Mac.N.Hom Systems

Hydraulic Rudder Control System

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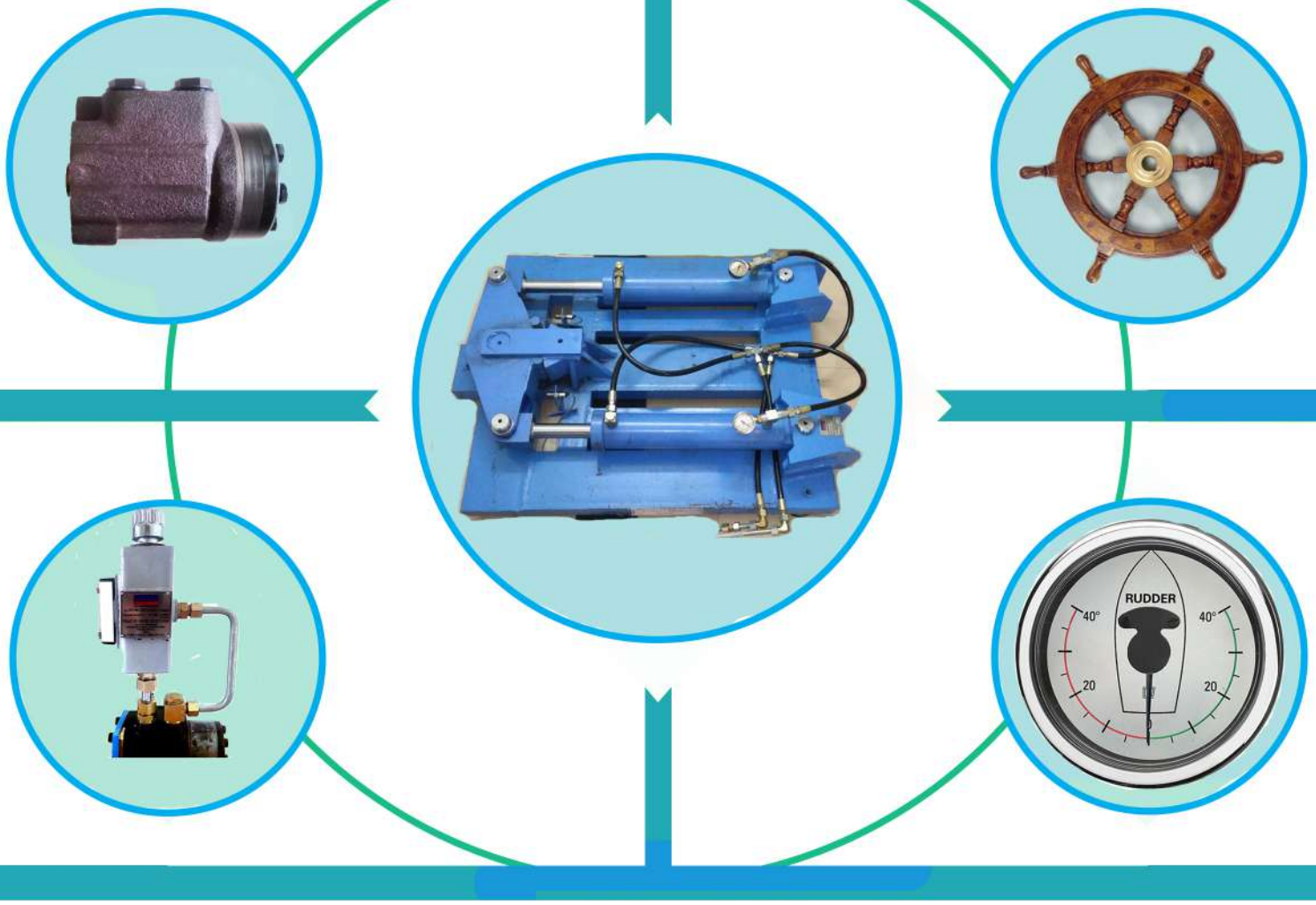

Model:JumboZ **User Manual**

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1. Introduction

Water borne vessels, big or small , need navigation control to cruise through water and to move through a controlled path. As vessels move forward by pushing the water backward, the guidance of the vessel by turning it Starboard or Port side can be controlled by directing the pushed water towards respective direction.

A plate of steel connected to a rod, which is extended to a convenient height of the boat deck, is used to deflect water on both sides, according to the requirement of turning. this plate is called the RUDDER PLATE and the shaft extending to the deck, connected to the rudder plate is called the RUDDER-STOCK. The Boat driver will use Mechanical or hydraulic system to turn an arm connected to the Rudder stock to do the Turning Job.

This arm used to turn the rudder plate is called the TILLER ARM. Though control of Tiller arm is easy for small boats running slow in backwaters/ lakes etc, it requires high effort and skill to hold tiller arm in right position or turn to required direction in sea, as well as during fast movement in back waters.

In fast moving, large modern vessels, heavily powered engines are used for propeller rotation to push high volume of water backwards. To control the turning of rudder plate against this heavy load of water, modern hydraulic controls are used. These hydraulic systems control the tiller arm movement effortlessly ,resulting in Precise angular movement of Rudder plate and total control over Navigation of vessels.

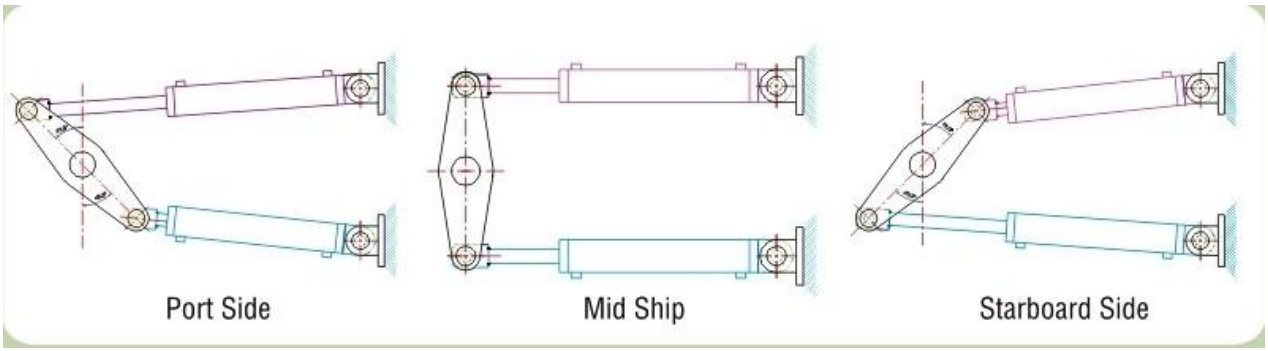


Figure 1.1: Different Rudder Positions

2. Sequence of Operation

The Joystick provided at the wheelhouse is used to Steer the vessel to Port side/ Starboard side. When the joystick is turned to starboard side an electrical impulse from steering control panel, inside wheelhouse goes to the DC valve of the Power pack unit in engine room. The DC motor of the power pack unit draws power from alternator coupled with vessels engine and in turn runs a Gear Pump.

The gear pump produces Pressurized oil supply, which is regulated by PRV and fed into the DC valve. when the impulse from the Wheelhouse comes to the DC valve, the valve directs this pressurized oil to respective ports of the Actuators. This pressurized oil makes the Actuator Extend/Retract. The tiller arm connected to the actuator thus turn angularly from Left to Right. The rudder plate connected to the tiller arm by rudder stock also turns. The rudder plate directs the stream of water coming from the propeller thus achieving the turning of vessel. For the vessel to turn to the STARBOARD side the rudder plate is turned to STARBOARD side thus directing stream of water from propeller to STARBOARD side. If the rudder plate is turned to the PORT side to the vessel will turn to PORT side.

3. Salient Features

- Twin Actuator based robust drive
- Hydraulic System with Overload Protection.
- Long Maintenance Free Service Life.
- Upto 45° turning from centre to both sides.
- Automatic Holding of Rudder plate position.
- Frictionless, Rust resistant, Coated Seamless steel tubes for Oil Transmission.

