Mallard CONTROL

Installation, Operation, and Maintenance Instructions

MODEL 3900

March 2002

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1.0 GENERAL

1.1 Model Number Information

Sample Model Number: 3900 - 10 FS – S V RD - S M

PROCESS CONNECTION SIZE	CODE
1”	10
2”	20

PROCESS CONNECTION TYPE	CODE	
FNPT (Screwed)	FS	
Socket Weld	SW	
Butt Weld, Sch. 40	B4	
Butt Weld, Sch. 80	B8	
Butt Weld, Sch. 160	B1	
Flanged	**RF**	**RJ**
ANSI 150	F1	J1
ANSI 300	F3	J3
ANSI 600	F6	J6
ANSI 900	F9	J9

MATERIALS OF CONSTRUCTION			CODE
Cage / Body	**Displacer**	**Shaft / Blk Brg**	
WCC Steel	316 SST	303 SST	–
WCC Steel	316 SST	316 SST	A
WCC Steel (NACE)	Alloy 20	316 SST	N

PILOT	CODE
Pneumatic Snap	S
Electric SPDT, Explosion-Proof	E
Electric DPDT, Explosion-Proof	D

SEAL MATERIAL	CODE
Buna-N	B
Viton	V
Special (specify)	X

MOUNTING ORIENTATION / SWITCH ACTION	CODE
Left Hand / Direct (Open Pneumatic Pilot on Rising Level)	LD
Left Hand / Reverse (Open Pneumatic Pilot on Falling Level)	LR
Left Hand / Electric Pilot	LE
Right Hand / Direct (Open Pneumatic Pilot on Rising Level)	RD
Right Hand / Reverse (Open Pneumatic Pilot on Falling Level)	RR
Right Hand / Electric Pilot	RE

SUPPLY / OUTPUT GAUGES	CODE
Standard Service	S
316 SST	6
316 SST, Liquid-Filled	L

CASE	CODE
Marine Service	M
Marine Service with Piped Exhaust	N

1.2 Specifications

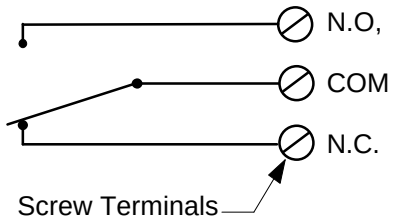
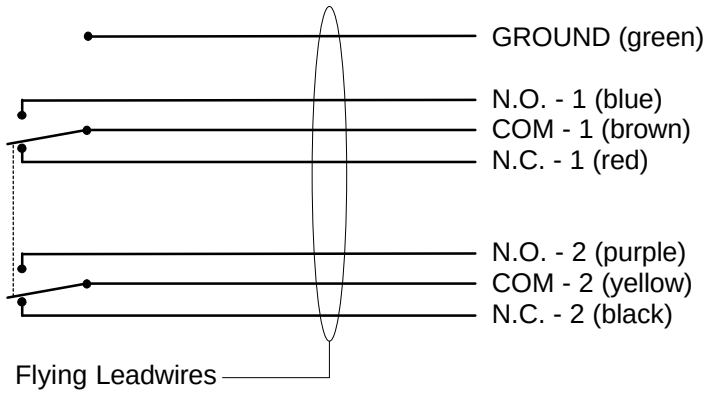
1.2.1 Pneumatic Pilot

Output	0-20 / 0-30 psig
Supply Pressure Requirements	20-30 psig (min)
Minimum Liquid Specific Gravity	0.50
Pilot Capacity	0.282 C_V
Proportional Band Adjustment Range	20 to 150%

1.2.2 Electric Pilot

	Electric Snap, SPDT, Explosion-proof	Electric Snap, DPDT, Explosion-proof
Contact Rating	• 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	
Minimum Liquid Specific Gravity	0.50	0.70
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 Approximate Weight, Pounds (Kg)

