MOOG CONTROLS REPORT CDS6530

MODEL 770-128D

CURRENT TO HYDRAULIC PRESSURE (I/H) CONVERTER
INSTALLATION, OPERATION, AND CALIBRATION MANUAL

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SECTION 1.0 INTRODUCTION

1.1 SCOPE

This document contains instructions for the installation, operation, and calibration of Moog Controls Model 770 Current to Hydraulic Pressure (I/H) Converters. This document should be thoroughly reviewed prior to installation, operation, or calibration of the I/H converter. Specific attention should be given to the WARNING and CAUTION notes.

A Troubleshooting table at the end of the calibration and testing section will assist in identifying common faults.

1.2 DESCRIPTION

1.2.1 General

Moog Controls Model 770 current to hydraulic pressure (I/H) converter provides output pressure directly proportional to input command current. The I/H converter is specifically designed for turbine applications that operate at low hydraulic supply pressures of 70 to 600 psi. The converter is a two stage device consisting of a nozzle flapper first stage, and a sliding spool second stage.

The I/H converter is hydraulically configured to provide three way operation while maintaining the output pressure at a commanded level. The first stage is configured to provide maximum spool driving force concurrent with minimizing the effects of supply pressure variation on the output pressure. This configuration allows output pressure control to vary from the return pressure level to the supply pressure level.

The I/H converter is manifold mounted for ease of installation and maintenance.

Integral electronics and a pressure transducer provide closed-loop output pressure control. The electronics are accessible through a removable cover. Potentiometers are provided for various adjustments including output pressure level and range. A failure indication relay and an optional signal proportional to output pressure are available for monitoring purposes.

For safety, the I/H converters with sealed conduit connections (see Table 1.5.1) are designed to meet North American requirements for Certification in Class 1, Division 1, Group D environments (explosion-proof). Controlled clearances (flame paths) exist from within the electrical housing to the outside atmospheric environment as well as into the hydraulic plumbing. This eliminates the requirement for external flame arresters in the supply line. I/H converters with an MS3102 type pin connector (see Table 1.5.2) do not meet Class 1, Division 1, Group D requirements due to the connector.

A function diagram of the I/H converter is shown in Figure 1.2.1. Brief individual descriptions of each main component are given in the following paragraphs.

1.2.2 DC/DC Converter

The I/H converter operates on unregulated 18 to 32 Vdc input. An internal switching type DC/DC converter converts the unregulated input power to regulated ±15 Vdc. Input to the DC/DC converter is polarity protected to prevent possible damage to the unit.

1.2.3 Input Signal Conditioning

The typical input command current signal for most I/H models is 4-20 mA. Internal electronics range and bias the current command before the command is routed to the main pressure control loop circuitry. Command conditioning allows for adjustment to the output pressure range and level to suit user requirements (see Figure 1.5.2, depending on model).

1.2.4 Pressure Transducer and Conditioning

Output pressure is measured by an internal pressure transducer. The signal generated by the transducer is conditioned by the control circuit board. Null bias and gain adjustments are provided for the pressure transducer signal.

The pressure transducer is designed to provide 275% static over pressure protection without the need for re-calibration, and 2000% over rated pressure at burst.

1.2.5 Loop Amplifier Gains

The loop amplifier compares the conditioned current command and the conditioned transducer pressure signal. The difference between these two signals is the loop error signal. The loop error signal is amplified and fed into the torque motor. Both proportional gain and integrator gain are provided (P-I control). The integrator keeps the pressure error to a minimum.

1.2.6 Dither Generator

Dither is provided to assist in increasing the system performance (threshold and linearity) by reducing the effect of load actuator friction or sticking. The dither signal is superimposed on the signal from the loop gain amplifier. An amplitude adjustment is provided on the circuit board. The dither frequency is factory set to approximately 20 Hz.

1.2.7 Loop Bias (PI Bias)

The loop bias is provided to center the error loop signal about zero. This centers the error window trip signal used to open the fault indication relay. This bias is factory set and adjustment is generally not needed.

1.2.8 Error Detection Window

The error detection window monitors the pressure loop error signal. When the loop error exceeds the error window adjustment limit for 0.25 second, a signal will be sent to the failure indication relay to open its contacts. Adjustments are provided for setting the failure indication sensitivity.

1.2.9 Fault Relay

The fault relay is controlled by the error detection window signal. When the loop error signal exceeds the error window level (adjustable) for more than 0.25 second, the fault relay opens. The fault relay has two contacts. One contact controls the torque motor, the other is available to the user for external fault monitoring.

By ensuring the zero ohm jumper is not installed in R77, the I/H converter is configured to reduce the control pressure to the level of the return pressure when the relay opens. Alternatively, by installing the zero ohm jumper in R77, the I/H converter is configured to maintain the commanded control pressure when the relay opens.

1.2.10 First Stage Torque Motor

The first stage torque motor is used to convert low level electrical signals into hydraulic pressure, which in turn controls the second stage spool. The torque motor chosen for the application is based on Moog Controls' proportional servovalve design, and is field proven to be rugged and reliable. By design, the motor does not require high electrical power input, thereby reducing the overall power requirement and heat dissipation required for the electronics.

1.2.11 Second Stage

The second stage consists of a hardened bushing and spool assembly (martensitic stainless steel). A bias spring is provided to ensure low pressure at startup and shutdown. The second stage spool controls flow to the load.

1.2.12 Pressure Output Signal (Optional)

An optional 4-20 mA current signal proportional to the output pressure can be provided for user external circuitry. The 4-20 mA signal is scaled for the output control pressure range and is adjustable.

1.2.13 I/H Body Construction

The body and electronics housing of the I/H converter are made of aluminum. Stainless steel bolts are used throughout the design. On explosion-proof models, the user interface wire leads are molded into a replaceable connector, which in turn, mounts into the I/H converter body and extend 72 inches from a 0.5-14 NPT conduit port. Non-explosion-proof models use an MS3102 type pin connector. The body is designed for manifold mounting, allowing rapid change-out if needed. The unit is provided with an industrial grade paint finish.

1.2.14 Internal Hydraulic Filter

The I/H converter has an internal hydraulic filter that filters fluid to the torque motor. This filter is intended as a backup only. An external hydraulic filter should be used to filter fluid to the I/H converter.

1.2.15 Sub Plate Manifolds

An optional standard base mounting manifold (Moog Controls Part Number G1243AM2) may be used to connect the I/H valves to standard hydraulic fittings. The manifold is constructed of aluminum with three straight thread SAE ports. See Figure 1.4.1 or 1.4.2 for installation dimensions.

An adjustable metering orifice (AMO) manifold is also available as an option (Moog Controls Part Number G2761AM2). For improved dynamic performance in a pressure control system, an adjustable metering orifice (AMO) may be used as a means for adding hydraulic damping. The increase in damping allows a higher valve pressure loop gain (P3) to be used, thereby improving dynamic performance. This manifold incorporates an adjustable flow orifice between the return and control ports and may be field adjusted to set the optimum performance after final installation. See Figure 1.2.2 for installation dimensions.

An adjustable metering orifice (AMO) manifold with an additional hardware protection feature is also available as an option (Moog Controls Part Number G3745AM2). A pressure relief valve provides for adjustable control pressure limit settings. In the event of a control system failure, the control port is connected to return whenever control pressure reaches the relief valve setting. See Figure 1.2.3 for installation dimensions.

1.3 OPERATION

A command to the servo electronics is compared with the output of the pressure transducer. The resulting error causes a control current to drive the first stage torque motor, generating an output pressure. This resulting pressure from the first stage moves the second stage spool, reducing the error between the command and pressure transducer signal. When the error is eliminated, the first stage pressure stops the second stage spool at the precise position where the output pressure equals the command pressure. Thus, output pressure is proportional to the command signal.

Variations in load flow that tend to alter the load pressure will be sensed, and will cause the spool to move to a new equilibrium position, restoring the commanded load pressure. Thus, load pressure variations are automatically compensated.

Upon loss of electrical signal, the first stage of the I/H converter is mechanically biased to drive the second stage spool to a position that reduces the load pressure to the level of return pressure. In addition, a bias spring on the second stage spool assures low output pressure at start up.

Failure detection circuitry monitors the torque motor current. If the current levels are out of the limits of an adjustable error band for more than 0.25 second, an electromechanical relay opens and generates a fault signal. The torque motor circuit can be configured so that the I/H converter output pressure is reduced to the level of the return pressure when the relay opens.

1.4 GENERAL SPECIFICATIONS

The general specifications listed here apply to all standard Moog Controls current to hydraulic (I/H) converters. Figure 1.4.1 shows the overall dimensions of explosion-proof models with the conduit connector, along with a typical subplate manifold. Standard model specifications are located in Section 1.5 of this report. Please consult the factory for optional designs or requirements.

Weight (dry): .... 10.1 lb. (4.6 kg)

<u>ELECTRICAL</u>

Supply Voltage range: .... 18-32 Vdc (24 Vdc nominal)
Input power: .... < 4 W
Dither: .... 0-10 mA, fixed 20 Hz
Pressure Output monitor (optional):................... 4-20 mA
[load ≤ 500 ohms, typically 250 ohms]
Electrical user interface (Explosion-proof models)
Wiring (22 AWG):.. 6-wire pigtails (72 inch long min)
Electrical port: .... 0.5-14 NPT conduit connection

<u>HYDRAULIC</u>

Pressure: Operating (rated): .... See model Table 1.5.1
Proof Pressure:.............................. 150% of maximum rated supply
Burst: .... 250% of maximum rated supply
Fluid : Recommended viscosity range: ...... 50-2000 SUS (7.5 to 430 cSt)
Fluid cleanliness Level:................... ISO DIS 4406 code 18/16/13 max
16/14/11 recommended
Seals material: .... Viton-A (compatible with common hydraulic fluids)

<u>ENVIRONMENTAL</u>

Operating Temperature range:.......................... -40°F to 185°F [-40°C to 85°C]
Vibration: .... 10 to 500 Hz at 4.2 g's
Shock: .... 50 g half sine for 0.005 seconds (18 pulses total)

<u>PERFORMANCE</u>

Non-linearity: .... < 0.50% F.S.
Hysteresis: .... < 0.20% F.S.
Non-repeatability(over 60 to 90 F temp): .... < 0.25% F.S.
Non-repeatability (over full temp range):............ < 1.00% F.S.
Frequency Response
(small step, blocked load):................................. 0.01 to 0.05 second (typical)
Power up operation: .... Output pressure starts from return pressure and ramps up to command pressure. Time to ramp up is load dependent.

