monitor the progress of this removal in higher ranges to know when it is possible to increase boiler temperature and pressure.

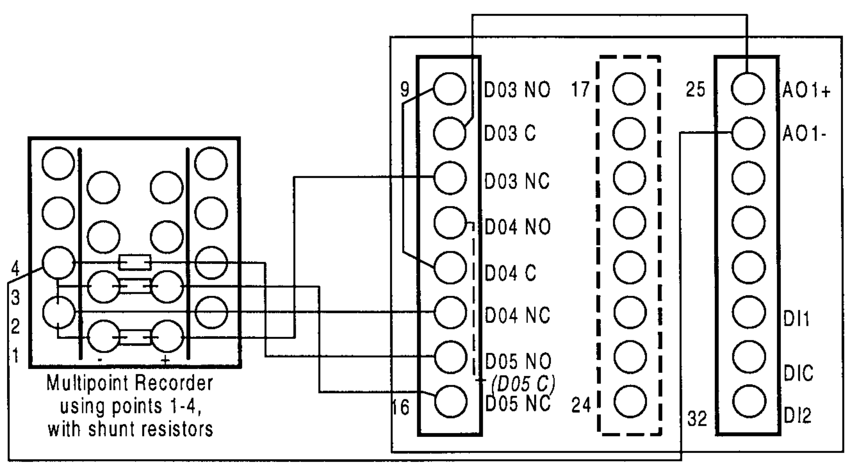
To provide a good resolution signal to a recorder or other data acquisition device during normal, low oxygen operating conditions, but still track the higher concentrations, output auto-ranging can be used. It automatically scales the Analog Output 1 0/4-20 mA signal to represent any of 4 user-configured ranges. See Section 3 - Programming Autoranging. For example, if the normal range is set up for 0-20 ppb, then above 20 ppb the scaling is 0-200; above 200, the output is 0-2000; and above 2000, the output is 0-20,000. Relays DO3, DO4, DO5 energize sequentially as increasing ranges are called up. There is a small deadband at the changeover points to prevent excessive jumping back and forth when measurement hovers around those values.

The wiring to achieve auto-ranging is given for a multipoint recorder in Figure H-1. In operation, the selected range will be recorded on its respective recorder point which provides the identification of the scaling. The unused points of the recorder stay at the low end of scale. For this setup, Relays 3, 4 and 5 must have assigned inputs Ranges 1, 2, and 3 respectively.

For data acquisition systems with greater capabilities, the Analyzer relay contacts can be connected to discrete inputs for scaling identification and only one analog input is needed in the data acquisition system, instead of the four used with the recorder. In that case, a jumper from terminal 9 to 13 is used and range indication would be given by continuity from terminal DO3C to: Range 1 - open, Range 2 - DO4NC, Range 3 - DO5NC, Range 4 - DO5NO.

Relay Action with Range Change

Diss Oxygen Valve (ppb)	Range (ppb)	D03	D04	D05	Recorder Point
0-22	0-22	Deenrg	Deenrg	Deenrg	1
20-200	20-200	Engr	Deenrg	Deenrg	2
200-2000	200-2000	Engr	Engr	Deenrg	3
2000-20,000	2000-20,000	Engr	Engr	Engr	4



Series 7020 Dissolved Oxygen Analyzer with terminals 9-16
Relay 4 Normally Open terminal is internally jumpered to Relay 5 Common.

Figure H-6-1 Output Auto Ranging Connections

Appendix I - Summary of CAL, CLEAN, and HOLD

The convenience of using the ADO analyzer is enhanced by the many ways in which cleanings and/or calibrations may be executed and holds activated.

It is the purpose of this appendix to summarize these.

