

**CARBON DIOXIDE DRY ICE
MODEL DE01RB-1500
PELLETIZER
OPERATION &
MAINTENANCE**

CARBON DIOXIDE DRY ICE MODEL DE01RB-1500 PELLETIZER OPERATION & MAINTENANCE MANUAL

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Revision 6 –Corrected Figure 4.2
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INTRODUCTION

TOMCO₂ EQUIPMENT COMPANY CARBON DIOXIDE DRY ICE PELLETIZERS

Tomco₂ has been a CO₂ equipment specialist for over thirty years. Tomco₂ manufactures Urethane Insulated CO₂ Storage Units, Vacuum Insulated CO₂ Storage Units, CO₂ ISO Containers, CO₂ Particle Filters, CO₂ Vaporizers, CO₂ Pumps, CO₂ Cleaning Systems, and CO₂ Water Treatment Systems.

Tomco₂ offers a 24-hours a day, 365 days a year, Parts and Service Department. The telephone number is 800-832-4262 (toll free in the U.S.) or 770-979-8000.

Our dry ice pelletizers are available in models capable of producing from 100 to 3000 lbs/hour . These units are made of the highest quality materials and workmanship.

Thank you for purchasing our CO₂ dry ice pelletizers, and if we can be of service to you, please contact us.

UNDERSTANDING CARBON DIOXIDE

Carbon dioxide is a chemical compound formed by combining one atom of carbon with two atoms of oxygen, and is expressed by the molecular formula CO_2 . Carbon dioxide can exist in any one or all three states of matter: solid, liquid, and/or vapor; depending on conditions of temperature and pressure.

Under normal atmospheric conditions, carbon dioxide exists as a colorless, odorless gas which is about 1.5 times heavier than air. Carbon dioxide will not burn or support combustion and will not sustain life.

When confined within a suitable pressure vessel, carbon dioxide can exist in any of three states of matter depending on conditions of temperature and pressure. The point at which all three states may exist in equilibrium is -69.9°F (-56.6°C) and 60.4 psig (4.2 bar). This is called the triple point. At temperatures and pressures lower than the triple point, carbon dioxide may be either a solid or a vapor, again depending on conditions. Dry ice (solid carbon dioxide), at a temperature of -109.3°F (-78.5°C) at atmospheric pressure, sublimates (transforms directly from solid into vapor without the formation of a liquid).

The critical point of carbon dioxide is 87.9°F (31.1°C) and 1070.6 psig (73.8 bar). At temperatures and pressures greater than 87.9°F (31.1°C) and 1070.6 psig (73.8 bar), carbon dioxide cannot exist as a liquid. At pressures and temperatures greater than the critical point, carbon dioxide exists only as a supercritical fluid.

At temperatures and pressures above the triple point and below the critical point, carbon dioxide liquid with overlying vapor may exist in equilibrium within a closed vessel. Within this range, there is a definite relationship between temperature, pressure, and density.

By following the vapor pressure curve in Figure 1.1 on page 1.3, it becomes obvious that if you desire to store liquid carbon dioxide at 70°F (21.1°C), the pressure vessel would have to be built to withstand pressures of around 840 psig (57.9 bar). By

INTRODUCTION

following the liquid density curve, one finds that the liquid becomes less dense as the temperature increases and at 70 °F (21.1 °C), the liquid density is around 47 pounds per cubic foot (754 kg/m³).

By comparing the pressure and liquid density at 70 °F (21.1 °C) [837.8 psig (57.8 bar) and 47.6 pounds per cubic foot (764 kg/m³)] with the pressure and density at 0 °F (-17.8 °C) [291.1 psig (20.1 bar) and 63.65 pounds per cubic foot (1022 kg/m³)], it is obvious that relatively large quantities of carbon dioxide liquid can be stored in relatively small, thin walled pressure vessels; hence low-pressure bulk storage of CO₂.

The term "low-pressure" is used in the industry to describe the storage of carbon dioxide at low temperatures below ambient, usually around 0 °F (-17.8 °C). It is a relative term and should not be taken literally, as the pressures involved range up to approximately 350 psig (24.1 bar).

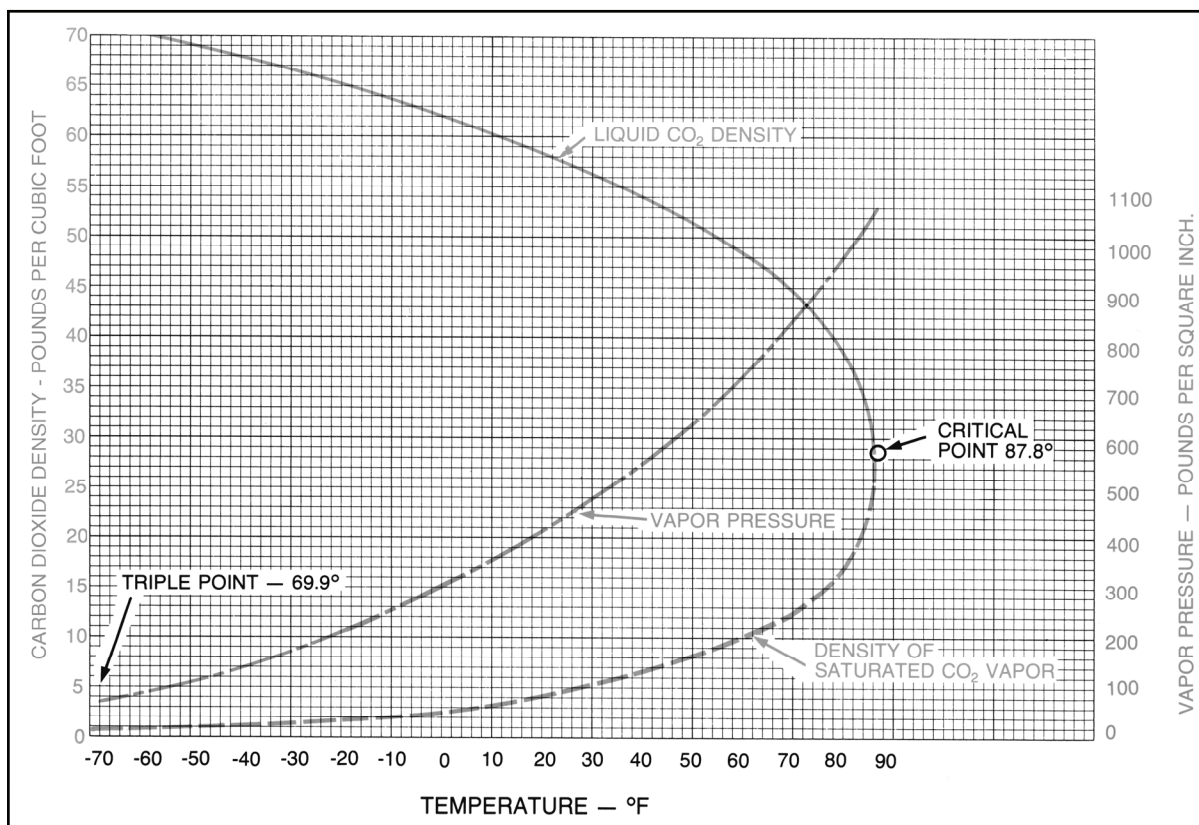


Fig. 1.1 - Carbon Dioxide Density & Vapor Pressure Curves

Molecular Weight	44.01 lb/lb-mol	44.01 kg/kg-mol
Vapor Pressure at 70 °F (21.1 °C) at 32 °F (0 °C) at 2 °F (-16.7 °C) at -20 °F (-28.9 °C) at -69.9 °F (-56.6 °C) at -109.3 °F (-78.5 °C)	838 psig 491 psig 302 psig 200 psig 60.4 psig 0 psig	57.79 bar 33.86 bar 20.83 bar 13.79 bar 4.17 bar 0 kPa
Density of the gas at 70 °F (21.1 °C) at 32 °F (0 °C)	0.1144 lb/ft ³ 0.1234 lb/ft ³	1.833 kg/m ³ 1.977 kg/m ³
Specific gravity of the gas at 70 °F (21.1 °C) at 32 °F (0 °C)	1.522 1.524	1.522 1.524
Specific volume of the gas at 70 °F (21.1 °C) at 32 °F (0 °C)	8.741 ft ³ /lb 8.104 ft ³ /lb	0.5457 m ³ /kg 0.5059 m ³ /kg
Density of liquid, saturated at 70 °F (21.1 °C) at 32 °F (0 °C) at 2 °F (-16.7 °C) at -20 °F (-28.9 °C) at -69.9 °F (-56.6 °C)	47.6 lb/ft ³ 58.0 lb/ft ³ 63.3 lb/ft ³ 66.8 lb/ft ³ 73.5 lb/ft ³	764 kg/m ³ 931 kg/m ³ 1016 kg/m ³ 1072 kg/m ³ 1179 kg/m ³
Sublimation temperature (1 atm)	-109.3 °F	-78.5 °C
Critical temperature	87.9 °F	31.1 °C
Critical pressure	1070.6 psig	73.81 bar, abs
Critical density	29.2 lb/ft ³	468 kg/m ³
Triple point	-69.9 °F at 60.4 psig	-56.6 °C at 4.16 bar
Latent heat of vaporization at 32 °F (0 °C) at 2 °F (-16.7 °C) at -20 °F (-28.9 °C)	100.8 Btu/lb 119.0 Btu/lb 129.6 Btu/lb	234.5 kJ/kg 276.8 kJ/kg 301.4 kJ/kg
Latent heat of fusion at -69.9 °F (-56.6 °C)	85.6 Btu/lb	199 kJ/kg
Density of liquid at 2 °F (-16.7 °C)	63.3 lb/ft ³	1015.9 kg/m ³
Latent heat of sublimation at -109.3 °F (-78.5 °C)	245.5 Btu/lb	571.0 kJ/kg

Table 1.1 - Physical Constants of Carbon Dioxide

LEARNING MORE ABOUT CARBON DIOXIDE

An important part of maintaining a carbon dioxide dry ice pelletizer is understanding the properties of CO₂. Therefore, maintenance and service of your pelletizer should be performed only by a qualified carbon dioxide equipment technician.

To start or increase your knowledge of carbon dioxide, we recommend that you begin with the pamphlets and literature from the CGA (Compressed Gas Association). The CGA has a number of pamphlets and videos on CO₂ and CO₂ equipment.

We recommend:

G-6 Carbon Dioxide

G-6.1 Standard for Low Pressure Carbon Dioxide Systems at Consumer Sites

G-6.4 Safe Transfer of Low Pressure Liquefied Carbon Dioxide in Cargo Tanks, Tank Cars and Portable Containers

G-6.7 Safe holding of liquid carbon dioxide containers that have lost pressure

G-6.9 Dry Ice

AV-7 Characteristics and Safe Handling of Carbon Dioxide

The CGA has other publications, videos, etc. that pertain to the CO₂ and CO₂ equipment. Contact the CGA for a list of available publications at:

Compressed Gas Association
1725 Jefferson Davis Hwy.
Suite 1004
Arlington, VA 22202-4102 USA
Phone: (703) 412-0900

CARBON DIOXIDE DRY ICE PELLETIZER **SPECIFICATIONS**

METHOD OF OPERATION: The dry ice pelletizer consists of a system for injecting liquid CO₂ into a compression cylinder. The process of reducing the pressure on the liquid from approximately 300 psi (20.68 bar), below the Triple Point, to atmospheric pressure causes about 40% of the carbon dioxide to change to a solid. The remaining carbon dioxide changes to a vapor and is vented from the machine. Finally, the solid is hydraulically extruded through a die to form dry-ice pellets. These pellets can range in size from 1/4" (6 mm) to 3/4" (19.05 mm) diameter.