1.4 GENERAL SPECIFICATIONS *con't*

FAILURE MODES

Input power fails:	Output pressure drops to return pressure.
Internal Control loop error excessive:	If error persists for more than 0.25 seconds, internal relay contacts and failure indication contacts open. If fail low configuration is selected, output pressure drops to return pressure.

CLASSIFICATION

I/H converters with the conduit connection have been designed to comply with Hazardous Area Requirements of:

- NFPA No. 70 National Electrical Code, Class 1, Division 1, Group D Hazardous Locations (NEMA/NEC Type 7)
- Factory Mutual (FM)
- Canadian Standards Association CSA C22.2, No. 30, Class 1, Division 1, Group D Hazardous Locations.
- European Standards for CE mark
- XXXXXXXXX
- XXXXXXXXXX

1.5 STANDARD MODEL SPECIFICATIONS

This section details standard model specifications. Please consult the factory if other designs are required.

Table 1.5.1 lists specifications for the explosion-proof models.

Figure 1.5.2 indicate the affects of the calibration range and level adjustments on output pressure versus command input.

Figure 1.5.1 indicates the flow multiplier versus converter pressure drop. This multiplier can be used to determine the I/H converter output flow for various pressure drops.

Table 1.5.1 Standard Moog Controls Explosion-Proof Models

Model	Electrical				Calibration [5]		Hydraulic			
	Command input	Command input resistance	Output pressure signal (4-20 mA)	Fault condition drops output pressure to return	Adjustable pressure **range (span)** over command input [1]	Adjustable pressure **level** at minimum command input [2]	Rated flow (250 psi)	Rated supply pressure [3, 4]	Internal leakage (250 psi)	Output pressure transducer rating [5]
	mA	ohms	psi		psi	psi	gpm	psi	gpm	psi
770-128D	4-20	250	0-250	No	15-250 (195)	0-250 (25)	8	70-500 (300)	<0.20	250

Notes:

1. Pressure range (span) in parentheses denotes I/H converter factory setting at time of shipping. For example, when shipped from the factory, the Model 770-128D has an output pressure range (span)of 195 psi over the 4 to 20 mA command input. See Figure 1.5.2.
2. Pressure level in parentheses denotes I/H converter factory setting at time of shipping. For example, when shipped from the factory, the Model 770-128D has an output pressure of 25 psi at the minimum command input of 4 mA. See Figure 1.5.2.
3. Supply Pressure in parentheses is used for factory calibration.
4. For increased reliability (increased main spool driving force), the factory recommends operating at a minimum supply pressure greater than 120 psi.
5. Output control pressure should not exceed pressure transducer rating
6. All I/H converters ship with dither disabled.

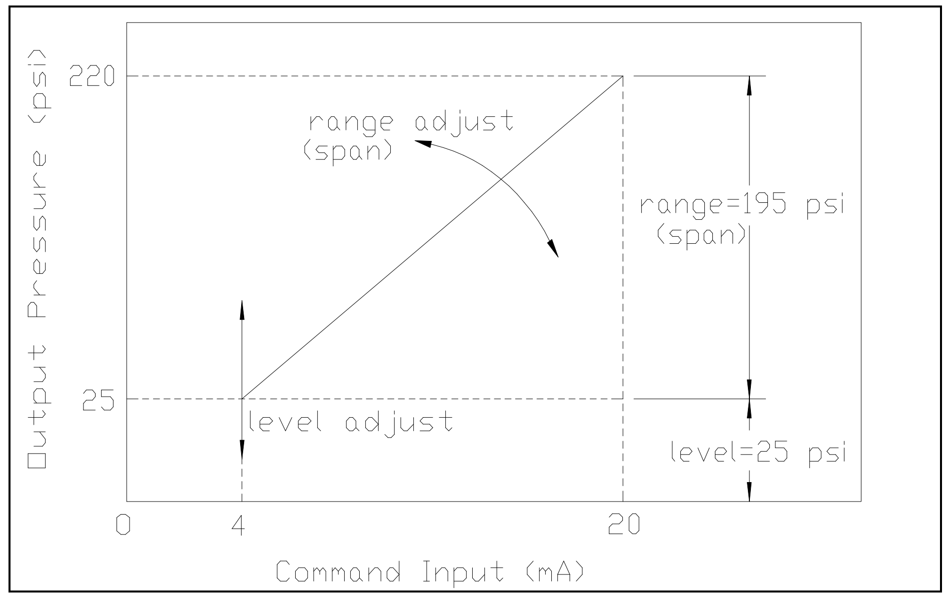


Figure 1.5.2
Output Pressure vs. Command Input Calibration
(Model 770-128D; factory setting when shipped; P_{supply} 300 psi)

SECTION 2.0 TOOLS AND TEST EQUIPMENT

2.1 GENERAL

This section lists the tools and test equipment used to perform installation and calibration of the Moog Controls I/H converter. Equivalent tools and test equipment may be used.
All test equipment should be regularly calibrated when in use to ensure accuracy equal to or better than the manufacturer's specifications.

2.2 TOOLS AND EQUIPMENT

a. Full set of hex key wrenches
b. Full set of flat blade screwdrivers
c. Extreme Pressure Lubricant #3 (Evans Products Co.)
d. Clean, lint free cloths or wipes
e. Electronic potentiometer screwdriver

2.3 TEST EQUIPMENT

Table 2.3.1 Test Equipment

Nomenclature	Part No./Mfg	Use
Hydraulic Power Supply	Petroleum base, 500 psi max, flow as required	Supplies hydraulic power for servoactuator testing
Digital Multimeter	Fluke Model 87 or equivalent	Measure continuity, resistance voltage and current
Oscilloscope	Tektronix Model 5223 or equivalent	Monitor dither output during testing
Current driver	MCI current driver or equivalent	Provide input 4-20 mA current to input
Supply pressure gauge *	0-500 psi rated	Monitor supply pressure
Control pressure gauge *	0-500 psi rated	Monitor control pressure
Return pressure gauge *	0-500 psi rated	Monitor return pressure

* If not available on system.

SECTION 3.0 INSTALLATION

3.1 GENERAL

This section covers the mechanical, hydraulic, and electrical connections necessary to install the I/H converter. Please review this section completely before installing the I/H converter.

3.2 RECEIVING AND UNPACKING

Inspect the shipping package for signs of careless handling before unpacking the I/H converter. Notify the shipper if damage is found. Carefully unpack the I/H converter.

Do not remove the hydraulic shipping plate at the bottom of the I/H converter until it is ready to connect to the hydraulic manifold.

3.3 MOUNTING

Four stainless steel socket head capscrews, 0.312–18UNC x 2.0 long, are provided with the I/H converter for mounting the converter to an interface hydraulic manifold. The converter is designed to be mounted on a manifold that contains the necessary hydraulic connections. Figure 1.4.1 provides the installation dimensions as well as the typical manifold interface requirements for explosion-proof models. Three sub plate manifolds are available from Moog Controls, see section 1.2.15. The I/H converter manifold ports use three universal o-rings (MS28775-15; 0.070 [1.78] sect. x 0.551 [14.00] I.D.). The surface to which the valve is mounted requires $^{63}\surd$.[∇∇] finish, flat within 0.001 [0.03] TIR. For additional optional manifold options, consult the factory for assistance. Phone numbers are listed in section 5.4.

Several items should be considered before mounting the I/H converter:

a) Whenever possible, mount the converter in a weather protected area.

b) The I/H converter can be mounted in any altitude; however, the transducer vent should not face directly upward. Additionally, vertical installation of the I/H converter is preferred, as it permits easier converter maintenance.

c) Be sure to provide the proper overhead clearance above the converter cover for disassembly. The electrical converter circuit board adjustments are located under the cover.

d) Avoid placing the converter near heat producing devices. Provide adequate ventilation.

e) The hydraulic manifold to which the I/H converter mounts should be adequately mounted and protected from excessive vibration.

3.4 HYDRAULIC CONNECTIONS AND FILTERING

The converter is designed to be mounted on a manifold that contains the necessary hydraulic connections. The I/H converter has three hydraulic ports located at the bottom of the converter body. They are the Supply (P), Return (R), and Control (C) pressure ports. Typical manifold hydraulic SAE ports for SAE fittings are shown in Figures 1.2.2, 1.2.3, 1.4.1.

3.4 HYDRAULIC CONNECTIONS AND FILTERING *con't*

a) Flush the supply, return, and control pressure lines with oil to remove any foreign material prior to connecting hydraulic lines to the converter.

b) A minimum 15 gpm, 5 micron hydraulic oil filter should be placed in the oil supply line just before the I/H converter.

c) Install permanent visual mechanical pressure gauges near the I/H converter so that supply and control pressures can be monitored. If permanent gauges are not installed, ports should be available so that test gauges can be used for monitoring supply and control during calibration.

d) Use rigid tubing on the output pressure line. This will improve pressure control performance.

e) The hydraulic return line should be connected to the oil sump in such a way as to reduce any back pressure to the I/H converter.

f) Check all hydraulic connections for leaks on initial start-up.

g) On initial start up, remove possible entrapped air in the hydraulic lines by slowly loosening a hydraulic fitting no more than one turn while supply pressure is on.