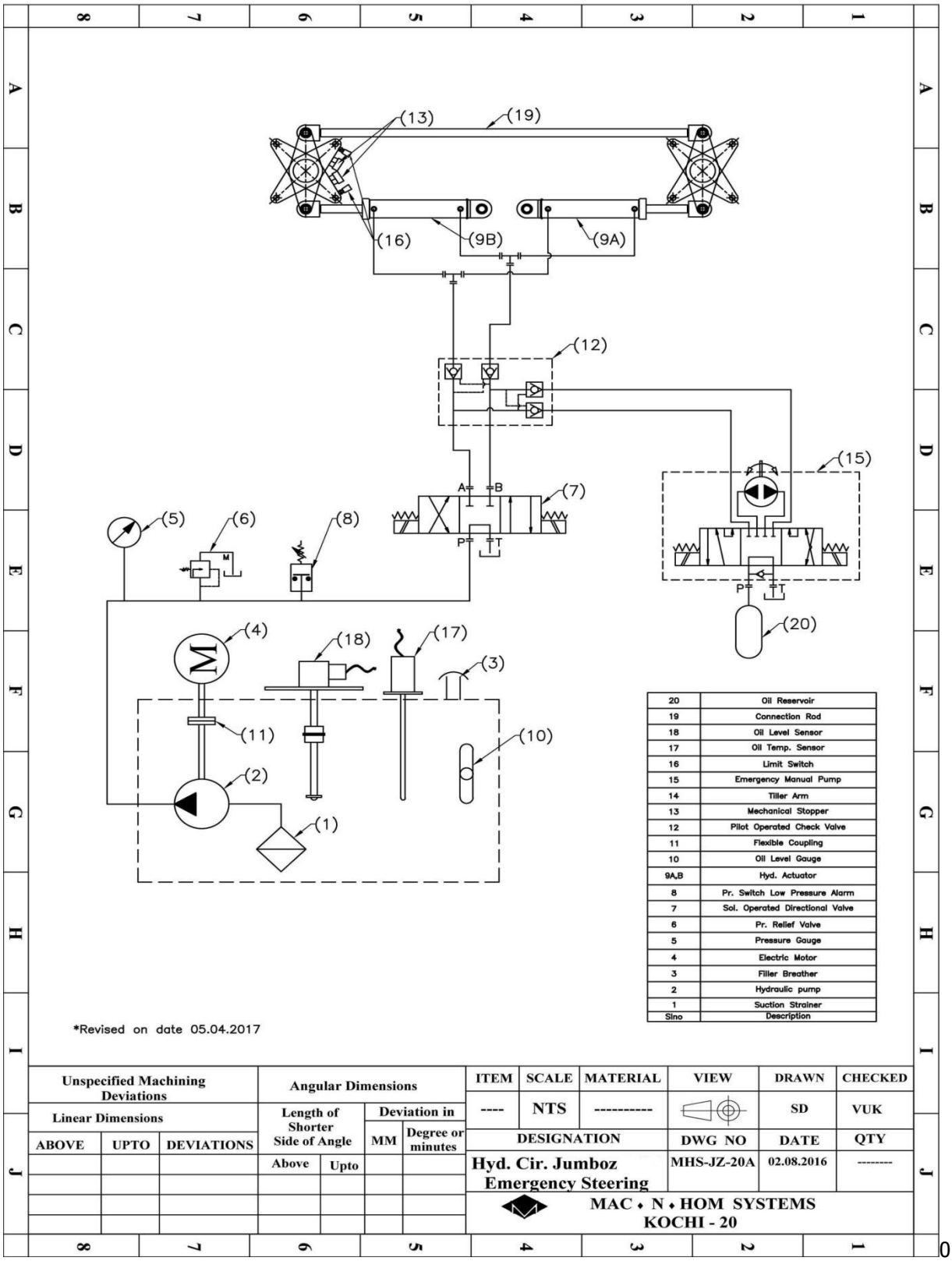


Figure 3.1: Hydraulic Circuit-JumboZ-2800E

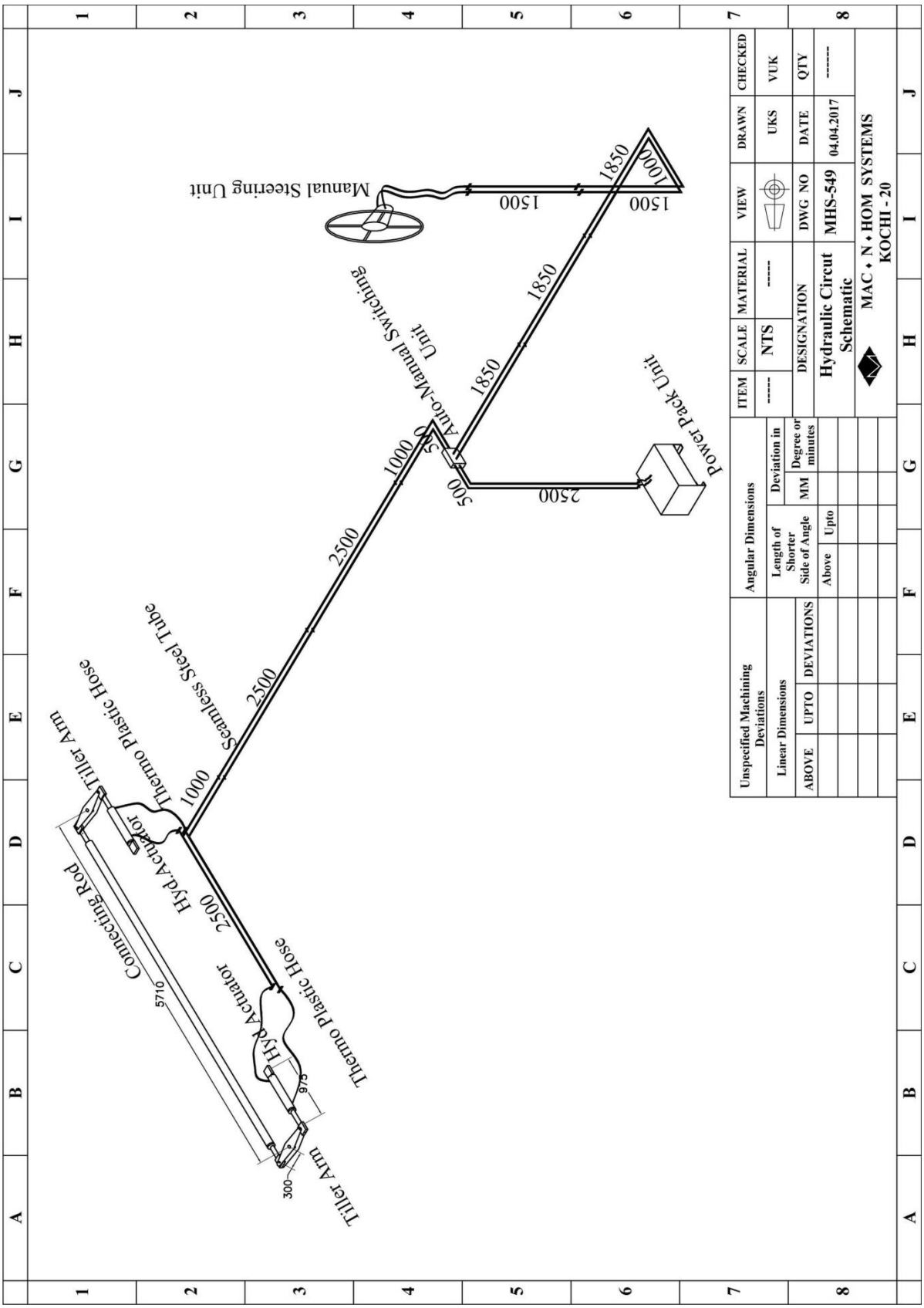


Figure 3.2: Sample Hydraulic Circuit-Schematic For Reference only