HYDRAULIC SYSTEM:

- High oil temperature automatic shut-off (greater than 158 °F (70 °C))
- Low oil level automatic shut-off
- High pressure relief valve (3000 psi (206.8 bar))

ELECTRICAL: 460 Volt 3 Phase (other voltages are available)

FEATURES:

- U.S.D.A (United States Department of Agriculture) approved
- Automatic operation

MODEL	DE01RB-1500
WIDTH	46" (116.9 cm)
LENGTH	130.5" (331.8 cm)
HEIGHT	83.5" (212.1 cm)
APPROX. WEIGHT	5200 lbs (2358.7 kg)
CYCLE TIME	40 seconds per cylinder
NUMBER OF CYLINDERS	2
MOTOR	30 HP (22.4 Kw)
HYDRAULIC OIL CAPACITY	180 gallons (681 liters)
HYDRAULIC PRESSURE RELIEF	3000 psig (206.8 bar)

Table 1.2 - Dry Ice Pelletizer Dimensional Data

CARBON DIOXIDE SAFETY

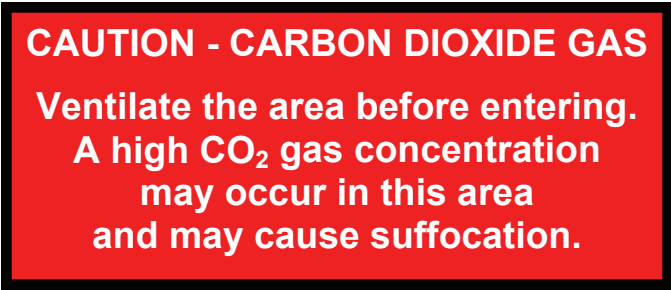
The text in this section has been adapted from CGA (Compressed Gas Association) publication CGA G-6 – 1984: Carbon Dioxide.

GENERAL SAFETY CONSIDERATIONS

Gaseous carbon dioxide is an asphyxiant. Concentrations of 10% or more can produce unconsciousness or death. Lower concentrations may cause headache, sweating, rapid breathing, increased heart rate, shortness of breath, dizziness, mental depression, visual disturbances, and shaking. The seriousness of the latter manifestations is dependent on the concentration of carbon dioxide and the length of time the individual is exposed.

Carbon dioxide is an odorless gas and should be treated as a material with poor warning properties. It is denser than air, and high concentrations can persist in open pits, tanks, or low depressions on the terrain. Before entering such an area, carbon dioxide monitoring should be carried out and the area cleared by forced ventilation, or a self-contained, supplied air respirator should be worn.

Appropriate warning signs should be affixed outside of those areas where high concentrations of carbon dioxide gas can accumulate. An example is shown below:



CAUTION - CARBON DIOXIDE GAS
Ventilate the area before entering.
A high CO₂ gas concentration
may occur in this area
and may cause suffocation.

RESCUE

Do not attempt to remove the individual without utilizing proper rescue equipment or you may also become a casualty. If the exposed person is unconscious, obtain assistance and put into effect the established emergency procedures.

INHALATION FIRST AID

Inhalation of gaseous carbon dioxide can adversely affect body function. Skin, eye, or mouth contact with dry ice (solid carbon dioxide) or compressed carbon dioxide can cause adverse effects.

If a person has inhaled large amounts of carbon dioxide and is exhibiting adverse effects, move the exposed individual to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get professional medical attention immediately.

EXTERNAL EXPOSURE FIRST AID

Skin or mouth contact with dry ice or with vapor or liquid carbon dioxide discharged from a container may result in frostbite, causing skin lesions or more serious injury from deep freezing of the tissues.

If dry ice or compressed CO₂ vapor comes in contact with the skin or mouth, stop the exposure immediately. If frostbite has occurred, obtain professional medical attention immediately. Do not rub the area. Do not apply heat warmer than 107 °F (41.7 °C).

Eye contact with dry ice or compressed CO₂ should be considered as a corneal burn. Frostbite of the eye structure may also occur.

If dry ice or CO₂ vapor or liquid comes in contact with the eyes, stop the exposure and obtain professional medical attention immediately.

INSTALLATION

INSTALLATION

INSTALLATION

Following is the standard installation procedure for a Tomco₂ Equipment Co. carbon dioxide dry ice pelletizer. **Note: This should be performed by a qualified carbon dioxide equipment technician only.** Refer to Figure 3.1 on page 3.4.

Note: A liquid CO₂ supply pressure of 250 to 300 psig (17.23 to 20.68 bar) is required for satisfactory performance. Contact Tomco₂ Equipment Co. if liquid CO₂ pressure will be lower than 250 psig (17.23 bar). Contact Tomco₂ Equipment Co. if liquid CO₂ Dew point will be above -60°F (-51.1°C). (Moisture content 13.04 ppm (WT/WT))

1. Install an insulated connecting line between the liquid process isolation valve on the carbon dioxide storage unit and the 1" FNPT connection on the rear of the pelletizer. We recommend a pre-insulated (insulated with 2 1/2" (63.5 mm) urethane) Type K copper. However, 1" NPT schedule 80 seamless pipe can be substituted. Include in this line a core type liquid CO₂ filter. We recommend a Sporlan Valve Co. model C-1449G for 1 1/8" copper or a Sporlan Valve Co. model C-1448P for 1" NPT pipe. Each of these filters uses a single Sporlan Valve Co. core model RC-4864. (Filters are available from Tomco₂ Parts and Service.) This line should be no longer than 25' (7.62 m). Tomco₂ recommends the use of an automatic vapor purge device on any pelletizer that has more than 25' (7.62m) of liquid supply piping. Contact Tomco₂ Equipment Co. if the installation will require more than 25' (7.62m) of liquid supply piping. The above is for a single machine operation. If several machines are connected to the same liquid line, larger pipe sizes must be used

Using an undersized liquid line will result in decreased production.

2. Install a connecting line between the vapor process isolation valve on the carbon dioxide storage unit and the 1/4" FNPT connection on the rear of the pelletizer. The construction material of this line must meet CGA requirements, local codes and be approved for a working pressure of 350 psig (24.1 bar).

Note: If isolation valves are included in the connecting lines (steps 1 & 2), a safety relief valve must be installed between the isolation valves and the liquid or vapor process isolation valves at the storage unit in the event that carbon dioxide becomes trapped between the two valves.



TRAPPING CARBON DIOXIDE IN A PIPE WITHOUT A SAFETY RELIEF VALVE CAN RESULT IN A RUPTURE OF THE PIPE CAUSING SERIOUS INJURY OR DEATH!

3. Install a low-pressure check valve (no greater than 5 psi cracking pressure) on the exhaust port of each heat exchanger and vent to the outdoors using either a flexible hose or suitable piping. Tomco₂ Parts and Service can supply the check valves and piping if needed. Slope piping at least 1/4" per foot (20mm per meter) away from the pelletizer and include a downturn in the piping to prevent moisture from entering the pelletizer. Back pressure on vapor exhaust lines in excess of 7 psi will cause a reduction in production capacity.

Note: Forced air ventilation can not be used for removing carbon dioxide vapor. The exhaust ports must be vented to the outdoors.



CARBON DIOXIDE IS AN ASPHYXIAN AND WHEN RELEASED IN HIGH CONCENTRATIONS AND IN CONFINED AREAS CAN CAUSE SUFFOCATION AND DEATH! CO₂ VAPOR IS HEAVIER THAN AIR AND WILL ACCUMULATE IN LOW AREAS OR DEPRESSIONS.

4. Fill the hydraulic fluid reservoir to the arrow marked on the sight glass with a good quality hydraulic fluid (Rando HD68 or equal) with a fluid viscosity of 150-300 SUS (ISO 32-68) @ 100 °F (37.7 °C).

INSTALLATION

Note: Equipment used in U.S.D.A. plants must use a food grade hydraulic fluid with similar properties (Citgo Clarion FG ISO 68 or equal).

5. Install power from a disconnect to the Control Panel (In accordance with the national electrical code). The power must be appropriate for a three phase a/c motors with a connected total of 32.5 horsepower.

WARNING:
**Be sure that the power source is
turned off.**

6. Connect the pelletizer to an earth ground before use because static electricity can build up on the pelletizer under certain conditions.
7. The pelletizer is equipped with two drip pans. The upper drip pan is located under the web plate and may collect oil and water. This drip pan should not be connected to waste water drains. The lower drip pan located under the cold end tubes will collect water and it can be connected to waste water drain.
8. The hydraulic power unit is equipped with an oil collection fence. This collection fence may collect water and oil and it should not be connected to waste water drain.