CAUTION:
Do not loosen the fitting more than one turn. If the fitting is loosened too much, the hydraulic connector could decouple.

h) The I/H converter has an internal hydraulic disk filter (40μ) that filters the fluid to the torque motor. This filter is intended as a backup only. An external filter, as described in section 3.4(b) should be installed. The internal backup filter has limited filtering ability.

i) The internal filter is designed for easy change-out in the field. When changing the filter, take care to keep components clean and to avoid cutting or nicking o-rings when installing them. Moog Controls filter part numbers are given in Figure 3.4.1.

Reference Figure 3.4.1 for pictorial of filter components. Replace the internal filter element as follows:

1) Turn off hydraulic supply. If there is any hot (over 120°F) equipment near the converter, allow time for it to cool down (below 110°F).
2) Clean around the filter holder (37).
3) Remove the four button head screws (38).
4) Remove the filter holder (37).
5) Remove and discard o-ring (33).
6) Remove, inspect and discard disc filter (35).

3.4 HYDRAULIC CONNECTIONS AND FILTERING *con't*

7) Remove and discard o-ring (36).

8) Install new o-ring (36).

9) Install new disc filter (35).

10) Install new o-ring (33) on the filter holder (37).

11) Install the four button head screws (38). Torque to 12 ±2 in-lbs.

12) Check for leaks on start-up.

3.5 ELECTRICAL CONNECTIONS

3.5.1 User Interface Wiring

The external electrical wiring must be connected as shown in Table 3.4.1. Electrical connections to the I/H converter are made at a 0.5-14 NPT conduit port. Turn off the power when connecting electrical signals.

a) Models incorporating the conduit port have an electrical wiring pigtail a minimum length of 72 inches. Six wires total (22 AWG).

b) Use 18-22 AWG twisted pair, jacketed or shielded wire for the current command leads. The shielding must be grounded at one end only.

c) On explosion-proof models, provide a shielded electrical conduit is recommended for the user interface wiring. The I/H converter wiring is potted with an explosion-proof seal in the converter body. No extra conduit seal is necessary.

Table 3.4.1 User Interface Wiring

User Interface		Circuit Board Connector J1 pins	Function
Connector Interface (pin) [4]	Pigtail Interface Wire Colors		
A	Orange	1	Supply, 18-32 Vdc (Nominal +24 Vdc)
B	Black	2	Common, 0 Vdc
C	Green	4	(+) Command, 4-20 mA
D	Green/white	3	(-) Command, 4-20 mA
E [1, 3]	Violet [1, 3]	5	Relay contact or optional pressure out, 4-20 mA (<500 ohm load, referenced to black)
F [2, 3]	Violet/white [2, 3]	6	Relay contact or optional pressure out, 4-20 mA w/relay cutout (<500 ohm load, referenced to black)

Notes:
1. If a continuous output pressure signal is required regardless of a fault relay condition, connect the Violet (pin E) wire to a load less than 500 ohms (typical use 250 ohms).
2. If the output pressure signal is desired to fail open circuit on a fault condition (fault relay open), connect the Violet/White (pin F) wire to a load less than 500 ohms (typical use 250 ohms).
3. The Violet (pin E) and Violet/White (pin F) wires should not be connected to a less than 500 ohm load simultaneously, because the output current from the valve will be split (2–10 mA). If both wires are to be connected, connect the less than 500 ohm load to the Violet (pin E) wire, and a high impedance buffer to the Violet/White (pin F) wire.
4. Electrical connector: MS3102-14S-6P.

3.5.2 Internal Wiring

Internal wiring of the I/H converter is completed at the factory. Should any electronic connector be removed, the following connection tables are provided for reference.

Note: All connectors mount to the circuit board with the solid face of the connector to the outside.

Table 3.4.2 Internal User Interface Wiring

Circuit Board Connector (J1)
J1-1 : Orange
J1-2 : Black
J1-3 : White/Green
J1-4 : Green
J1-5 : Violet
J1-6 : Violet/White

Table 3.4.3 DC-DC Converter Wiring

Circuit Board Connector (J2)	Function
J2-1 : Orange	Supply, 18-32 Vdc
J2-2 : Black	Common, 0 Vdc
J2-3 : N/A	N/A
J2-4 : Red	Regulated, +15 Vdc
J2-5 : Black	Common, 0 Vdc
J2-6 : White	Regulated, –15 Vdc

Table 3.4.4 Pressure Transducer Wiring

Circuit Board Connector (J3):	Function
J3-1 : Yellow	(+) Excitation, +10 Vdc
J3-2 : Black	(–) Excitation, 0 Vdc
J3-3 : Brown	Output (–), 0 Vdc
J3-4 : Blue	Output (+), 0-25 mV

Primary Transducer Body Connector Pins	Function
Pin A : Yellow	(+) Excitation, +10 Vdc
Pin B : Blue	Output (+), 0-25 mV (nom)
Pin C : Brown	Output (–), 0 Vdc
Pin D : Black	(–) Excitation, 0 Vdc
Pin E : N/C	

Table 3.4.5 Torque Motor Wiring

Circuit Board Connector (J4):	Function
J4-1 : Red	Coil 1 lead
J4-2 : White	Coil 2 lead
J4-3 : Green	Coil 2 lead
J4-4 : Black	Coil 1 lead

SECTION 4.0 CALIBRATION AND TESTING

4.1 GENERAL

The I/H converter has been functionally checked and calibrated at the factory.

Tables 1.5.1 lists the factory calibration parameters. If the factory calibration matches the user requirements, the I/H converter can be checked for proper operation directly at the user site. In this case, skip ahead to Section 4.3. If the factory calibration does not match the user requirements, the I/H converter must be re-calibrated and checked by the user. Proceed with Section 4.2 for proportional output pressure models.

Note: The factory can pretune I/H converters to meet specific user requirement, thus simplifying field installation. Please consult the factory if pretuning is desired.

CAUTION:

The printed circuit board contains static-sensitive parts. Observe the following precautions.

a: Avoid using plastic or vinyl around the circuit board as these items generate static electrical charges.

b: Use a ground strap when handling the printed circuit board.

c: When the printed circuit board is removed from the I/H converter, it should be stored in a protective anti static bag.

4.2 ADJUSTMENTS FOR CALIBRATION AND TESTING OF PROPORTIONAL OUTPUT PRESSURE MODELS

4.2.1 General

The procedure given in this section will completely setup and test the I/H converter for user operation.

Before proceeding with this section, ensure that the I/H converter is mounted and connected (hydraulic and electrical) according to Section 3.0. Connect supply and control test pressure gauges if permanent gauges were not installed per paragraph 3.4(c). Reference Figure 4.2.1 for the location of potentiometers on the printed circuit board. Reference Figure 1.2.1 for a functional diagram of the I/H converter.

WARNING:
The adjustment procedure must be performed with the main fuel control valve off. The I/H converter must not have control of the prime mover during the adjustment procedure

4.2.2 Accessing Adjustments

a) Place a static protection strap on your wrist to prevent possible static discharge to the electronic circuit board.

4.2.2 Accessing Adjustments *con't*

b) Remove five socket head cap screws (0.190-32UNF x 0.63 long) holding the top cover onto the electronics housing.

c) Use a screwdriver and or threaded holes carefully remove the cover. The electronic control board is mounted to the inside of the cover.

d) Once the cover is removed, it can be inverted and attached to the converter body by using one of the cover bolts. Take care to prevent excessive strain on wiring bundles.

e) Check wiring. The electrical connector connections are listed in Section 3.5.

f) If using an adjustable metering orifice manifold (G2761AM2 or G3745AM2) ensure the adjustable flow orifice is closed. See section 4.2.6 for setting instructions.

g) If using a pressure relief valve manifold (G3745AM2) see section 4.2.7 for setting instructions.

4.2.3 Preliminary Dither, Loop Gain, and Error Gain and Window Adjustments

Objective: Set initial setting of potentiometers P1 (dither), P6 (loop gain), P17 (error window), and P3 (error gain).

a) Turn the error window potentiometer P17 fully CW (maximum error window is approximately ± 7.5 volts). Thirty (30) CW turns will insure potentiometer is fully CW.

b) Turn error gain pot P3 fully CCW (30 turns CCW to insure).

c) Turn the dither amplitude potentiometer P1 fully CCW (lowest dither amplitude input). Thirty (30) CCW turns will ensure potentiometer is fully CCW.

d) Place JMP2 in the OFF position across pins 1 and 2 on the circuit board. (Turns dither off.)

e) Place JMP3 in the OFF position across pins 2 and 3 on the circuit board.

f) Turn the loop gain potentiometer P6 fully CCW (minimum setting).

4.2.4 Pressure Transducer Scaling and Zero

Objective: Set potentiometers P14 (pressure transducer gain), and P15 (pressure transducer zero).

a) Turn on 24 Vdc power to electronics. Using test points on the circuit board, check "+ 15 V" and "– 15 V" as referenced to "comm" test point (see Figure 4.2.1).

b) Let electronics warm up for 5 minutes.

4.2.4 Pressure Transducer Scaling and Zero *con't*

c) With zero system pressure, adjust potentiometer P15 until TP1 = 0.000 ± 0.002 Vdc.

d) Close the return and output pressure lines and pressurize the converter to the pressure rating of the pressure transducer (listed in Tables 1.5.1.
- 250 psi

Set pressure transducer gain potentiometer P14 to obtain TP1 = 10.00 ± 0.01 Vdc.

e) Repeat steps 4.2.4(c) and (d) until no adjustment is needed.