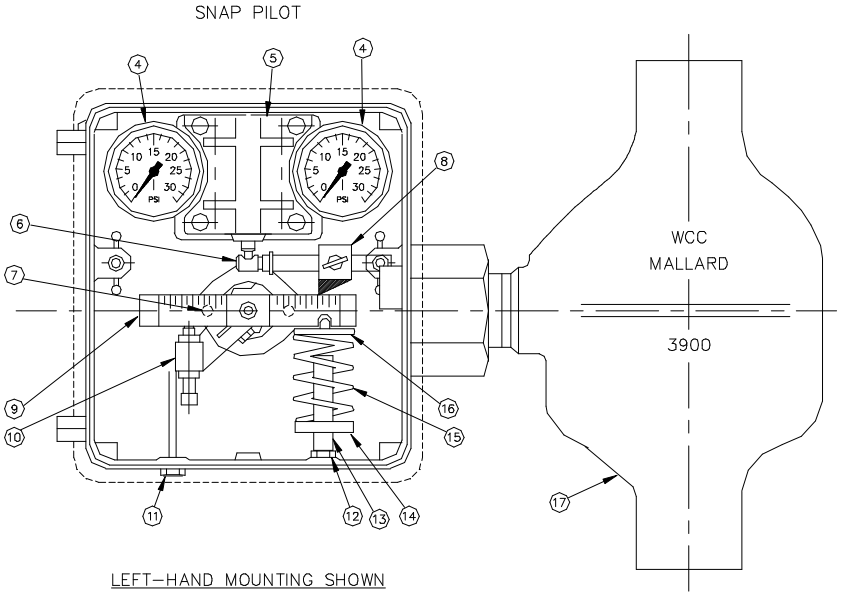
	Process Connection Size			
Connection Type	1.00”		2.00” (1)	
FNPT	47	(20.9)	N/A	N/A
BWE[1]	N/A	N/A	47	(20.9)
SWE[1]	47	(20.9)	N/A	N/A
150# RF[1]	52	(23.6)	59	(26.8)
300# RF[1]	55	(24.9)	63	(28.6)
600# RF[1]	55	(24.9)	67	(30.4)
600# RTJ[1]	55	(24.9)	67	(30.4)
900# RF[1]	64	(29.0)	95	(43.1)
900# RTJ[1]	64	(29.0)	95	(43.1)

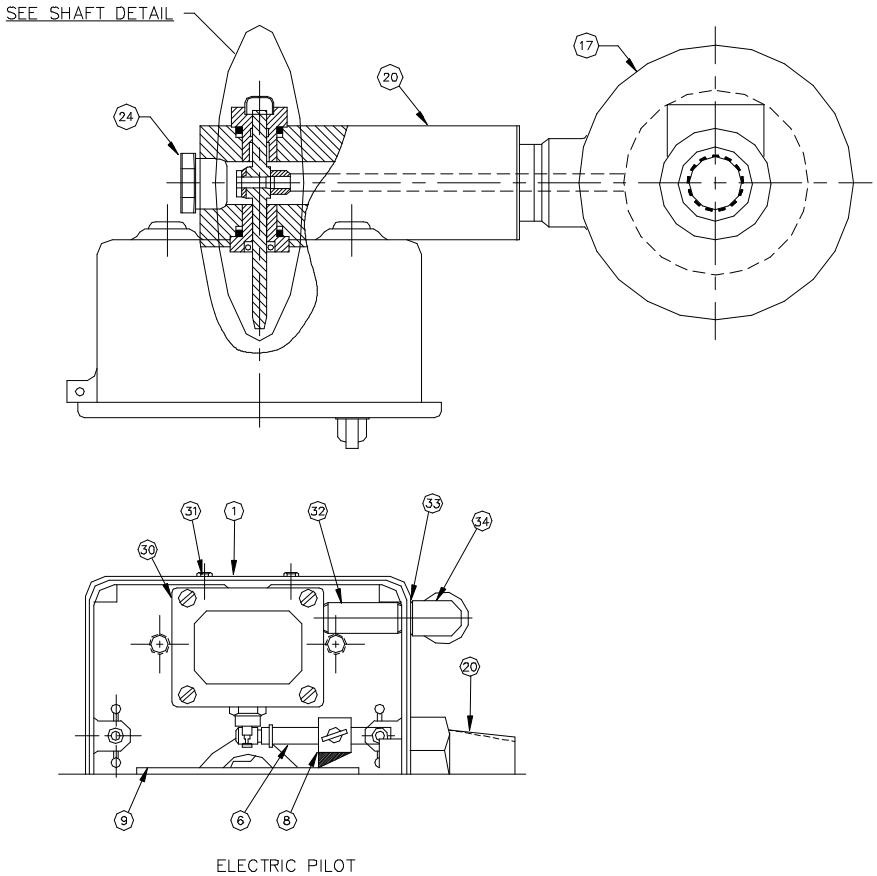
1. Top & Bottom connections only.