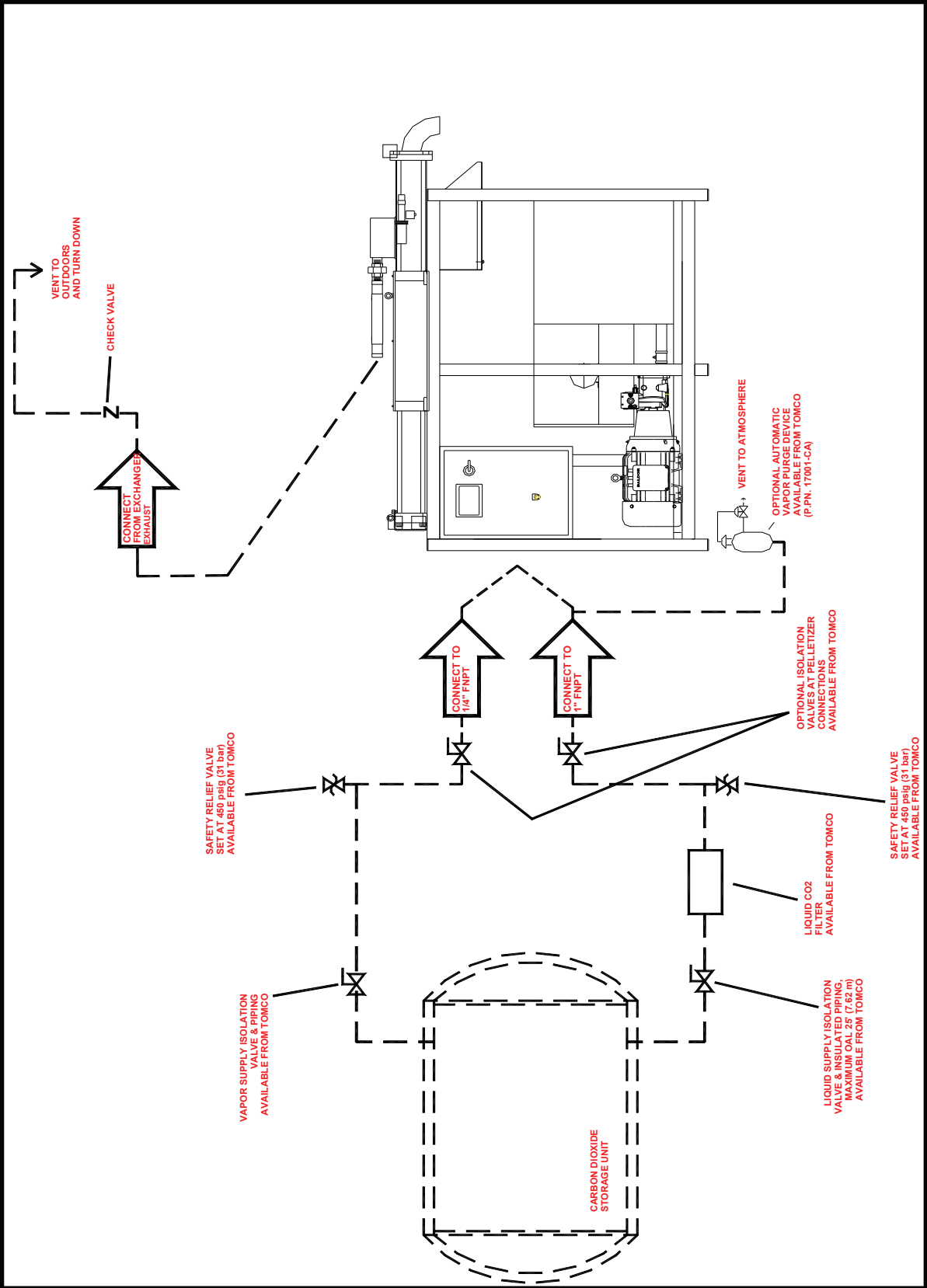


Figure 3.1 - Typical Pelletizer recommended installation

OPERATION & MAINTENANCE

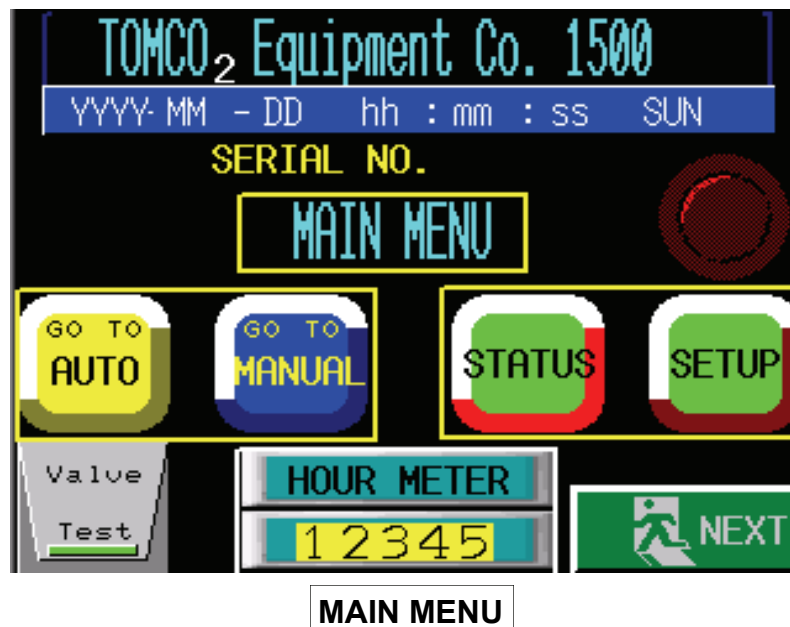
MANUAL OPERATION

Note: Manual operation can not be used for production purposes and should only be used for maintenance.

Note: A light tower is provided to show pelletizer status and warning. The light colors are as follows:

- A. Amber light is on for five seconds after pelletizer start is initiated. This warns personnel that pelletizer is starting operation.
- B. Amber light is on when one of the two operation cylinders is in a fault condition.
- C. Green light is on when the pelletizer is operating and no faults are present.
- D. Red light is on when the pelletizer stops completely due to a fault condition.

1. Turn on electrical power to the control panel.
2. Be sure the EMERGENCY STOP button is pulled out.
3. The Main Menu is displayed on the monitor. The monitor is touch a screen operator (HMI)



4. The MAIN MENU is displayed. Touch Manual Button.



NOTE: Be sure motor rotation is correct.

5. Touch MANUAL START button to start hydraulic power unit.
6. Touch and hold EXTEND or RETRACT button for movement of the cylinder.



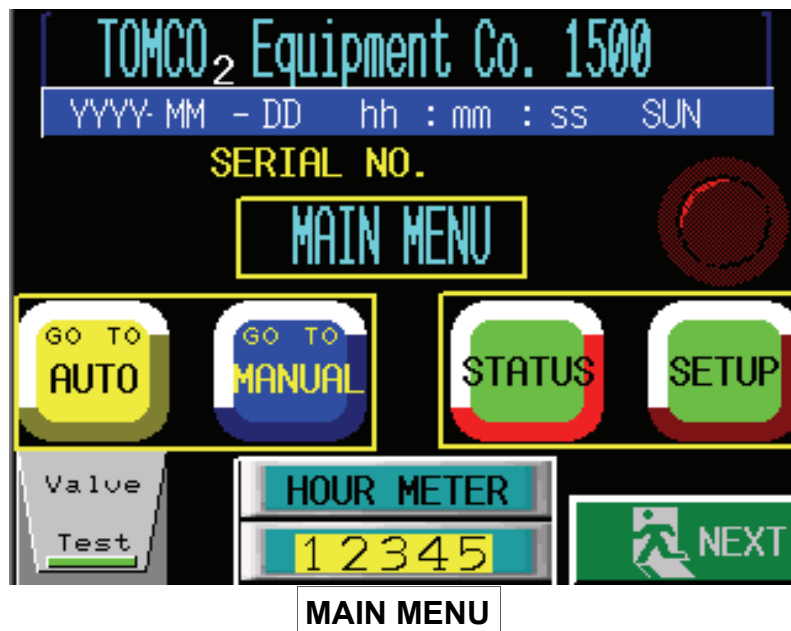
DO NOT INJECT LIQUID CARBON DIOXIDE INTO THE CYLINDER UNLESS THE CYLINDER IS COMPLETELY RETRACTED. DOING SO WILL RESULT IN CARBON DIOXIDE BEING INJECTED BEHIND THE PISTON AND WILL RESULT IN DAMAGE TO THE COMPRESSION CYLINDER OR PISTON.

NOTE: Only ONE Cylinder can be moved at a time.

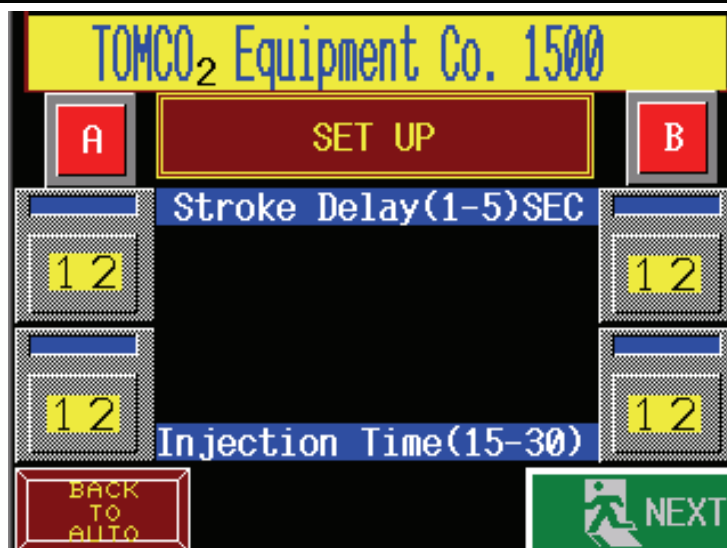
NOTE: The INJECT button will not lock in the MAN (manual) position and must be held for the duration of the liquid CO₂ injection.

7. Extend or extrude dry ice through the extrusion die by holding the corresponding cylinder button (A CYL or B CYL) in EXT (extend) position until the cylinder fully extends.
8. Retract the cylinder by touching the RETRACT button and holding until cylinder is fully retracted.
9. Repeat for B cyl.
10. Touch STOP button.
11. Touch BACK button to return to MAIN MENU.

SETUP



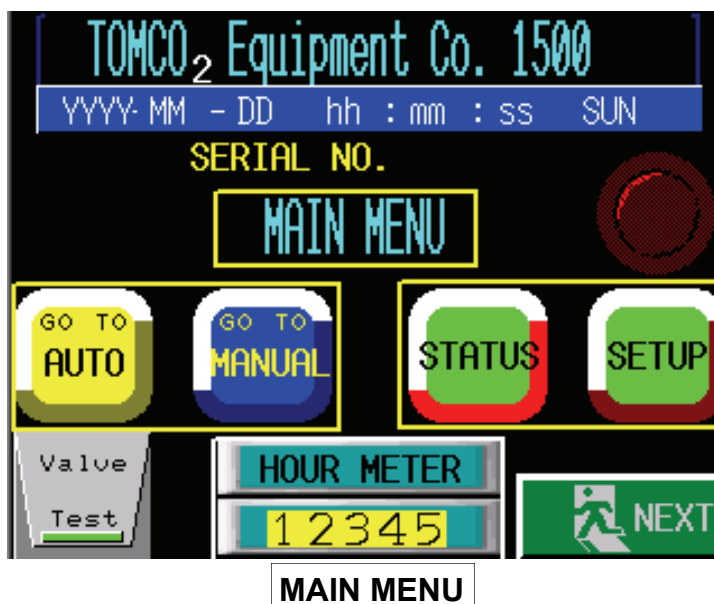
1. Touch SETUP button.
2. SETUP SCREEN will appear.



3. Verify that setup values are correct (Factory settings are: stoke delay is two seconds and injection time is twenty-five seconds).

NOTE: Set values may be changed by touching the displayed value button. A key pad screen will appear.

4. Touch clear on the key pad.
5. Touch Values desired, then touch enter.
6. Verify that the correct value is displayed.
7. Touch BACK or NEXT to return to the MAIN MENU or to scroll the various screens.



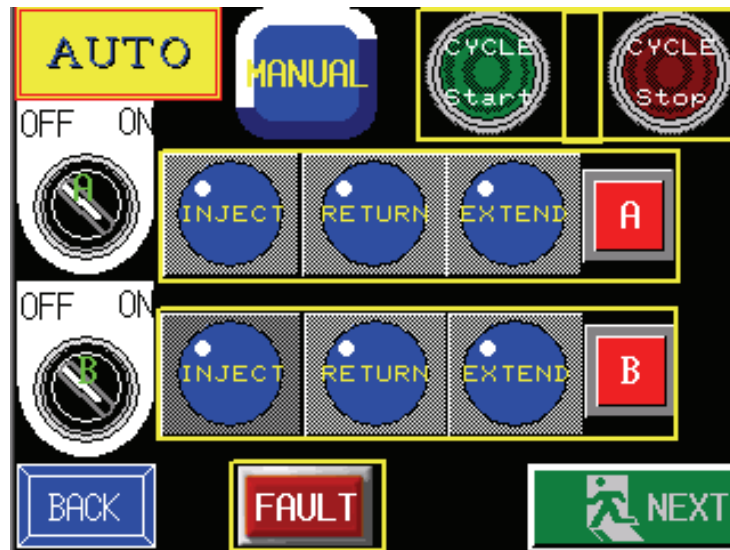
AUTOMATIC OPERATION

1. Touch the AUTO button on the MAIN MENU.

NOTE: The AUTO MODE screen will appear.

Note: A light tower is provided to show pelletizer status and warning. The light colors are as follows:

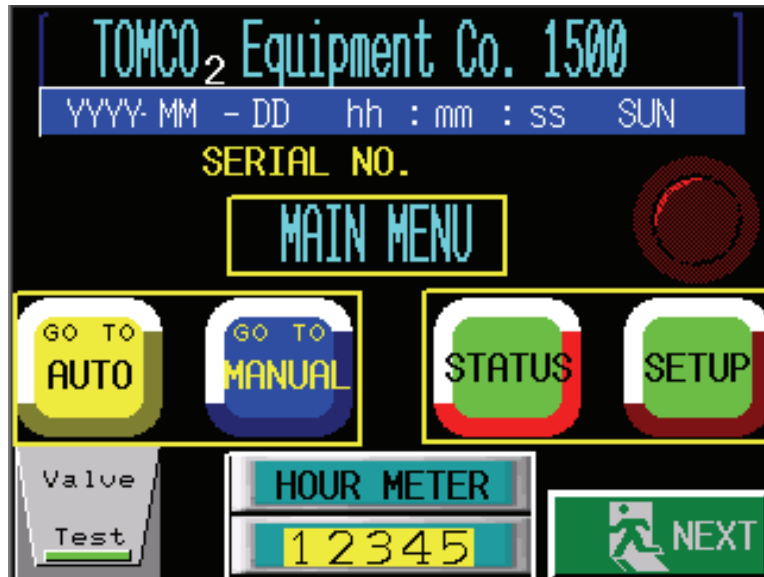
- A. Amber light is on for five seconds after pelletizer start is initiated. This warns personnel that pelletizer is starting operation.
- B. Amber light is on when one of the two operation cylinders is in a fault condition.
- C. Green light is on when the pelletizer is operating and no faults are present.
- D. Red light is on when the pelletizer stops completely due to a fault condition.