4.2.5 Pressure Loop Gain and Offset

I. Objective: Set initial loop gain potentiometer (P6) and bias pot (P7).

a) Ensure the hydraulic supply pressure is off and the electronics are on.

b) Using the command current signal and/or potentiometers P10 (position span) and P12 (position zero), set TP4 = 0.00 ± 0.01 Volts.

c) Measure TP9 voltage with TP4 set at 0.00 ± 0.01 Volts.

d) Measured TP9 voltage must be 0 ± 0.2 Volts. If TP9 is greater than 0 ± 0.2 Volts, check pressure transducer zero as described in section 4.2.4 and check P6 potentiometer setting in section 4.2.3.

e) With TP9 voltage at 0 ± 0.2 Volts adjust PI bias pot P7 to obtain 0 ± 0.2 Volts at TP2 (valve current).

f) Using the command current signal and/or potentiometers P10 (position span) and P12 (zero), set TP4 = –1.00 ± 0.01 Volts.

g) Turn the loop gain potentiometer P6 CW until the TP9 voltage reads +5 ± 0.1 Volts. This is the initial setting of potentiometer P6 and should provide good pressure control. Note that the loop gain setting level is dependent on the load configuration; hence, it may be possible to use a higher loop gain. The P6 setting will be checked below.

II. Objective: Final loop gain potentiometer (P6) check.

h) Place JMP3 in the ON position across pins 1 and 2 on circuit board (activates integrateor).

I) Set the supply pressure to your requirement. Do not exceed the rated supply pressure of the model specification in Table 1.5.1. For good pressure control, the supply pressure should be at least 20 psi above the maximum required output pressure.

j) Turn the electronics on and set the command input to 20 mA.

4.2.5 Pressure Loop Gain and Offset *con't*

k) Adjust span potentiometer P10 until the desired TP1 (maximum output pressure desired) voltage is obtained. Position zero potentiometer P12 might also have to be adjusted to obtain the TP1 voltage.

Note: [TP1 (volts)] = [Pout desired (psi)]*[10V/transducer pressure used in step 4.2.4(d)].

l) Ensure the converter is stable and provides acceptable pressure control by using small step commands. Monitor TP1 control pressure on an oscilloscope. Any TP1 control pressure oscillations should damp out quickly. If using an adjustable metering orifice manifold (G2761AM2 or G3745AM2) pressure oscillations can be damped out using the adjustable flow orifice. See section 4.2.6 for details.

m) If necessary, adjust loop gain potentiometer P6 (CW increases gain; CCW decreases gain) until converter output begins to become unstable or provides acceptable pressure control, while approximately maintaining TP1 voltage. TP1 voltage can be maintained by adjusting position span potentiometer P10, or by adjusting the command signal. Ensure the converter is stable by using step commands. Back-off on the P6 potentiometer CCW one turn.

n) Set the input command to 20 mA and adjust potentiometers P10 and/or P12 to obtain TP1 voltage calculated in step 4.2.5(i).

Note: If the return pressure is elevated above atmosphere, it may not be possible to completely zero out TP9.

4.2.6 Adjustable Metering Orifice Setting (Optional Manifold G2761AM2 or G3745AM2)

On initial startup, the adjustable metering orifice should be set to the fully closed position.

a) Turn the jam nut counterclockwise several turns, this will allow the threaded adjuster screw position to be varied.

b) Start by first turning the threaded screw clockwise until it bottoms, then turn the jam nut clockwise to lock the screw in place.

c) If the pressure loop gain (P6) cannot be set high enough, or the output pressure oscillates too much, open the adjustable flow orifice by turning the threaded screw one-half turn counterclockwise.

d) Recheck I/H converter performance. Turn the threaded screw counterclockwise, which opens the flow orifice, one turn at a time until acceptable performance is obtained. The threaded screw should not have to be opened more than three full turns. If more than three turns are required, the loop gain (P6) is most likely set too high.

e) When acceptable performance is obtained, turn jam nut clockwise to lock threaded screw in place. Ensure command level and range settings per section 4.2.8 can be achieved for adjustment setting utilized.

4.2.7 Pressure Relief Valve Setting (Optional Manifold G3745AM2)

On initial startup, the pressure relief setting should be high enough so as to not affect command level and range setting adjustments in section 4.2.8. Relief valve range is 50 to 200 psi.

a) Turn the jam nut counterclockwise several turns, this will allow the threaded adjuster screw position to be varied.

b) Turn the threaded screw clockwise to increase the pressure relief setting, counterclockwise will decrease the pressure relief setting.

c) Verify the pressure setting by adjusting the control port output pressure until flow out return or return port pressure increases.

d) Repeat setup 4.2.7a-c until no adjustment is needed.

e) When adjustments are completed, turn jam nut clockwise to lock threaded screw in place.

4.2.8 Command Level and Range

Objective: Set potentiometers P10 (command span) and P12 (command zero).

a) With command set to 4 mA, adjust position zero potentiometer P12 until the desired TP1 voltage is obtained. [TP1 (volts)] =

[Pout desired (psi) at 4 mA]*[10V/transducer press used in step 4.2.4(d)]

Note: Check the return pressure of the valve using a visual gauge to ensure it is below the control pressure desired. If return pressure is higher than the desired control pressure, the valve will not function properly.

b) Set the command input to 20 mA. Adjust position span potentiometer P10 until the desired TP1 voltage is obtained. [TP1 (volts)] =

[Pout desired (psi) at 20 mA]*[10V/transducer press used in step 4.2.4(d)]

c) Repeat step 4.2.8 a and b until no adjustment is needed (approximately 4 times).

d) If the valve is configured to drop the control pressure to the return pressure on a fault condition (R77 removed – see section 4.2.13), perform step (e); otherwise, proceed to section 4.2.9.

e) Turn off the supply pressure. Set the command current to the minimum amplitude level your controller will output (typically between 0 and 4 mA). Measure TP3 (error) voltage. TP3 must be less than 7.0 Volts. TP3 can be reduced by reducing P3 (error gain) or by lowering the minimum command current.

Note: The fault relay contacts open when TP3 is greater than 7.5 Volts. This can cause valve start-up problems. For example, if the supply pressure is off and the electronics are powered up so that the minimum input command generates a TP3 voltage greater than 7.5 Volts, the fault relay contacts open and control pressure will remain at the return pressure level when the supply pressure is turned on. Figure 1.2.1 illustrates this with a functional diagram.

4.2.9 Dither

Objective: Set potentiometer P1 (dither amplitude).

Note: The factory recommends that dither be used only if required due to user load friction.

If dither is not required, turn P1 full CCW (lowest dither amplitude input) and place JMP2 across Pins 1 and 2. (Turns dither off.)

a) Place jumper JMP2 across Pins 2 and 3. (Turns on dither.)

b) Converter current TP2 should have a square wave of approximately 0.02 Vp-p at 20 Hz.

c) To increase the dither amplitude, adjust potentiometer P1 CW. Dither amplitude can be observed by monitoring TP2. Set dither amplitude until the actuator begins to move.

d) Turn P1 CCW one turn.

4.2.10 Failure Mode Select For Excessive Loop Error

a) When circuit board R77 is removed, a fault indication will disable the closed loop controller and drive the output control pressure to the return pressure level.

4.2.11 Fault Relay Test (non-pressure monitor models)

a) Set command input to 20 mA.

b) Monitor the TP3 voltage signal.

c) Slowly reduce supply pressure while observing the TP3 voltage. As supply pressure is reduced, the TP3 voltage signal should increase.

d) When TP3 is approximately 7.5 volts, the relay should open. The measured resistance from VIOLET WIRE to VIOLET/WHITE WIRE should read a minimum of 1M ohms when the relay opens. See Figure 1.2.1.

4.2.12 Pressure/Relay Monitor Output Test (pressure monitor models)

For continuous output pressure monitoring regardless of a fault condition, use the VIOLET WIRE referenced to the BLACK WIRE. A load resistor less than 500 ohms must be placed across the VIOLET WIRE and the BLACK WIRE. In this configuration, a fault indication signal from the VIOLET/WHITE WIRE can be obtained by using a high impedance buffer amplifier so as not to load down the output current driver. Ensure the JMP1 jumper is installed as shown in Figure 1.2.1.

4.2.12 Pressure/Relay Monitor Output Test (pressure monitor models)

a) Set monitor signal zero and span set control pressure range as desired with 4 to 20 mA input command signals.

- Place a 250 ohm resistor across the VIOLET WIRE to the BLACK WIRE and measure the output current as a function of the command current by measuring voltage across 250 resistor.
- With 4 mA command input adjust, transmitter (P13) to obtain 4 mA output through 250 ohm resistor.
- With 20 mA command input, adjust transmitter scale (P10) to obtain 20 mA output through 250 ohm resistor.

b) Check Fault Relay Operation Test (error window)

- Set command input to 20 mA.
- Monitor TP3 voltage signal.
- Slowly reduce the supply pressure while observing the TP3 voltage. As the supply pressure is reduced, the TP3 voltage signal should increase.
- When TP3 is approximately 7.5 volts, the relay should open. The measured voltage from the VIOLET/WHITE WIRE to the BLACK WIRE will drop to zero volts when the relay contacts open. See Figure 1.2.1.

4.2.13 Electrical Failure Mode Test

a) Set supply pressure to the required level (same as Section 4.2.5).

b) Set current command to 20 mA.

c) Turn the +24 Vdc power supply off.

d) Check that the control pressure drops to approximately the level of return pressure (control pressure fails low, except on models noted).

4.2.14 Assembly

a) Set the cover in place on the electronics housing. Be sure the wiring is not trapped between the cover and the housing.

b) Bolt the cover in place with the five socket head cap screws. Torque to 40 ± 5 inch-pounds.

4.4 FUNCTIONAL TESTING ONLY (FACTORY PRE-CALIBRATED)

4.4.1 General

The procedure given in this section is for testing a pre-calibrated I/H converter. Use this section if factory calibration meets user requirements. Refer to Table 1.5.1 for factory calibration settings.

> **WARNING:**
> **The adjustment procedure must be performed with the main fuel control valve off. The I/H converter must not have control of the prime mover during the adjustment procedure**

Before proceeding with this section, ensure that the I/H converter is mounted and connected (hydraulic and electrical) according to Section 3.0. Connect supply and control test pressure gauges if permanent gauges were not installed per paragraph 3.4(c).