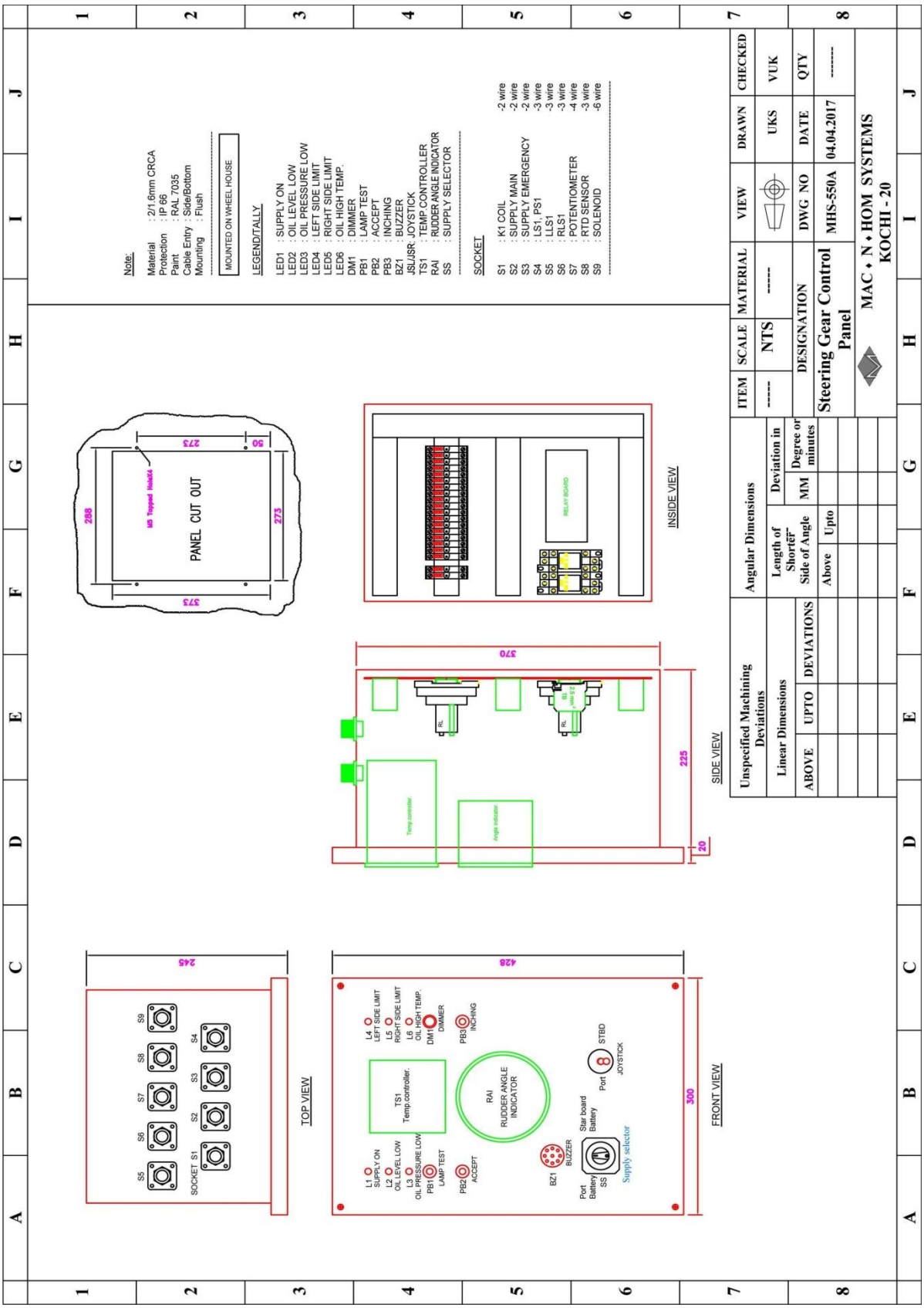


Figure 3.3: Steering Control Panel-(I)

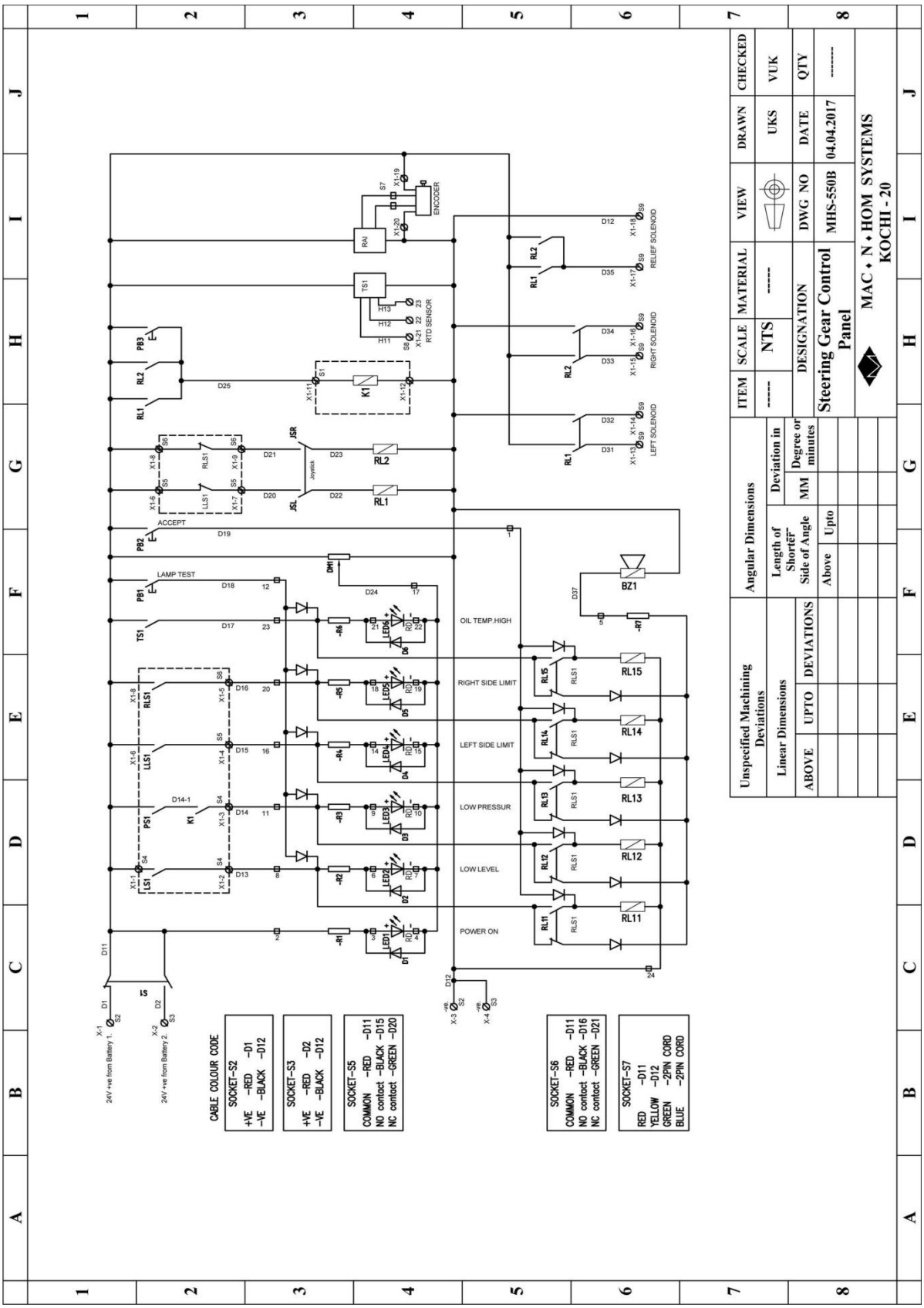


Figure 3.4: Steering Control Panel-(II)