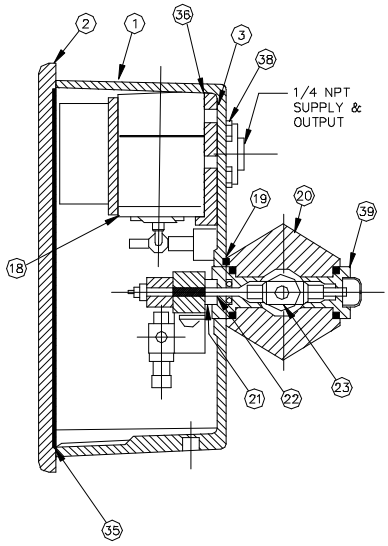
1.2.5 Materials of Construction / Temperature Rating

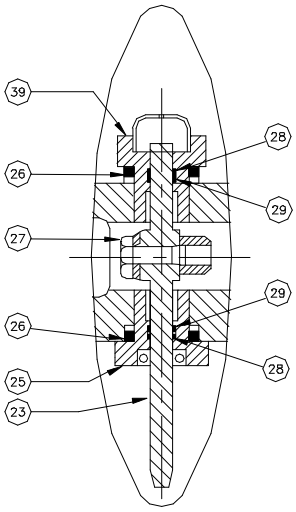
Part	Material	Wetted Part Temperature Rating
Body	1018 steel	-20 to 400°F
Cage	ASTM A216 WCC steel	-20 to 400°F
Case & Cover	Anodized Die Cast Aluminum	N/A
Pilot Body	Anodized Aluminum	N/A
Pilot Gaskets / Diaphragm	Buna-N Viton (optional)	-20 to 180°F -20 to 400°F
Pilot Internal Valving	303 SST	N/A
Shaft	303 SST 316 SST (optional)	-20 to 400°F -20 to 400°F
Bearing Blocks	303 SST 316 SST (optional)	-20 to 400°F -20 to 400°F
Bearings	440C SST	-20 to 400°F
Seals	Buna-N Viton (optional)	-20 to 180°F -20 to 400°F
Displacer	316 SST	-20 to 400°F
Displacer Arm	302 SST	-20 to 400°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

