Section **7**

Pneumatic System

GENERAL DESCRIPTION

The machine's pneumatic system is used for starting, stopping and activating the diesel shutdown system of the engine package. Auxiliary circuits are also employed for safety interlocking with the park brake, operator activated air horn and make up tank head pressure. The system comprises of an air compressor, storage receiver, air starter motor and auxiliary components for pressure regulation and engine control.

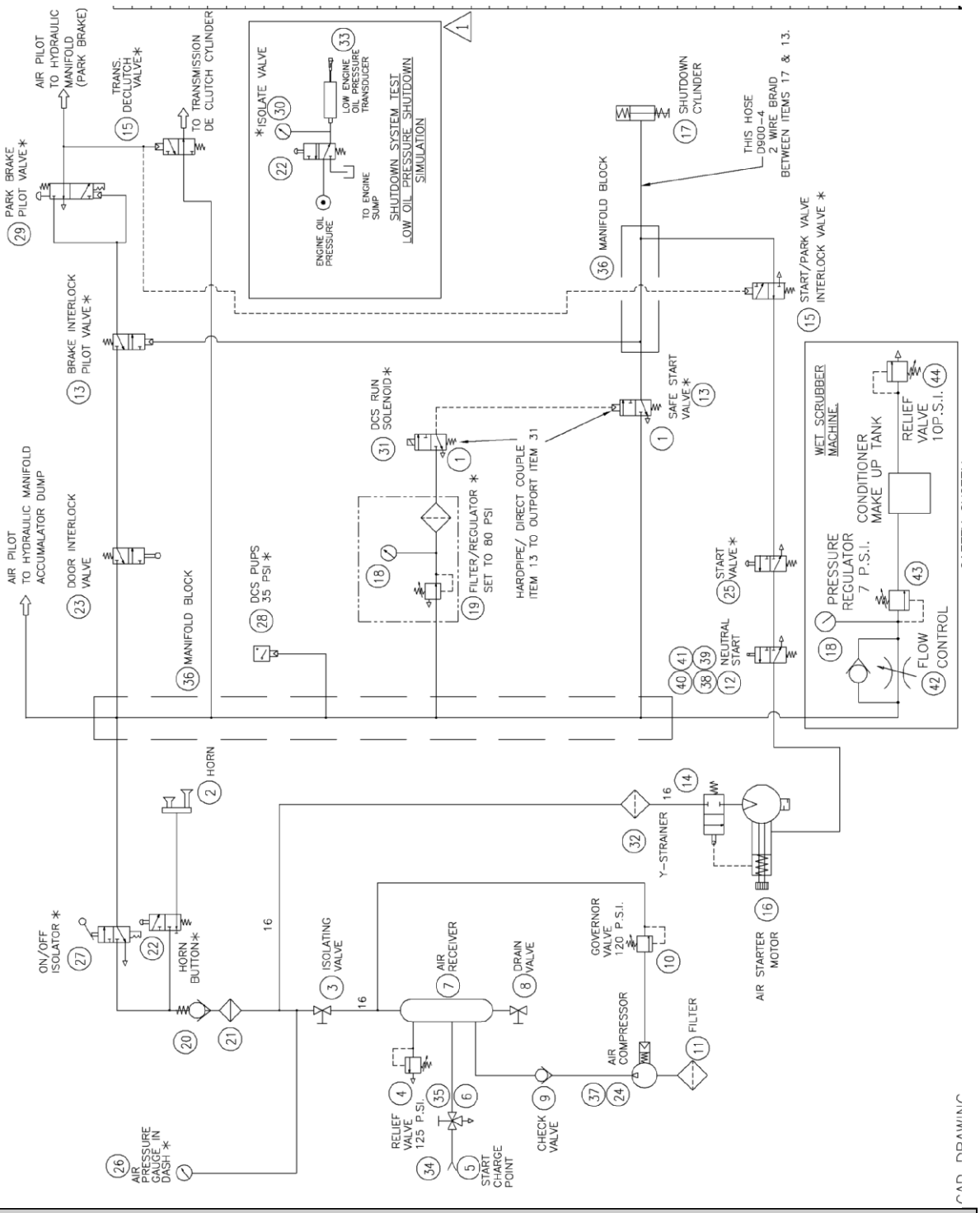
A water-cooled air compressor is driven from a mechanical take off on the engine and is constantly running whenever the engine is running. Air compression is controlled via a separately mounted governor valve which acts in conjunction with the unloading mechanism in the compressor cylinder head. The governor starts and stops compression of air by loading and unloading the compressor when the system reaches the desired maximum and minimum pressure.

