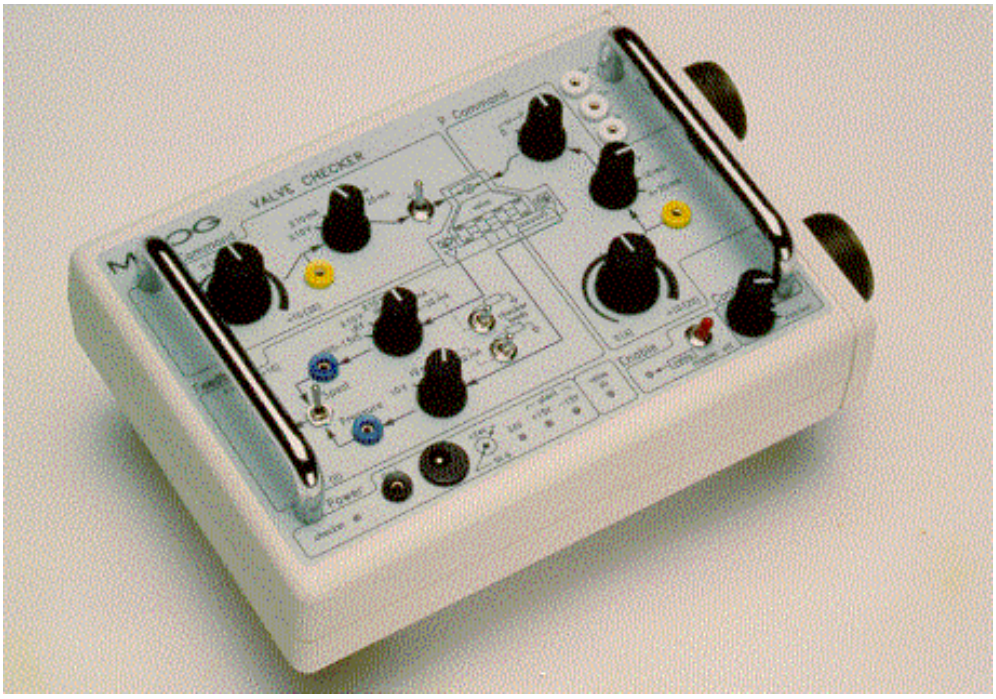
APPLICATION NOTES

VALVE CHECKER

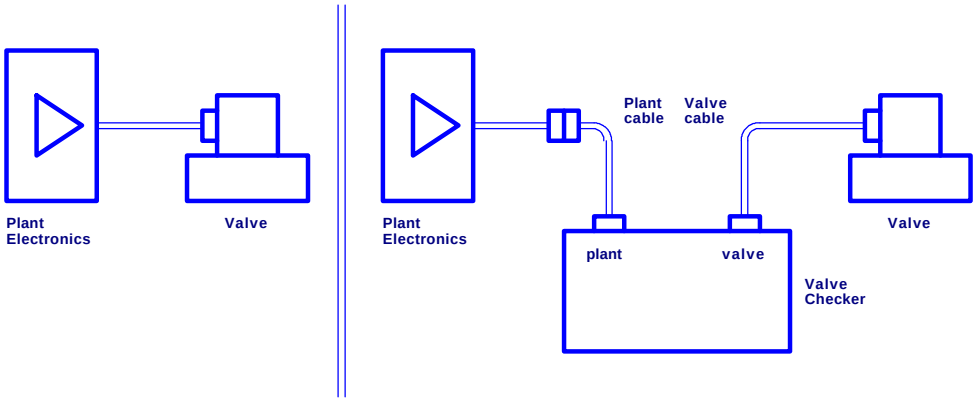
M040-120-001



CONTENTS

1. DESCRIPTION

1.1 The Moog M040-120 Valve Checker is an instrument capable of checking the complete range of Moog proportional and servo valves. The feature that makes it so versatile is the way it can test a valve while the valve is still installed in its normal operating plant. This is done at two levels:



1.1.1 Plant (In Line)

The plant and valve operate normally. The Valve Checker is connected between the plant electronics and the valve such that all the plant electronics' signals to and from the valve are connected as normal. The Valve Checker monitors the plant electronics' signals and the signals back from the valve, enabling a check of the valve's performance.