2. Be sure E-stop button on panel is out. A small flashing E-stop signal will flash on main screen if E-stop button is depressed.
3. Touch CYCLE START button.

NOTE: THE MACHINE WILL PERFORM A SELF TEST.

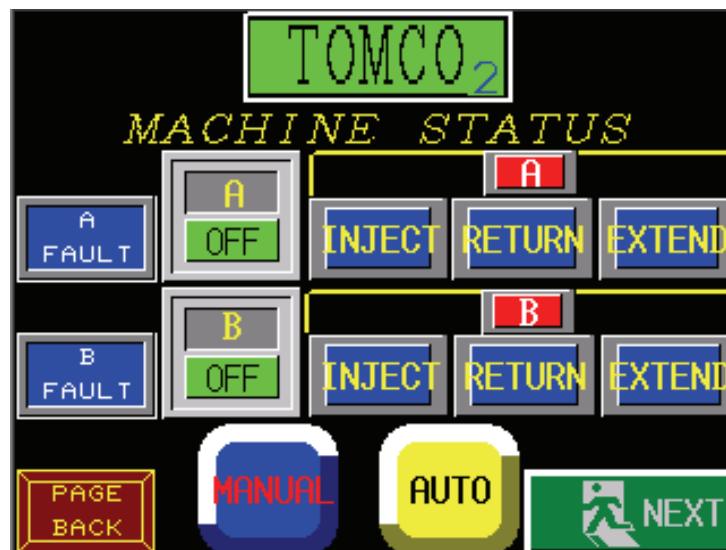
4. Touch BACK button and MAIN MENU will appear.



MAIN MENU

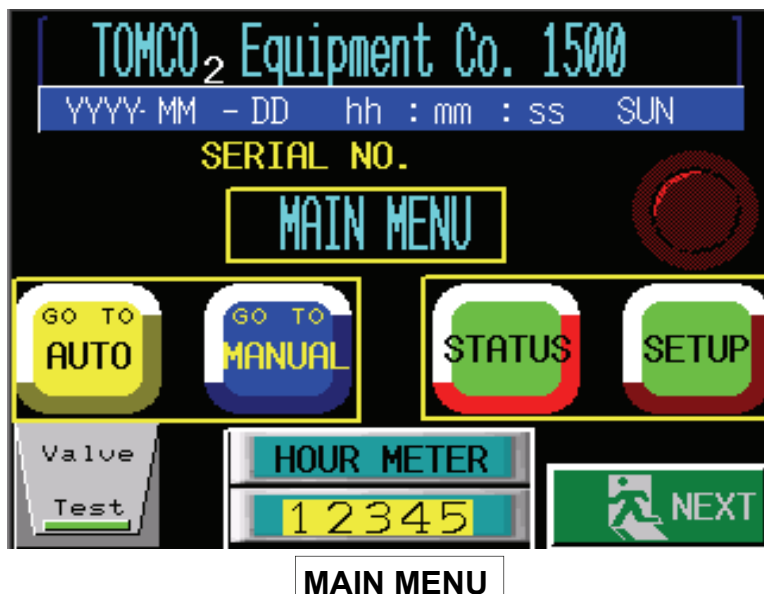
MACHINE STATUS

1. Touch the STATUS button and the STATUS screen will appear.

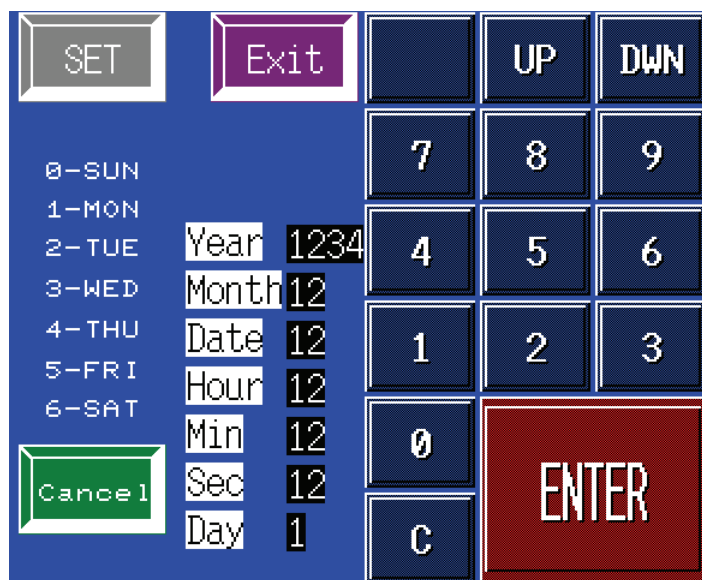


2. Touch the BACK button.

SET CLOCK SCREEN



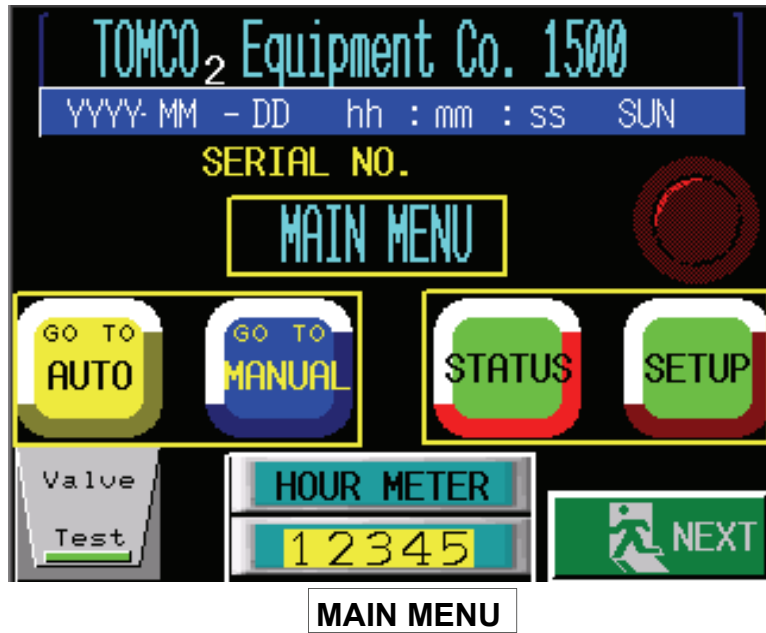
1. Touch NEXT button (keep touching NEXT button until SET CLOCK screen appears).



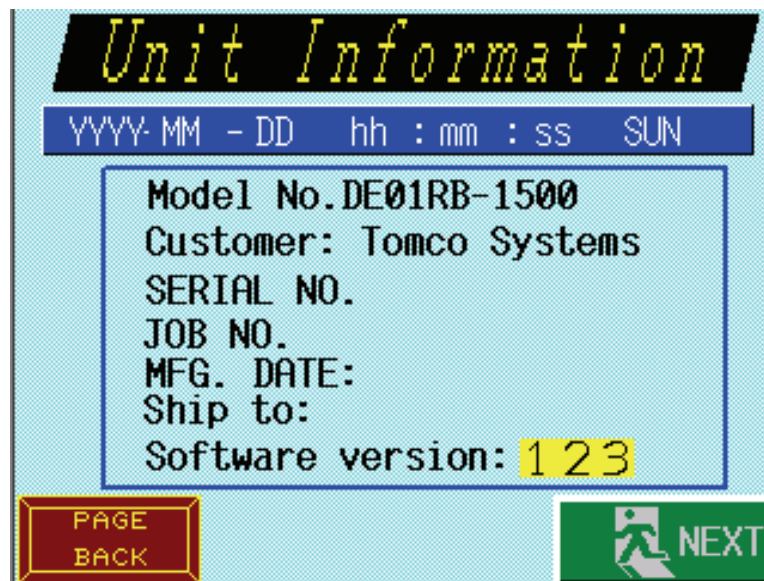
2. To set the Year, Month, Date, Hour, Min, Sec, and Day touch the set button.
3. Touch Year button and use the keypad to set Year number and touch ENTER.
4. Repeat these steps for the Month, Date, Hour, Min, Sec, Day.

5. When finished with setting touch the SET button.
6. Touch EXIT button to return to MAIN MENU.

UNIT INFORMATION



1. Repeatedly touch NEXT button until Unit Information screen appears.



2. Touch NEXT button.

NOTE: THE CONTACT TOMCO SCREEN WILL APPEAR.

CONTACT TOMCO SCREEN



IMPORTANT NOTES ON AUTOMATIC OPERATION

1. Periodically monitor the compression cylinder pressure by observing the gauge(s) at the front of the extruder. The compression cylinder pressure should be approximately 35 - 40 psig (2.4 - 2.8 bar) during the injection cycle. If the pressure is outside of this range, see Section 5 - TROUBLE-SHOOTING.



WARNING: IF THE METERING VALVE IS SET TOO HIGH, THE INJECTION VALVE WILL CYCLE ON AND OFF. PROLONGED CYCLING WILL SIGNIFICANTLY REDUCE THE LIFE OF THE VALVE.

2. To end dry ice production, push the CYCLE STOP button. The pelletizer will complete the current cycle before stopping.
3. To stop the pelletizer immediately press the EMERGENCY STOP button. The pelletizer will not complete the current cycle and CO₂ may be left in the compression cylinder. Any CO₂ left in the compression cylinder will sublime and vent to atmosphere through the extrusion die. When the pelletizer is restarted, the machine will go through an automatic clean-out cycle before beginning an injection cycle, so no user action is required when restarting.

MAINTENANCE

AFTER THE FIRST 48 HOURS OF OPERATION

Check the torque value on the die bolts, tie rod bolts, and web plate bolts according to Figures 4.3. If necessary re-torque following the procedures found on page 4.20.

WEEKLY

- Inspect all metal surfaces for rust or damage to paint. Repair as needed.
- Inspect hydraulic lines for signs of a leak. Have leaks repaired by a qualified service technician.
- Check the hydraulic fluid level at the sight glass and add hydraulic fluid as needed.
- Check to be sure that all covers and guards are in place and functioning properly. Make any repairs or replacements as needed.
- Check oil cooler for clogging and clean if necessary.

AFTER EVERY 500 HOURS OF OPERATION

Check the torque value on the die bolts, tie rod bolts, and web plate bolts according to Figures 4.3 . If necessary re-torque following the procedures found on page 4.20.

AFTER EVERY 2000 HOURS OF OPERATION

Compression Cylinder Rebuild

Refer to Figures 4.2 for the exploded view of the hydraulic cylinder and compression cylinder major components.

1. Disconnect electrical power and follow your company's lock out and tag out safety procedures.

2. Close the isolation valves at the carbon dioxide storage unit and bleed pressure from each line.
3. Remove the extrusion die cover.
4. Remove the extrusion die.
5. Remove the rod coupling.
6. Manually extend the compression cylinder piston rod until the piston exits the end of the compression cylinder.
7. Remove the compression cylinder piston rod bearing and seal retaining ring.
8. Remove the compression cylinder piston rod bearing and bearing seal.
9. Install new rod bearing and bearing seal.
10. Replace the retaining ring.
11. Remove bolts from piston and discard.
12. Remove stainless steel retaining ring.
13. Remove nylon piston cover and discard.
14. Check the set screws in the piston to be sure they are tight (if applicable).
15. Install new piston cover on the compression cylinder piston.
16. Reassemble in the reverse order with new bolts, nuts, and cotter pins and torque to 20-35 ft. lbs. Be sure to grease the rod coupling with a light coating of grease.

Note: Be certain that the compression cylinder, compression cylinder piston, and extrusion die are completely free of all moisture before reassembling. Refer to the Torquing Procedure on page 4.18 for the proper sequence and torque values of the die bolts and tie rod bolts.