4.4.2 Command Level and Range Test

a) Turn on 24 Vdc power to the electronics.

b) Set command current to 4 mA. Refer to Table 1.5.1 for output pressure at 4 mA.

c) Turn on hydraulic supply to the factory calibrated pressure. Refer to Table 1.5.1 for supply pressure.

d) Observe the control pressure at 4 mA command. Refer to Table 1.5.1, column “Adjustable pressure level at minimum command input”. If the I/H converter is configured for 4 to 20 mA pressure output signal, verify the signal per Section 4.2.12.

e) Set command current to 20 mA. Refer to Table 1.5.1 for output pressure at 20 mA.

For example; at time of shipping, model 770-126C output pressure at 20 mA is 35 psi, model 770-128D output pressure at 20 mA is 220 psi.

$$\left\{\begin{array}{c}\text{output}\\\text{pressure}\end{array}\right\} = \left\{\begin{array}{c}\text{pressure value in}\\\text{parentheses in column}\\\text{"adjustable pressure \textbf{range}}\\\text{over command input"}\end{array}\right\} + \left\{\begin{array}{c}\text{pressure value in}\\\text{parentheses in column}\\\text{"adjustable pressure \textbf{level}}\\\text{at minimum command input"}\end{array}\right\}$$

Observe the control pressure. If the I/H converter is configured for 4 to 20 mA pressure output, verify the signal per Section 4.2.12.

4.4.3 Pressure Loop Gain Check

a) Ensure the command current equals 20 mA, and the supply pressure is set to the required value.

b) Apply a small step current command to the I/H converter and observe the control pressure output. Observe the output pressure for stability. If the I/H converter tends to be unstable, reduce the pressure loop gain per Section 4.2.5 or if using an adjustable metering orifice manifold (G2671AM2) see section 4.2.6.

4.4.4 Electrical Failure Mode Test

a) Set supply pressure to the required level (same as Section 4.4.2c).

b) Set current command to 20 mA.

c) Turn the power to the electronics off (+24 Vdc).

d) Check that the control pressure drops to approximately the level of return pressure.

4.5 TROUBLESHOOTING

Table 4.5.1 lists some of the more common problems that can occur when installing and operating the I/H converter. Possible causes and remedies are provided. If problems persist after review, call the factory for technical assistance. Phone numbers are listed in section 5.4.

Table 4.5.1 I/H Converter Troubleshooting

Observation	Possible Cause	Remedy	Section(s)
Output control pressure oscillates.	• Electrical loop gain too high.	• Turn loop gain Pot down.	4.2.5, 4.3.5 1.2.15
	• Electrical dither amplitude too high.	• Turn down dither amplitude or turn off dither.	4.2.9 4.3.7
	• Entrapped air in hydraulic lines.	• Bleed out air.	3.4 (g)
Output control pressure drops to return.	• Hydraulic supply pressure is less than commanded causing cutout relay to open.	• Increase hydraulic supply and/or reduce commanded. • Check relay operation.	4.2.10, 4.2.11 4.2.12, 4.3.8, 4.3.9, 4.3.10
	• Rate of change of the command signal is greater than the output pressure can follow, causing relay to open.	• Reduce rate of command signal and/or increase loop error window. • Reduce command signal to allow internal relay to close and provide normal closed loop operation.	4.2.10, 4.2.12 4.3.8, 4.3.10
	• Fault cutout relay to torque motor is enabled.	• Install a zero ohm jumper in R21 to inhibit the fault relay to torque motor, if desired.	4.2.10 4.3.8

Table 4.5.1 I/H Converter Troubleshooting *Con't*

Observation	Possible Cause	Remedy	Section(s)
Output pressure does not vary.	• No electrical supply power.	• Check electrical supply power.	3.5
	• Wired incorrectly.	• Check user interface wiring. Check internal electrical connectors for proper installation.	3.5
	• Electrical error window set too small.	• Increase error window.	4.2.3 (a)
	• Excessive Control loop error voltage.	• Reduce command and/or control loop gain to increase error required to cause relay to open.	4.2.8, 4.2.10 4.2.11, 4.2.12 4.3.6, 4.3.8 4.3.9, 4.3.10
	• Internal relay is on.	• Install a zero ohm jumper in R21 to inhibit the fault relay to torque motor, if desired.	4.2.8, 4.2.10 4.3.6, 4.3.8
	• External hydraulic filter is plugged.	• First check fault relay. • Replace hydraulic filter element.	4.2.11, 4.2.12 4.3.9, 4.3.10
	• Torque motor internal backup hydraulic filter is plugged.	• Replace the backup filter.	3.4 (h) 4.2.10, 4.3.8
Output pressure not properly calibrated.	• "Range" and "level" potentiometers not properly set.	• Recalibrate "range" and "level" potentiometers.	4.2.8, 4.3.6
Optional output pressure signal fails to open circuit in a fault condition.	• Monitoring optional output pressure signal through fault relay.	• Monitor optional output pressure signal that does not go through the fault relay.	4.2.12 4.3.10
Output control pressure does not drop to return on a fault indication.	• Fault cutout relay to torque motor disabled.	• Enable torque motor cutout relay by removing the zero ohm jumper in R21.	4.2.10, 4.2.11 4.2.12 4.3.8, 4.3.9 4.3.10
No Fault indication observed.	• Incorrect wiring.	• Check wiring.	3.5
Output control pressure cannot get low enough.	• Return pressure too high.	• Reduce return pressure.	3.4
	• Wrong range and level of command signal.	• Check electrical level and range settings.	4.2.8, 4.3.6
Output control pressure cannot get high enough.	• Return pressure too high.	• Reduce return pressure.	3.4 (e) 4.2.8 (a) 4.3.6 (a)
	• System requires too much flow.	• Increase hydraulic supply and/or reduce command input.	3.4, 4.2.5 (g) 4.2.8 (e), 4.3.6 (e)
	• Adjustable metering orifice open too far.	Close AMO to minimum level required.	1.2.15

Table 4.5.1 I/H Converter Troubleshooting *Con't*

Observation	Possible Cause	Remedy	Section(s)
Poor output control pressure; pressure oscillates.	• Electrical loop gain is not high enough.	• Increase loop gain.	4.2.5
	• Pressure reverberations in control pressure line. (Water Hammer Effect)	• If the loop gain cannot be increased because of stability problems, consider using an adjustable metering orifice (AMO) manifold to add system damping	1.2.15
Range and level of output pressure slightly different than calibrated.	• Different supply pressure used to calibrate range and level.	• Calibrate "range" and "level" potentiometers at the supply pressure the valve will operate at.	4.2.8 4.3.6
	• Low electrical loop gain.	• Also see - Observation "poor output control pressure performance".	4.2.5 1.2.15

SECTION 5.0 REPAIR INSTRUCTIONS

5.1 GENERAL

The I/H converter is not field repairable. Repair of the unit must be done by Moog Controls Inc. or its authorized service facilities.

5.2 RETURN FOR REPAIR

All I/H converters returned for repair should be tagged with the following information. Attach the tag to the unit.

a) Customer's name and address.

b) Name and location at which the I/H converter is installed.

c) Moog Controls part number and serial number.

d) Description of the failure.

e) If known, the required electrical calibration (level and range) as well as the supply pressure. If requested, Moog Controls' repair department will preset the I/H converter electronics.

f) Install the I/H converter hydraulic shipping plate if available.

g) Use adequate packing material to protect the I/H converter during shipping.

5.3 AUTHORIZED SERVICE SHIPPING ADDRESS

Please use the following address when returning parts to Moog Controls.

Moog Controls Inc.
300 Jamison Road
East Aurora, New York 14052

5.4 TELEPHONE AND FAX NUMBERS

For technical, repair, or sales information, please call Moog Controls' main office at:

Phone number: (716) 655-3800
Fax number: (716) 655-1803

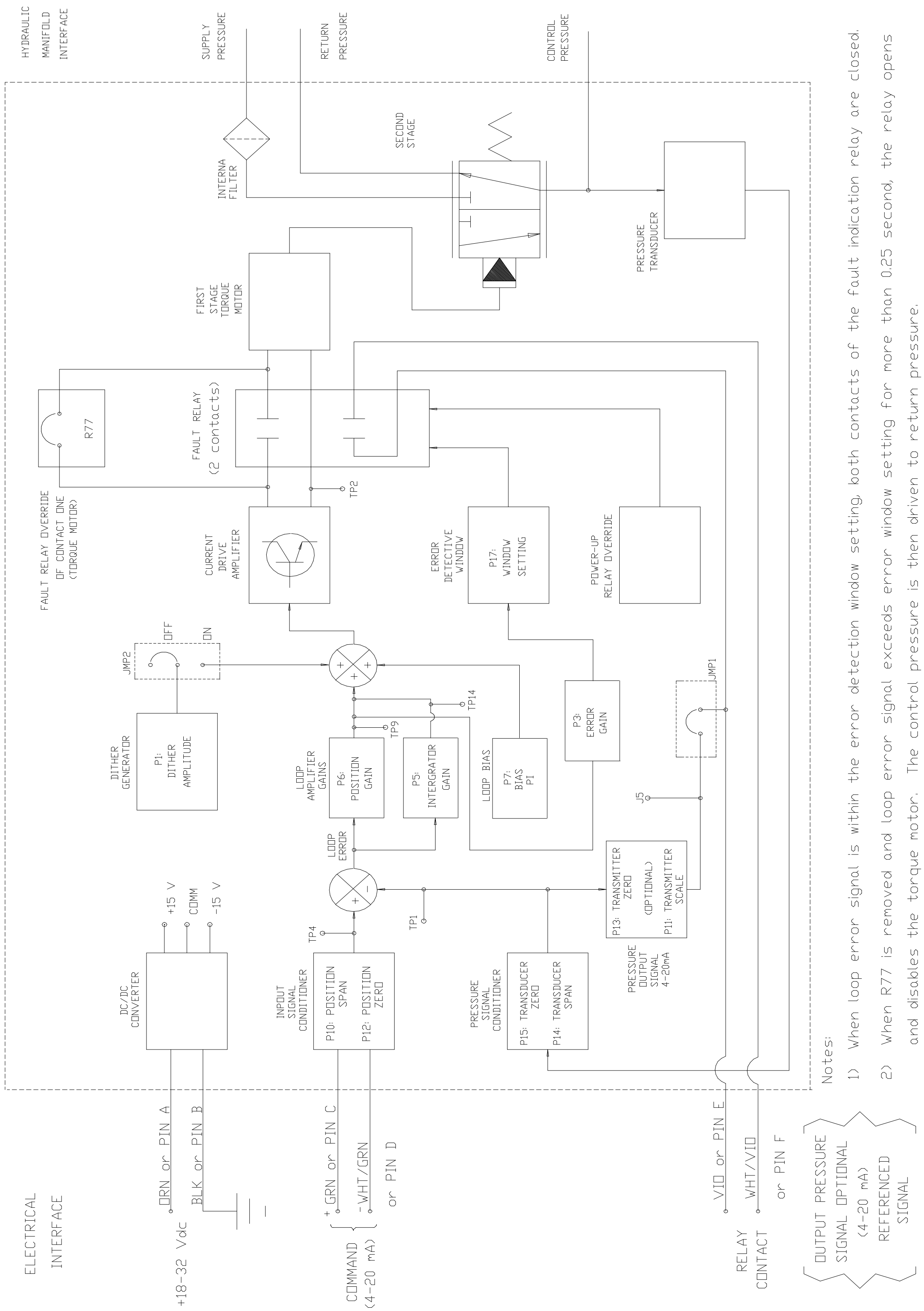


Figure 1.2.1 Function Diagram of Proportional Output Pressure I/H Converter

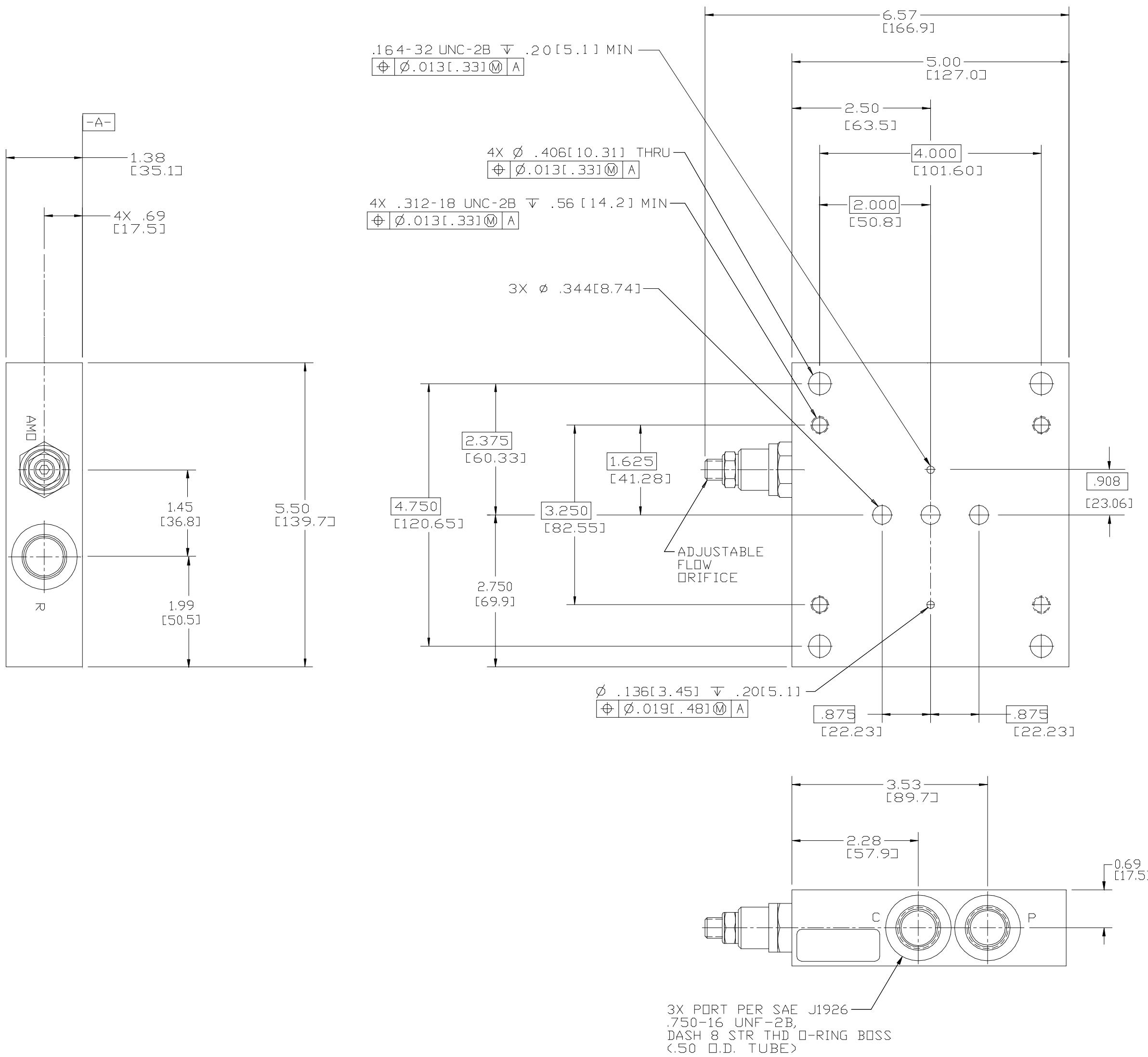


Figure 1.2.2 Optional Adjustable Metering Orifice (AMO) Manifold (Part Number G2761AM2)

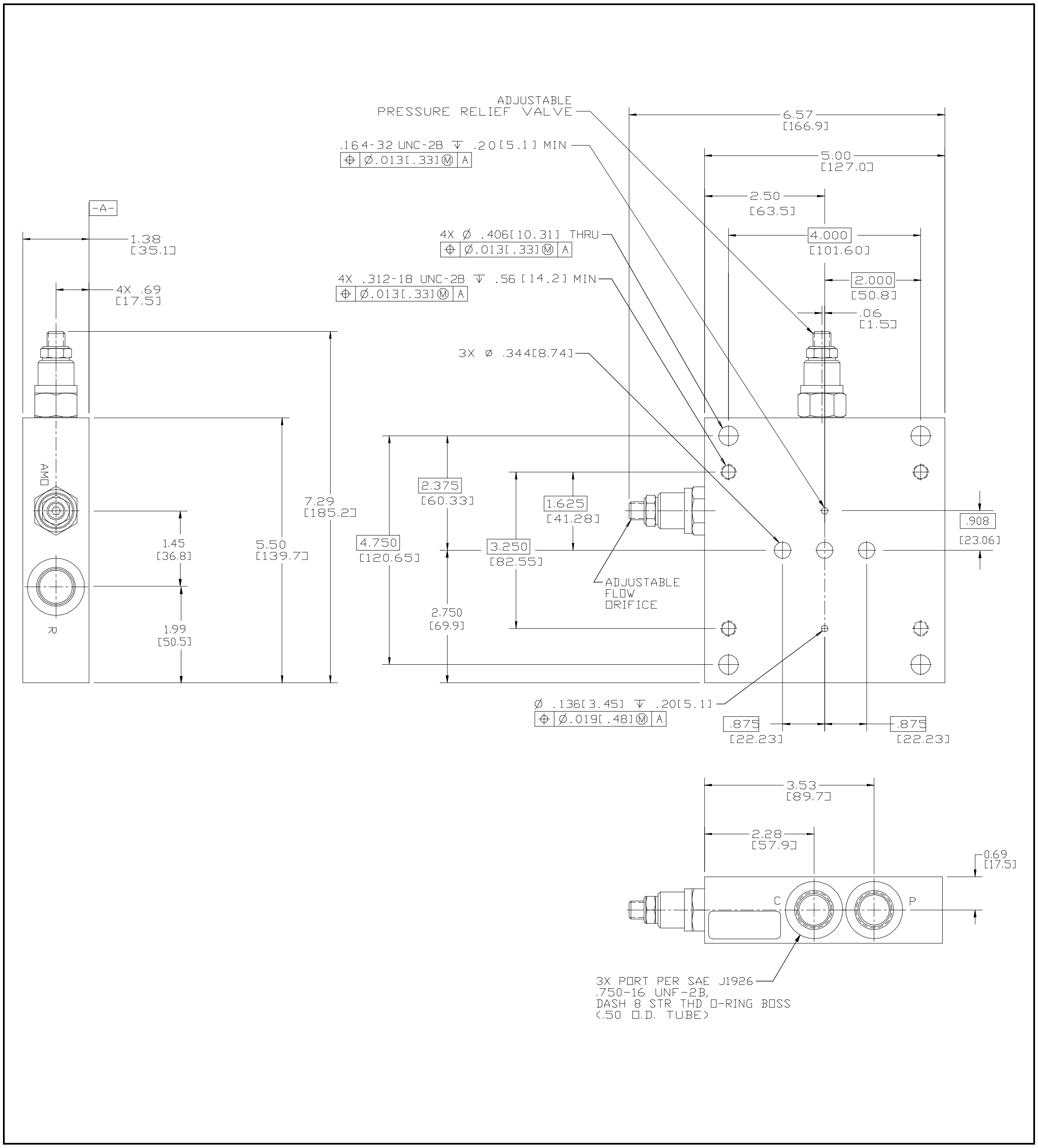


Figure 1.2.3 Optional Adjustable Metering Orifice and Pressure Relief Valve (AMO/PRV) Manifold (Part Number G3745AM2)