1.1.2 Checker (Stand Alone)

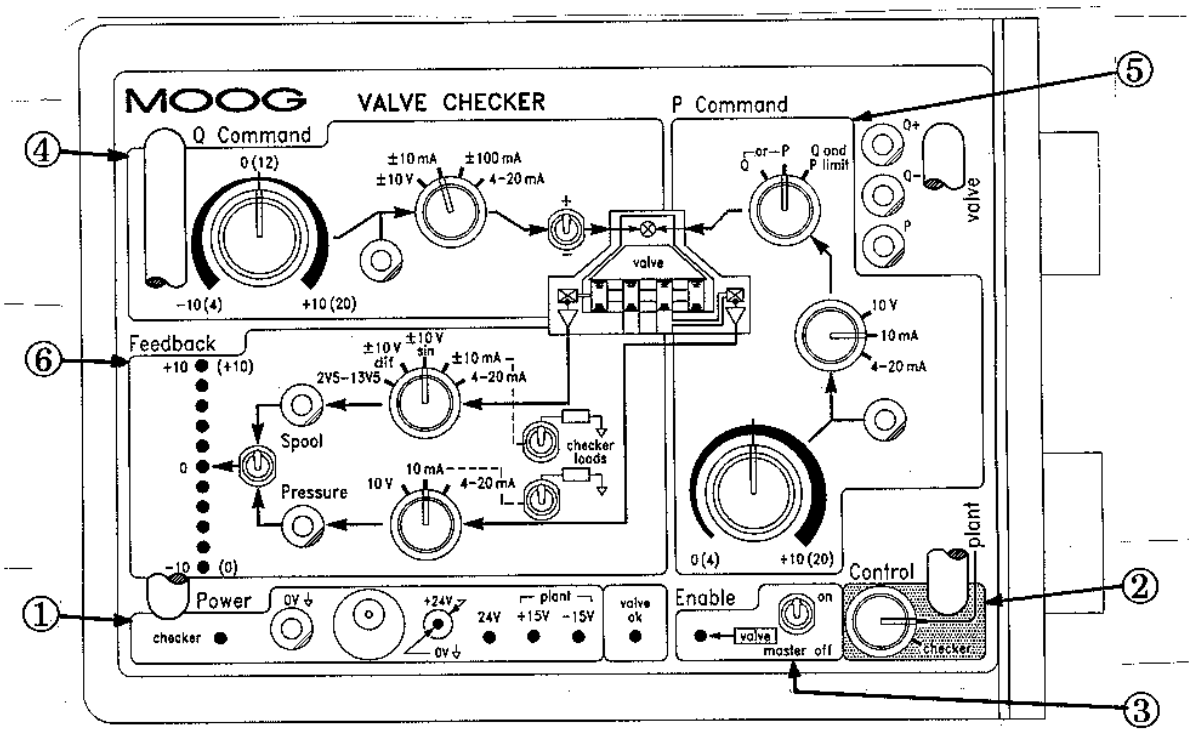
In this mode the Valve Checker generates the command to the valve and monitors the signals back from it. The valve remains installed in the plant but the plant command signals are disconnected. Checking while still installed in the plant provides the added benefit of checking the valve by observing the reaction of the plant to the Valve Checker's commands.

1.2 The Valve Checker is powered by the plant electronics which also continue to supply the valve in both *plant* and *checker* modes of operation. There is a +24V D.C power connector on the front panel to enable operation of 24V D.C powered valves, without connection to the plant electronics' power.

1.3 Two cables connect the Valve Checker to the plant electronics and valve. Connection is made by removing the plant cable from the valve, connecting the Valve Checker *plant* cable to this cable and then connecting the Valve Checker *valve* cable to the valve. Each type of valve requires its own individual pair of cables. A table in chapter seven details the cables.