AFTER EVERY 10000 HOURS OF OPERATION

Hydraulic Cylinder Rebuild

Refer to Figures 4.2 for the exploded view of the hydraulic cylinder and compression cylinder major components.

1. Disconnect electrical power and follow your company's lock out and tag out safety procedures.
2. Disconnect the hydraulic hoses and drain the hydraulic fluid from the hydraulic cylinder.
3. Remove the hydraulic cylinder rear end cap.
4. Remove the hydraulic cylinder tube.
5. Remove the rod coupling.
6. Remove the hydraulic cylinder piston and rod assembly.
7. Remove the hydraulic cylinder rod bearing, bearing seal and rod wiper retaining ring.
8. Remove the hydraulic cylinder rod bearing, bearing seal and rod wiper.
9. Install new hydraulic cylinder rod bearing, bearing seal and rod wiper.
10. Replace the retaining ring.
11. Remove the hydraulic cylinder piston seals and wear band.
12. Install new hydraulic cylinder piston seals and wear band.
13. Install the hydraulic cylinder rod and rod coupling.
14. Remove the O-rings from the hydraulic cylinder.

15. Install new tube O-rings on the hydraulic cylinder and install the hydraulic cylinder.

16. Replace the hydraulic cylinder end cap.

Note: Refer to the Torquing Instructions or the proper sequence and torque values of the tie rod bolts.

16. Reconnect the hydraulic hoses and check the hydraulic fluid level at the sight glass.
Add hydraulic fluid as needed.

Piston seal replacement procedure.

Leaky seals can sometimes cause a hazardous situation and can allow air to be drawn into a recovery system. The procedure for replacing the cold end cylinder seals is outlined below:

Note: If this procedure is done with care, the extrusion die does not have to be re moved.

1. Allow the machine to thaw out completely before beginning this procedure.
2. Extend the hydraulic cylinder fully.
3. Disconnect all electrical power and follow your company's lock out and tag out safety procedures.
4. Remove limit switch assembly and set it aside.
5. Remove the bearing retainer ring.
6. Remove the rod coupling.
7. Reconnect power to the machine and retract the hydraulic cylinder.
8. Disconnect all electrical power and follow your company's lock out and tag out safety procedures.
9. Carefully pull the old seal and bearing off the piston rod.
10. Install the new seal and bearing on the piston rod as far as possible by hand.

11. Reconnect power to the machine and extend the cylinder.
12. Disconnect all electrical power and follow your company's lock out and tag out safety procedures.
13. Install bolts and use the seal retainer ring to press the seal into its final position.
14. Install rod coupling.

AS REQUIRED

Hydraulic Fluid Change and Filter Replacement

Change the hydraulic fluid and hydraulic fluid filter according to the fluid manufacturer's recommendations.

Filter Screen Cleaning or Replacement

Refer to Figures 4.1 for the exploded view of the transition box assembly.

1. Disconnect the exhaust connection at the union fitting on the transition box.
2. Remove the transition box.
3. Remove the filter screen retaining plate.
4. Remove the filter screen, using caution to avoid tearing it.
5. Clean the filter screen with a solvent type cleaner. Note: If filter screen is torn or damaged, it must be replaced with a new one.
6. Completely dry the filter screen with CO₂ vapor or a dry air source.
7. Replace all gaskets.
8. Reassemble in the reverse order.

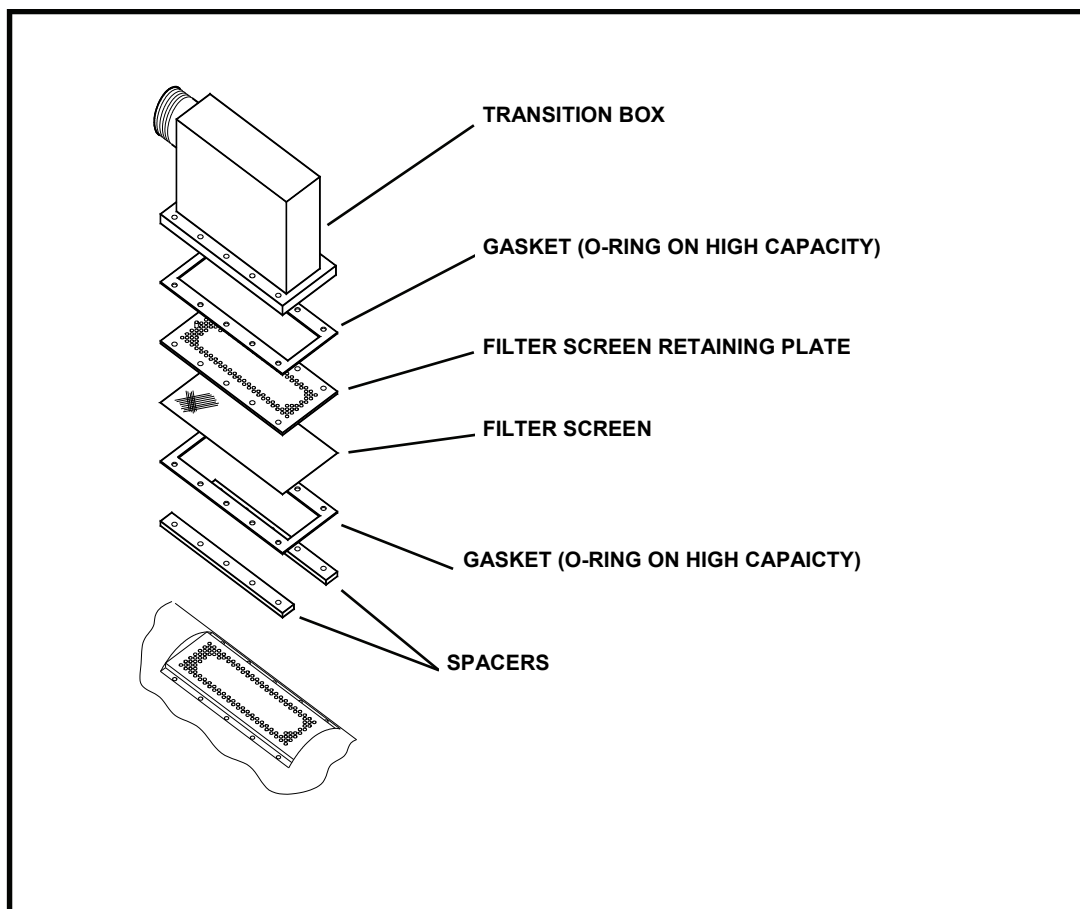


Figure 4.1 - Model DE01RB-1500 Transition Box Assembly Exploded View

TORQUE PROCEDURES

All Tomco₂ Equipment Co. Dry Ice Pelletizers are designed and built to provide many years of service. However, these pelletizers undergo many cycles of severe loading and unloading.

In order for the pelletizers to survive the fatiguing encountered with cyclic loading, it is imperative that key components are torqued evenly and adequately. This torque value will apply a large pre-load to the bolt and is very advantageous in reducing the effects of fatigue. The result is a smaller variation in the cyclic loading occurring during the extrusion of dry ice.

Figures 4.3 show the torque sequences and final torque values for the fasteners that require torquing. The fasteners should be torqued in four (4) steps. Following the torque sequence shown torque each fastener to approximately 25% of the recommended final torque value. Repeat the torque sequence three more times, each time increasing the value by approximately 25% of the recommended final torque value.

Example: Extrusion Die

	<u>Torque Value</u>
Step 1	70 ft-lb (10 kg m) (91 Nm)
Step 2	140 ft-lb (19 kg m) (183 Nm)
Step 3	210 ft-lb (29 kg m) (274 Nm)
Step 4	280 ft-lb (39 kg m) (365 Nm)

Note: All threads must be clean and well lubricated with an appropriate lubricant.

Note: Check the torque value of each fastener immediately following the first 48 hours of operation and subsequently after every 500 hours of operation. Re-torque if necessary. Repeat this after every scheduled cylinder rebuild.

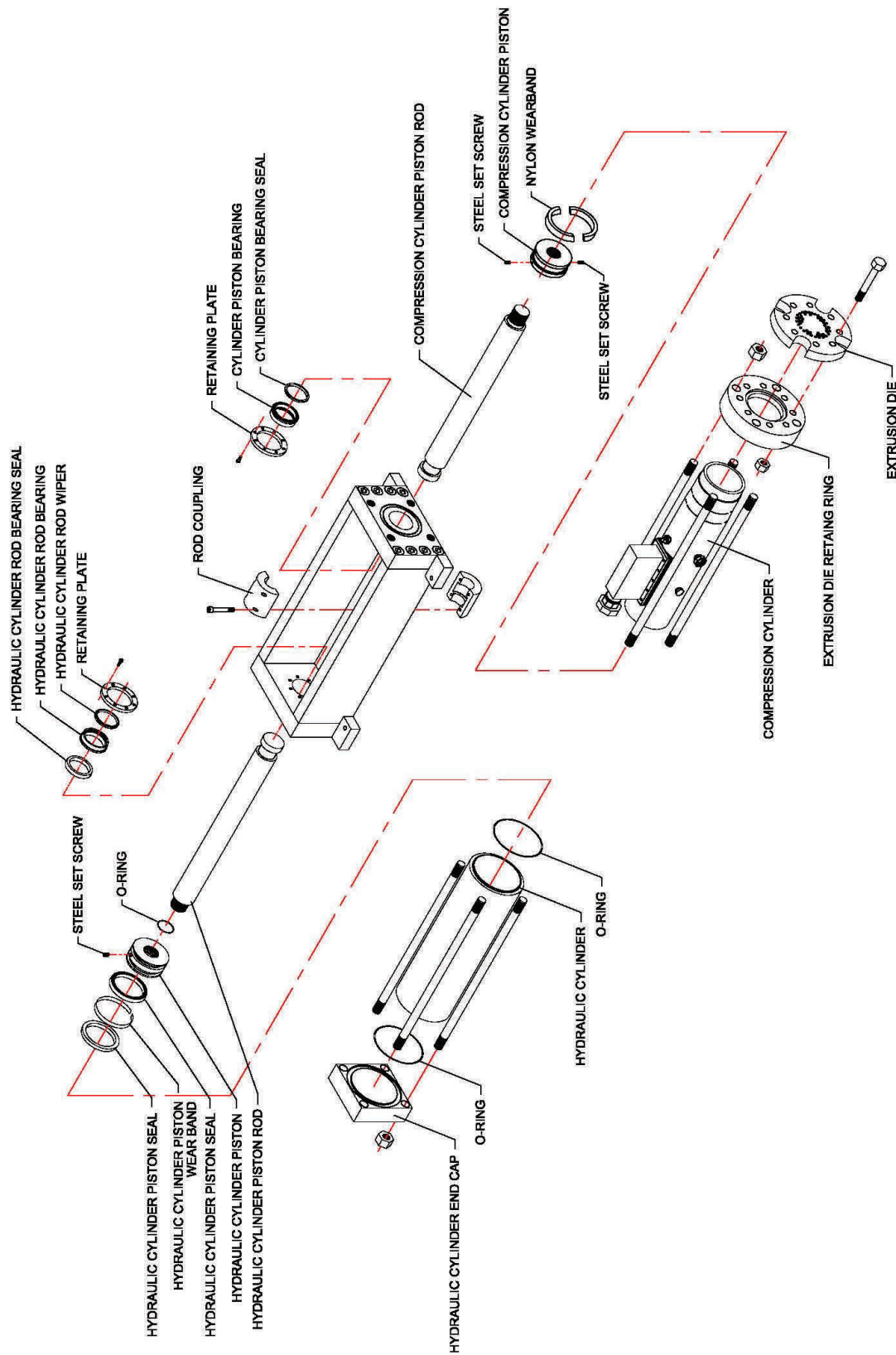
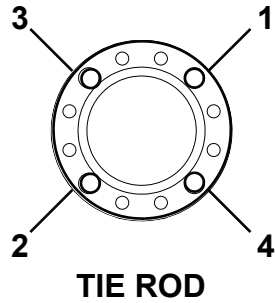


