Mallard CONTROL

Installation, Operation, and Maintenance Instructions

MODEL 3200 / 3201

March 2002

CONTENTS

1.0 GENERAL

1.1 Model Number Information

Sample Model Number: 3200 - 20 MS 0 – S RD B - S S

END CONNECTION SIZE	CODE
1.50"	15
2.00"	20
2.50"	25
3.00"	30
4.00"	40
6.00"	60
8.00"	80

END CONNECTION TYPE	CODE
Screwed MNPT	MS
Grooved	GR
Butt-Weld, Sch. 40	B4
Butt-Weld, Sch. 80	B8
Butt-Weld, Sch. 160	B1
Butt-Weld, Sch. XXH	BX
Union Type	UT
Slip-On Flange	SO
Raised Face Flange	RF
Ring Type Joint Flange	RJ
Special - to be specified	SP

PRESSURE RATING	CODE
MNPT (6000 psig)	0
ANSI 150 (275 psig)	1
ANSI 300 (740 psig)	3
ANSI 600 (1480 psig)	6
ANSI 900 (2220 psig)	9
ANSI 1500 (3750 psig)	5
ANSI 2500 (6170 psig)	2
Other	X

MATERIALS OF CONSTRUCTION			CODE
Body	**Shaft**	**Brg. Block**	
1018 / A105 C.S.	303 SST	303 SST	-
1018 / A105 C.S.	316 SST	316 SST	A
1018 / A105 C.S. (NACE)	316 SST	316 SST	N

PILOT	CODE
Snap (Pneumatic On/Off)	S
Throttle (Pneumatic Modulating)	T
SPDT (Electric On/Off; explosion-proof housing)	E
DPDT (Electric On/Off; explosion-proof housing)	D

MOUNTING / CONTROLLER ACTION	CODE
Left Hand / Direct	LD
Left Hand / Reverse	LR
Right Hand / Direct	RD
Right Hand / Reverse	RR

SEAL MATERIAL	CODE
Buna-N	B
Viton	V
Special - to be specified	X

GAUGE TYPE	CODE
Brass Internals (standard)	S
316 SST Internals	3

CONTROLLER CASE	CODE
Standard	S
Piped Exhaust	P
Marine Service	M
Marine Service with Piped Exhaust	N

1.2 Specifications

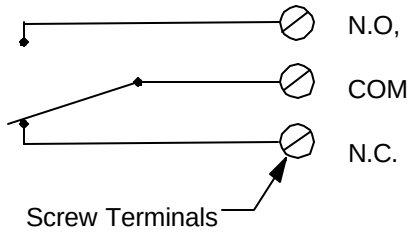
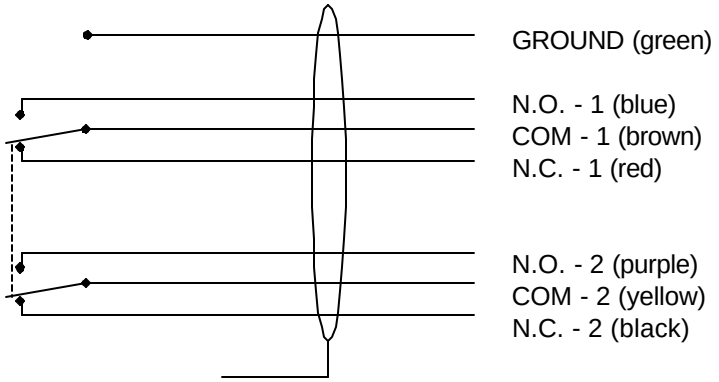
1.2.1 Pneumatic Pilot

Output	Snap (On/Off)	Throttle (Modulating)
	0-20 / 0-30 psig	3-15 / 6-30 psig
Supply Pressure Requirements	20-30 psig (min)	35-40 psig (min)
Liquid Specific Gravity	Top Level: 0.35 to 2.0 Interface Level: 0.035 min. differential	
Pilot Capacity	0.282 C_V	0.394 C_V
Proportional Band Adjustment Range	20 to 150%	7 to 55%

1.2.2 Electric Pilot

Contact Rating	Electric Snap, SPDT, Explosion-proof	Electric Snap, DPDT, Explosion-proof
	• 15 amps @ 125, 250, or 480 VAC • 0.5 amps @ 125 VDC • 0.25 amps @ 250 VDC	• 10 amps @ 125, 250, or 480 VAC • 0.3 amps @ 125 VDC • 0.15 amps @ 250 VDC
Enclosure Rating	Class I, Groups C & D, Div. 1 Class I, Group B (optional) Class II, Groups E, F, and G, Div. 1	
Approvals	UL, CSA	
Repeatability	1%	
Linearity	1.75%	
Dead Band	5% of span	
Liquid Specific Gravity	Top Level: 0.35 to 2.0 Interface Level: 0.035 min. differential	
Proportional Band Range	7 to 55%	20 to 150%

1.2.3 Electric Pilot Wiring

Single Pole – Double Throw	
Double Pole – Double Throw	

1.2.4 Operating Temperature Limits

Body Material	Seals	Displacer Material	Temperature Limits	
			°F	°C
C.S.	Buna	PVC	-20° to 140°	-29° to 60°
C.S.	Buna	Acrylic	-20° to 180°	-29° to 82°
C.S.	Buna	316 SST	-20° to 180°	-29° to 82°
C.S.	Viton	PVC	-20° to 140°	-29° to 60°
C.S.	Viton	Acrylic	-20° to 200°	-29° to 93°
C.S.	Viton	316 SST	-20° to 400°	-29° to 204°

1.2.5 Displacer Pressure Ratings

Material	Maximum Pressure	
	Psig	Bar
PVC	6170	426
Acrylic	6170	426
316 SST	2000 @ 180°F[1] 1595 @ 400°F	138 @ 82°C[1] 110 @ 204°C

1. 2000 psig pressure rating is based @ 180°F (82°C). The maximum pressure rating @ 400°F (204°C) is 1595 psig (110 bar). For applications requiring higher pressure ratings for SST displacers @ 400°F (204°C), consult Factory or your local Mallard Representative.