1.4 There are six functional blocks on the front panel.

1. Power/Valve OK
2. Control
3. Enable
4. Q. Command
5. P. Command
6. Feedback



1.4.1 **Power/Valve OK**

The *24V LED* illuminates with both plant 24V and the front panel 24V connector supply.

The *checker LED* indicates the internal ±15V supply is healthy. This internal ± 15V supply does not power the valve.

The *valve OK LED* illuminates when the valve OK logic signal from the valve is positive.

1.4.2 **Control**

This switch selects the two operating modes:

- *Checker mode* gives valve commands of pressure P, flow Q and valve enable generated by the Checker, with the valve generated signals of pressure, spool position, enable OK and valve OK, monitored on the Valve Checker and passed back to the plant electronics.
- *Plant mode* gives valve commands of pressure P, flow Q and valve enable generated by the plant electronics, with the valve generated signals tested in the same way as in *checker mode*.

Note that a three position rotary switch is used to select between

plant and checker modes. The third unmarked position selects plant.

1.4.3 Enable

The *enable LED* illuminates when the enable OK signal from the valve is positive. The enable signal to the valve comes from the plant electronics when *plant mode* is selected. When *checker mode* is selected it comes from the *enable on switch*. However, the enable to the valve can be turned off by selecting *master off* when either *plant or checker mode* is selected.

As well as enabling the valve, the enable signal also enables the Valve Checker out put signals derived from either the checker itself, or the plant electronics.

This provides a safety feature that quickly kills all signals in the event of damaging or dangerous plant movements.

1.4.4 Q Command

This block is active only when *checker mode* is selected and *Q* is selected on the *P command mode selector* switch, to the left of the yellow test points.

The *white test point* gives a 0 to ± 10V signal proportional to the actual voltage or current being delivered to the valve.

The +/- *switch* connects the valve drive signal to the non-inverting (+ve gives P →A) and inverting (+ve gives P→B) inputs.

The actual voltage on the valve input pins can be measured on the *yellow Q+* and *Q- test points*. A knowledge of the valve input impedance is necessary to gain any benefit from this measurement.

1.4.5 P Command

This block is used in conjunction with, or in place of, the Q block, to test PQ valves. It is active only when *checker mode* is selected. The *white test point* gives a 0 to +10V signal proportional to the actual voltage or current being delivered to the valve.

The *Q/P/Q&P limit selector switch* selects the operating mode by connecting the valve signal pins in the required manner rather than turning the P command signal on and off:

- *Q mode* connects the signals so no pressure control is active.
- *P mode* gives only pressure control, flow being dependent totally on the pressure selected and the load.
- *Q and P limit mode* gives flow control from the Q block until the load pressure rises to the P command pressure. At this point the PQ valve will close to maintain the pressure. If the pressure falls below the P command setting the valve reverts to flow control.

1.4.6 **Feedback**

1.4.6.1 **Spool**

The spool position signal from the valve is always monitored and passed on to the plant electronics regardless of the mode of operation. The *blue spool test point* gives a 0 to ± 10V signal proportional to the spool signal from the valve. The *LED display* to the left of the test point provides a rudimentary indication of the signal. The centre *yellow null LED* will be illuminated for a spool signal of less than ± 10%.

An understanding of the *checker load switch* is important for successful use of the Checker when the spool signal is a current (±10mA or 4-20mA). When the valve outputs a current there must be a path through which the current can flow for the Checker to be able to measure the current. When the plant electronics do not provide this load, or the Checker is not connected to the plant electronics, the *Checker load switch* connects a 200 Ohm load to ground on the spool signal, enabling a current to flow.

Note that a six position rotary switch is used to select the five feedback signals. The sixth unmarked position selects 4-20mA.

1.4.6.2 **Pressure**

The pressure signal from the valve is always monitored and passed on to the plant electronics. The *blue pressure test point* gives a 0 to 10V signal proportional to the pressure signal from the valve. The *LED display* gives a 0 to 100% pressure indication rather than 0 to ± 100% as for the spool position. The *yellow* LED is no longer an indication of a null condition.

The *checker load switch* provides a current path when 10mA or 4-20mA signals are being monitored.