The air receiver acts as an accumulator, storing a volume of compressed air for system use at start up. The receiver is fitted with a pressure relief valve set at 125 psi, main drain valve and inlet valve to enable external filling. The stored compressed air, governed at 120 psi, is delivered to the pneumatic system via the main air isolation valve at the receiver.

Starting is achieved by directing pilot air pressure to the air starter motor relay. This relay pilots the main air supply to the starter motor which engages the starter motor pinion gear to mesh with the engine ring gear which in turn cranks the engine.

The engine safe start circuit assures that the transmission is selected to neutral and the engine monitoring sensors are healthy prior to activating the starter motor. The engine oil pressure sensor is overridden at start up, this is to allow pressure to be developed by the engine oil system. Once the engine has started and the engine start button is released the oil pressure sensor will become active, allowing air pressure to be held in the engine shutdown cylinder which, in turn, delivers the fuel supply to the governor. Stopping the engine may be done automatically by activation of one or more engine sensors or by manual activation of the on/off toggle switch in the operator's compartment. Both of these actions remove air pressure from the shutdown cylinder, which cuts fuel supply to the engine via a return spring on the governor stop lever.

The manual park brake application is interlocked with the shutdown cylinder and can only be released with the engine running. Once the park brake is released it supplies air to the transmission declutch valve.



Pneumatic Schematic

SAFETY PRECAUTIONS

The following safety precautions are not intended to be exhaustive. Safe work practices should be used when servicing or operating heavy machinery.

ALWAYS give the engine an opportunity to cool down before performing servicing around the rear frame as engine components around this location are hot and could cause burns or scalding.

ALWAYS be aware of, and isolate, other forms of energy and pinch points (fan, belts, pulleys) when accessing the engine compartment including pneumatic stored pressure, engine coolant pressure and other heat sources such as engine block and exhaust system components.

ALWAYS tag out a machine before undertaking any work on that machine.

ALWAYS install the articulation lock when accessing the machine articulation area as machine articulation will result in crush injuries.

ALWAYS install the lift arm stands when access underneath the lift arm assembly is required. Remove any load before raising the lift arm assembly.

NEVER assume that all forms of energy have been isolated unless you have confirmed for yourself

Air in many parts of these circuits is under pressure. Removal of hoses or fitting without prior bleeding of receiver and lines will create an unsafe condition where serious injury could occur.

Air in this system could be under pressure ensure personal protective equipment is fitted and system is bleed before working on any air circuit.

The air circuit is interlinked with the intrinsically safe diesel control system of the machine.

AIR COMPRESSOR

The air compressor is driven from engine timing drive gears. Lubrication is via and oil line from the engine oil gallery in the engine block to the front of the compressor. Cooling is achieved from the cooling lines from the engine cooling system.

COMPRESSOR MOUNTING

Servicing

Replace the air compressor inlet filter every month or 250 service hours.

To remove and replace the air compressor inlet filter:

1. Ensure that the engine has had sufficient time to cool and is isolated and tagged as described in Section 1.
2. Isolate the pneumatic system using the main air isolation valve located at the air receiver.
3. Locate the filter housing above the air compressor assembly.
4. Remove the filter by unscrewing the retaining clamp at the base of the filter.
5. Remove the filter and discard in a responsible manner.
6. Fit the new filter and tighten clamp.

COMPRESSOR

If the pneumatic system fails to maintain sufficient charge pressure the compressor may be faulty and will need to be removed for inspection and overhaul.