1.2.6 Materials of Construction / Temperature Rating

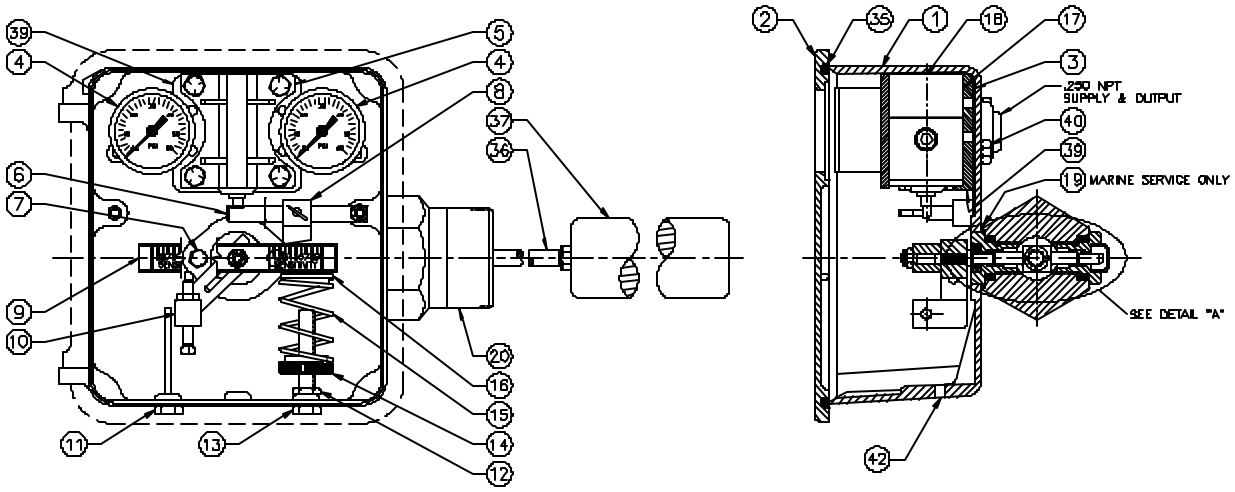
Part	Material	Wetted Part Temperature Rating
Body	Screwed or butt-weld: 1018 steel Flanged: 1018 / A105 steel	-20 to 600°F
Case & Cover	Anodized Die Cast Aluminum	N/A
Pilot Body	Anodized Aluminum	N/A
Pilot Gaskets / Diaphragm	Buna-N Viton (optional)	-20 to 180°F -20 to 400°F
Pilot Internal Valving	303 SST	N/A
Shaft	303 SST 316 SST (optional)	-70 to 600°F -70 to 600°F
Bearing Blocks	303 SST 316 SST (optional)	-70 to 600°F -70 to 600°F
Bearings	440C SST	-70 to 600°F
Seals	Buna-N Viton (optional)	-20 to 180°F -20 to 400°F
Displacer	PVC Acrylic (optional) 316 SST (optional for NACE)	-20 to 140°F -20 to 200°F -70 to 600°F
Displacer Arm	302 SST	-70 to 600°F
Vertical Hanger (Swivel)	316 SST	-70 to 600°F
Vertical Displacer Extension Chain	302 SST	-70 to 600°F
Gauges	Bronze 316 SST (optional) 316 SST liquid-filled (optional)	N/A
Torque Bar	Aluminum 303 SST (Marine option)	N/A
Flapper Bar	303 SST	N/A
Fulcrum	Nylon	N/A
Spring	SST	N/A
Spring Adjusting Knob	Aluminum 303 SST (Marine option)	N/A

1.2.7 Minimum Allowable Fluid Specific Gravity

Top Level Control					Interface Differential Detection				
Pilot	Horizontal Displacer		Vertical Displacer		Pilot	Horizontal Displacer		Vertical Displacer	
	Std.[1]	Special[3]	Std.[2]	Special[3]		Std.[1]	Special[3]	Std.[2]	Special[3]
Snap	0.28	0.10	0.21	0.10	Snap	0.28	0.030	0.21	0.050
Throttle	0.56	0.20	0.42	0.20	Throttle	0.56	0.060	0.42	0.100

1. Based upon 1.88" Dia. X 12" Lg. displacer with 12.50" Lg. displacer Arm.
2. Based upon 1.88" Dia. X 12" Lg. displacer with 15.00" Lg. displacer Arm.
3. Special displacer and displacer arm configurations required - consult Factory or your local Mallard Representative.

1.3 Model 3200 Parts List



LEFT – HAND MOUNTING SHOWN

ITEM	DESCRIPTION	MALLARD PART NO.	QTY	MAT'L
1	Case Ass'y (Electric) Case Ass'y w/o Manifold (Pneumatic) Case Ass'y w/Manifold (Pneumatic)	60010 60243 60012	1	ALUM
2	Door	60024	1	ALUM
3	Manifold / Case Gasket	60198 60189	1	Buna-N Viton
4	Gauge (Output & Supply), 0-30 psi Gauge (Output & Supply), 0-60 psi Gauge (Output & Supply), 0-100 psi	60016 60245 60250	2	Bronze
5	Clamp Kit, Clamp Hex Cap Screw, .250-20 X 2.00"	60050 60032 60028	1 1 4	ALUM SST
6	Flapper Bar Kit, Flapper Bar OR Flapper Bar (Electric) Lock Nut, 10-32 Retaining Ring	60052 60014 60015 60026 60030	1 1 1	303 SST 303 SST SST SST
7	Hex Cap Screw .25 - 20 x .50	60096	2	SST
8	Fulcrum Kit: Fulcrum Thumb Screw, 10-32	60054 60036 60018	1 1	Nylon SST
9	Torque Bar Kit, Standard: Torque Bar Lock Nut, 10-32 Sensitivity Scale	60058 60070 60026 60074	1 1 1	ALUM SST Vinyl
10	Level Adjustment Bar Kit Level Adjusting Bar Level Adjusting Screw, 250-28 Hex Jam Nut, .250-28 Hex Cap Screw, 250-28 X .760"	60060 60048 60052 60050 60046	1 1 1 2	ALUM SST SST SST
11	Hex Cap Screw, 375-24 X .50"	60088	1	SST
12	Hex Jam Nut, .375-24	60090	1	SST
13	Stud, 375-24 X 2.12"	60094	1	SST
14	Lower Spring Retainer	60068	1	ALUM
15	Spring, Medium Duty (none) Spring, Light Duty (green) Spring, Heavy Duty (yellow) Spring, X-Heavy Duty (red)	60040 60038 60042 60044	1	316 SST 316 SST 316 SST 316 SST

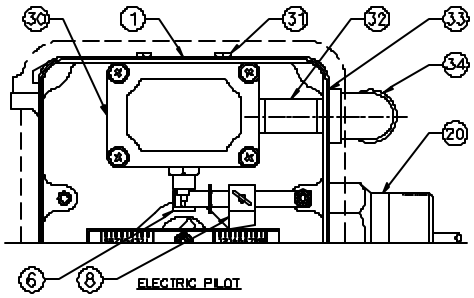
ITEM	DESCRIPTION	MALLARD PART NO	QTY	MAT'L
16	Upper Spring Retainer	60064	1	ALUM
17	Manifold / Pilot Gasket	60034 60035	1	Buna-N Viton
18	Snap Pilot Throttle Pilot	60188 60188	1	
20	Body	See Table	1	1018 CS
21	Spacer	60062	1	303 SST
22	Flat Washer	60092	1	SST
23	Shaft	60084 60085	1	303 SST ◊316 SST
* 24	Body / Case O-Ring	60086	1	Buna-N
25	Block Bearing	60058 60059	1	303 SST ◊316 SST
* 26	Block Bearing O-Ring	60078 60080	2	Buna-N ◊Viton
◊ 27	Back-Up Ring	60076	2	TFE
* 28	Shaft O-Ring	60082 60084	2	Buna-N ◊Viton
29	Swivel	60100	1	SST
30	Switch, Ex-Proof, DPDT Switch, Ex-Proof, SPDT	60238 60240	1	EXD-Q EX-Q
31	Hex Cap Screw, 10-32 X 0.38"	60242	2	SST
32	.500" x 2.50" Pipe Nipple	60244	1	CST/PLTD
33	O-Ring	60078	1	Buna-N
34	Pipe Elbow, .50" NPT	60246	1	N L/PLTD
35	Door Gasket	60056	1	Neoprene
† 36	Displacer Arm, HORIZONTAL (12.5") Displacer Arm, VERTICAL (14.0")	60178 60180	1	304 SST 304 SST
TT37	Displacer, 1.88" x 12.00" Displacer, 2.00" x 14.00" Displacer, 1.88" x 12.00" Displacer, 2.00" x 14.00" Displacer, 1.88" x 12.00"	60184 60186 60188 60170 60172	1	PVC PVC Acrylic Acrylic SST
38	Displacer Extension Kit	60098	1	SST
39	Manifold	60264	1	Alum
40	Hex Screw, .250-28 x 0.625"	60250	6	SST
41	Block Bearing (capped)	60061 60063	1	303 SST ◊316 SST
42	Screen	10014	1	SST