2. SPECIFICATION

Q Command Outputs	± 10V, ±10mA, ±100mA, 4-20mA, plant command
Q Command Test Point	0 to ± 10V
P Command Outputs	0 to + 10V, 0 to+10mA, 4-20mA, plant command
P Command Test Point	0 to + 10V
P&Q Commands output Swing	10V
Q (Spool)Feedback	2.5 to 13.5V, ±10V differential, ±10V single ended, ± 10mA, 4-20mA
Q (spool)Feedback Test Point	± 10V
P Feedback	0 to +10V, 0 to + 10mA, 4-20mA
P Feedback Test Point	0 to +10V
Supply	
± 15V	± 9 to ± 18 V, ± 80mA at ± 15V, excluding valve
24V	18 to 36 V, 100mA at 24 V, excluding valve
Weight	740g
Dimensions	205W x 138H x 70D
Enable & Valve OK threshold	on at 8.5V off at 6.5V
EMC	EN 50082-1 EN 55011 1A IEC 801-2 IEC 801-3
Protective earth	EN 60204-1 equal-potential

Q = Flow (proportional to spool position)
P = Pressure
m.f.b = Mechanical feedback
e.f.b = Electrical feedback

3. CONNECTING TO VALVE AND PLANT

3.1 Select the appropriate cable pair for the valve being tested. Use the cable list in chapter seven.

3.2 Disable the process that the valve is controlling by turning off electrical power and hydraulic pressure.

CAUTION: Be sure that the power down sequence is orderly so no damage can be done to the process.

3.3 Remove the process plant cable from the valve and mate this cable connector with the Valve Checker *plant cable*.

3.4 Mate the Valve Checker *valve cable* with the valve.

3.5 Select *master off* on the *enable switch*.
Restore power and hydraulic pressure.

CAUTION: Be sure that the power up sequence is orderly so no damage can be done to the process.

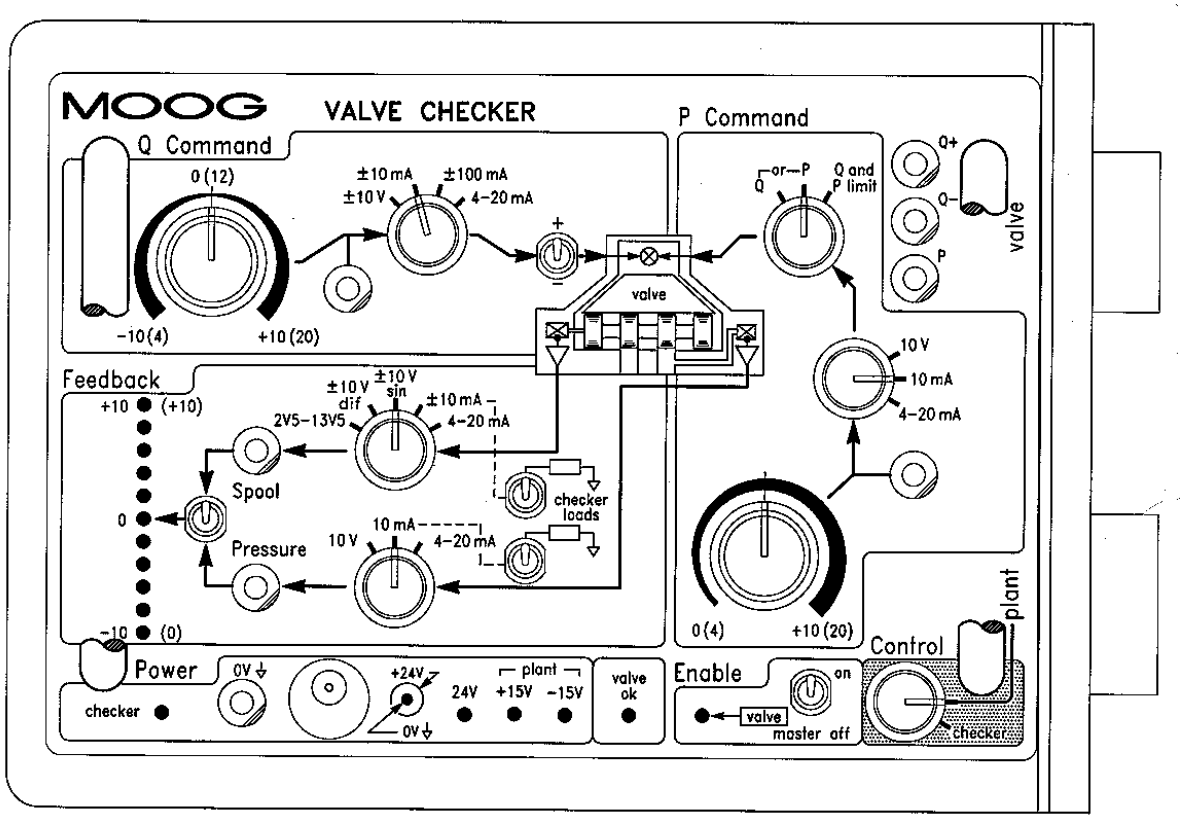
3.6 Verify that the *checker power LED* is illuminated.