To remove and replace the air compressor:

1. Ensure that the engine has had sufficient time to cool and is isolated and tagged as described in Section 1.
2. Drain all air pressure from the air receiver to assure full isolation to the compressor. As the air compressor is water-cooled the cooling system will need to be drained. See Section 2 for the correct procedure for draining the cooling system.

The engine cooling system runs at a nominal 100 kPa pressure and can reach temperatures of more than 100°C. Release stored pressure and wear personal protective equipment when accessing.

3. Remove the air compressor intake filter, the governor air line and the stainless steelbraided delivery hose from the compressor. Plug the hose ends to avoid contamination.
4. Remove the two cooling hoses from the air compressor. Plug the hose ends to avoid contamination.
5. Remove the oil delivery line from the engine to the compressor.
6. Remove the two mounting bolts from the front of the timing cover and three mounting bolts from the rear of the compressor and remove the bracket.
7. Remove compressor assembly clear of the engine.
8. Fit a new gasket to the compressor.
9. Fit the new compressor and secure with the mounting bolts.
10. Refit the two cooling hoses, two air hoses, lubricating oil lines and air filter.

AIR RECEIVER

The air receiver accepts air pumped from the air compressor and stores it at a maximum pressure of 830 kPa (120 psi) as set by the governor valve mounted on the side of the compressor. A pressure relief valve mounted on the air receiver assures that the maximum stored pressure does not exceed 860 kPa (125 psi). The base of the air receiver is fitted with a drain cock to enable stored pressure to be safely directed away from personnel, as well as provide low drain point for the removal of water. Air is delivered to the air receiver via a one-way check valve to retain air pressure when the engine has stopped.

A three-way ball valve is also fitted to enable receiver filling from an external air supply. The valve has three positions *in, off, tank*.

To fill the air receiver via an external air hose:

1. Connect an external air supply to the min-sup coupling and fit safety pin.
2. Rotate the three-way ball valve from the *tank* to the *off* position and apply air pressure from the supply hose.
3. Rotate the ball valve from the *off* to the *in* position. This allows air to be delivered into the air receiver.
4. Once the correct air pressure has been obtained (observed at the air pressure gauge in the operator's compartment) turn the external air pressure off.
5. Rotate the three-way ball valve to the *tank* position. This opens the supply hose to the drain line and closes the inlet to the tank. Pressure in the hose is relived via the drain line to enable easy and safe disconnection of the min-sup coupling.

Main Air Manifold

Servicing

The air receiver should be drained of accumulated water daily.

To drain the air receiver:

1. Ensure that the engine has had sufficient time to cool and is isolated and tagged as described in Section 1.
2. Locate the main air drain valve at the lower most point on the air receiver.
3. Open the main air drain valve allowing water to be purged from the tank. It is not necessary to drain all air from the air receiver. A short burst of released air is sufficient.

The governor valve should be checked for correct operation every 250 service hours.

To check for correct operation:

1. Start the engine and ensure the external air supply is isolated.
2. Observe the air pressure gauge in the operator's compartment. The compressor should unload at 120 psi.
3. To check that the governor valve is loading, bleed air from the air receiver at approximately 80 psi.

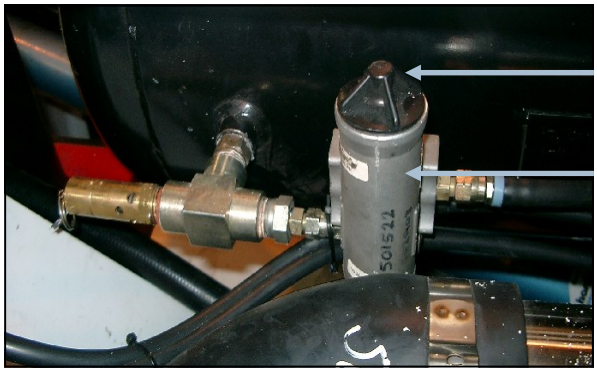
   NOTE: The pressure differential between loaded and unloaded is fixed at 30 psi-40 psi and it can not be adjusted.