1.3 Parts List









SHAFT DETAIL

ITEM	DESCRIPTION	PART NO.	QTY	MAT'L
1	CASE ASS'Y W/ MANIFOLD (PNEUMATIC PILOT) CASE ASS'Y W/O MANIFOLD (PNEUMATIC PILOT) CASE ASS'Y (ELECTRIC PILOT)	60012 60243 60010	1	ALUM ALUM ALUM
2	COVER	60023	1	ALUM
* 3	MANIFOLD/CASE GASKET MANIFOLD/CASE GASKET	60198 60199	1	BUNA-N VITON
4	GAUGE (OUTPUT & SUPPLY), 0-30 PSI GAUGE (OUTPUT & SUPPLY), 0-60 PSI GAUGE (OUTPUT & SUPPLY), 0-100 PSI	60016 60248 60250	2 2 2	BRONZE BRONZE BRONZE
5	CLAMP KIT: CLAMP HEX CAP SCREW, 1/4-20 X 2"	80050 60032 60028	 1 4	 ALUM SST
6	FLAPPER BAR KIT: FLAPPER BAR LOCK NUT, 10-32 RETAINING RING FLAPPER BAR (ELECTRIC PILOT)	80052 60014 60026 60030 60015	 1 1 1 1	 303 SST SST SST 303 SST
†† 7	HEX CAP SCREW	60097	2	SST
8	FULCRUM KIT: FULCRUM THUMB SCREW, 10-32	80054 60036 60018	 1 1	 NYLON SST
9	TORQUE BAR KIT; MARINE TORQUE BAR LOCK NUT, 10-32 SENSITIVITY SCALE	80056 60072 60026 60074	 1 1 1	 303 SST SST VINYL
10	LEVEL ADJUSTMENT BAR KIT, MARINE: LEVEL ADJUSTING BAR HEX CAP SCREW, 1/4-28 X 3/4" HEX JAM NUT, 1/4-28 LEVEL ADJUSTING SCREW, 1/4-28	80060 60049 60046 60050 60052	 1 2 2 1	 SST SST SST SST
11	HEX CAP SCREW, 3/8-24 X .50"	60088	1	SST
12	HEX JAM NUT, 3/8-24	60090	1	SST
13	STUD, 3/8-24 X 2.12"	60094	1	SST
14	LOWER SPRING RETAINER	60066	1	303 SST
15	SPRING	60038		316 SST
16	UPPER SPRING RETAINER	60054	1	ALUM
** 17	CHAMBER ASSEMBLY W/DISPLACER CHAMBER ASSEMBLY W/DISPLACER	60252 60253	1	WCC W/SST ◊WCC W/ALLOY 20
18	SNAP PILOT	60186	1	
†† 19	INSULATOR GASKET	60236	1	PHENOLIC
20	BODY	60256	1	1018 CS
21	SPACER	60062	1	303 SST
22	FLAT WASHER	60092	1	SST
23	SHAFT SHAFT	60257 60258	1	303 SST ◊316 SST
24	HEX PIPE PLUG, 0.75 NPT	60260	1	A105/PLTD
25	BLOCK BEARING BLOCK BEARING	60058 60059	1	303 SST ◊316 SST
†* 26	BLOCK BEARING O-RING BLOCK BEARING O-RING	60080 60078	2	◊VITON BUNA-N
27	HEX CAP SCREW, 1/4-20 X 0.50	60262	1	316 SST
†* 28	RING BACK-UP	60076	2	TFE
†* 29	SHAFT O-RING SHAFT O-RING	60082 60084	2	BUNA-N ◊VITON
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	1/2" X 2.5" PIPE NIPPLE	60244	1	CSTL/PLTD
* 33	O-RING	60078	1	BUNA-N
34	PIPE ELBOW, 1/2" NPT	60246	1	M.I./PLTD
35	COVER GASKET	60056	1	NEOPRENE
* 36	MANIFOLD/PILOT GASKET MANIFOLD/PILOT GASKET	60034 60035	1	BUNA-N VITON
37	MANIFOLD	60264	1	ALUM
38	HEX SCREW, 1/4-28x0.5"	60096	6	SST
39	BLOCK BEARING (CAPPED) BLOCK BEARING (CAPPED)	60061 60063	1	303 SST ◊316 SST