3.7 Select either *plant* (in line) mode or *checker* (stand alone) mode on the *control selector switch*.
See chapter four for instructions on *plant mode* operation and chapter five for instructions on *checker mode* operation.

CAUTION: Do not spill oil on the Valve Checker. Oil can enter the housing and damage the internal electronic circuit.

Do not subject the Valve Checker to severe shock or vibration. Damage to the internal electronic circuit may result.

4. PLANT MODE OPERATION



4.1 Having successfully connected the Valve Checker as per chapter three, select *plant mode* on the control selector switch.

CAUTION: Ensure the *enable switch* is in the *master off* position and leave it in this position until all switch selections are made and the test is ready to proceed.

4.2 In plant mode the Q and P command sections are inoperative. The P,Q and enable commands come from the plant electronics.

4.3 In the feedback block select the appropriate spool (Q) and pressure (P) signals. If selecting either 10mA or 4-20mA check if the plant electronics provides a load that enables a current signal to flow. If there is no load turn on the *checker load switch*.

4.4 Begin the test by turning on the *enable switch*. The *enable OK LED* should illuminate. On valves that do not have an “enable signal input” and an “enable OK output”, the Valve Checker cable loops the enable back to the enable OK so the LED illuminates. Chapter seven lists which valves have true enable signals. Check the same list to see which valves produce a valve OK output and then check the *valve OK LED*.

4.5 Measure the actual spool and pressure signals on the *blue test points*. The voltages on these test points are standardised to 0 to ± 10V for spool (Q) and 0 to + 10V for pressure (P).

4.6 The plant electronics' command, directly on the valve input pins, can be measured on the *yellow test points*. A knowledge of the valve input impedance is required to make any real sense of these signals.