To check for the correct governing pressure simply observe the maximum and minimum pneumatic pressure on the pressure gauge located in the operator's compartment. Pressure in the system should constantly rise to a maximum of 830 kPa (120 psi) with a tolerance of -5 psi. If the governed pressure is outside this range, adjustment is required.

To adjust the governor valve for the correct pressure:

1. Start the engine.
2. Locate the governor valve and remove the dust cap on the bottom of the canister.
3. Loosen the lock nut and rotate the adjusting screw clockwise to increase the governed pressure or counter-clockwise to reduce the governed pressure.
4. Verify governed pressure by running the engine and viewing the maximum pressure indicated on the pneumatic pressure gauge located in the operator's compartment.
5. When 120 psi is reached lock the lock nut and replace the dust cap.

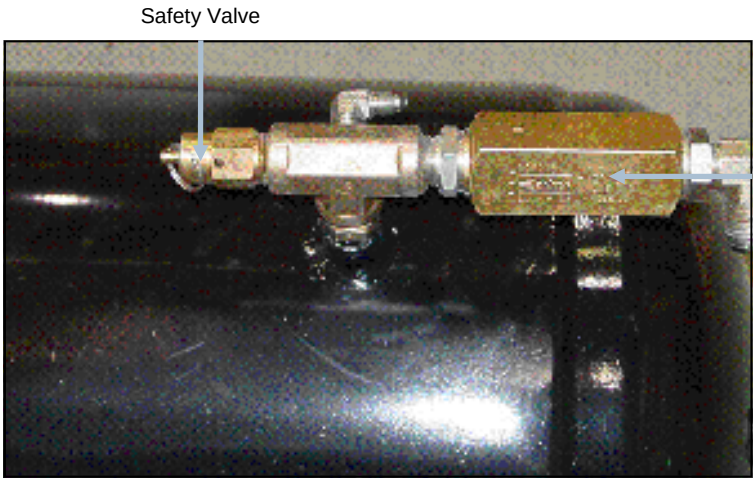
The air receiver pressure relief valve should be checked for correct relief setting every 3000 service hours.



To check and adjust the air receiver relief valve:

1. Start the engine.
2. Observe the pressure on the air pressure gauge in the operator's compartment.
3. Locate the governor valve located on the side of the compressor.
4. Rotate the governor adjusting screw clockwise to increase the pressure to 125 psi on the gauge in the operator's compartment.
5. Locate the relief valve on the air receiver and adjust until the air lifts the seat and starts venting to atmosphere.
6. Lock the relief valve at this setting.
7. Rotate the adjusting screw counter-clockwise on the governor screw on the side of the compressor to reduce the governed pressure.
8. Drain air from the air receiver till the operator's air pressure gauge is 70 psi.
9. Let the air pressure build up until governed pressure is reached.
10. Rotate the adjusting screw clockwise to increase the pressure.
11. When 120 psi is reached on the gauge in the operator's compartment lock the lock nut on the adjusting screw and replace the dust cap.
12. Drain some air from the air receiver and let the pressure build up to check if the governed pressure maintains 120 psi on the gauge in the operator's compartment.

The air receiver is a pressure vessel inspection and certification of the air receiver must be carried out every 12 months by a licensed boiler inspector.



Air Receiver Safety Relief Valve

STARTER MOTOR

The engine starter motor is a pneumatic driven motor mounted on the engine flywheel housing. When air pressure is delivered to the starter motor a drive pinion on the motor shaft engages with the teeth on the engine flywheel ring gear to crank the engine.

Servicing

A silencer mounted on the exhaust port of the starter motor is used to minimise starter motor noise emission. The silencer is basically a wire gauze type muffler. Over time the muffler may become clogged with foreign material which will reduce starting efficiency. The silencer should be removed and cleaned every 1000 service hours.

To remove and clean the starter motor silencer:

1. Ensure that the engine has had sufficient time to cool and is isolated and tagged as described in Section 1.
2. Isolate the pneumatic system using the main air isolation valve located at the air receiver.
3. Locate the starter motor silencer at the starter motor exhaust port.
4. Remove the silencer by unscrewing the three bolts at the rear of the starter motor.
5. Clean the silencer with clean fuel oil and allow to dry.
6. Replace the silencer and check for free air flow by activating the starter motor.