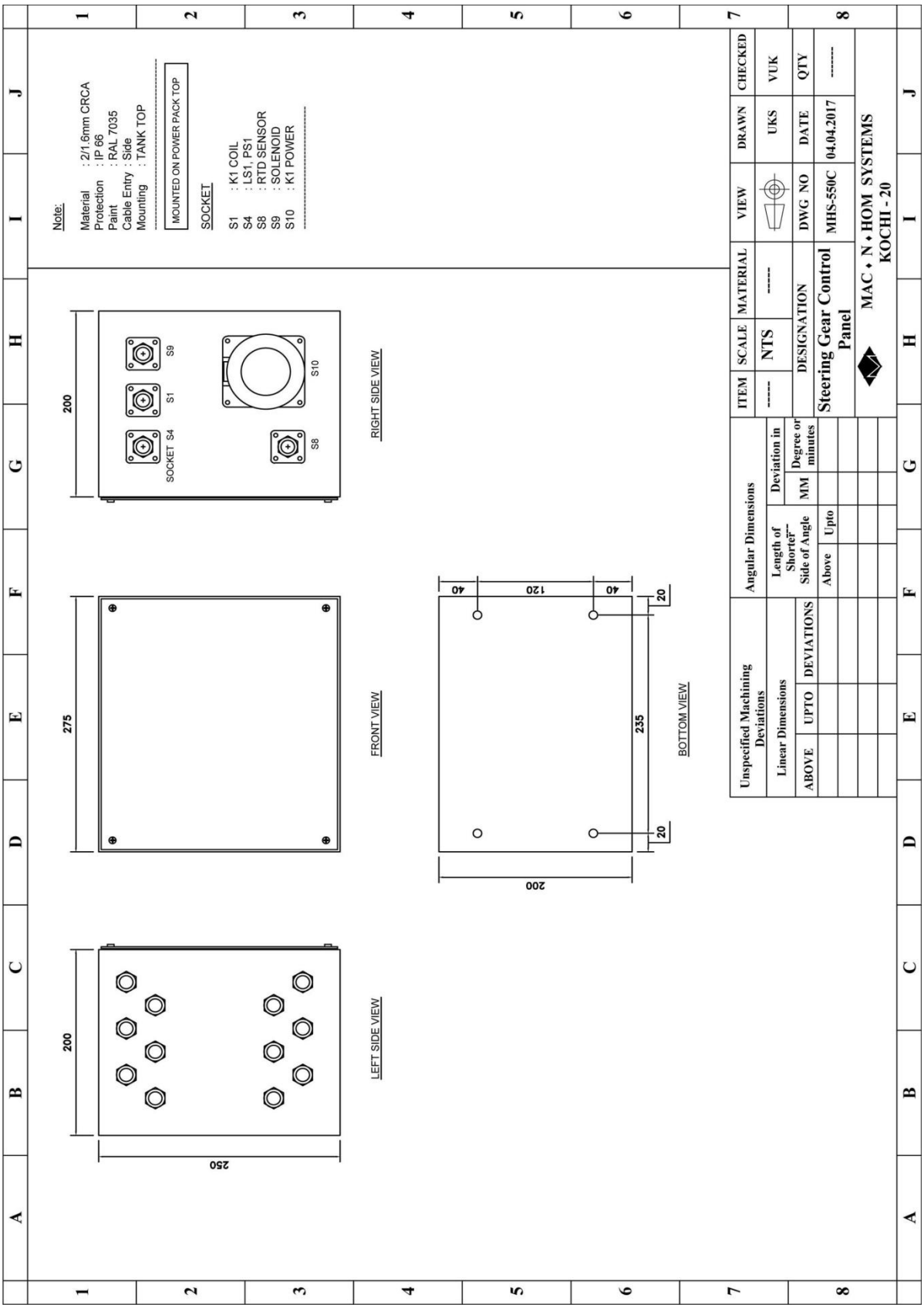


Figure 3.5: Steering Control Panel-(III)

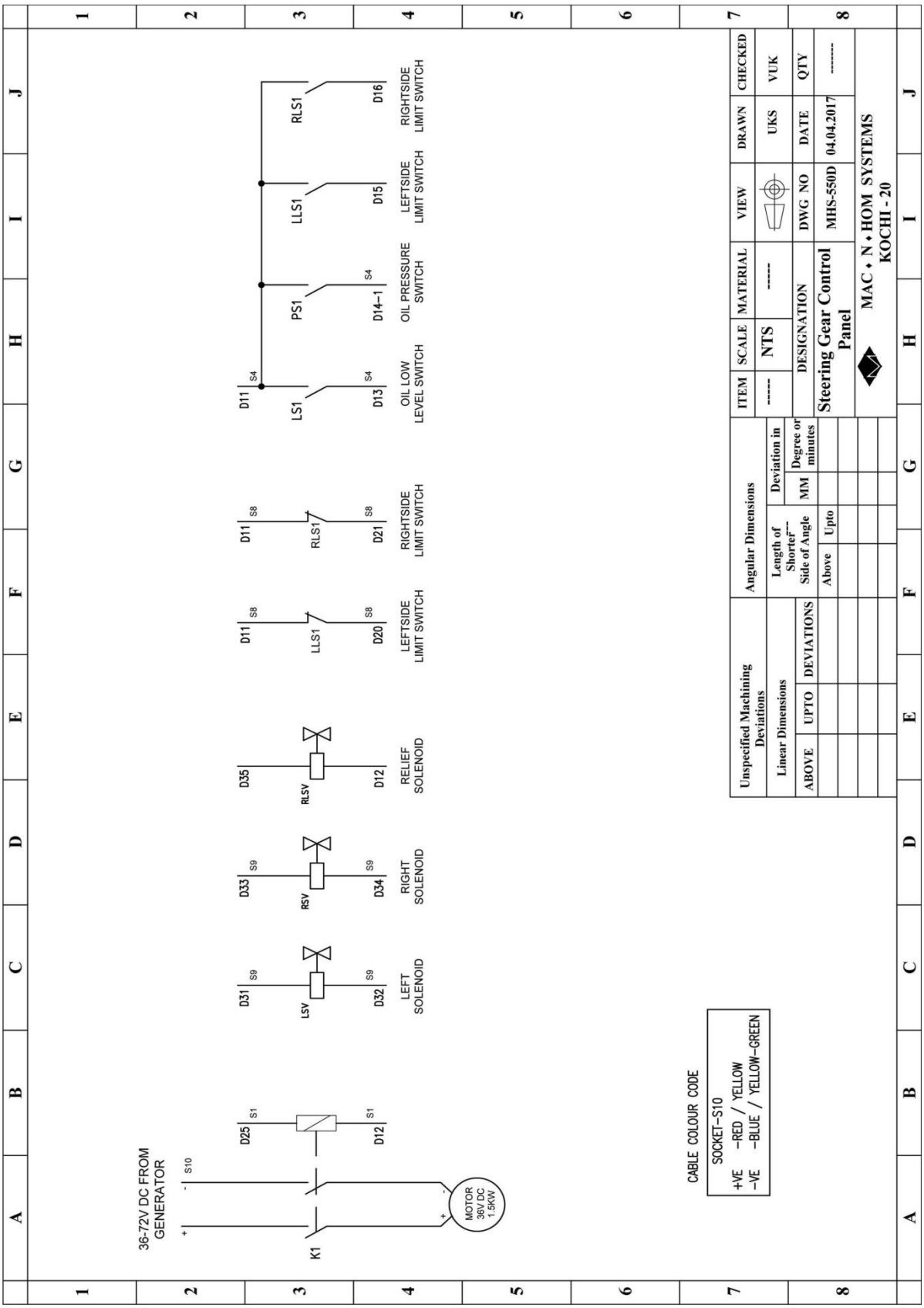


Figure 3.6: Steering Control Panel-(IV)