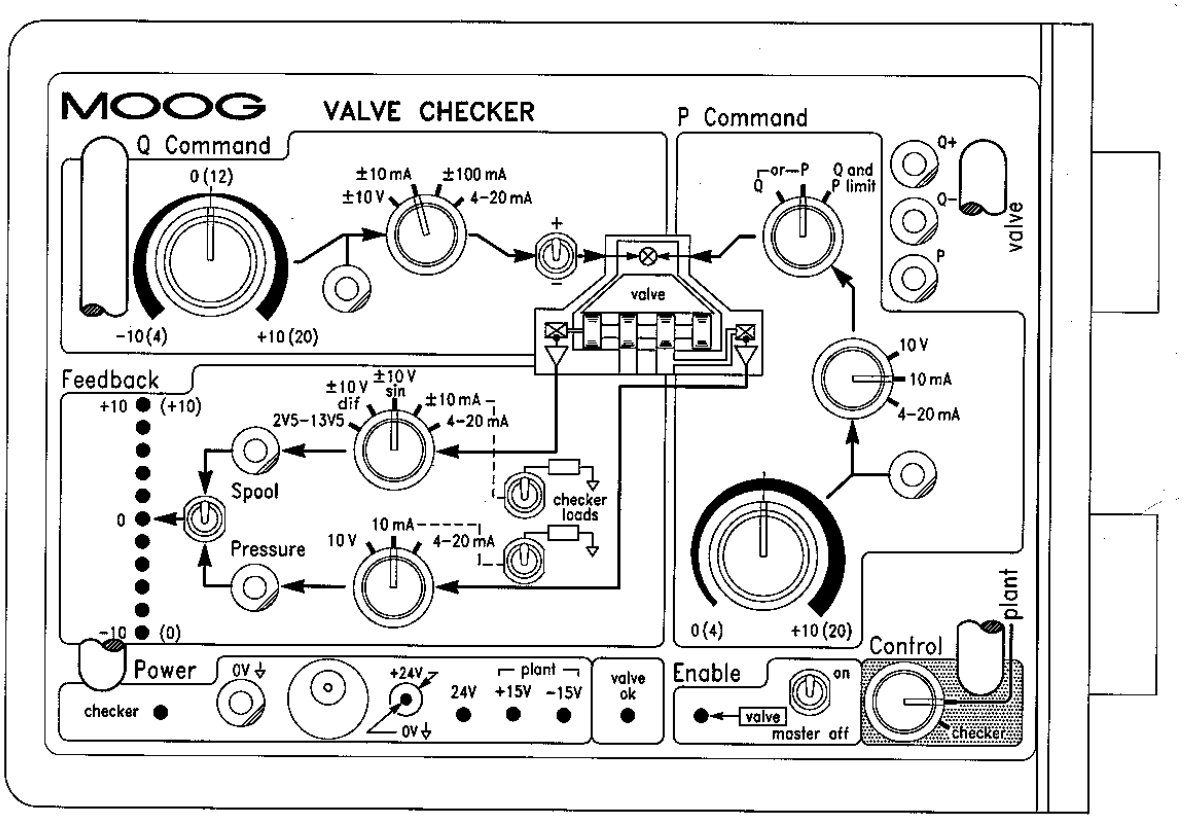
For example, a D66X valve with a ± 10mA Q command, an input impedance of 400 Ohm and the Q- pin grounded will give a Q+ voltage of ±4V. However, if you measure approximately +13V it is likely there is no current flowing. If you measure approximately OV it is likely the command from the plant is not connected. These test points are useful if a test shows a fault and you want to be sure that it is the valve and not the Valve Checker causing it.

Q+ and Q- valve pin numbers

Valve	Q+ pin	Q- pin
D66X 12 pin	D	E
D66X 11+PE	4	5
D66X 6+PE	D	E
D691 12 pin	D	-
D691 11+PE	4	-
D633/4 6 pin	D	E
D633/4 6+PE	D	E
D656 6/7 pin	D	-
D656 12 pin	D	-

4.7 The *LED display* shows the signal level selected by the display *toggle switch* between the two *blue test points*. This *display* provides a rudimentary check of the feedback signals. When *spool* is selected the centre *yellow null LED* is illuminated when the spool position is within ± 10% of null. When *pressure* is selected it is no longer a null indicator, minimum pressure being indicated by the bottom (O) LED. The *display* does not operate for pressure when testing D651-4 PQ valves. This is because the pressure feedback signal for these valves is a negative voltage and the *display* operates only for positive pressure signals.

5. CHECKER MODE OPERATION



5.1 Having successfully connected the Valve Checker as per chapter three, select *checker mode* on the *control selector switch*.

CAUTION: Ensure the *enable switch* is in the *master off* position and leave it in this position until all switch selections are made and the test is ready to proceed.

5.2 Set the *Q command pot* to its centre zero position and select the signal type appropriate to the valve being tested. Set the ± *polarity switch* as required. If testing a PQ valve this switch is automatically over-ridden because PQ valves do not have dual (±) Q command inputs. If you are uncertain of the polarity, it is recommended to use + as a starting point and check the direction of actuator travel in the process plant, when testing begins.

5.3 If testing a PQ valve, set the *P command pot* to minimum (fully counter clockwise) and select the signal type appropriate to the valve being tested. Select the mode of operation of the PQ valve.