* INCLUDED IN SOFT-GOODS KITS

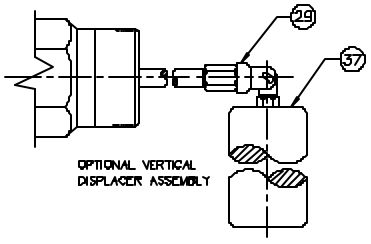
† DISPLACER ARMS ARE SIZED FOR SPECIFIC APPLICATIONS. SPECIFY EXACT LENGTH WHEN RE-ORDERING.

TT SPECIAL DISPLACER SIZES AND CONFIGURATIONS ARE AVAILABLE FROM THE FACTORY UPON REQUEST

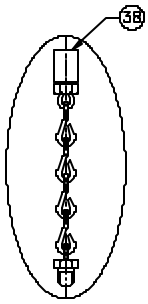
◊ MEETS NACE MR-01-75 SPECIFICATIONS



ELECTRIC PILOT



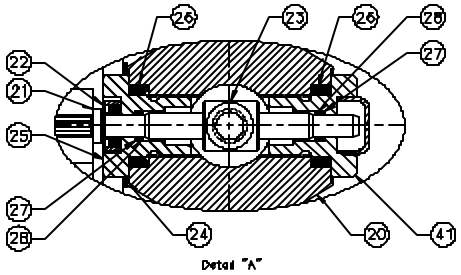
OPTIONAL VERTICAL
DISPLACER ASSEMBLY



OPTIONAL VERTICAL
DISPLACER EXTENSION

TABLE 1

DINN	2.00"	3.00"	4.00"	6.00"
NPT	60106	N/A	N/A	N/A
150# RF	60108	60122	60136	60150
300# RF	60110	60124	60138	60152
600# RF	60112	60126	60140	60154
600# RJ	60114	60128	60142	60156
900# RF	60113	60127	60141	60155
900# RJ	60116	60130	60144	60158
1500# RF	60117	60131	60145	60159
1500# RJ	60118	60132	60146	60160
2500# RJ	60120	60134	60148	60162



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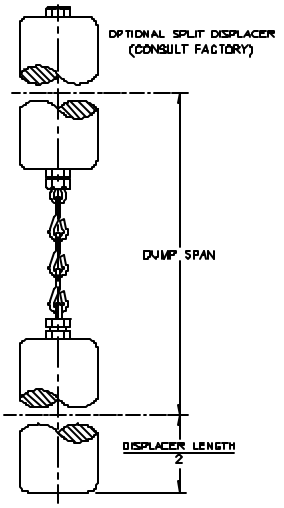


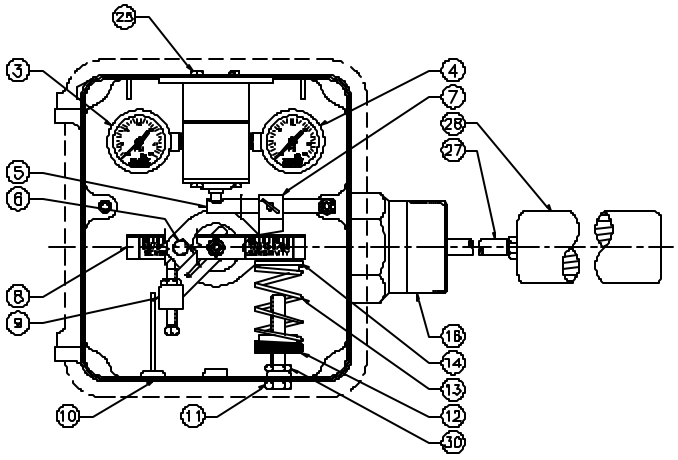
REPAIR KITS

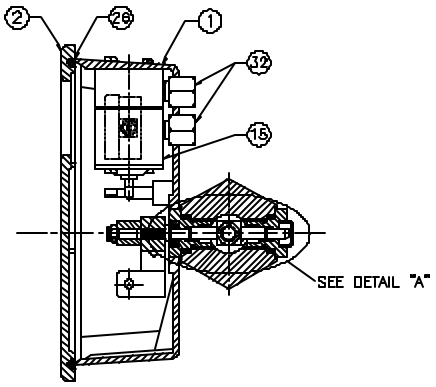
DESCRIPTION	PART NO
SNAP PILOT REPAIR KIT	B0082
THROTTLE PILOT REPAIR KIT	B0084
SOFT-GOODS REPAIR KIT, BUNA-N	B0085
SOFT-GOODS REPAIR KIT, VITON	B0088
MARINE INSULATOR KIT	B0070

MARINE OPTION

ITEM	DESCRIPTION	PART NO.	QTY	MAT'L
7	Hex Cap Screw	60095	2	SST
8	Torque Bar Kit, Marine	60056		
	Torque Bar	60072	1	303 SST
	Lock Nut, 10-32	60026	1	SST
	Sensitivity Scale	60074	1	Vinyl
10	Level Adjustment Bar Kit, Marine	60028		
	Level Adjusting Bar	60049	1	SST
	Level Adjusting Screw, .250-28	60052	1	SST
	Hex Jam Nut, .250-28	60060	2	SST
	Hex Cap Screw, 250-28 X 750"	60046	2	SST
14	Lower Spring Retainer, Marine Service	60084	1	303 SST
19	Insulator Gasket	60236	1	Phenolic