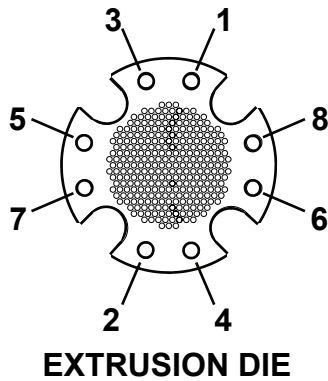
Figure 4.2- Model DE01RB-1500 Hydraulic and Compression Cylinder Exploded



TIE ROD

Fastener - 1 1/8" - 12 UNF Tie Rod with Matching Hex Nut

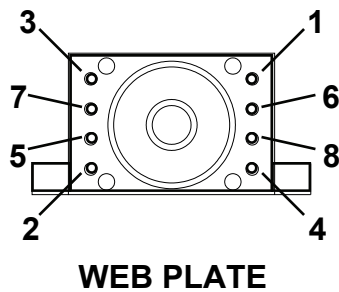
Final Torque Value - 950 ft lbs (132 m kg) (1293 Nm)



EXTRUSION DIE

Fastener - 3/4" - 16 x 3 1/2" UNF Grade 8 SHCS

Final Torque Value - 280 ft lbs (39 m kg) (381 Nm)



WEB PLATE

Fastener - 1" - 14 x 4 1/2" UNF

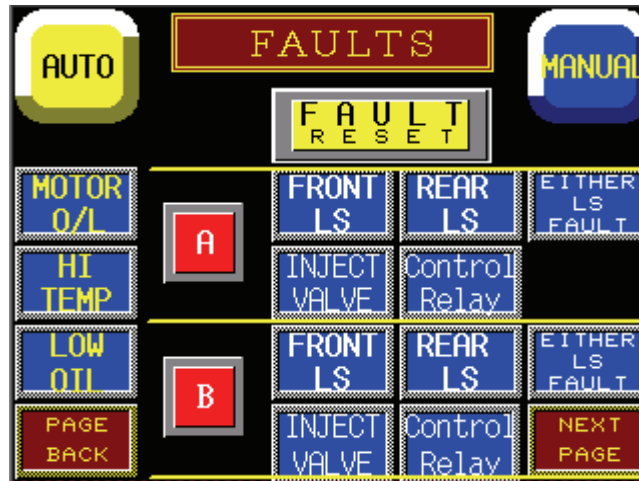
Final Torque Value - 700 ft lbs (97 m kg) (951 Nm)

Figure 4.3 - Model DE01RB-1500

TROUBLE- SHOOTING

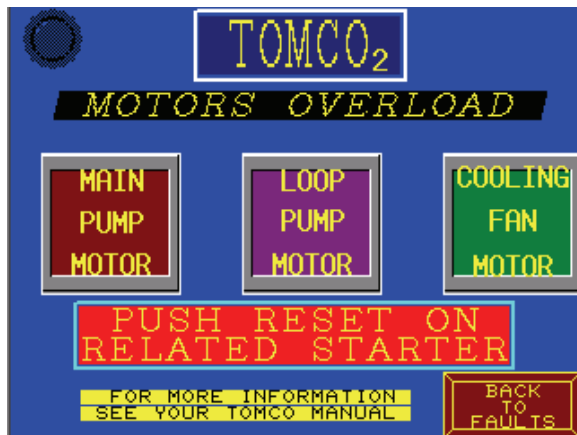
FAULT SCREEN

NOTE: IF A FAULT BUTTON IS FLASHING TOUCH THE FAULT BUTTON AND THE FAULT SCREEN WILL APPEAR.

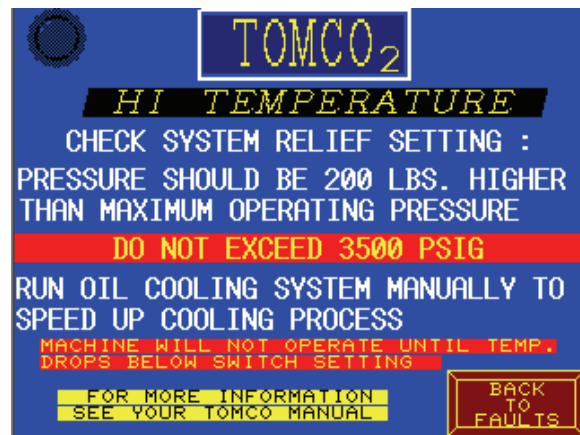


NOTE: A RED LIGHT INDICATES THE FAULT SOURCE

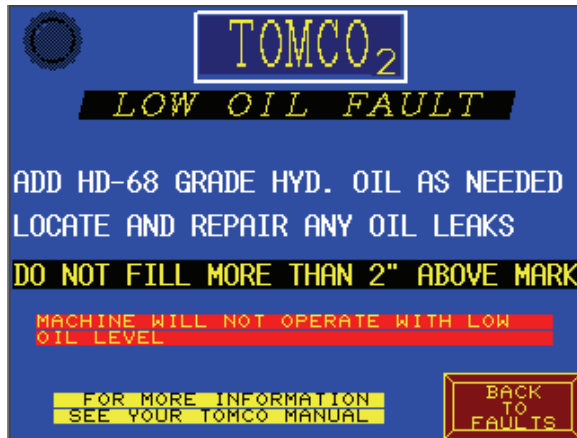
1. After correcting the problem touch the RESET button.
2. Touch the fault that is indicated for troubleshooting assistance.



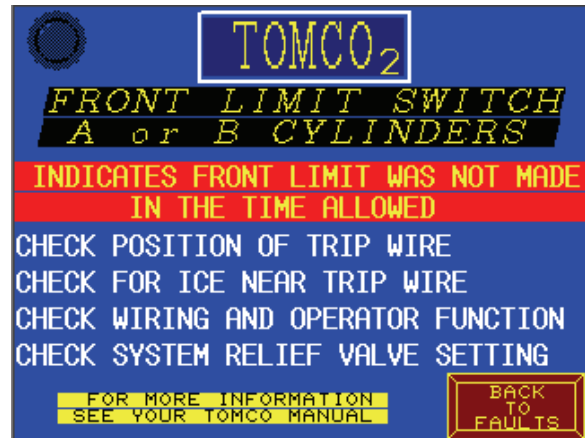
MOTOR OVELOAD SCREEN



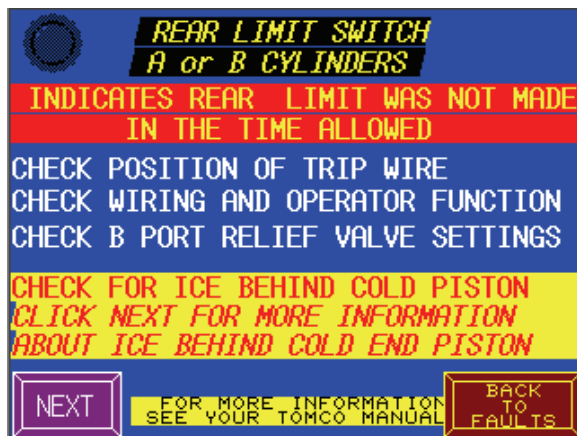
HIGH TEMPERATURE SCREEN



LOW OIL FAULT SCREEN



FRONT LIMIT SWITCH SCREEN

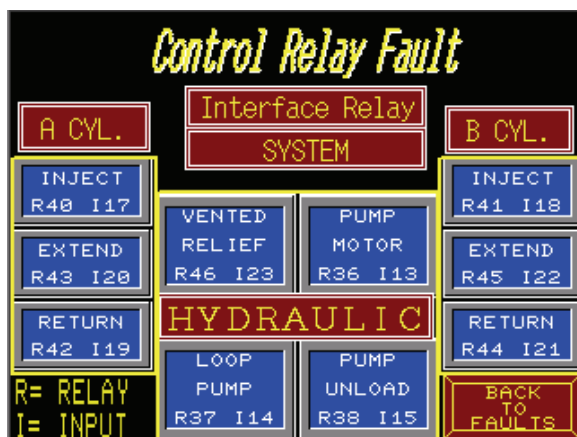


REAR LIMIT SWITCH SCREEN

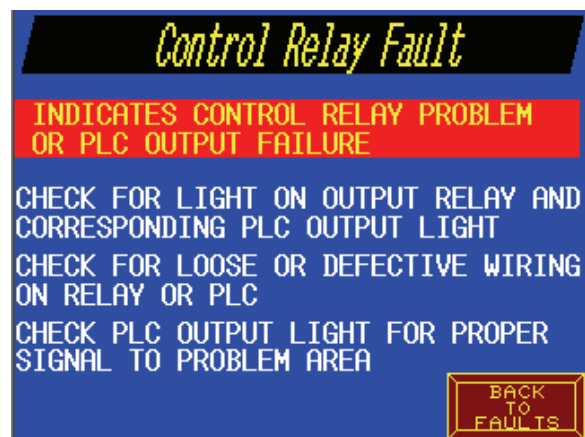


EITHER LIMIT SWITCH

3. Touch the CONTROL RELAY button for relay faults.
4. Touch indicated relay for troubleshooting assistance.



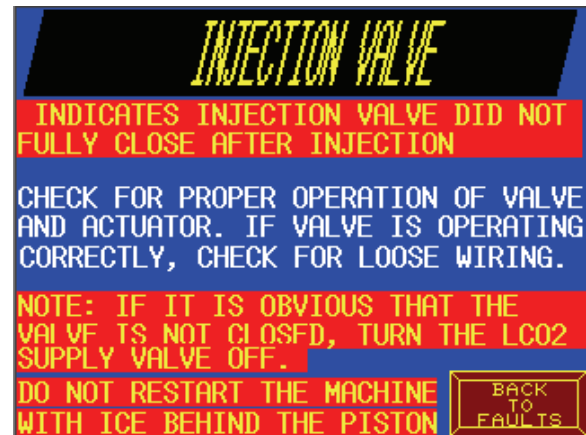
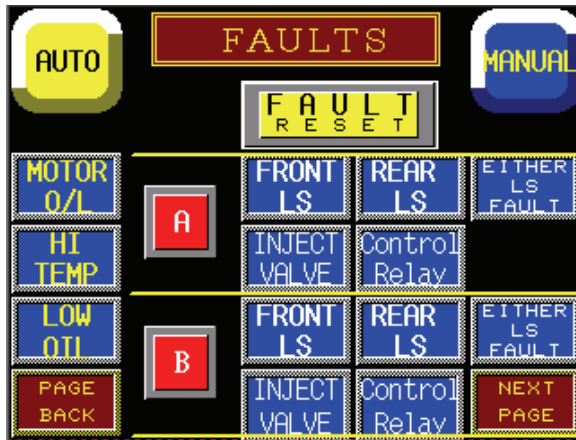
CONTROL RELAY FAULT SCREEN



INDICATED CONTROL RELAY FAULT SCREEN

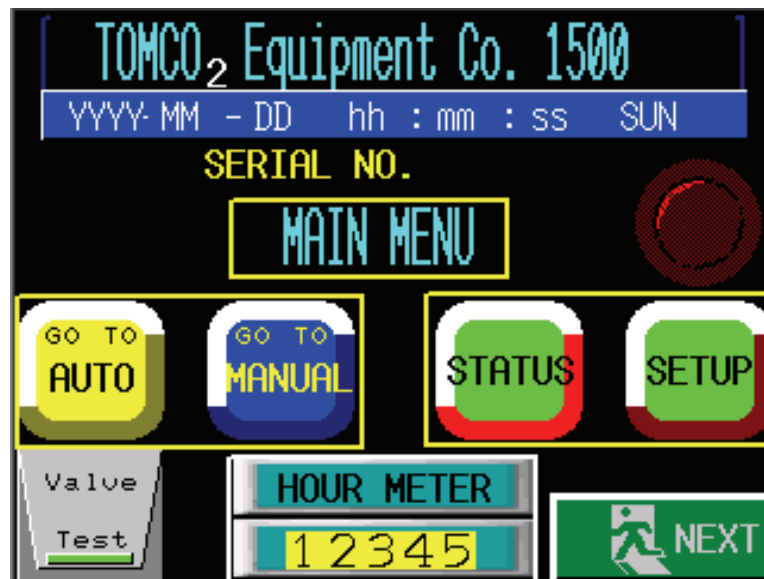
TROUBLESHOOTING

5. Touch BACK button to return to fault screen.
6. Touch INJECT VALVE button for the Injection valve troubleshooting screen.