Q - flow control only
P - pressure control only
Q&P limit - flow control with Q command until P command pressure is reached at which point pressure limiting control occurs.

CAUTION: The M040-120 Valve Checker is wired for PQ valves in the main flow path only. It is not suitable for testing PQ valves in bypass connection.

5.4 In the feedback block select the appropriate spool (Q) and pressure (P) signals. If selecting either 10mA or 4-20mA check if the plant electronics provides a load that enables the current signal to flow. If there is no load turn on the *checker load switch*.

5.5 Begin the test by turning on the *enable switch*. The *enable OK LED* should illuminate. On valves that do not have an "enable signal input" and an "enable OK output", the Valve Checker cable loops the enable back to the enable OK so the LED illuminates. Chapter seven lists which valves have true enable signals. Check the same list to see which valves produce a valve OK output and then check the v*alve OK LED*.

5.6 Adjust the *P and Q commands pots*. Measure the command value, standardised to 0 to ±10V for Q and 0 to +10V for P, on the *white test points*. Compare these values to the actual valve output on the *blue test points*. For correct function they should be the same; within accuracy limits.

5.7 The accuracy limit of the Valve Checker is ± 0.2V for all signals other than 4-20mA on the spool, where it is ±0.4V. This means that if you read a command of 5.6V the feedback signal could be between 5.4 and 5.8V and the valve will be functioning correctly. For a spool signal of 4-20mA this would be 5.6V to 6.0V for correct functioning.

See pg. 10 for a table of Q+ and Q- valve pin numbers.

5.8 The *yellow test points* enable a measurement directly on the valve input pins. This is useful if a test shows a fault and you want to be sure it is the valve and not the Valve Checker causing it. A knowledge of the input impedance of the valve is necessary to make any real sense of these measurements.

5.9 The *LED display* shows the signal level selected by the *display toggle switch* between the two *blue test points*. This *display* provides a rudimentary check of the feedback signals. When *spool* is selected the centre *yellow null LED* is illuminated when the spool position is within ±10% of null. When *pressure* is selected it is no longer a null indicator, minimum pressure being indicated by the bottom (O) LED. The *display* does not operate for pressure, when testing D651-4 PQ valves. This is because the pressure feedback signal for these valves is a negative voltage and the *display* operates only for positive pressure signals.

6. EXTERNAL 24V SUPPLY

6.1 The Valve Checker can be powered from the plant electronics via the plant connector or the front panel 24V connector. When 24V is supplied to this front panel connector three things happen:

- The Valve Checker internal power is derived from this supply.
- The 24V supply to valves powered by 24V is derived from this supply.
- ±15V powered valves continue to be powered from the plant electronics.

6.2 Supply requirements are:

- 2.1mm diameter connector: 24V outside contact, OV inside contact
- 18V to 36V input range
- 100 mA at 24V to power the Valve Checker with no load

6.3 Typical 24V maximum supply requirements for some valves are:

- D633 - 1.2A
- D634 - 2.2A
- D635 - 1.0A
- D66X - 300mA
- D691 - 300mA

CAUTION: When the external 24V supply is connected, the plant 24V is always automatically disconnected and the valve powered from the external 24V supply. It is essential that the external supply you connect has adequate current capacity, to power the valve you are checking.