Failure of the starter motor to crank the engine could be caused by a faulty starter motor. In this case the starter motor will need to be removed for inspection and overhaul or otherwise replaced.

To remove and install the starter motor:

1. Ensure that the engine has had sufficient time to cool and is isolated and tagged as described in Section 1.
2. Isolate the pneumatic system using the main air isolation valve located at the air receiver.
3. Locate the starter motor at the bottom of the engine block at the flywheel housing.
4. Disconnect the air supply hose from the start relay valve and the two pilot hoses to the starter motor. Plug the hose ends to avoid contamination.
5. Remove the three bolts and lock washers that secure it to the flywheel housing.
6. Pull the motor forward of the flywheel housing and remove.
7. Installation is the reverse procedure.

Starter Motor Assembly

SAFETY CIRCUIT

DIESEL CONTROL SYSTEM

The diesel control system comprises of seven sensors. These are integrated with the air circuit via a solenoid valve which supplies air to a fuel shutdown cylinder. When the engine is running all shutdown sensors are active. If any sensor activates air pressure is removed from the fuel shutdown cylinder and the engine stops.

All the valves are integral components in the diesel engine system flameproof certification. Do not use other than Bucyrus supplied valves in the diesel engine system as the system explosion protection certification will be compromised.

MAKE UP TANK HEAD PRESSURE

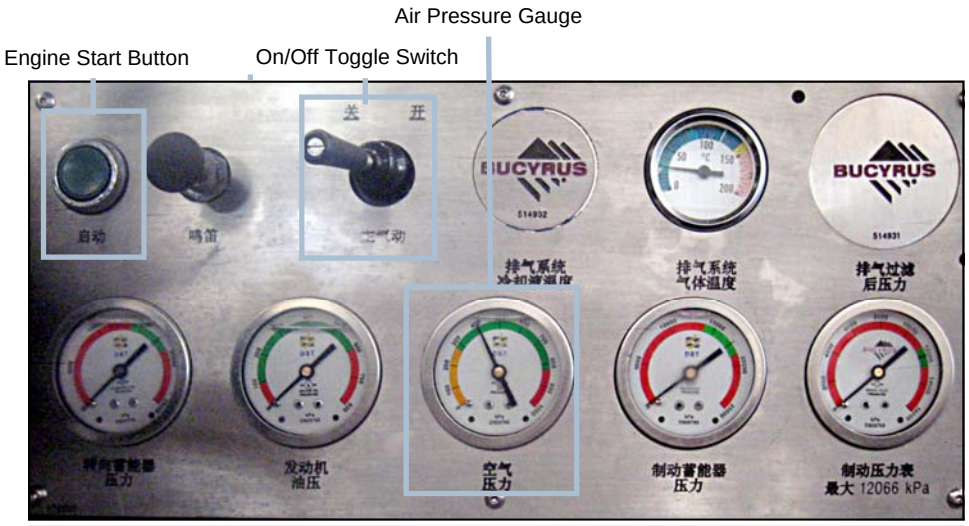
The make up tank head pressure is provided via air pressure through a flow control which is adjusted to be fully open and then through a pressure regulator valve (7 psi). The pressure assists in pushing the water through the tanks and into the conditioner. The top tank is fitted with a 10 psi relief valve.

Flow Control and Regulator Valve

Filler Cap and Relief Valve

SAFE START SYSTEM

The safe start system ensures the machine can not be started with the machine in gear (by means of the neutral start switch) or if there are any safety system sensors in the open position. On start up the engine oil pressure sensor is ignored by the diesel control system control. This allows the engine sufficient time to develop the minimum operating pressures after start up. The engine coolant temperature and exhaust temperature sensors are required to be in a healthy state before starting is available. The display will indicate the status of each sensor. Once engine oil pressure is achieved the display will indicate the system is in engine running mode.