1.4 Model 3201 Parts List





ITEM	DESCRIPTION	MALLARD PART NO.	QTY	MAT'L
1	Case Ass'y 3201	60001	1	ALUM
2	Door	60024	1	ALUM
3	Gauge (Supply), 0-30 psi Gauge (Supply), 0-60 psi	60022 60340	1	Bronze
4	Gauge (Output), 0-30 psi Gauge (Output), 0-60 psi	60020 60341	1	Bronze
5	Flapper Bar Kit Flapper Bar Lock Nut, 10-32 Retaining Ring	60052 60014 60026 60030	1 1 1	303 SST SST SST
6	Hex Cap Screw	60008	2	SST
7	Fulcrum Kit. Fulcrum Thumb Screw, 10-32	60054 60036 60018	1 1	Nylon SST
8	Torque Bar Kit, Standard Torque Bar Lock Nut, 10-32 Sensitivity Scale	60058 60070 60026 60074	1 1 1	ALUM SST Vinyl
9	Level Adjustment Bar Kit. Level Adjusting Bar Level Adjusting Screw, 250-28 Hex Jam Nut, .250-28 Hex Cap Screw, .250-28 X .750"	60060 60046 60002 60050 60048	1 1 1 2	ALUM SST SST SST
10	Screen	10014	1	SST
11	Stud, .375-24 X 2.12"	60004	1	SST
12	Lower Spring Retainer	60068	1	ALUM
13	Spring, Medium Duty (none) Spring, Light Duty (green) Spring, Heavy Duty (yellow) Spring, X-Heavy Duty (red)	60040 60038 60042 60044	1	316 SST 316 SST 316 SST 316 SST

ITEM	DESCRIPTION	MALLARD PART NO.	QTY	MAT'L
14	Upper Spring Retainer	60054	1	ALUM
15	Pilot	See Table	1	
16	Body	See Table	1	1018 CS
17	Spacer	60062	1	303 SST
18	Flat Washer	60062	1	SST
19	Shaft	60064 60065	1	303 SST ◊316 SST
20	Block Bearing	60058 60059	1	303 SST ◊316 SST
* 21	Block Bearing O-Ring	60078 60080	2	Buna-N ◊ Viton
* 22	Back-Up Ring	60076	2	TFE
* 23	Shaft O-Ring	60082 60084	2	Buna-N ◊ Viton
24	Swivel	60100	1	SST
25	Hex Cap Screw, 10-32 X 0.38	60242	2	SST
26	Door Gasket	60056	1	Neoprene
† 27	Displacer Arm, HORIZONTAL (12.5") Displacer Arm, VERTICAL (15.0")	60178 60180	1	304 SST 304 SST
†† 28	Displacer, 1.88" x 12.00" Displacer, 2.00" x 14.00" Displacer, 1.88" x 12.00" Displacer, 2.00" x 14.00" Displacer, 1.66" x 12.00"	60164 60166 60168 60170 60172	1	PVC PVC Acrylic Acrylic SST
29	Displacer Extension Kit	60098	1	SST
30	Hex Nut, .375-24	60090	1	B&T
31	Block Bearing (capped)	60061 60063	1	303 SST ◊316 SST
32	BRASS FITTING	60194	2	BRASS

* INCLUDED IN SOFT-GOODS KITS

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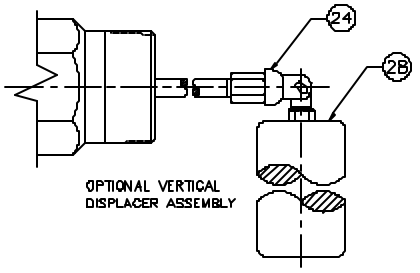
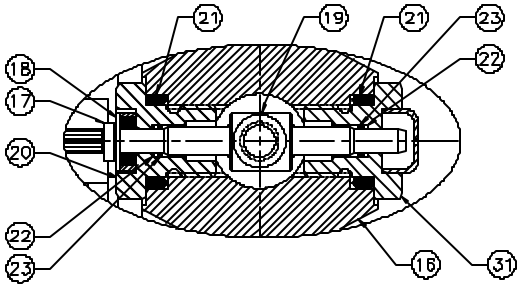
◊ MEETS NACE MR-01-75 SPECIFICATIONS



OPTIONAL VERTICAL
DISPLACER ASSEMBLY



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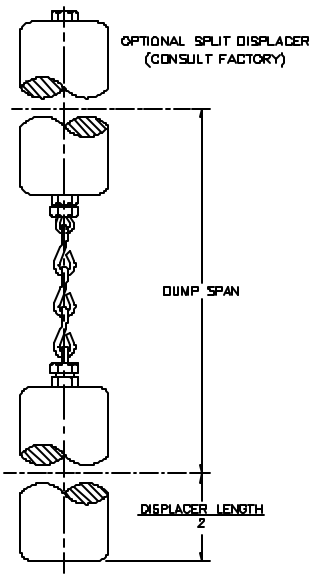


TABLE 1

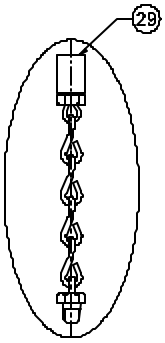
CONN.	2.00"	3.00"	4.00"	6.00"
NPT	60105	N/A	N/A	N/A
150# RF	60108	60122	60136	60150
300# RF	60110	60124	60138	60152
600# RF	60112	60126	60140	60154
600# RJ	60114	60128	60142	60156
900# RF	60113	60127	60141	60155
900# RJ	60116	60130	60144	60158
1500# RF	60117	60131	60145	60159
1500# RJ	60118	60132	60146	60160
2500# RJ	60120	60134	60148	60162

REPAIR KITS

DESCRIPTION	PART NO.
SNAP PILOT REPAIR KIT	80062
THROTTLE PILOT REPAIR KIT	80064
SOFT-GOODS REPAIR KIT, BUNA-N	80065
SOFT-GOODS REPAIR KIT, VITON	80068