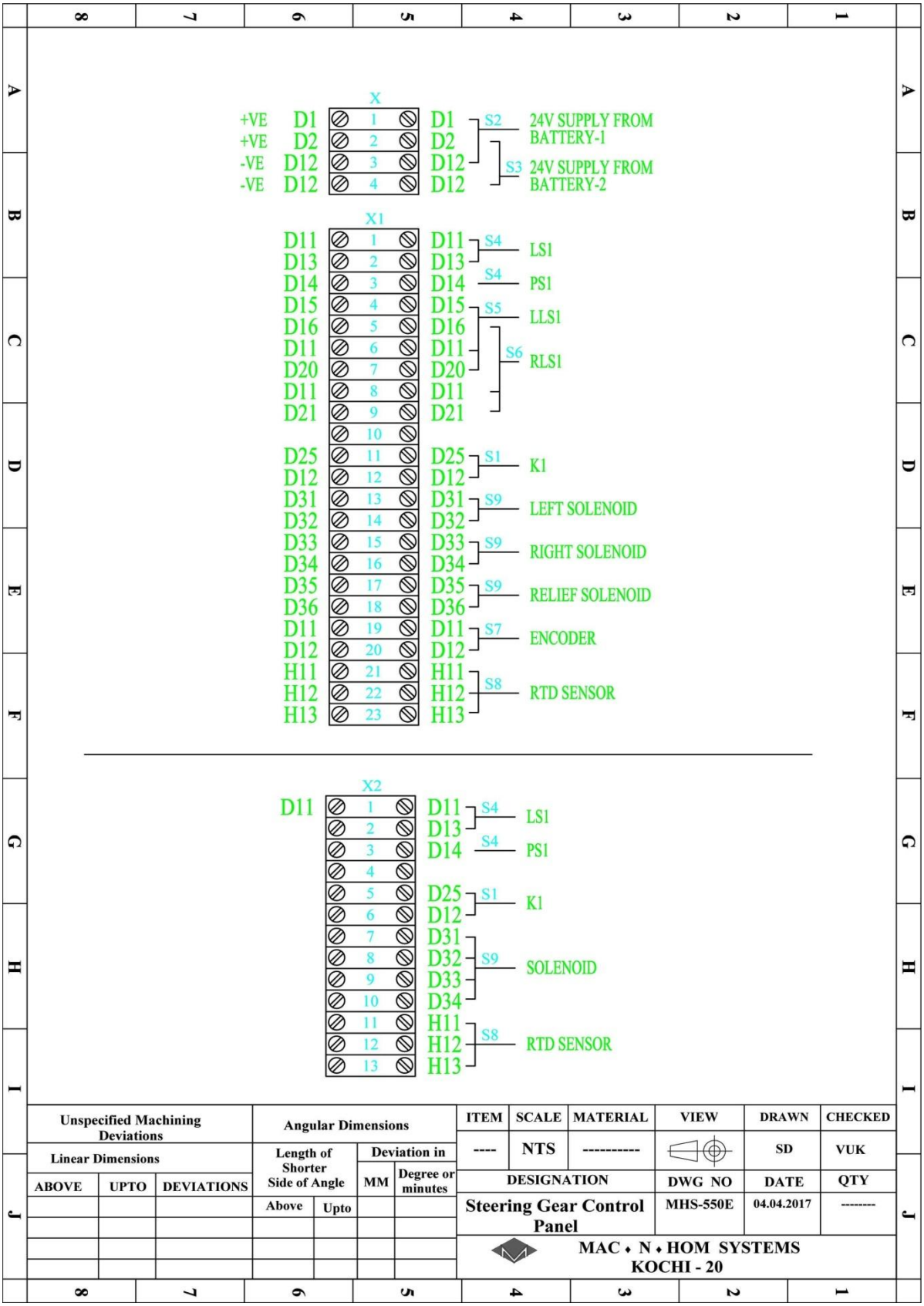


Figure 3.7: Steering Control Panel-(V)

4. Suction Strainer

Suction Strainer protect hydraulic pumps and control systems from solid contaminants. They should be used as immersion suction filters on pump inlet lines. These units have various application possibilities: as in-tank filters mounted directly to the reservoir, in the intake lines of hydraulic pumps to afford a degree of protection from contaminants to the pump and other components in the hydraulic system. It allow 20 lpm of fluid flow through it. It is fitted with reusable SS 149 micron STD mesh.

Figure 4.1: Suction Strainer

5. Hydraulic Gear Pump

A gear pump uses the meshing of gears to pump fluid by displacement. They are one of the most common types of pumps for hydraulic fluid power applications.

Gear pumps are also widely used in chemical installations to pump high viscosity fluids. There are two main variations; external gear pumps which use two external spur gears, and internal gear pumps which use an external and an internal spur gears (internal spur gear teeth face inwards). Gear pumps are positive displacement (or fixed displacement), meaning they pump a constant amount of fluid for each revolution. Some gear pumps are designed to function as either a motor or a pump.

Figure 5.1: Suction Strainer

6. Filler Breather

To strain fluids being added to tanks and to filter entering air. These units are offered for top or side mounting, with choice of neck height, basket depth, inner guards, dipsticks and magnets. In all-metal, all-stainless, or all-nylon construction. This is a combination unit for filtering air displacement from the reservoir and for straining oil while filling. Mounting options include Tank Top and Side Mounting. The displacement capacity is 250 LPM and 700 LPM and filtration is up to 40 microns. The air displacement from underneath the cap assembly improves performance. Power coated cap and nylon or nickel-chrome plated strainer body ensures corrosion resistance. The unit comes completely assembled with internal safety chain and fasteners. The mounting surface should be free of burrs, flat and clean to provide a good sealing surface for the flange. It is for use with Hydraulic/Lubrication oil reservoir applications, including machine tools, mobile equipment, industrial machinery, etc.

Figure 6.1: Filler Breather

7. Oil Level Gauge

Level Gauge can be used on any reservoir containing mineral and petroleum-based hydraulic fluids to indicate oil level. Level gauges are available with or without temperature gauges and are available in two sizes - 3" and 5" between bolt centers. They are easily readable through a magnifying sight glass. These level gauges offer complete protection to any reservoir. The Level Gauges are available ready to assemble. Only two holes are to be drilled onto the tank to fix the level gauge.

Figure 7.1: Oil Level Gauge

8. Pressure Gauge

The Bourdon pressure gauge uses the principle that a flattened tube tends to straighten or regain its circular form in cross-section when pressurized. Although this change in cross- section may be hardly noticeable, and thus involving moderate stresses within the elastic range of easily workable materials, the strain of the material of the tube is magnified by forming the tube into a C shape or even a helix, such that the entire tube tends to straighten out or uncoil, elastically, as it is pressurized. In practice, a flattened thin-wall, closed-end tube is connected at the hollow end to a fixed pipe containing the fluid pressure to be measured. As the pressure increases, the closed end moves in an arc, and this motion is converted into the rotation of a (segment of a) gear by a connecting link that is usually adjustable. A small-diameter pinion gear is on the pointer shaft, so the motion is magnified further by the gear ratio.

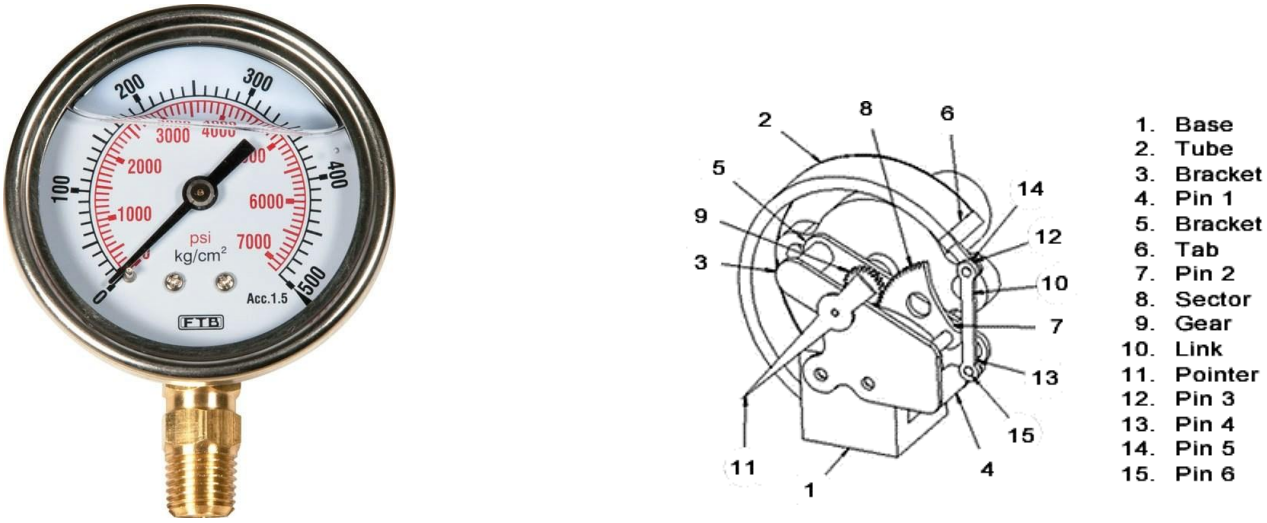


Figure 8.1: Pressure Gauge.

9. Non- Return Valve

A non-return valve can be fitted to ensure that a medium flows through a system in the right direction, where pressure conditions may otherwise cause reversed flow. A non-return valve allows a medium to flow in only one direction. The flow through the non-return valve causes a relatively large pressure drop, which has to be taken into account when designing the system

Figure 9.1: Non- Return Valve

10. Pressure Relief Valve

The Pressure relief valve (RV) is a type of valve used to control or limit the pressure in a system or vessel which can build up by a process upset, instrument or equipment failure, or fire.