* RECOMMENDED SPARE PARTS

** 1" NPT SIDE & TOP/BOTTOM CONNECTIONS STANDARD

† INCLUDED IN SOFT GOODS REPAIR KITS

†† INCLUDED IN MARINE INSULATOR KIT

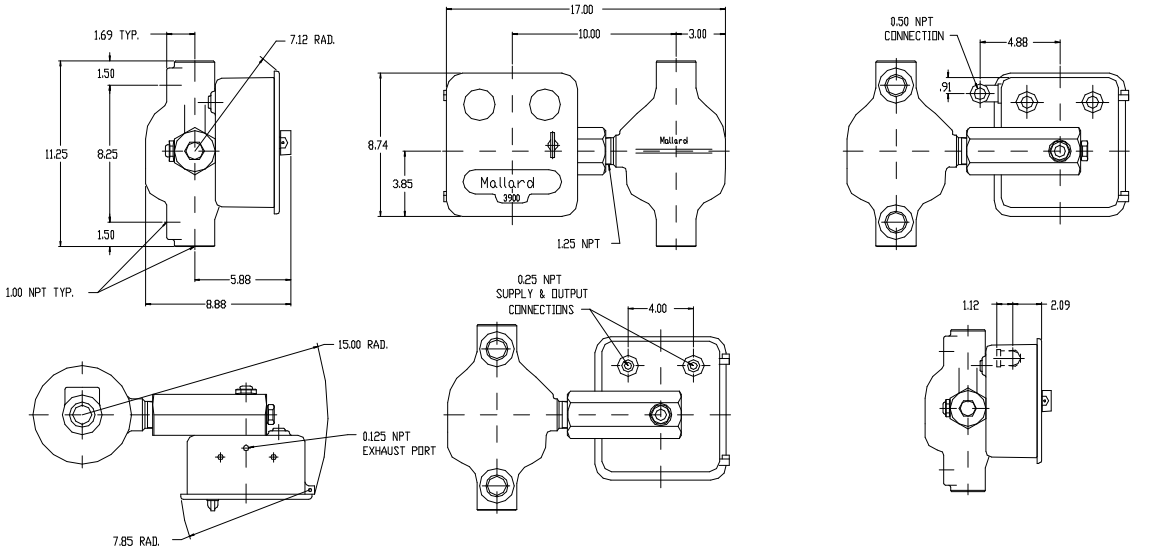
◊ MEETS NACE MR-01-75 SPECIFICATIONS

KITS

SOFT GOODS REPAIR KIT, BUNA-N	80066
SOFT GOODS REPAIR KIT, VITON	80068
SNAP PILOT REPAIR KIT, BUNA-N	80062
SNAP PILOT REPAIR KIT, VITON	80063
MARINE INSULATOR KIT	80070

INSULATOR KIT P/N 80070(INCLUDES #7 & #19)

1.4 Dimensions



2.0 INSTALLATION

2.1 Assembly

The Mallard model 3900 Liquid Level Switch is completely assembled at the factory and shipped as one piece. No assembly is required.

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 3900 Liquid Level Switch 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, or an electrical SPDT or DPDT output signal by using an electric limit switch.