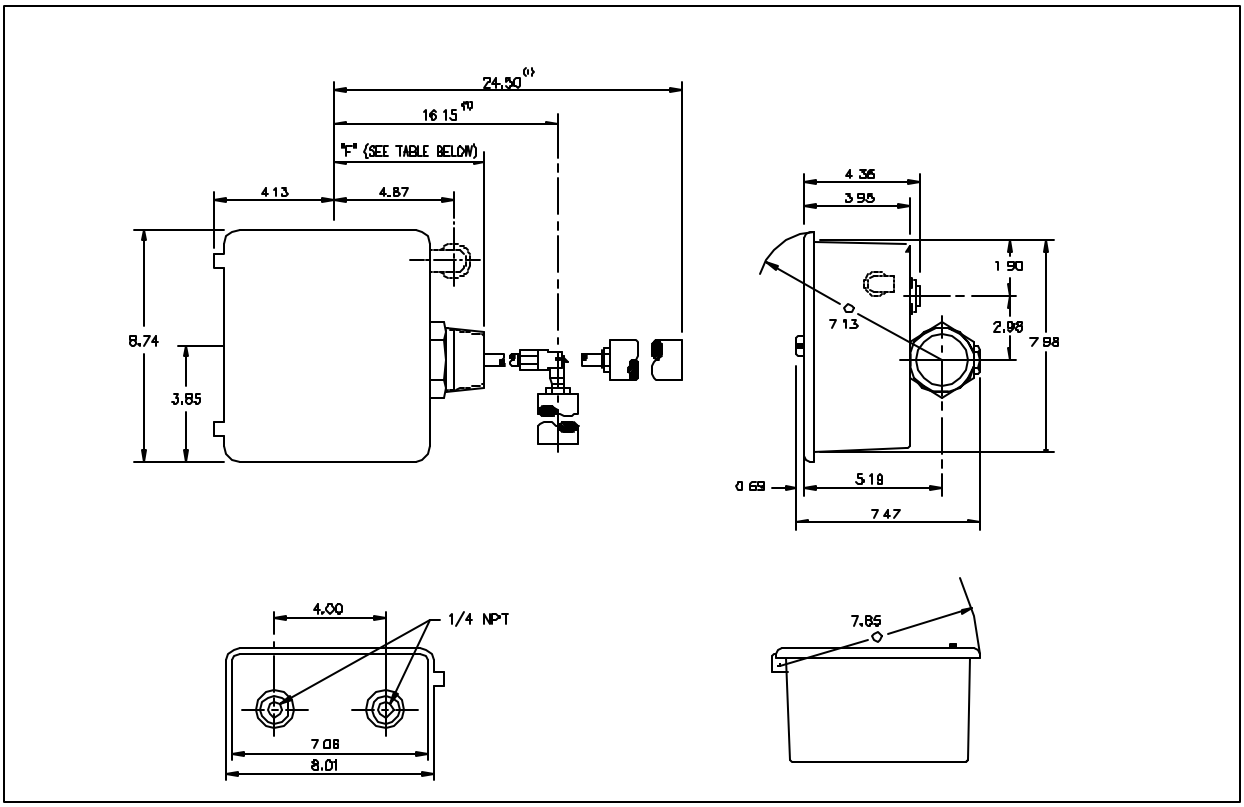
PILOTS

DESCRIPTION	PART NO
SNAP	60186
THROTTLE	60188
SNAP WITH GAUGES/FITTINGS	85016
THROTTLE WITH GAUGES/FITTINGS	85018



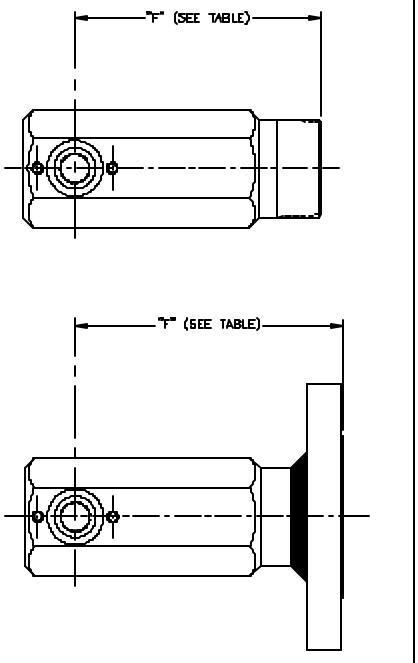
OPTIONAL VERTICAL
DISPLACER EXTENSION

1.5 Dimensions



1. 16.15" dimension based upon standard vertical service configuration of 15" arm with a 12" lg. displacer. Other arm lengths and displacer sizes are available upon request. 24.50" dimension based upon standard horizontal service configuration of 12.50" arm with a 12" lg. displacer. Other arm lengths and displacer sizes are available upon request.

Dimension "F"					
Vessel Connection	Body Size				
	2.00	3.00	4.00	6.00	8.00
Butt-Weld Sch. 40	6.00	-	-	-	-
Sch. 80	6.00	-	-	-	-
Sch. 160	6.00	-	-	-	-
Sch. XXH	6.00	-	-	-	-
Slip-on	6.00	-	-	-	-
Screwed Male NPT	6.00	-	-	-	-
Grooved	6.00	6.88	6.94	6.04	*
150# RF	6.50	6.56	6.56	6.50	*
150# RTJ	6.69	6.88	6.88	6.69	*
300# RF	6.81	6.75	6.88	6.94	*
300# RTJ	7.06	7.00	7.25	7.19	*
600# RF	7.19	7.12	7.50	7.62	*
600# RTJ	7.25	7.31	7.56	7.69	*
900# RF	8.00	9.63	10.13	*	*
900# RTJ	8.06	9.69	10.19	*	*
1500# RF	8.00	10.25	10.63	*	*
1500# RTJ	8.06	10.31	10.69	*	*
2500# RF	8.50	11.06	11.75	*	*
2500# RTJ	8.56	11.13	11.81	*	*



* Consult Factory.

2.0 INSTALLATION

2.1 Assembly

When you receive your new Mallard model 3200 Level Controller, you should find the following pieces in the shipping container:

- Controller
- Displacer
- Displacer Arm

Other miscellaneous pieces may be included as well, depending on the specifications for your application.

2.2 Start-up

a. Rock the torque bar back and forth by hand to verify that the displacer arm is not resting against the vessel nozzle. The displacer arm should be centered in the nozzle. Adjust the balance spring compression with the adjusting knob to position the displacer arm.

To raise the displacer arm, turn the adjusting knob CLOCKWISE (increasing spring compression). To lower the displacer arm, turn the adjusting knob COUNTERCLOCKWISE (decreasing spring compression).

b. Adjust controller proportional band (sensitivity) by sliding the fulcrum along the flapper bar. To decrease the proportional band (increase controller sensitivity), loosen the thumb screw and slide the fulcrum away from the pivot point (toward the pilot). Tighten the thumb screw when finished.

To increase the proportional band (decrease controller sensitivity), loosen the thumb screw and slide the fulcrum toward the pivot point (away from the pilot). Tighten the thumb screw when finished.

3.0 OPERATION

3.1 Theory of Operation

The operation of the model 3200 Liquid Level Controller is based upon the “Force Balance Principle”, illustrated in Figure 1. The weight of a displacer-type level sensing element produces a force which is applied to one side of the Torque Bar through a series of shafts and levers. This force is balanced by the opposing force of a compressed spring on the other side of the Torque Bar. As the level rises, the increased immersion of the displacer in the liquid causes the relative weight of the displacer to decrease, due to the buoyancy force being produced. This, in turn, results in a decrease in force applied to the Torque Bar. The Torque Bar then rotates until the forces are again balanced. Torque Bar rotation is detected by the pilot through a fulcrum mounted on a lever (Flapper Bar) to affect the desired controller output. The output signal can be a pneumatic on/off signal by using the snap pilot, a pneumatic modulating signal by using the throttle pilot, or it can be an electrical SPDT or DPDT output signal by using an electric limit switch.

Figure 1

3.2 Level Adjustment

As mentioned above, the balance spring is compressed to a point where the force applied from the spring to the torque bar equals the opposing force caused by the weight of the displacer. The liquid level control point is changed by adjusting the balance spring compression with the adjusting knob, as shown in Figure 2.

To INCREASE the liquid level control point, DECREASE BALANCE SPRING COMPRESSION. An increase in liquid level causes an decrease in the relative weight of the displacer, thereby requiring less opposing force to achieve balance.

To DECREASE the liquid level control point, INCREASE BALANCE SPRING COMPRESSION. A decrease in liquid level causes an increase in the relative weight of the displacer, thereby requiring more opposing force to achieve balance.