Right Hand Side Operator's Panel

On/off Toggle Switch: The on/off toggle switch supplies system air to the diesel control system start initiate sensor which activates the diesel control system to indicate the relevant conditions. It also supplies the start circuit and park brake circuit when switched to the *on* position.

Air Pressure Gauge: The air pressure gauge shows the air pressure under storage in the air receiver. The normal system pressure should be 120 psi by means of a regulator mounted on the compressor

Engine Start Button: Once the on/off toggle switch is on the diesel control system will check the relevant conditions. It will then open the *run solenoid valve*, this pilots the *safe start valve* and allows air to be supplied to the *start valve* which when depressed will supply air via the neutral start valve and safe start valve to the relay valve on the main air line to the starter motor.

Safe Start Valve

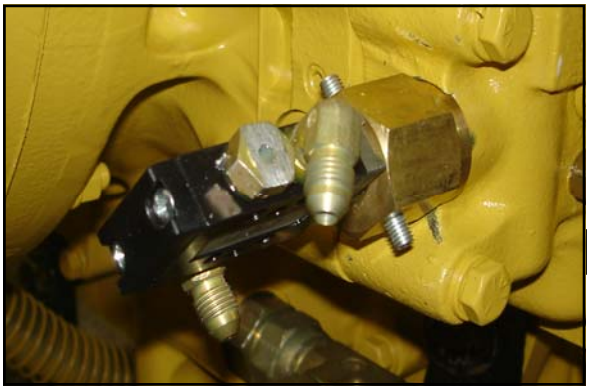
The safe start valve is piloted by the *run solenoid* and ensures that the machine will not start if the diesel control system has found a fault in the relevant engine conditions.

Transmission Neutral Start Valve

Ensures air pressure is not supplied from the safe start to the start relay valve unless the transmission is in the neutral position.

Start Relay Valve

The start relay valve is piloted by the start valve. The valve opens to allow air from the main air supply to rotate the starter motor thus cranking the engine for startup.



Start Relay Valve

BRAKE AND TRANSMISSION INTERLOCK SYSTEM

Starting is interlocked to the transmission via the neutral start valve. The transmission directional control lever must be in the neutral position to allow the starter motor to engage. A transmission declutch valve disengages the transmission if the park brake is applied.

Engine Off

Brake system interlocking is provided at engine shutdown and start up by releasing air to atmosphere via the *brake interlock pilot valve*. Before starting lack of air pressure supplied through the *safe start valve* stops the actuation of the park brake valve. This is also achieved via the operator's compartment door interlock valve if the door is not closed and latched. These valves supply system air pressure to the *park/brake valve pilot valve* in the operator's compartment to the *park brake hydraulic valve* on the main control manifold which applies and releases the spring applied and pressure released machine brakes by means of system oil pressure.