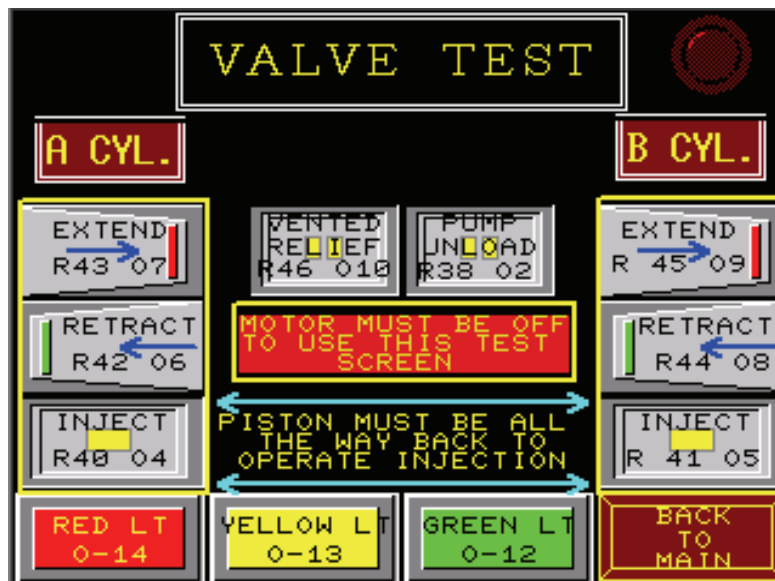


INJECTION VALVE SCREEN

1. Touch BACK button to return to MAIN MENU



2. Touch VALVE TEST button and VALVE TEST screen will appear.



NOTE: This screen is be used for confirming PLC outputs. It is a maintenance screen only. Touching any button should activate the PLC output, Light it's control relay and power the related load.

TROUBLESHOOTING

All troubleshooting should only be performed by a qualified carbon dioxide service technician. Reference the appropriate Wiring Schematic Drawing and the appropriate Process and Instrumentation Diagram Drawing in the Appendix of this manual for component identification.

PROBLEM	POSSIBLE CAUSE	REMEDY
Compression cylinder pressure too high (55 - 60 psig (3.79 - 4.13 bar))	1. Moisture or debris on the exhaust filter screen 2. Restriction in the vapor exhaust line 3. Metering valve open too much 4. Injection valve not closing properly	1. Replace or clean according to the procedure on page 4.6 2. Locate and remove restriction 3. Close valve until pressure drops to 35 - 40 psig (2.4 - 2.8 bar) during liquid CO₂ injection 4. Check vapor supply pressure, should be minimum 90 psig (6.2 bar) - if vapor supply pressure above 90 psig (6.2 bar), repair or replace injection valve actuator
Compression cylinder pressure too high (exceeds 60 psig (4.13 bar))	1. Over pressure switch out of adjustment or defective	2. Repair or replace and troubleshoot causes 1-4 above
Compression cylinder pressure too low (0 - 20 psig (0 - 1.37 bar))	1. Closed or restricted liquid supply line 2. Metering valve closed too much 3. Storage unit pressure too low 4. Injection valve not opening fully 5. Transition box leaking 6. Injection valve not seating properly, allowing CO₂ to leak through when closed causing plug	1. Check supply valve and/or strainer or filter 2. Open valve during injection cycle until pressure rises to 35 - 40 psig (2.4 - 2.8 bar) 3. Storage unit pressure should be minimum 200 psig (13.8 bar), 250 - 300 psig (17.2 - 20.7 bar) is preferable 4. Check the vapor supply pressure (max 125 psig (8.6 bar)) 5. Replace gasket(s), check and replace filter screen according to procedure on page 4.6 if necessary 6. Repair or replace
Dry ice pellets blow out during compression stroke	1. Dirt, moisture or debris on the exhaust filter screen causing excessive pressure 2. Excess vapor trapping between piston face and plug on compression stroke 3. Limit switch out of adjustment causing dry ice plugs that are too short	1. Replace or clean according to the procedure on page 4.6 2. Adjust timer(s) on touch screen to higher setting to increase the delay prior to the compression stroke, allowing the excess vapor time to exhaust 3. Adjust limit switch away from extrusion die slightly to produce longer dry ice plug.

PROBLEM	POSSIBLE CAUSE	REMEDY
Injection time too long or too short	1. Timer(s) setting out of adjustment	1. Adjust timer(s) settings on touch screen as needed
Hydraulic pressure sustains relief setting pressure for more than 5 seconds	1. Moisture on extrusion die or inside compression cylinder accumulating during shut down period 2. Excess moisture in liquid CO ₂ supply (dew point above -60 °F (-51 °C))	1. Remove extrusion die, clean and dry die and inside of compression cylinder thoroughly and reinstall, being certain to torque according the procedures on page 4.12 2. Check liquid CO ₂ supply dew point
Hydraulic cylinder does not move	1. Solenoid coil on hydraulic control valve burned out 2. Valve relay is not working 3. PLC output is bad 4. Hydraulic control valve or hydraulic pilot valve spool is jammed by foreign particles	1. Replace solenoid coil, check control voltage (high or low voltage will cause solenoid coil to burn out) - for double solenoid valves, make sure both solenoid coils are energized at the same time 3. Disassemble hydraulic control valves and hydraulic pilot valve, clean and reassemble 4. Repair or replace 5. Disassemble hydraulic control valves and hydraulic pilot valve, replace any damaged parts and reassemble
Hydraulic pump does not deliver hydraulic fluid	1. Hydraulic fluid level low 2. Closed or restricted hydraulic fluid supply line to pump 3. Leak in fluid intake line 4. Fluid viscosity too high (especially in cold conditions) 5. Pump rotation reversed 6. Pump broken 7. Pump coupling broken	1. Add hydraulic fluid to proper level 2. Check supply valve 3. Repair 4. Use hydraulic fluid with a lower viscosity or install a low density immersion heater suitable for hydraulic fluid (contact Tomco for more information) 5. Correct pump rotation - Note: Continued operation of pump in wrong direction can damage pump 6. Replace 7. Replace

TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	REMEDY
No hydraulic pressure in system	1. Hydraulic relief valve setting incorrect 2. Hydraulic relief valve relieving below set pressure 3. Hydraulic cylinder piston rings and seals worn 4. Decompression valve stuck open	1. Reset to specifications 2. Repair or replace 3. Replace worn rings and seals 4. Repair or replace
Hydraulic pump making excessive noise	1. Closed or restricted liquid supply line 2. Leak in fluid intake line 3. Leak at pump shaft packing and/or seals 4. Hydraulic fluid level low 5. Fluid viscosity too high (especially in cold conditions) 6. Pump coupling loose or worn	1. Check supply valve and/or strainer or filter 2. Repair 3. Repair 4. Add hydraulic fluid to proper level 5. Use hydraulic fluid with a lower viscosity or install a low density immersion heater suitable for hydraulic fluid (contact Tomco for more information) 6. Tighten or replace
Excessive wear or breakage of pump parts	1. Abrasive material in hydraulic fluid 2. Hydraulic fluid does not meet specifications 3. Other	1. Replace or clean hydraulic fluid filter, clean hydraulic reservoir and change hydraulic fluid 2. Use hydraulic fluid with a viscosity of 150-300 SUS (ISO 32-68) @ 100 °F (37.7 °C) such as Rando HD68 or equal 3. See problem <i>Hydraulic pump making noise</i> above
Hydraulic fluid leaks from around pump shaft or housing	1. Pump shaft packing and/or seals worn 2. Head packing seals damaged 3. Excessive case pressure due to re-	1. Replace worn packing and seals 2. Replace damaged head packing seals 3. Clean case drain line
Control Panel Message "MOTOR OVERLOAD"	1. Excessive hydraulic pump pressure 2. Moisture on extrusion die or inside compression cylinder	1. Check pump pressure control settings 2. Remove extrusion die, clean and dry die and inside of compression cylinder thoroughly and reinstall, being certain to torque according the procedures on page 4.12
Control Panel Message "LOW OIL LEVEL"	1. Possible leaks in hydraulic system	1. Repair leaks, add hydraulic fluid to proper level

PROBLEM	POSSIBLE CAUSE	REMEDY
Control Panel Message	1. Hydraulic relief valve setting too low	1. Reset to specifications
Control Panel Message "CYL A FRONT LIMIT SWITCH FAULT" or "CYL B FRONT LIMIT SWITCH FAULT" (dual cylinder models only)	1. Moisture on extrusion die or inside compression cylinder 2. Hydraulic relief valve setting too low 3. Hydraulic pump pressure setting incorrect 4. Defective limit switch	1. Remove extrusion die, clean and dry die and inside of compression cylinder thoroughly and reinstall, being certain to torque according the procedures on page 4.12 2. Reset to specifications 3. Check pump pressure control settings 4. Repair or replace
Control Panel Message "CYL A REAR LIMIT SWITCH FAULT" or "CYL B REAR LIMIT SWITCH FAULT" (dual cylinder models only)	1. Cylinder not fully retracted during CO ₂ injection 2. B port relief valve set to low or defective 3. Limit switch not tripped or defective	1. Manually retract cylinder and check for defective hydraulic piston rings if cylinder drifts away from fully retracted position 2. Check setting

You can contact TOMCO₂ EQUIPMENT CO. for parts and service 24 hours a day, 7 days a week at:

TOMCO₂ EQUIPMENT COMPANY

3340 Rosebud Road
Loganville, Georgia 30052 USA

Telephone

(770) 979-8000 • Toll Free in the U.S. (800) 832-4262

Fax

(770) 985-9179

Parts & Service Fax

(770) 979-2514

E-Mail

Tomcoparts@tomcoequipment.com

Internet

www.tomcoequipment.com

REPAIR & ADJUSTMENTS

REPAIR & ADJUSTMENTS

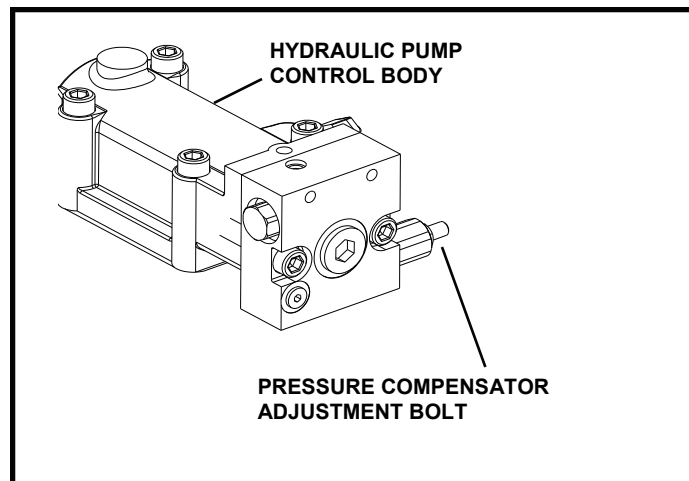
All repairs and adjustments should be performed by a qualified carbon dioxide equipment service technician. The following applies to all single pump machines.

HIGH-LOW PRESSURE COMPENSATOR ADJUSTMENT

The high-low pressure compensator will provide the highest possible pump flow until a preset pressure is reached. The pump then de-strokes to provide a minimum preset flow rate regardless of system pressure. The high-low pressure compensator is preset at the factory but may need to be adjusted, particularly after pump repair or replacement. The high-low pressure compensator must be adjusted properly to provide satisfactory pump operation.