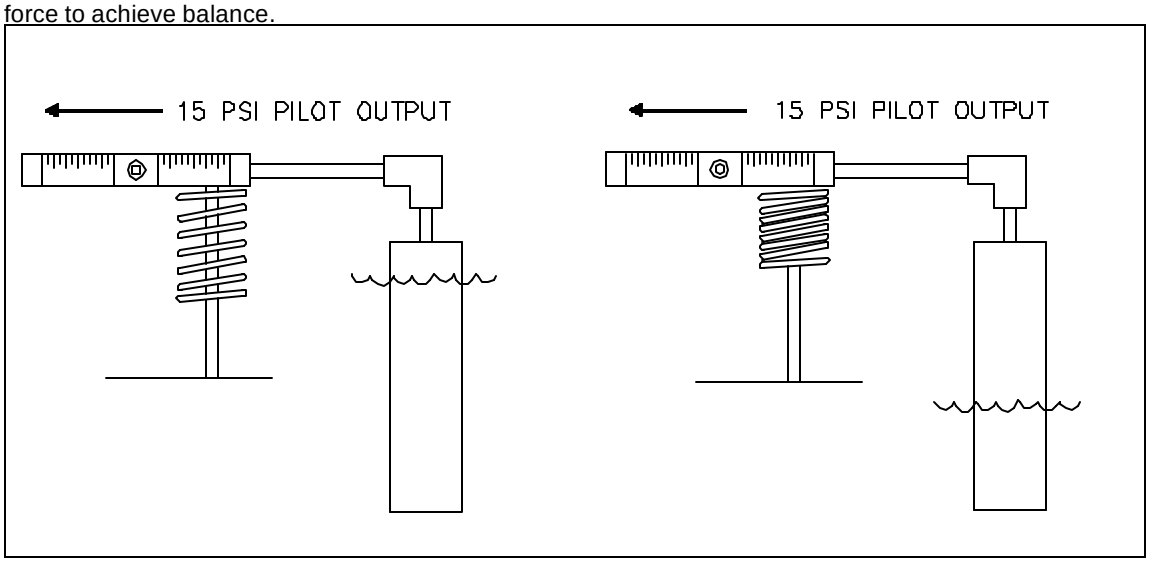


Figure 2. Level Adjustment

3.2.1 Liquid Interface

Initial controller setup for interface level applications is as follows:

1. Position fulcrum approximately ¼" from the torque bar snap ring, and slowly reduce spring compression to allow the upper fluid to rise and submerge the displacer.
2. Once submerged in the upper fluid, slowly increase spring compression until an output signal increase is obtained, then slowly remove compression again until the output signal returns to zero. At this point, the controller is ready to control the lower fluid level.

3.3 Proportional Band

Proportional band is the ratio of used displacer length to the total length of the displacer. "Used displacer length" is defined as the change in input (level) that affects a corresponding 100% change in controller output (control valve position). For example, if a change in level of four inches causes the controller output to change from 0% to 100%, and the total displacer length is 12", then the proportional band is 33%. By changing the proportional band to 50%, the change in level to affect the same 100% change in output will then be six inches. Summarily, increasing proportional band (from 33% to 50% in example) is synonymous with decreasing controller sensitivity(4" to 6" change in example), and vice versa.

3.3.1 Proportional Band Adjustment

Figure 3 illustrates the controller's proportional band adjustment.

To decrease the proportional band (increase controller sensitivity), loosen the thumb screw and slide the fulcrum away from the pivot point (toward the pilot). Tighten the thumb screw when finished.

To increase the proportional band (decrease controller sensitivity), loosen the thumb screw and slide the fulcrum toward the pivot point (away from the pilot). Tighten the thumb screw when finished.

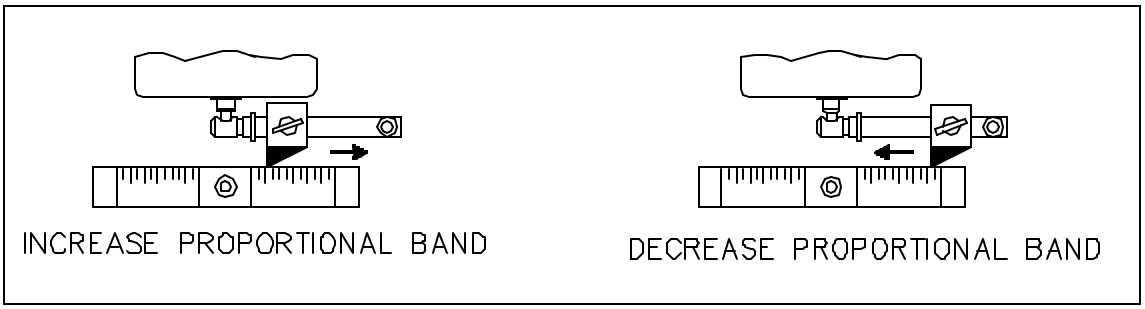


Figure 3. Proportional Band Adjustment

3.4 Controller Mounting

The model 3200 Liquid Level Controller can be set up as Right Hand Mount or Left Hand Mount. The orientation of the level controller mounted to the vessel, while facing the front of the controller, determines the mounting style, illustrated in Figure 5. If the controller is to be mounted on the right side of the vessel, then it is considered “Right Hand”. If the controller is to be mounted on the left side of the vessel, then it is considered “Left Hand”. The mounting orientation can be easily reversed in the field.

3.4.1 Mounting Orientation Conversion

Figure 4 identifies the various controller parts referenced in this section.

Disassembly:

1. Remove balance spring compression with the adjusting knob.
2. Remove the balance spring and upper spring retainer from the controller.
3. Remove the spring stud bolt and lower spring retainer from the controller.
4. Remove the lock nut (7/16” wrench) which holds the torque bar in place, and remove the torque bar from the controller.
5. Remove the lock nut (7/16” wrench) which holds the flapper bar in place, and remove the flapper bar from the controller.
6. Loosen the two hex head cap screws (1/2” box-end wrench) that secure the level adjusting bar to the controller shaft. When the screws are sufficiently loosened so that the level adjusting bar is not compressed onto the shaft, slide the level adjusting bar off of the shaft, and remove the spacer from the shaft, as well.
7. Remove the two hex head cap screws that attach the controller case to the controller body.
8. Remove the case from the controller body.

Conversion and Re-Assembly:

1. Position controller case on controller body to achieve the desired mounting configuration, and install the two hex head cap screws into the case mounting holes. Tighten to 6 ft-lbs of torque.
2. Slide spacer on the shaft, then slide the level adjusting bar in place on the shaft. Make sure that the level adjusting screw is positioned such that there is an equal number of threads exposed above and below the level adjusting bar.
3. Snug up the two hex head cap screws on the level adjusting bar. Do not fully tighten yet.
4. Slide the torque bar onto the shaft temporarily to position the level adjusting bar. Position the level adjusting bar so that the torque bar is parallel with the displacer arm when the round tip of the level adjusting screw is touching the torque bar. Remove the torque bar while holding the level adjusting bar in position, then tighten the cap screws to firmly secure the level adjusting bar in place. Tighten the screw nearest the slotted end of the level adjusting bar first.