Cleanings

1. **Manual Cleaning -** The user may remove the probe from the sample to inspect and/or clean it at any time. Unless specific hardware is installed, such as a relay contact connected from the probe mounting to one of the ADO discrete inputs, the ADO analyzer will simply respond to the apparent new dissolved oxygen concentration equal to air saturation as programmed. For instance, if the sample DO is 2 ppm, the control setpoint is 4 ppm, the control output is controlling aeration and the control action is reverse, aerators that were on [trying to raise the DO to setpoint] will turn off. Furthermore, any high alarms with setpoints less than the air saturation value will be activated. Thus, if the ADO is being used as a controller, pressing the button before removing the probe would result in the recorder trace changing significantly while the probe was in the air confirming that the probe was probably at least removed from the sample, if not cleaned.
2. **Time-Initiated Cleaning -** The AUTO CAL/AUTO CLEAN feature -- Cleaning and/or Calibration is initiated when the programmed clock time or duration is reached. If HOLD OUTPUTS -- YES was selected alarms and analog outputs will be held at the values they had just before initiation of the operation.
3. **Calibrate button-** pressing the button will initiate a cleaning, if programmed to do so in PROGRAM - SET UP BUTTONS. The timing of the cleaning is that programmed into the AUTO CAL/AUTO CLEAN feature. If HOLD OUTPUTS - YES was chosen when programming the AUTO CAL/AUTO CLEAN feature, it applies to a >] button cleaning, too.
4. **DO CLEAN --** The cleaning programmed under -PROGRAM-AUTO CAL/AUTO CLEAN may be initiated from the ON-LINE-AUTOCAL STATUS screen. If HOLD OUTPUTS - YES was chosen when programming the AUTO CAL/AUTO CLEAN feature, it will apply to this cleaning, too.
5. **Cleaning initiated by closing Discrete Input 1 -** Closing DI1 initiates the NEXT SCHEDULED user-programmed Automatic Calibration/Automatic Cleaning operation and HOLD applies if chosen in programming AUTO CAL/AUTO CLEAN.
6. **Clean Limit Cleaning --** When the DO falls below the CLEAN LIM PPM value programmed under PROGRAM-AUTO CAL/AUTO CLEAN [PPM analyzers only], the cleaning [but not a subsequent calibration] programmed under PROGRAM -- AUTO CAL/AUTO CLEAN is executed and, if the resulting DO fails to rise above the CLEAN LIM PPM value, a diagnostic AUTO CLEAN FAIL is displayed. If HOLD OUTPUTS - YES was chosen when programming the AUTO CAL/AUTO CLEAN feature, it applies to this cleaning, too.

Calibrations

ATTENTION

For sample and pressure calibrations, where the probe need not be removed from the sample, HOLD may not be necessary.

1. **Manual Calibrations -** Manual Air Calibration, Sample Calibration, Zero Calibration [7021 PPB only] and Pressure Calibration are selected and executed from the ON-LINE--MANUAL CALIBRATION screen. See Section 4.3 - Manual Calibration. If HOLD action is desired during these calibrations, the button must be pushed.

2. **Time-Initiated Calibration -** The AUTO CAL/AUTO CLEAN feature - Cleaning and/or Calibration is initiated when the programmed clock time or duration is reached. If HOLD OUTPUTS - YES was selected alarms and analog outputs are held at the values they had just before initiation of the operation.
3. **CAL button -** pressing the button will initiate an air calibration, if programmed to do so in PROGRAM - SET UP BUTTONS. If HOLD OUTPUTS - YES was chosen when programming the AUTO CAL/AUTO CLEAN feature, it applies to a CAL button calibration, too.
4. **DO CAL -** The calibration programmed under PROGRAM-AUTO CAL/AUTO CLEAN may be initiated fro the ON-LINE - AUTOCAL STATUS screen. If HOLD OUTPUTS - YES was chosen when programming the AUTO CAL/AUTO CLEAN feature, it applies to this calibration, too.
5. **Calibration initiated by closing Discrete Input 1 -** Closing DI1 initiates the NEXT SCHEDULED user-programmed Automatic Calibration/Automatic Cleaning operation and HOLD applies if chosen in programming AUTO CAL/AUTO CLEAN.

Holds

Analog Outputs and Alarm Conditions are held for any of the following actions:

1. The button is pushed.
2. The Program or Maintenance Modes are entered.
3. A timed Automatic Calibration/Automatic Cleaning is initiated and HOLD OUTPUTS - YES has been programmed.
4. A cleaning is initiated because the DO has fallen below the CLEAN LIM PPM and HOLD OUTPUTS - YES has been programmed.
5. The >] button is pushed and HOLD OUTPUTS - YES has been programmed.
6. From the AUTOCAL STATUS screen, DO CLEAN or DO CAL is selected and HOLD OUTPUTS - YES has been programmed.
7. Discrete Input 1 is closed and HOLD OUTPUTS - YES has been programmed.

The Control output only is held but may be adjusted manually for either of the following actions:

1. Discrete Input 2 is closed.
2. The ADO is operating as a controller in the automatic mode and the auto/manual button is pushed placing the ADO into the manual mode.

Appendix J- Automatic Calibration in Pure Water

A typical setup for automatic calibration in a boiler water sampling system is shown in Figure 4-6. The solenoid valve and connections must be positively airtight to prevent leakage and erroneous measurements. The solenoid valve is wired to the normally open contacts of the dedicated relay (input programmed for PRB OUT) and appropriate power. When automatic calibration is initiated, the following sequence occurs:

1. HOLD is activated
2. PRB OUT relay is activated
3. Calibration waits for stability and stores calibration data (or times out & retains existing data)
4. PRB OUT relay is deactivated
5. Delay occurs for resume time interval, then HOLD is deactivated-normal operation resumes.