The pressure is relieved by allowing the pressurized fluid to flow from an auxiliary passage out of the system. The relief valve is designed or set to open at a predetermined set pressure to protect pressure vessels and other equipment from being subjected to pressures that exceed their design limits. When the set pressure is exceeded, the relief valve becomes the ”path of least resistance” as the valve is forced open and a portion of the fluid is diverted through the auxiliary route. The diverted fluid is usually routed back to the reservoir tank. As the fluid is diverted, the pressure inside the vessel will stop rising. Once it reaches the valve’s reseating pressure, the valve will close.

Figure 10.1: Pressure Relief Valve

11. Sol. Operated Direction Control Valve

Directional control valves are one of the most fundamental parts in hydraulic machinery as well and pneumatic machinery. They allow fluid flow into different paths from one or more sources. They usually consist of a spool inside a cylinder which is mechanically or electrically controlled. The movement of the spool restricts or permits the flow, thus it controls the fluid flow. In normal position of the manually actuated 5/3 DC valve all port P is connected to port T. When actuated in first position, paths from port P to port A and from port B to port T are open. When actuated in second position paths from port P to port B and port A to port T are open.

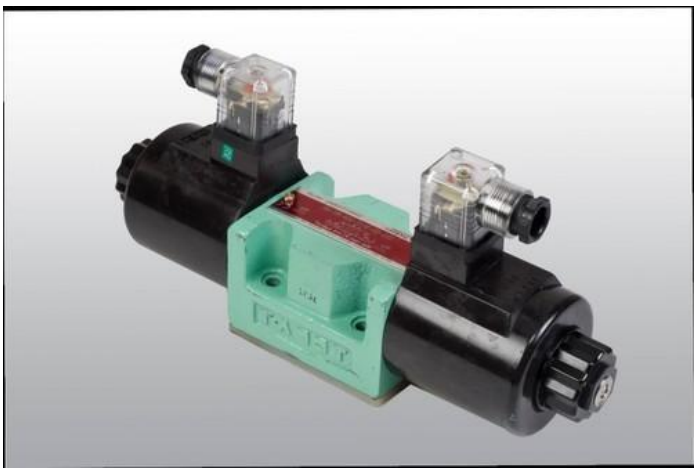


Figure 11.1: Solenoid Operated Direction Control Valve

12. Pressure Switch

A pressure switch is a form of switch that closes an electrical contact when a certain set pressure has been reached on its input. The switch may be designed to make contact either on pressure rise or on pressure fall.

A pressure switch for sensing fluid pressure contains a capsule, bellows, Bourdon tube, diaphragm or piston element that deforms or displaces proportionally to the applied pres- sure. The resulting motion is applied, either directly or through amplifying levers, to a set of switch contacts. Since pressure may be changing slowly and contacts should operate quickly, some kind of over-center mechanism such as a miniature snap-action switch is used to ensure quick operation of the contacts. One sensitive type of pressure switch uses mercury switches mounted on a Bourdon tube; the shifting weight of the mercury provides a useful over-center characteristic.

The pressure switch may be adjustable, by moving the contacts or adjusting tension in a counterbalance spring. Industrial pressure switches may have a calibrated scale and pointer to show the set point of the switch. A pressure switch will have a differential range around its set point in which small changes of pressure do not change the state of the contacts. Some types allow adjustment of the differential.

The pressure-sensing element of a pressure switch may be arranged to respond to the difference of two pressures. Such switches are useful when the difference is significant, for example, to detect a clogged filter in a water supply system. The switches must be designed to respond only to the difference and not to false-operate for changes in the common mode pressure.

Figure 12.1: Pressure Switch

13. Hydraulic Actuator

Two Hydraulic Actuators are planned to turn the tiller arm to both sides of the vessel, smoothly and precisely. Oil supply ports are provided on both sides of this actuators, through which, oil can be supplied to the piston of the actuator. As pressurized oil is supplied from the Power pack to the Linear actuator, the piston-rod will move forward or backward, depending on, to which supply port, oil is provided. The Piston rod-end / Ram- end of this actuator has a flexible connector, which can be coupled to the Tiller arm.