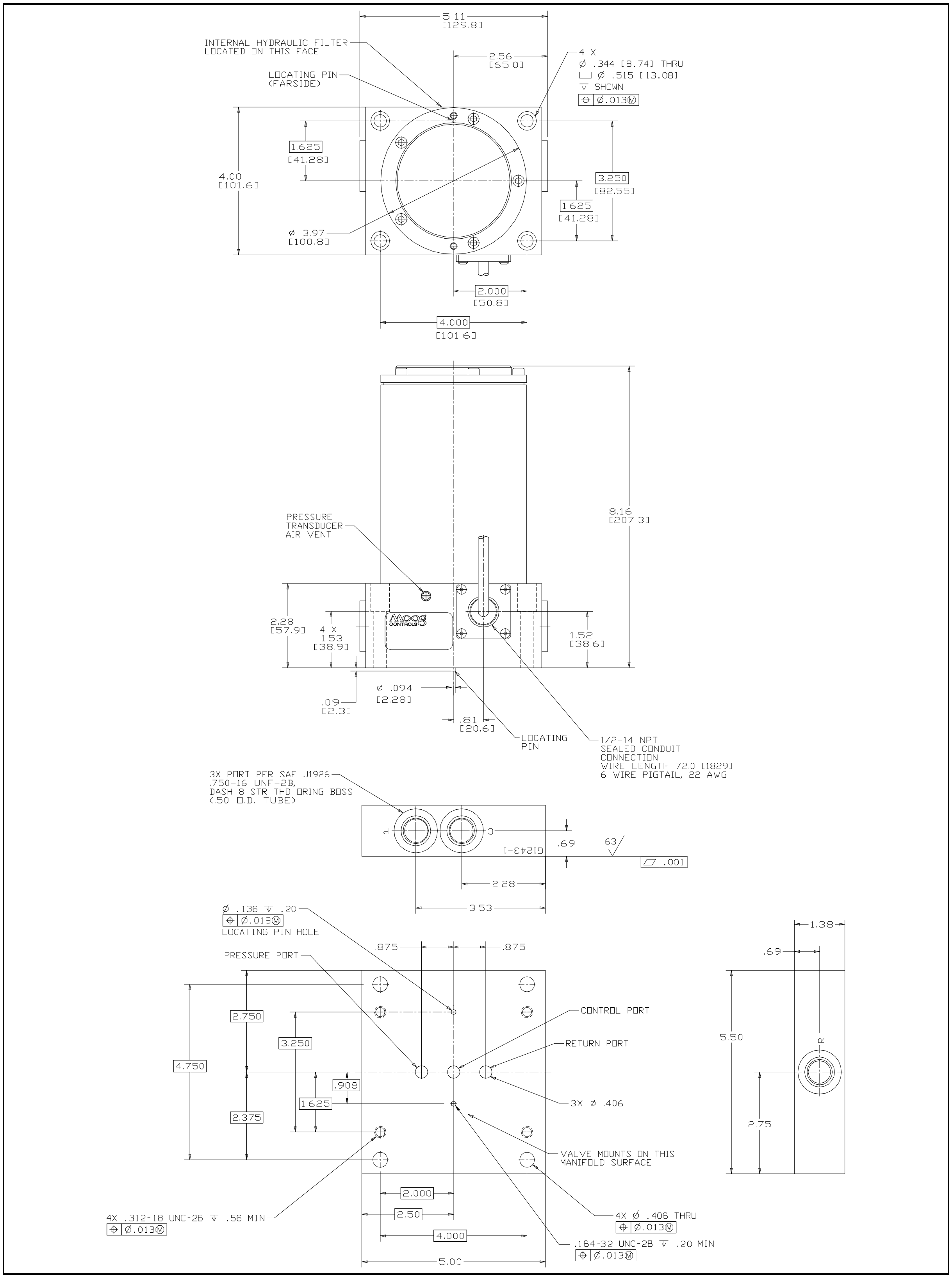
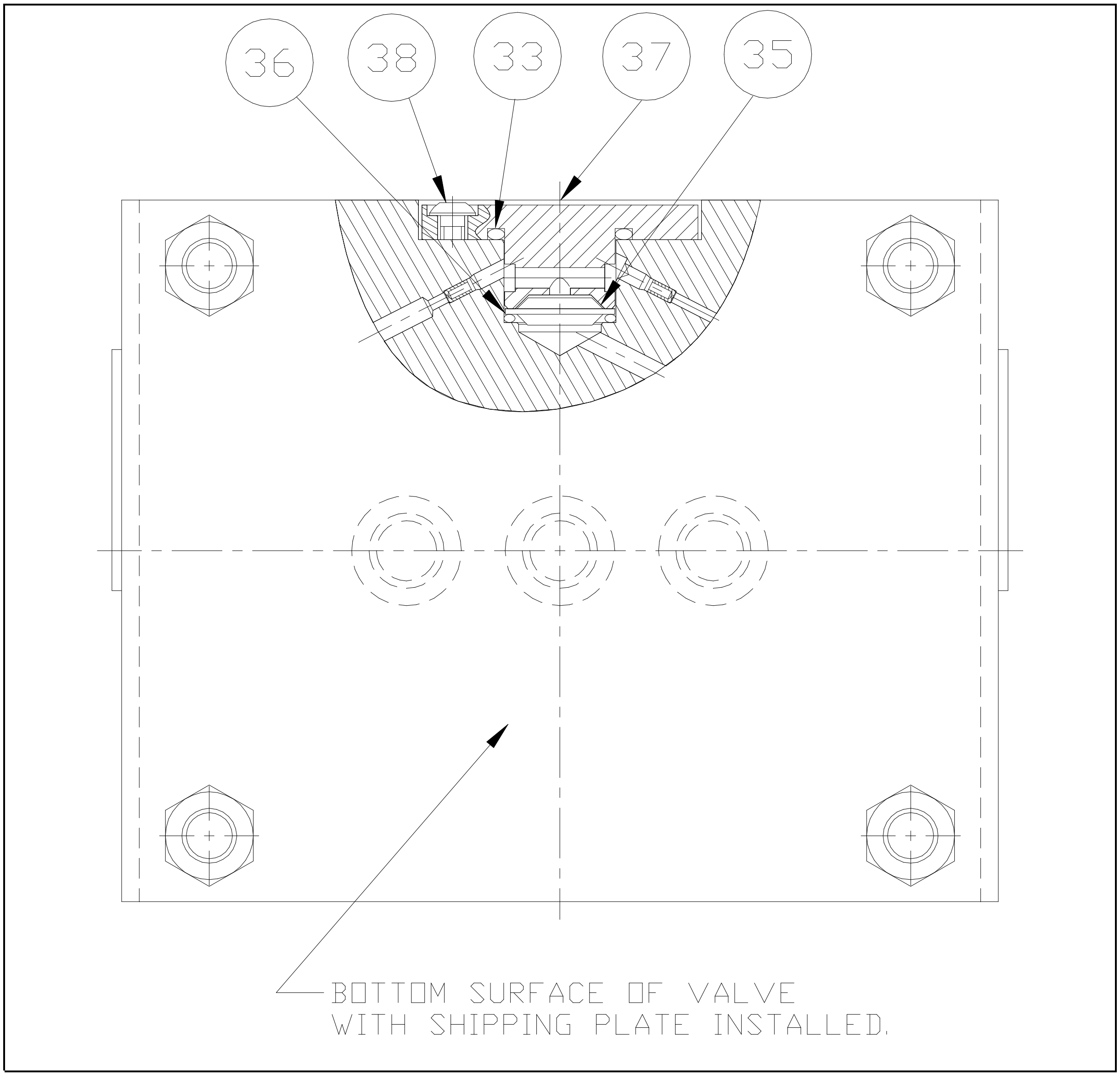


Figure 1.4.1 I/H Converter Installation Dimensions (Explosion-Proof Models)

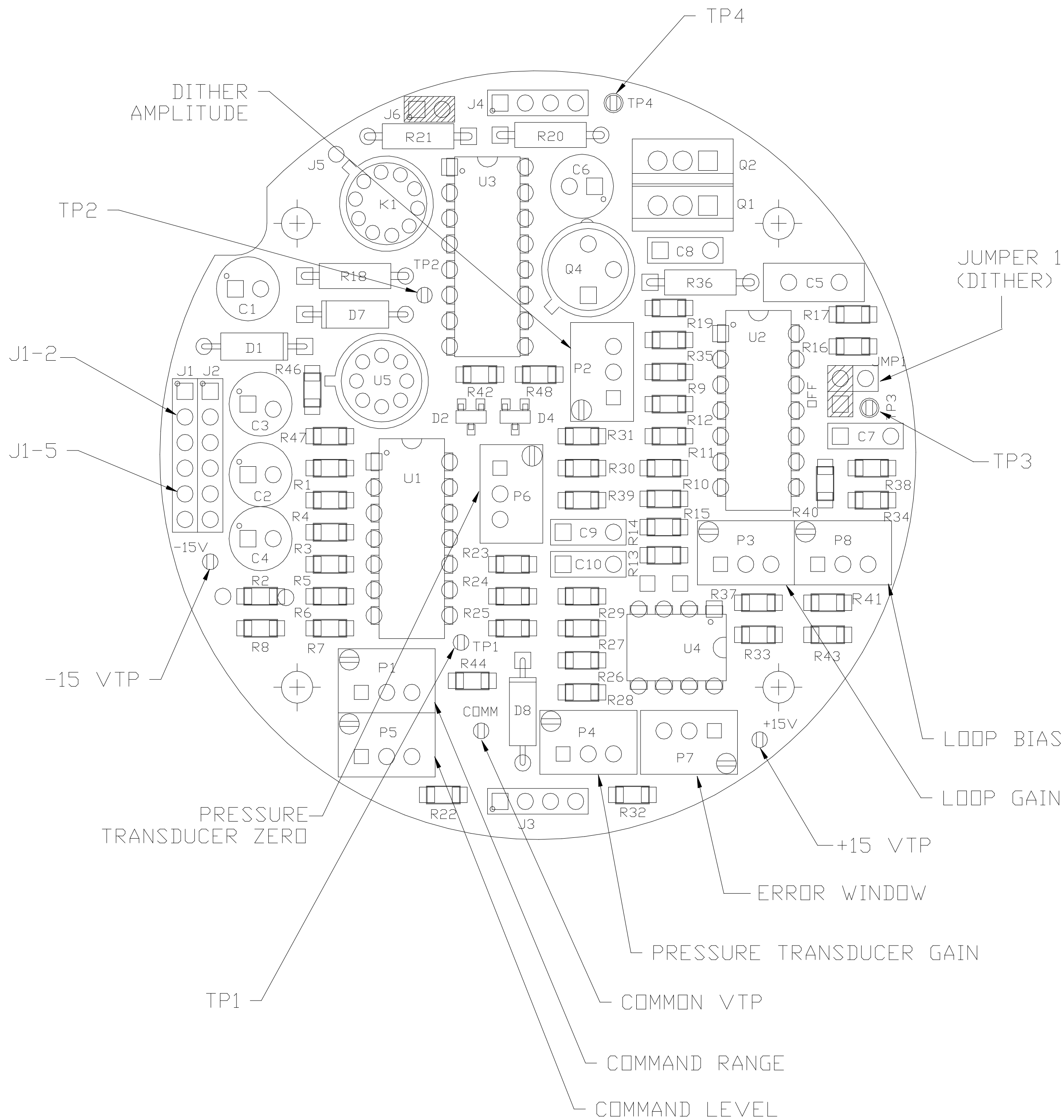
Data is representative of I/H Converter Model 770-128D in combination with manifold part number G1233AM2 (for various valve pressure drops). For flow versus control pressure data using I/H - manifold combinations other than that listed above, consult Moog Controls Engineering (section 5.0).