5. Slide the torque bar back onto the shaft. Make sure that the countersunk hole for the balance spring upper retainer is facing down. Install the lock nut on the end of the shaft to hold the torque bar in place.
6. Slide the flapper bar onto the pivot pin (see Section 3.5, Controller Action, to determine the proper installation of the flapper bar for your application) and install the retaining lock nut. The flapper bar must be free to pivot. Therefore, do not apply an excessive amount of torque to the lock nut.
7. Install balance spring stud bolt and lower spring retainer. For left-hand mounting, the stud bolt is installed on the right side. For right-hand mounting, the stud bolt is installed on the left side.
8. Install the balance spring and the upper spring retainer. Engage the upper spring retainer with the countersunk hole in the torque bar.
9. Apply compression to the balance spring with the spring adjusting knob.

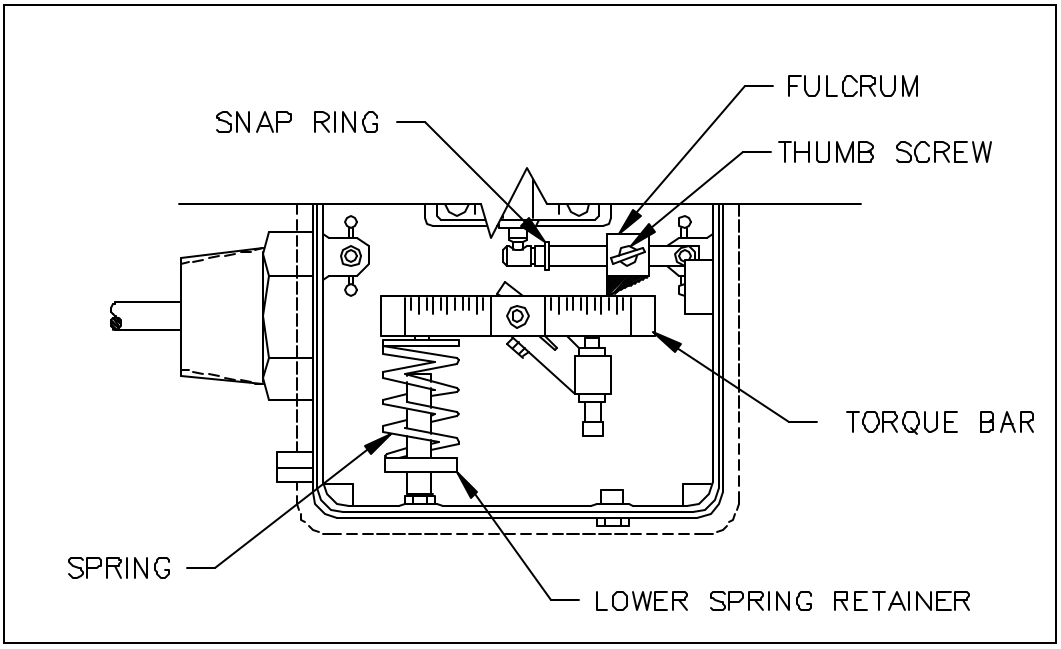


Figure 4. Level Controller Internals

3.5 Controller Action

Controller action is determined by the installation of the flapper bar, as shown in Figure 5. Control is considered “Direct-Acting” when the controller output changes in the same direction as the liquid level. For example, the controller output signal will increase as the liquid level increases, and vice versa. Control is considered “Reverse-Acting” when the controller output changes in the opposite direction as the liquid level. For a direct-acting controller, the flapper bar pivot point is on the same side as the balance spring. For a reverse-acting controller, the flapper bar pivot point is on the opposite side as the balance spring.

3.5.1 Controller Action Conversion

To convert the controller from Direct-Acting to Reverse-Acting, or vice versa, the following procedure should be followed:

1. Relieve balance spring compression with the adjusting knob.
2. Remove pivot pin lock nut, and slide the flapper bar off of the pivot pin.

3. Remove the thumb screw from the fulcrum, and replace the thumb screw into the screw hole on the opposite side of the fulcrum.
4. Connect the flapper bar to the pivot pin on the opposite side of the controller housing.
5. Install the pivot pin lock nut to hold the flapper bar in place.
6. Adjust the balance spring compression with the adjusting knob.

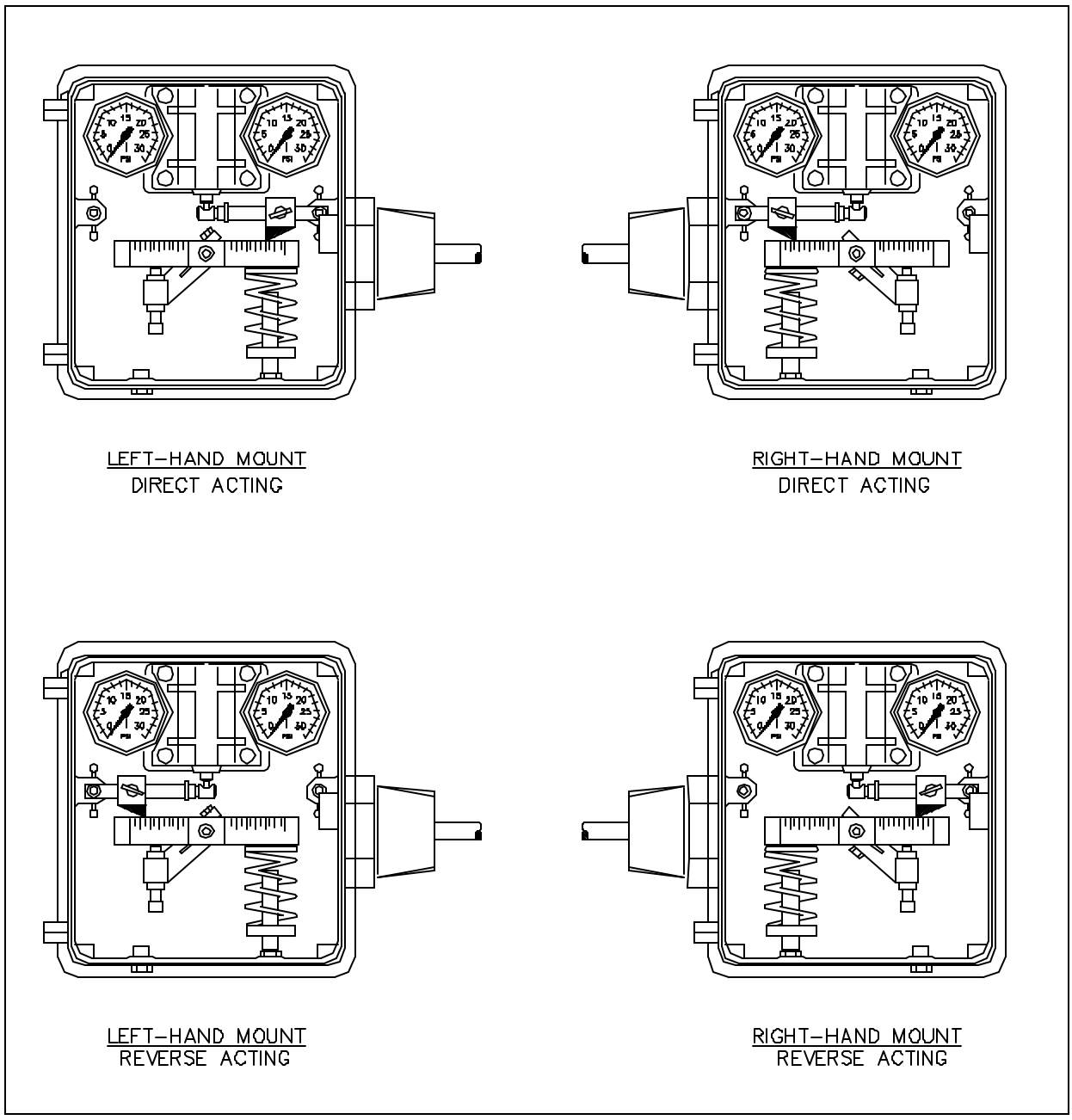
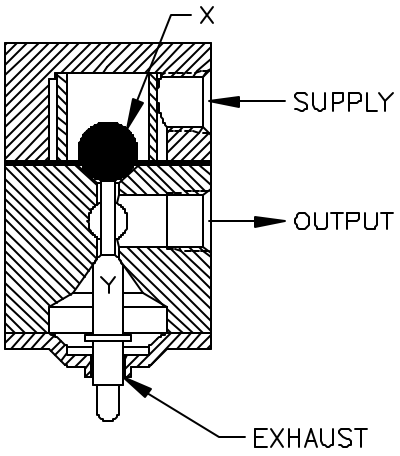