Engine Running

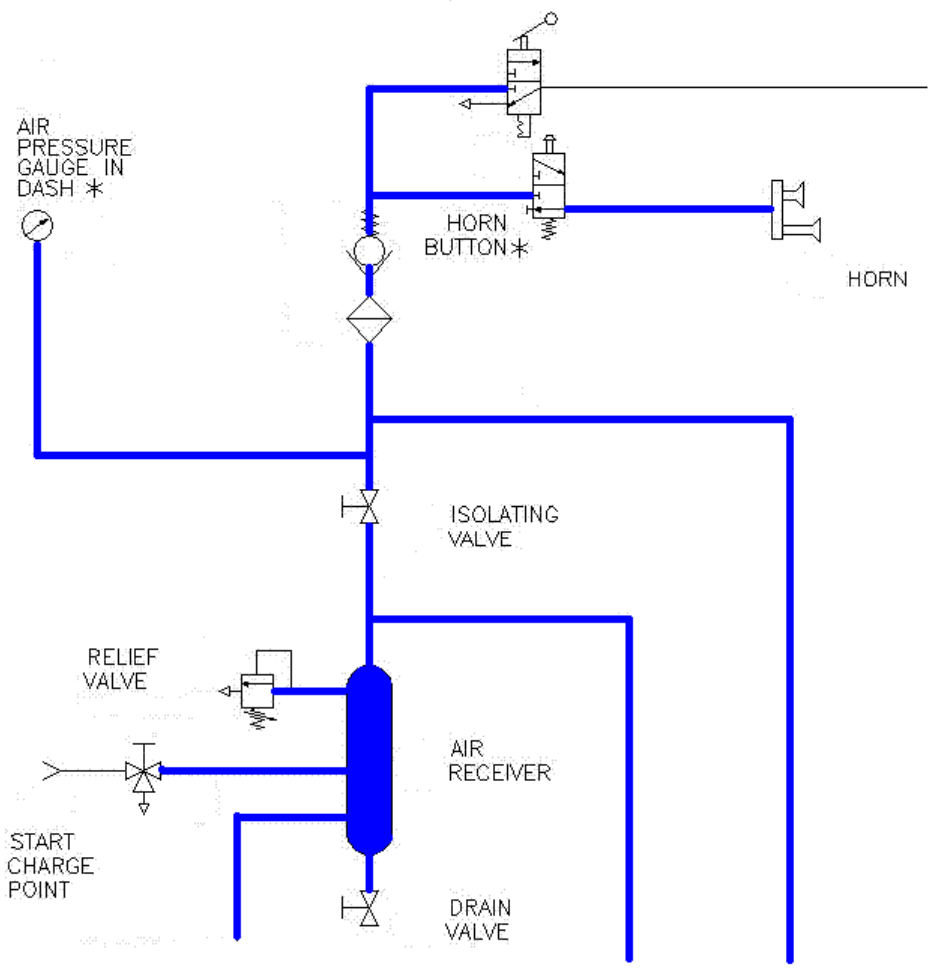
When the engine is running air pressure pilots the *brake interlock pilot valve* and allows air to be delivered to the *park/brake valve pilot valve* which, in turn applies and releases the brakes via pilot air pressure to the *park brake hydraulic valve*.

OPERATOR'S HORN

The operator's horn push button is located in the operator's compartment. Application of the button delivers air pressure to the air horn for an audible warning.

CAUTION

Do not use the machine horn with the engine shutdown. As the compressor is not delivering air to the receiver the horn will quickly exhaust the stored air in the receiver and result in an insufficient air supply for starting.



Horn Circuit

PNEUMATIC SYSTEM TROUBLESHOOTING

The following pneumatic system troubleshooting guide is intended to provide basic guidance for analysing typical system faults and determining probable causes. This guide is not intended to be exhaustive but to provide personnel with a basic guide for fast rectification

Symptom	Probable cause	Caused by	Remedy
Engine will not crank at start up.	No air pressure to starter motor.	No air pressure in the air receiver.	Fill air receiver from an external supply.
		Main air isolation valve at the air receiver is closed.	Open main air isolation valve.
		On/off toggle switch in the operator's compartment is in the *off* position.	Toggle the on/off toggle switch to the *on* position.
		Transmission directional control lever is not set to the neutral position or is faulty.	Set transmission directional control lever to neutral. Replace valve if required.
		Exhaust temperature or exhaust gas temperature sensor activated. Engine temperature or coolant level activated.	Verify sensor status from indication panel. Allow sufficient time for the sensor to cool or replace sensor if suspected as faulty. Check engine coolant level.
		Neutral start interlock not functioning.	Check neutral start interlock function.
		Low hydraulic oil.	Fill hydraulic tank.
Poor engine cranking performance.	Insufficient air pressure to starter motor.	Pneumatic system bypass.	Check pneumatic system for leaks and rectify as required.
		Low system air pressure.	Check system air pressure. Reset governor pressure if required.
		Damaged or faulty relay valve.	Check and clean relay valve replace if required.
		Blocked starter motor silencer.	Check and clean starter motor silencer if required.
		Starter motor internal bypass.	Remove and overhaul or replace starter motor.
System pressure fails to charge to 120 psi when engine is running.	Insufficient air pressure received from compressor.	Governor setting out of adjustment. Bypass in compressor.	Test and adjust governor. Remove and overhaul or replace compressor.

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