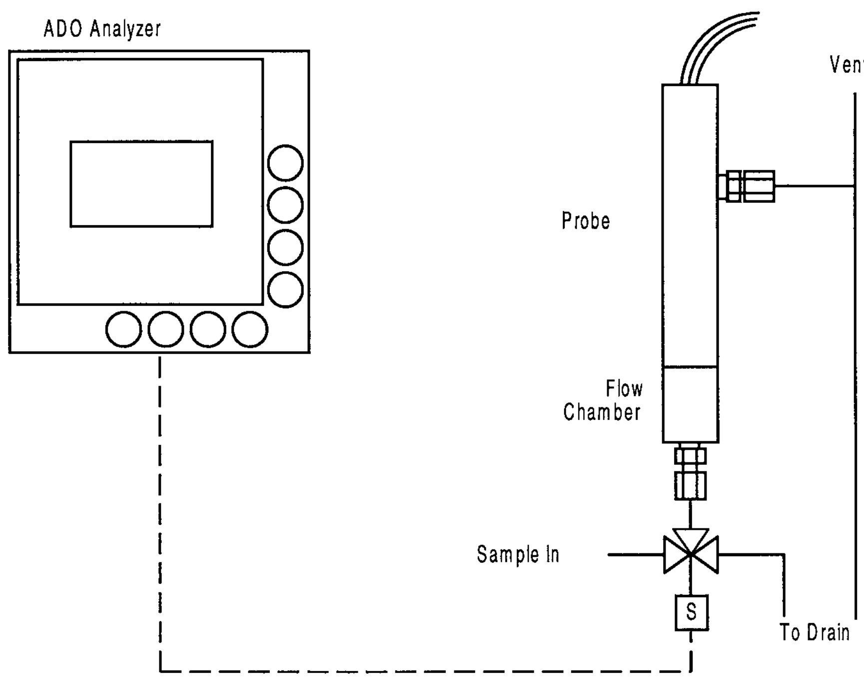


Figure J-1 Automatic Calibration Scheme for Pure Water

Appendix K - Automatic Cleaning And Calibration in Wastewater

The Honeywell Series 7020 Dissolved Oxygen Analyzer has unique capabilities to provide timing, sequencing logic and relay activation for unattended automatic cleaning and/or calibration. The particular automatic maintenance function desired, cleaning and/or calibration, and the frequency of each, is user configurable. The configured sequence can be initiated by the internal clock or by an external contact closure connected to DI1, as well as by the >] button on the front of the analyzer.

Relays must be dedicated for probe removal (PRB OUT) and cleaning and calibration (CLN/CAL) from the RELAY INPUT menu. The AUTO CAL/AUTO CLEAN menu contains the sequence timing settings. In operation, the full cleaning and calibration sequence is:

1. HOLD is activated
2. PRB OUT and CLN/CAL relays are activated for clean time duration
3. CLN/CAL relay is deactivated
4. Calibration waits for stability and stores calibration data (or times out and retains existing data)
5. PRB OUT relay is deactivated
6. Delay occurs for resume time interval, then HOLD is deactivated-normal operation resumes

[For cleaning only or calibration only, only the PRB OUT relay is used and either the calibration step 4 or the clean time step 2 are omitted, respectively.]

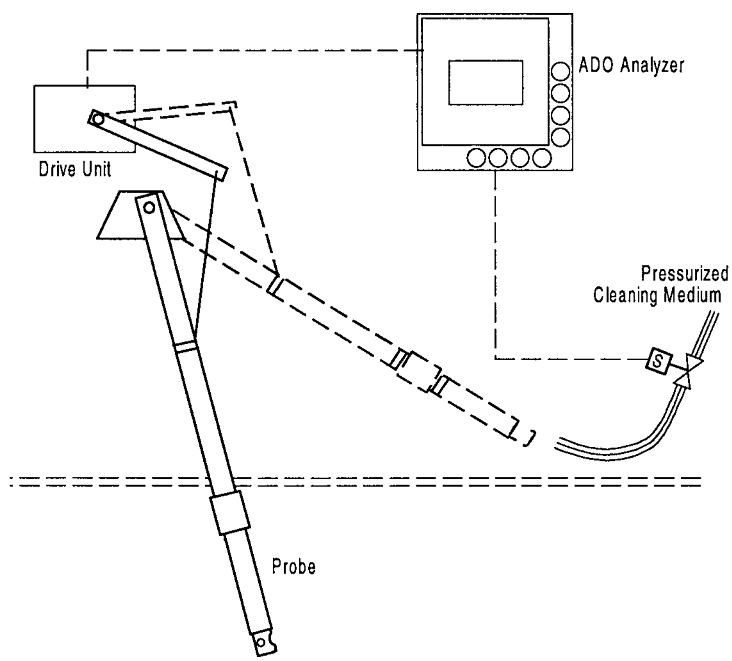


Figure K-1 Automatic Cleaning and Calibration Scheme for Wastewater