Figure 5. Controller Mounting and Action Configurations

3.6 Snap Pilot Operation

The snap pilot is made up of two valves: one to admit system supply pressure, and one to exhaust system pressure. Ball “X” controls the flow of supply gas into the pilot and is held closed on the pilot seat by force exerted by the supply pressure acting upon the seating area of the ball.

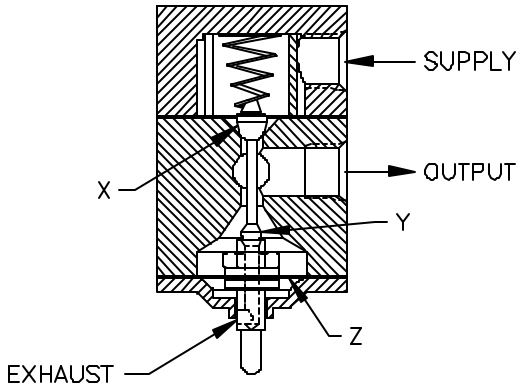


When force transmitted from the flapper bar to the thrust pin “Y” becomes sufficient to overcome the force holding ball “X” seated, ball “X” snaps off the pilot seat allowing supply gas to flow past ball “X” and through the output port of the pilot. The spherical seating end of the thrust pin “Y” seats and closes the exhaust port simultaneously when ball “X” snaps open. The seating area of the thrust pin is smaller than the seating area of ball “X”; therefore, the thrust pin must remain seated against the supply pressure until force on the thrust pin from the flapper bar diminishes.

A simultaneous action occurs as force from the flapper bar on the thrust pin “Y” is removed. When this happens, the supply pressure will unseat the thrust pin and open the exhaust port in the pilot and ball “X” will re-seat and close off the supply port. The difference in seating areas give this pilot its “snap” action.

3.7 Throttle Pilot Operation

The throttle pilot, like the snap pilot, is also made up of two internal valves. In addition, the throttle pilot utilizes a resilient diaphragm “Z” in conjunction with the valves to create a Force Balance Pilot.



The pilot output supply pressure acts upon the diaphragm “Z” so that the diaphragm pushes back with the same force being applied to the thrust pin by the flapper bar, thus the term *Force Balance*.
The throttle pilot functions in a similar manner as the snap pilot except that the output pressure is proportional to the amount of force applied to the lower seat by the flapper bar. An increase in force on the peanut produces a proportionate increase in pilot output pressure.

As forces change on the peanut, the pilot seeks a new balance point by exhausting the supply output at valve “Y” or unseating valve “X” to increase output pressure. Supply gas does not flow while the pilot is in balance.

4.0 MAINTENANCE

4.1 Preventive Maintenance

The model 3200 Level Controller is specifically designed to provide maintenance-free service in the harsh environments found in oil and gas production and transmission facilities, and should last for many years without any special maintenance requirements. Should leakage occur, replace the O-ring seals. Refer to the parts list in Section 1.3 for ordering information on replacement parts and repair kits.

4.2 Troubleshooting

Symptom	Probable Cause	Corrective Action
Direct-Acting[1] controller is producing output signal when liquid level is below(1) the displacer.	a. The balance spring is overly compressed.	a. Remove spring compression with the adjusting knob until the output signal goes to zero. Recheck when the liquid level rises.
	b. The displacer arm is set too high, or the displacer is encountering an obstruction inside the vessel.	b. Check for freedom of movement by rocking the torque bar by hand. If the torque bar will only move in one direction, turn the level adjusting screw to bring the displacer arm down to allow freedom of movement.
	c. Foreign matter has entered the pilot valving and prevented proper seating of the pilot components.	c. Disconnect supply and output tubing. Remove the four screws from the pilot clamp so that the pilot can be extracted. Disassemble the pilot and clean thoroughly. Reassemble the controller and follow the recommended start-up procedures.

1. For Reverse-Acting controllers, the same corrective action will apply, but the symptoms will be reversed.

(continued)

4.2 Troubleshooting (continued)

Symptom	Probable Cause	Corrective Action
Direct-Acting[1] controller is producing no output signal when liquid level is above[(1)] the displacer.	a. The balance spring is under compressed.	a. Increase spring compression with the adjusting knob until an output signal is indicated on the controller output gauge. Output pressure should then go off when fluid level drops. Make further adjustments to spring compression as necessary to affect the desired results.
	b. The displacer arm is set too low, or the displacer is encountering an obstruction inside the vessel.	b. Check for freedom of movement by rocking the torque bar by hand. If the torque bar will only move in one direction, turn the level adjusting screw to bring the displacer arm up to allow freedom of movement.
Control is sluggish and non-repeatable; may fail to either produce output signal or remove output signal.	The displacer or displacer arm is encountering an obstruction (foreign debris, paraffin buildup, etc.) that is inhibiting free movement.	Remove the controller from service and thoroughly clean out the controller body with solvent.
Unstable control of liquid/liquid interface: may lose liquid or may overflow.	Check to ensure that displacer arm is free and that the displacer is not hitting the inside of the vessel. If all is clear, then the displacer is improperly sized.	Obtain exact specific gravities or API gravities of both upper and lower liquids, and contact Mallard for displacer sizing assistance.

1. For Reverse-Acting controllers, the same corrective action will apply, but the symptoms will be reversed.