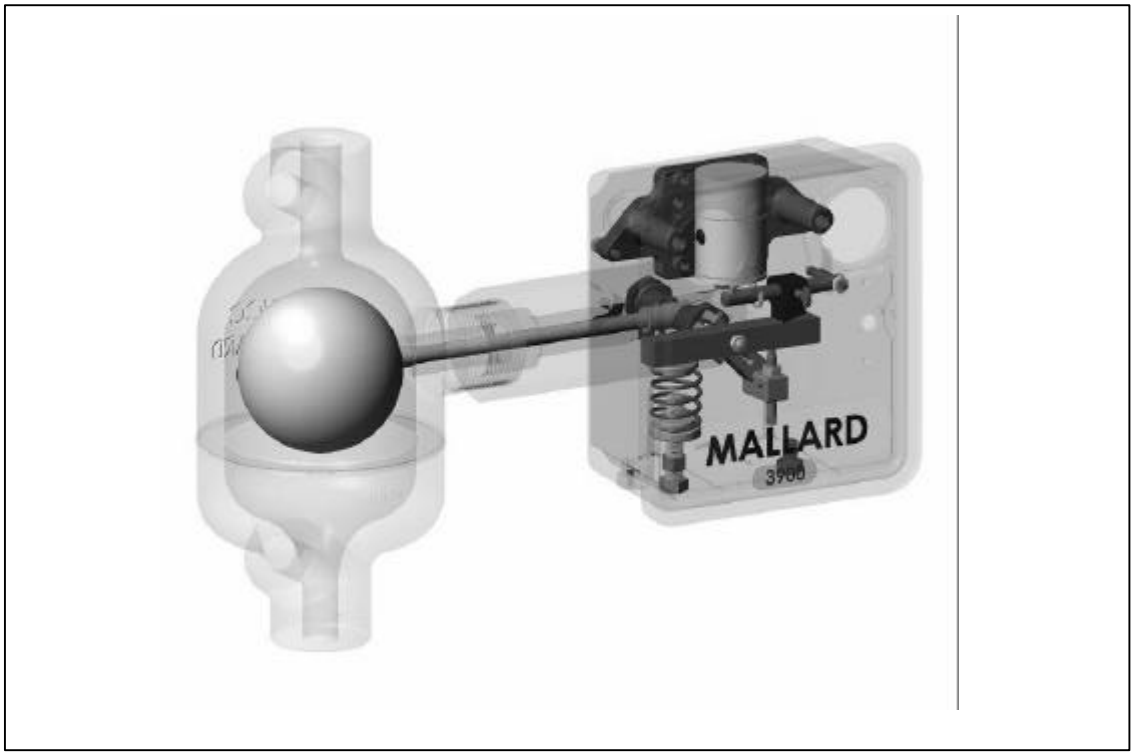


Figure 1. Force Balance Schematic

3.2 Controller Mounting

The model 3900 Liquid Level Switch 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 3. 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.

3.2.1 Mounting Orientation Conversion

Figure 2 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 and then slide the level adjusting bar in place on the shaft. Make sure that the level adjusting screw is positioned such that there are 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 and 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 3.3, 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.

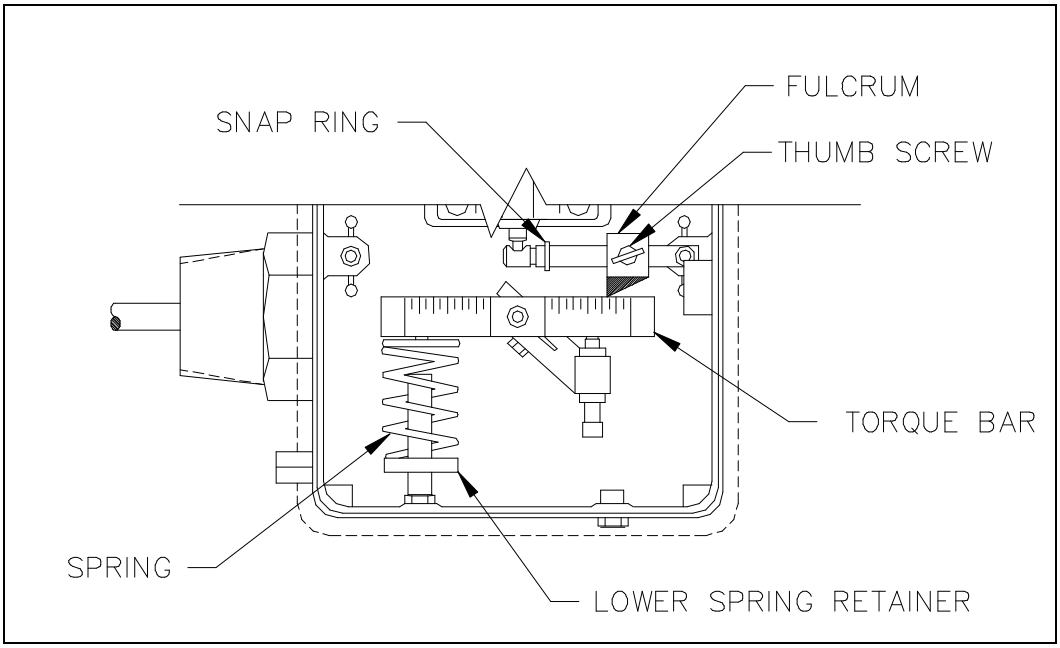


Figure 2. Level Controller Internals

3.3 Controller Action

Controller action is determined by the installation of the flapper bar, as shown in Figure 3. 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.

3.3.1 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.