Figure 13.1: Photo of Hydraulic Actuators undergoing Endurance test in Test Rig

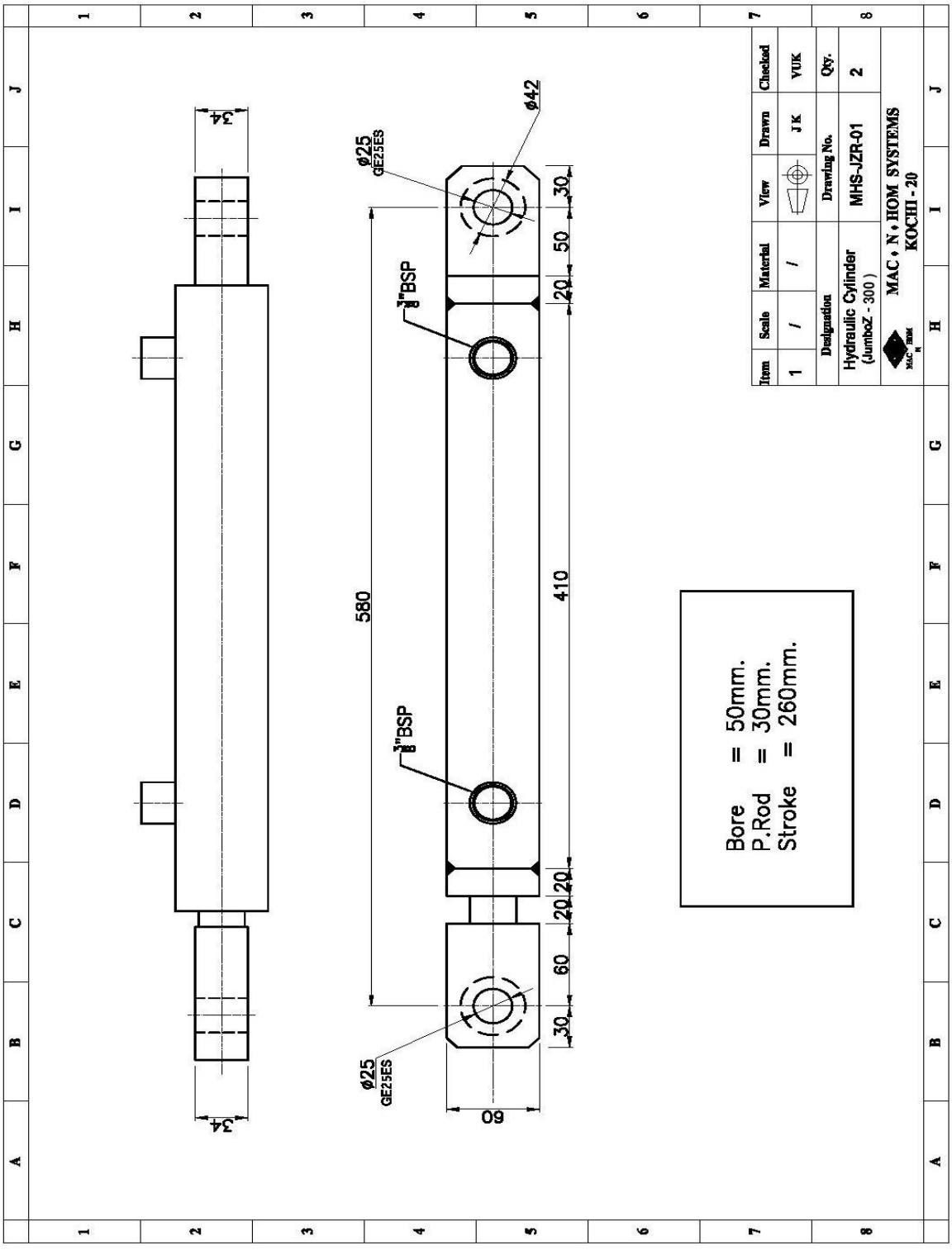


Figure 13.3: Section Drawing: Hydraulic Actuator

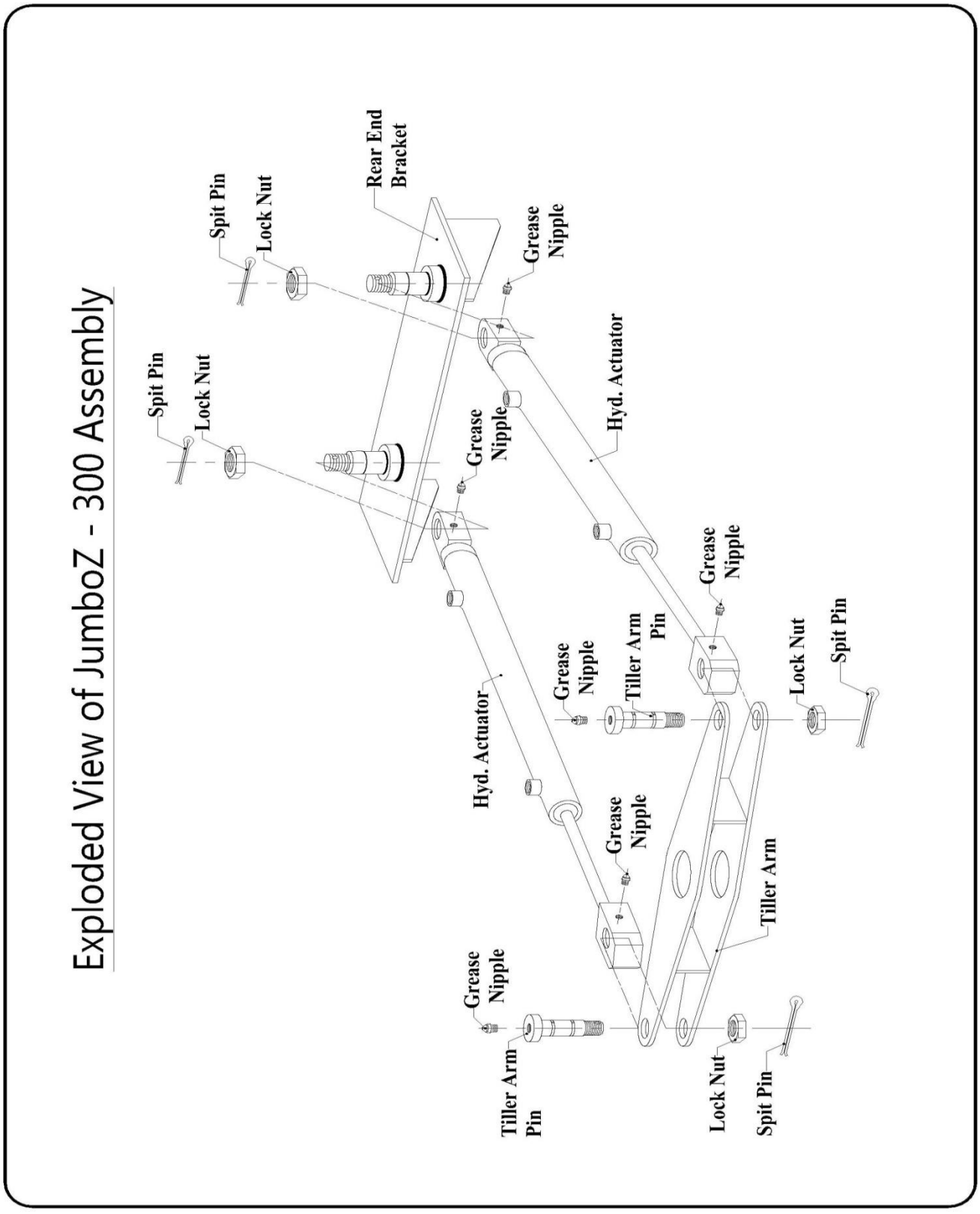


Figure 13.4: Exploded view of JumboZ-2800 assembly

14. Flexible Coupling

Hydraulic coupling is a hydrodynamic device used to transmit rotating mechanical power. It has been used in automobile transmissions as an alternative to a mechanical clutch. It also has widespread application in marine and industrial machine drives, where variable speed operation and controlled start-up without shock loading of the power transmission system is essential. They operate over a wide temperature range at speeds up to 5,000 RPM and are effectively used in applications such as motor/generator sets, pump sets and many light to medium duty industrial coupling applications. No lubricants are ever required, eliminating the need for seals. The resilient nature of the Nylon material makes the contact of the hubs and sleeves almost frictionless. Not requiring lubrication readily permits the use of these couplings in vertical and blind assembly applications where the slip-together components offer easy inspection and adjustment.

Features of Hydraulic Couplings:

- Moulded nylon sleeve.
- No internal frictional loss or heat buildup.
- Minimum backlash
- High ambient temperature allowed.
- Resistance to dirt, moisture, most chemicals.
- Low maintenance (no seals, lubricant, retainers).
- High torque, low inertia.

Figure 14.1: Flexible Coupling

15. Limit Switch

In electrical engineering a limit switch is a switch operated by the motion of a machine part or presence of an object.

They are used for controlling machinery as part of a control system, as a safety interlocks, or to count objects passing a point.[1] A limit switch is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection.

Limit switches are used in a variety of applications and environments because of their ruggedness, ease of installation, and reliability of operation. They can determine the pres- ence or absence, passing, positioning, and end of travel of an object. They were first used to define the limit of travel of an object; hence the name ”Limit Switch”.

A limit switch with a roller-lever operator; this is installed on a gate on a canal lock, and indicates the position of a gate to a control system. Standardized limit switches are industrial control components manufactured with a variety of operator types, including lever, roller plunger, and whisker type. Limit switches may be directly mechanically operated by the motion of the operating lever.

Figure 15.1: Limit Switch

16. Manual Pump.

The Helm Pump (Model:MS-320) unit has built-in relief and check valves. Thus it is very compact steering unit which reduces the need for additional hydraulic components in the system. Discharge 320 cc per revolution. The manual pump is OPEN CENTER, NON LOAD REACTION TYPE.

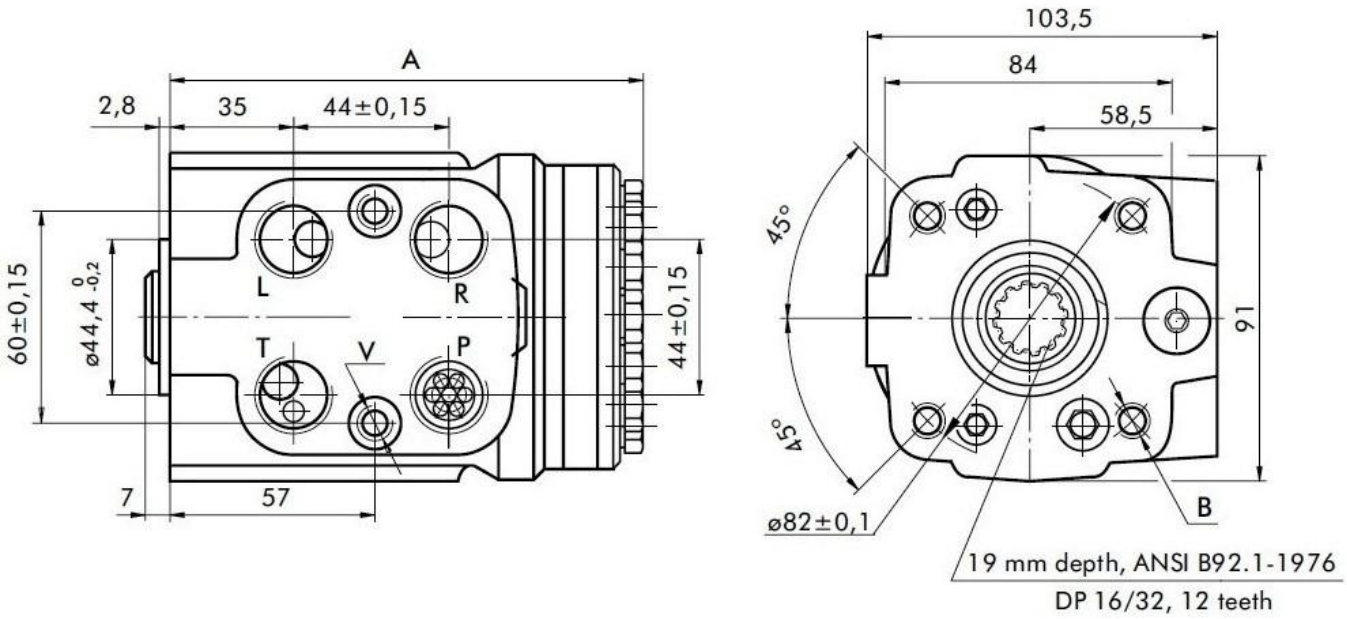
OPEN CENTER

- Simplest, most economical system.
- Uses a fixed displacement pump.
- In neutral position pump and tank are connected.