Figure 1.5.1 I/H Converter Flow Multiplier versus Pressure Drop



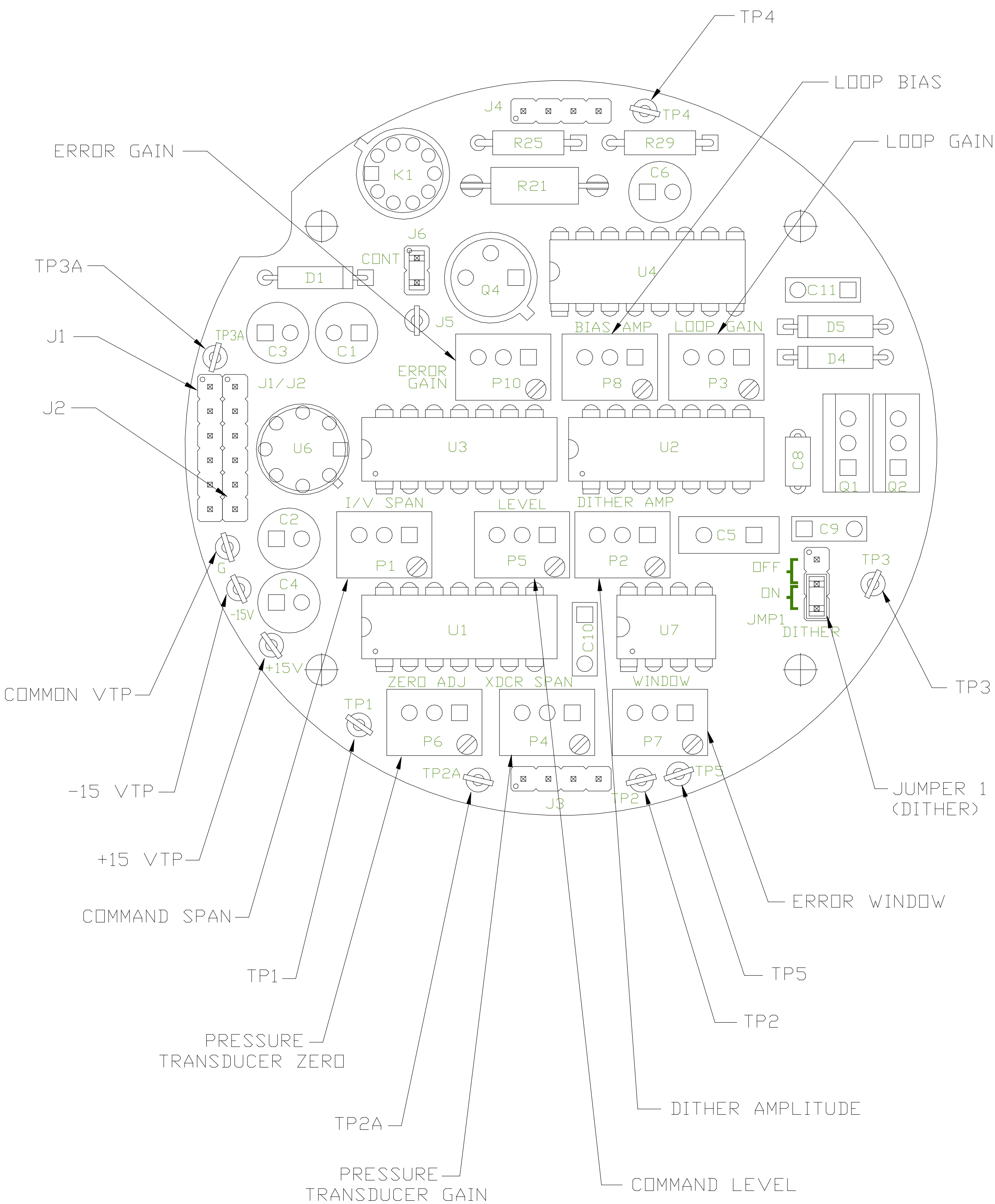
Balloon Number	Description	Part Number
33	O-Ring, 0.079 [2.00] sect x 0.669 [17.00] I.D., DIN 3770-17-20	G2140-17-20
35	Filter, Disk	58746-3-40
36	O-ring, Viton, 0.059 [1.50] sect x 0.512 [13.00] I.D., DIN 3770-13-15	G2140-13-15
37	Holder, Filter	B32768-8
38	Screw, Button Head	A31371-206P

Figure 3.4.1 Detail Showing the Internal Hydraulic Filter



Note: Components may vary slightly between model numbers.

Figure 4.2.1 Printed Circuit Board Layout for Proportional Output Pressure Models



Note: Components may vary slightly between model numbers.

Figure 4.3.1 Printed Circuit Board Layout for Inverse Proportional Output Pressure Models

Warranty

(a) Moog Controls warrants that each item of its manufacture is free from defects in material and workmanship at the date of shipment. This warranty shall not apply to any part or parts supplied to but not manufactured by Moog Controls. As to such parts, Moog Controls agrees to purchase the same from a reputable supplier and to assign to its customer whatever rights Moog Controls may have under warranties of such suppliers.

(b) Unless otherwise specified, Moog Controls' obligation under this warranty is limited to replacing or repairing any item which, within twenty-four months from date of shipment, is proven by Moog Controls' inspection to have been defective at the time of shipment. As a condition of this warranty, purchaser shall notify Moog Controls in writing of any claimed defect immediately upon discovery and shall return the item to Moog Controls for inspection. Unless specifically approved in writing, Moog Controls shall not provide uncompensated field service repairs or alterations unless Moog Controls has previously agreed in writing to such allowance. Moog Controls shall not be responsible for any work done or repairs made by others and disassembly by anyone other than authorized Moog Controls personnel may void the terms of this warranty.

(c) Assistance in the installation of equipment is not warranted by Moog Controls in the absence of a specific written agreement to that effect.

(d) MOOG CONTROLS SHALL NOT BE LIABLE FOR IMPROPER USE, INSTALLATION, OPERATION OR MAINTENANCE OF ITEMS MANUFACTURED BY MOOG CONTROLS, NOR FOR ANY DAMAGE RESULTING FROM IMPROPER USE, INSTALLATION OPERATION OR MAINTENANCE. IN ADDITION, MOOG CONTROLS SHALL NOT BE RESPONSIBLE FOR ANY DAMAGES FOR LOSS OF PRODUCTION OR PROFITS, DAMAGE TO PRODUCT OR ECONOMY OF OPERATION, OR ANY OTHER CONSEQUENTIAL OR INCIDENTAL DAMAGES OCCASIONED BY DEFECTS IN OR FAILURE OF ANY GOODS SUPPLIED BY MOOG CONTROLS, OR BY DEFECTS IN OR FAILURE OF ANY PRODUCT IN WHICH A COMPONENT MANUFACTURED BY MOOG CONTROLS IS INCORPORATED.

(e) MOOG CONTROLS SHALL NOT BE RESPONSIBLE FOR THE PERFORMANCE OF ANY PRODUCT WHICH INCORPORATES COMPONENT PARTS MANUFACTURED BY MOOG CONTROLS UNLESS SUCH PERFORMANCE IS EXPRESSLY DESIGNATED AS MOOG CONTROLS' RESPONSIBILITY UNDER THE TERMS OF THE WRITTEN AGREEMENT BETWEEN MOOG CONTROLS AND THE CUSTOMER.

(f) THE WARRANTIES CONTAINED HEREIN ARE EXCLUSIVE AND ARE GIVEN IN LIEU OF ALL OTHER WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

			REV.	CRN	DATE
PREPARED	CMK	10-21-96	**REV.**	**CRN**	**DATE**
ORIGINATED	JLH	11-04-94	NC	105398	CMK/MDW 10-21-96
APPROVED	DKB				
APPROVED	MDW	11-04-94			
APPROVED					
OTHER					

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iv	NC	4-4	NC	6-4	NC
		4-5	NC	6-5	NC
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1-2	NC	4-7	NC	6-7	NC
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1-6	NC	4-11	NC	6-11	NC
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1-8	NC	4-13	NC		
		4-14	N		
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		4-16	NC		
3-1	NC	4-17	NC		
3-2	NC				
3-3	NC	5-1	NC		
3-4	NC				
3-5	NC				