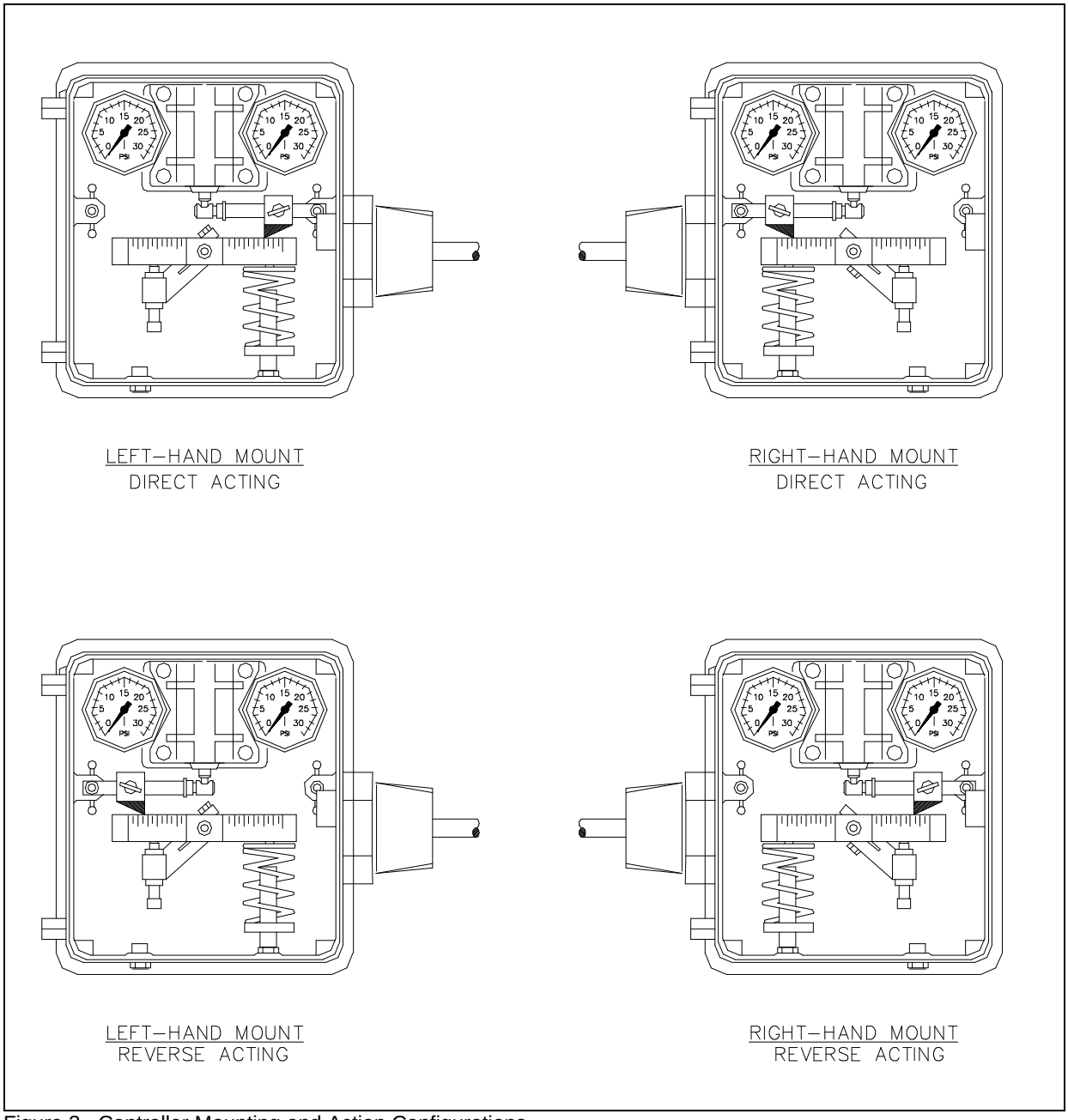
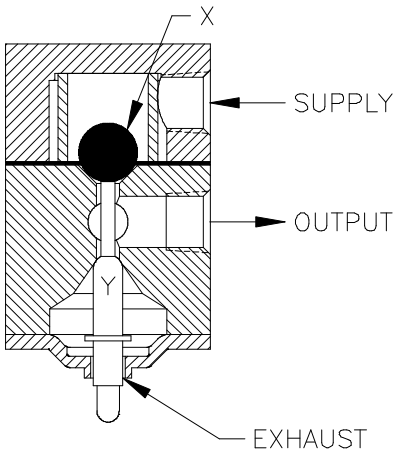


Figure 3. Controller Mounting and Action Configurations

3.4 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.

4.0 MAINTENANCE

4.1 Preventive Maintenance

The model 3900 Level Switch 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 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.

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