7. CABLE LIST

NO	Model No	Type	Connector	Supply	B96838 Valve Cable	B96837 Plant Cable	Enable to Valve (G)	Enable OK (M)	Valve OK (T)
1	D633/4	DDV	6 Pin	+24V	-001	-001	no	*	no
2	D66X	Prop	6+PE	+24V	-002	-002	yes	*	no
3	D635	DDV-P	6+PE	+24V	-003	-003	no	*	no
4	D66X	Prop	12 Pin	±15V	-004	-004	no	*	yes
5	D66X D769	Prop	6 Pin	±15V	-005	-005	no	*	no
6	D691	PQ	12 Pin	+24V	-006	-006	yes	yes	yes
7	D66X D765	Prop	6+PE	±15V	-007	-007	no	*	no
8	D656	PQ main flow path	12 Pin (J to E)	±15V	-008	-008	no	*	yes
9	D651 to D654	PQ main flow path	5&6 Pin	±15V	-009	-009	no	*	no
10	D656	PQ main flow path	6&7 Pin	±15V	-010	-010	no	*	no
11	D656	PQ main flow path	12 Pin	±15V	-011	-011	no	*	yes
12	D691	PQ	11+PE	±15V	-012	-012	no	*	yes
13	D691 D66X	PQ ,Prop	11+PE	+24V	-013	-013	yes	yes	yes
14	D633/4	DDV	6 +PE	+24V	-014	-014	no	*	no
15	mfb	Series coils	4 Pin		-015	-015/ -016	no	*	no
16	mfb	Parallel coils	4 Pin		-016	-015/ -016	no	*	no

***** the enable OK indicator is illuminated by the enable command from the Valve Checker

8. PERFORMANCE CHECKS

The Checker can be used to test null, threshold, step response and hysteresis. Because threshold and hysteresis on efb valves are very low, it can be difficult to get an accurate figure if the valve is operating within specification. Testing threshold and hysteresis is only of value if the valve is well out of specification; and then only to confirm incorrect operation, rather than accurately quantifying it.

8.1 Null

The Spool null position of a flow control (Q) valve is generally the point at which there is no flow from either port. This is the case with axis cut spools. However, valves can have overlapped, underlapped and combinations of the three types that can make checking null a little tricky.

An accurate understanding of the specified null characteristic of a valve is essential before any sense can be made of null measurement results.

8.11 To check the null of an axis cut, or quasi axis cut spool (3% overlap), set the *Q Command* so the actuator controlled by the valve is stationary. Measure the command. This measurement is the null offset, or null error, of the valve. It will be difficult to get the actuator to stop for both types of axis cut spool. A slight drift one way or another is acceptable.

8.1.2 Checking the null on an overlapped valve is a little more difficult. Find a *Q Command* that holds the actuator stationary, or near stationary. A small amount of actuator creep is normal. Increase the *Q Command* until positive actuator movement is observed. Record this value.

Decrease the *Q Command* until an equal reverse actuator movement is observed. Record this value. The two readings should be equal in magnitude but opposite in sign. The difference in the magnitude of the two readings is a measure at the null offset.

8.2 Threshold

8.2.1 Threshold on all types of valves is so low that it is difficult to use the Valve Checker to get an accurate figure. However the procedure outlined below will enable you to determine if the valve being checked is faulty, assuming the actuator has low threshold.

- Bring the actuator to a stop with the *Q Command.*
- Place your hand on the rod and gland and carefully move the *Q Command* back and forth around null.
- Check the motion of the rod as its direction reverses. The motion should be smooth and free of jerks.

8.2.2 On efb valves with spool position feedback, the same test can be done while monitoring the spool feedback signal with an oscilloscope or chart recorder. As the *Q Command* is smoothly reversed about null, the spool signal should show no discontinuity.

8.3 **Step Response**

Set the *Q Command* to a small value, say 10%. By switching the command on and off with the *enable switch* and observing the spool position feedback signal on an oscilloscope, the step response can be shown. A alternative method is to set a 10% Q Command and reverse the command to the valve by switching the ± *switch.* This method is applicable to Q only efb valves.

Caution: **This test may be detrimental to the process or machine, so should only be done with care.**

8.4 **Hysteresis**

8.4.1 To check hysteresis on an efb valve, ie; a valve with spool position feedback, set the *Q Command* fully negative. Increase the *Q command* until the spool is at null. Only increase the *Q command*. Do not decrease it. Measure the command signal.

8.4.2 Over a period of several seconds increase the *Q Command* to maximum and then back to null. It is important to come to null while decreasing the command. The measurement will be invalid If the command is reversed as null is approached. Now measure the command signal at null.

8.4.3 The difference between the two null measurements is the hysteresis. This figure actually includes threshold. However, threshold is normally much smaller than hysteresis and so the figure obtained is a valid hysteresis value.