1. Disconnect electrical power and follow your company's lock out and tag out safety procedures.
2. Adjust compensator to 1000 psi, turn in to increase and out to decrease.
3. Hold the adjustment screw to prevent it from turning and tighten the locknut.

NOTE: Motor must be off to make minimum volume adjustments.



**Figure 6.1 - High-Low Pressure
Compensator Adjustment**

MINIMUM VOLUME CONTROL ADJUSTMENT

The minimum volume control provides an adjustable minimum hydraulic pump volume regardless of hydraulic system pressure. The minimum volume control is preset at the factory but may need to be adjusted, particularly after pump repair or replacement or if supply voltage is not 60 Hz. The minimum volume control must be adjusted properly to provide satisfactory pump operation.

1. Disconnect electrical power and follow your company's lock out and tag out safety procedures.
2. Open the electrical control panel and attach an amp meter to one leg of the voltage supply wiring above the contactor



USE EXTREME CAUTION WHEN ELECTRICAL POWER IS TURNED ON AND THE ELECTRICAL PANEL IS OPEN. CONTACT WITH ELECTRICAL CIRCUITS CAN CAUSE DEATH!

3. Turn on the electrical power to the pelletizer.
4. Begin operation according to the procedure found on page 4.2.
5. Monitor the amp meter while the pelletizer makes dry ice. The amp reading should peak at the amp rating which corresponds to the machine voltage as indicated on the motor data plate. If the amp reading is too high or too low proceed to the next step.
6. Loosen lock nut on minimum volume adjuster.

NOTE: Motor must be off to make minimum volume adjustments.

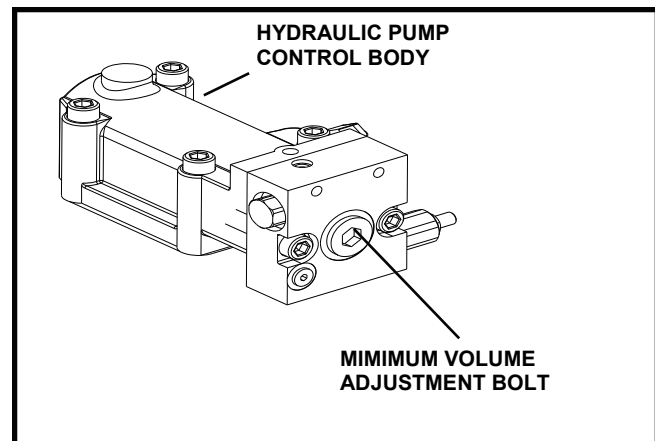


Figure 6.2 - Minimum Volume Control Adjustment

REPAIR & ADJUSTMENTS

7. Using an allen wrench, adjust the minimum volume control adjusting screw. Turn the screw clockwise to increase the amp reading or counterclockwise to decrease the amp reading. Make adjustments in 1/8 turn increments.
8. Use the allen wrench to prevent the adjustment screw from turning and tighten the locknut.
9. Allow the pelletizer to operate normally for approximately one hour and check the load amperage again. If necessary readjust the minimum volume control.
10. Stop the pelletizer operation and lock out electrical power to the pelletizer.
11. Disconnect the amp meter and close the electrical panel.

APPENDIX

GLOSSARY

Carbon Dioxide	The chemical compound formed by combining one atom of carbon with two atoms of oxygen
CO₂	The atomic formula for carbon dioxide
Critical Point	The temperature and pressure above which a chemical compound can only exist as a supercritical fluid - for Carbon Dioxide: 87.9 °F (31.1 °C) and 1070.6 psig (73.8 bar)
Dew Point	The temperature at which water dissolved in carbon dioxide condenses
Dry Ice	The solid form carbon dioxide
Sublime	To change from a solid to a vapor without becoming a liquid
Supercritical Fluid	A chemical compound at temperature and pressure greater than its critical point
Triple Point por)	The conditions at which all three states (solid, liquid and vapor) of some chemical compounds can exist at equilibrium. For Carbon Dioxide the conditions are: -69.9 °F (-56.6 °C) and 60.4 psig (4.2 bar)

REFERENCES

Compressed Gas Association
1725 Jefferson Davis Hwy.
Suite 1004
Arlington, VA 22202-4102 USA
Phone: (703) 412-0900

LIMITED WARRANTY

All equipment manufactured and sold by Tomco₂ Equipment Company, hereinafter identified as **TOMCO₂**, shall be warranted against defects in materials and workmanship (normal wear and tear excluded) under normal use and service for a period of one year from the date of invoice or hour usage for the following equipment:

Pelletizer/Extruder/Disc Press	2,000 hours
AH-45/CM-40 Pump	2,000 hours
CO ₂ Cleaning System	15,000 cycles or about 2,000 hours

This Limited Warranty shall be invalidated if the products:

- a) have not been installed, handled, or used in accordance with TOMCO₂'s recommended procedures.
- b) have been damaged through the negligence or abuse of the customer or any subsequent purchaser.
- c) are damaged by causes external to the products, including (without limitation) shipping damage, or accident or catastrophe of nature.
- d) have been subjected to repairs or attempted repairs by any person other than an authorized TOMCO₂ service technician.
- e) have been repaired using non-TOMCO₂ spare parts.

The limit of TOMCO₂'s entire warranty obligation is, at TOMCO₂'s election, replacing, issuing credit or repairing any covered part of such equipment, which TOMCO₂'s examination determines to be defective. These remedies are exclusive and are the sole measure of recoverable damage.

A claim must be made within 30 days after the defect is discovered and any claim not made within the specified time period may be deemed by TOMCO₂ to be waived or released by purchaser.

Defective part(s) must be returned to TOMCO₂ within 20 days upon receipt of replacement part to receive valid warranty consideration. Upon receipt of the defective part, TOMCO₂ will make a warranty determination in accordance with our limited warranty and notify purchaser in the event parts are not covered.

Prior to returning any part to TOMCO₂, a returned goods authorization number (RGA) must be obtained from the Parts and Service Department. Parts must be returned to TOMCO₂ Equipment Company at 3340 Rosebud Road, Loganville, Georgia 30052, with the transportation charges prepaid and the following information provided:

- a) Company name
- b) Company address
- c) Contact name
- d) Contact telephone number
- e) Quantity, description, model number and, if applicable, a serial number of each item being returned
- f) Reason for return
- g) Original TOMCO₂ sales order number, invoice number or customer purchase order number
- h) Return goods authorization number (RGA) must appear on the shipping label and packing slip

TOMCO₂ shall not be liable for consequential damages or any special, incidental, or other cost, expense or damage, including harm to others or loss of profits. Neither TOMCO₂ nor purchaser shall seek, from the other, reimbursement or indemnity for claims related to the equipment that involves its employees or its visitors.

THIS IS THE ONLY WARRANTY GIVEN BY TOMCO₂ EQUIPMENT COMPANY, EXCEPT AS PROVIDED HEREIN; TOMCO₂ DISCLAIMS ALL OTHER WARRANTIES, EXCEPT TITLE, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

This warranty excludes products, accessories, parts or attachments that are not manufactured by TOMCO₂ except to the extent of the warranty from the original manufacturer assigned by TOMCO₂. Copies of such applicable warranties are available upon request of TOMCO₂.

Revised 1-28-02

QTY	PART NUMBER	DESCRIPTION
2	267304	Filter Screen, 4" x 11" (101.6 mm x 279.4 mm)
2	970236	Nylon Piston Wearbands 7" (177.8 mm)
2	3320-YRSK	Rod Seal
2	3327L	Rod Bearing
2	3320-74	Hydraulic Cylinder Rebuild Kit
1	3185-4	Hydraulic Fluid Filter
1	970235	Compression Cylinder Piston Assembly
2	71180-21	1/2" (12.7 mm) Injection Ball Valve
1	71180.22	Injection Ball Valve Actuator
1	1080-91	Limit Switch
2	3686	Compression Cylinder Pressure Switch
2	4553-160	Compression Cylinder Pressure Gauge, 0 - 100 psig
1	3192	Hydraulic Pressure Gauge, 0 - 5000 psig

Table 7.1.7 - Replacement Parts for Model DE01RB-1500

NOTES

CUSTOMER QUESTIONNAIRE

Name _____

Company _____

Phone _____ Date _____

Application**Please Complete and Mail to:**

TOMCO₂ EQUIPMENT COMPANY
 Engineering Department
 3340 Rosebud Rd.
 Loganville, GA 30052 USA

or fax to:

(770) 985-9179

1. How did you receive this manual? Was the manual . . .
 - a. Included in a product shipment?
 - b. Given to you by management?
 - c. Purchased by you?
 - d. Given to you by a colleague?
 - e. Other?
2. How frequently do you use this manual?
 - a. Quarterly
 - b. Monthly
 - c. Weekly
 - d. Daily
 - e. Hourly
 - f. Seldom
3. Under what circumstances do you use this manual? _____

4. Describe the last time you used this manual. _____

5. What task or project were you performing when you used this manual? _____

6. How do you use this manual? Do you . . .
 - a. Sit down and read it?
 - b. Refer to a certain section while performing a task or project?
 - c. Look up information for someone else?
 - d. Refer to it only when you have a problem to solve?
 - e. Other? _____
7. How do you look up information in this manual? Do you . . .
 - a. Use the table of contents?
 - b. Flip through the pages until you locate the right section?
 - c. Flip to the tabbed sections, then proceed to locate information?
 - d. Other? _____
8. When you use this manual, how easy is it to find information? Do you . . .
 - a. Always locate the right section immediately?
 - b. Sometimes turn to another section before you locate the right one?
 - c. Take more than three times to locate information?
 - d. Fail to locate information?
9. Do you record notes in the margins of this manual? ☐ Yes ☐ No
10. If yes, what notes do you write down? _____

*continued on other side***User-Friendliness**

APPENDIX

11. Evaluate how descriptive or detailed key manual components are. Complete the following statements using a 1 to 4 scale. 1 is not descriptive and detailed, 4 is very descriptive and highly detailed.

The headings in this manual were	1	2	3	4
The sub-headings in this manual were	1	2	3	4
The instructions in this manual were	1	2	3	4
The illustrations, graphics in this manual were	1	2	3	4

12. Evaluate the readability of this manual. Complete the following statements by using a 1 to 4 scale. 1 is hard to read, 4 is very easy to read.

The headings in this manual were	1	2	3	4
The sub-headings in this manual were	1	2	3	4
The instructions in this manual were	1	2	3	4
The illustrations, graphics in this manual were	1	2	3	4

13. Evaluate the accuracy of this manual. Complete the following statements using a 1 to 4 scale. 1 is not accurate, 4 is accurate.

The headings in this manual were	1	2	3	4
The sub-headings in this manual were	1	2	3	4
The instructions in this manual were	1	2	3	4
The illustrations, graphics in this manual were	1	2	3	4

14. What sections, if any, were inaccurate? _____

15. Who else uses this manual? _____
16. What do they use it for? _____

Overall Impression

17. What do you like best about this manual?

- | | | |
|--|--------------------------------------|--|
| ☐ Graphics | ☐ Color | ☐ Special sections |
| ☐ Illustrations | ☐ Size | ☐ Job aids |
| ☐ Format | ☐ Length | ☐ Supplemental material |
| ☐ Style | ☐ Consistency | ☐ Other _____ |

18. What do you like least about this manual?

- | | | |
|--|--------------------------------------|--|
| ☐ Graphics | ☐ Color | ☐ Special sections |
| ☐ Illustrations | ☐ Size | ☐ Job aids |
| ☐ Format | ☐ Length | ☐ Supplemental material |
| ☐ Style | ☐ Consistency | ☐ Other _____ |

19. What would you change about this manual? _____

20. What sections need to be updated? _____

21. What was your overall impression of this manual? _____