A NON-LOAD REACTION steering unit blocks the cylinder ports in neutral, holding the axle position whenever the operator releases the steering wheel.

Figure 16.1: Manual Pump

DIMENSIONS AND MOUNTING DATA

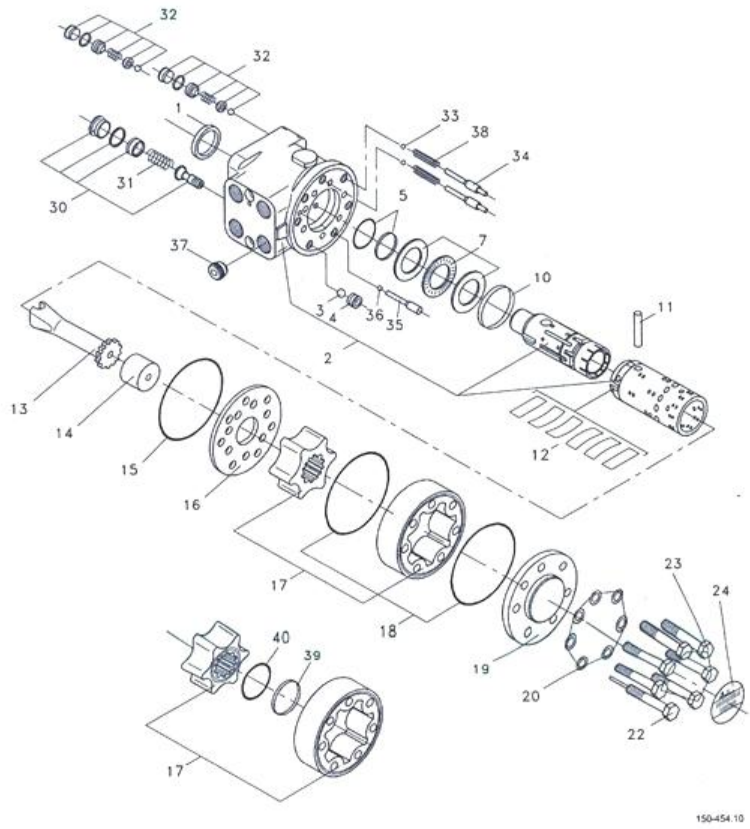


THREADED PORTS

code	Ports - P, T, R, L Thread	Column Mounting Thread - B	Valve Mounting Thread - V
-	G1/2 17 mm depth	4 x M10 18 mm depth	2 x M10x1 16 mm depth

Figure 16.2: Overall Dimensions: Manual Pump

Exploded View and Seal Kit



Callout	Description	Callout	Description
1	Dust seal ring	19	End cover
2	Housing, spool and sleeve. Check valve and the seats for relief and shock valves are locktited.	20	Washer
3	Ball 8.5 mm [0.33 in]	22	Special screw
4	Thread bushing	23	Screw
5	O-ring used with kin-ring (item 6)	24	Name plate
6	Kin-ring	30	Complete relief valve
7	Bearing assembly	31	Spring wire
10	Ring	32	Complete shock valve
11	Cross pin	33	Ball 3/16 in
14	Spacer	38	Spring
13	Cardan shaft	34	Rolled pin

Figure 16.3: Exploded View: Manual Pump

17. Hydraulic Connectors

Mainly three Types of connectors are used 1.Banjo Connectors
2.Male Stud Connectors
3.Coupling Connectors

17.1. Banjo Connectors

A banjo fitting (also called an internally relieved bolt) comprises a perforated hollow bolt and spherical union for fluid transfer.Compared to pipe fittings that are themselves threaded, banjo fittings have the advantage that they do not have to be rotated relative to the host fitting. This avoids risk of damage by twisting the hose when screwing the fitting into place. It also allows the pipe exit direction to be adjusted relative to the fitting, then the bolt tightened independently.

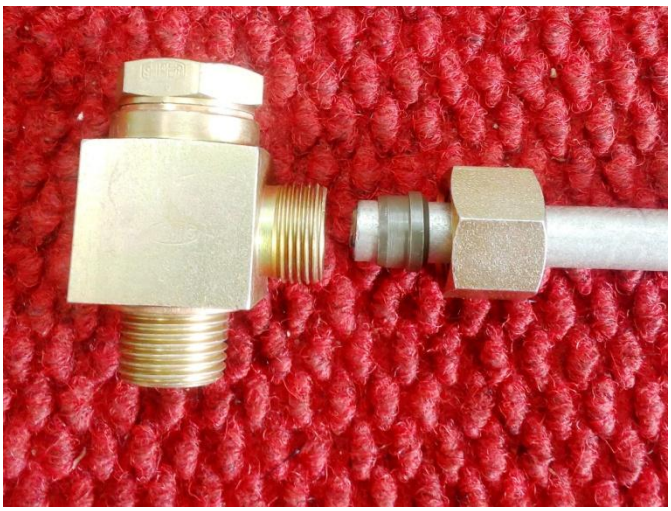


Figure 17.1: Banjo Connectors.

17.2. Male Stud Connectors

A Male Stud Connector comprises of 1/2" BSP Thread at one end and Nut and ferrule connector to suit Seamless steel pipes at other end.

Figure 17.2: Male Stud Connectors.

17.3. Coupling Connectors

A Coupling Connectors comprises of Nut and ferrule connector at both ends to suit Seamless steel pipes.

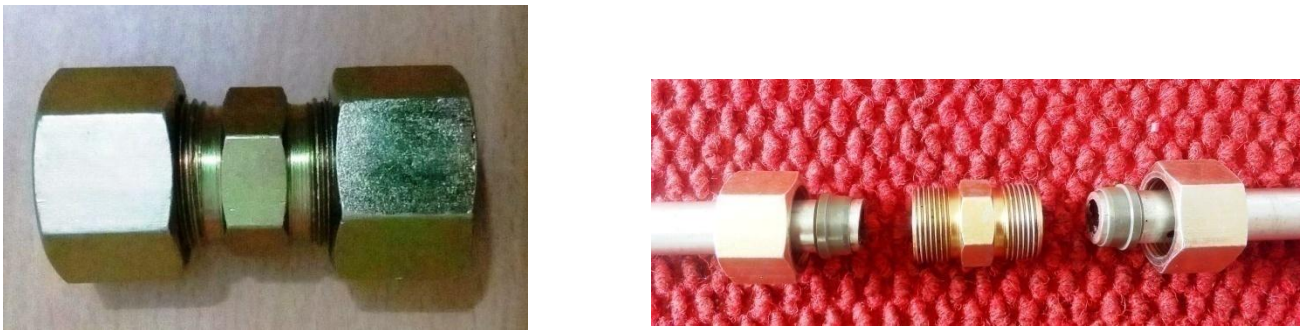


Figure 17.3: Coupling Connectors.

18. High Pressure Hydraulic Rubber Hose

High pressure hydraulic rubber hose is graded by pressure, temperature, and fluid compatibility. Hoses are used when pipes or tubes cannot be used, usually to provide flexibility for machine operation or maintenance. The hose is built up with processed rubber and polymer /steel wire layers. Processed rubber interior is surrounded by multiple layers of woven wire and rubber. The exterior is designed for abrasion resistance. The bend radius of hydraulic hose is carefully designed , since hose failures can be deadly, and violating the hose's minimum bend radius will cause failure. Hydraulic hoses generally have steel fittings Crimped on the ends.

Standard is SAE100 R1, Hose I.D is 1/2", Hose O.D is 19.1mm, Max Working Pressure is 2050 psi / 140 bar, Min Burst Pressure 560 bar.

Figure 18.1: High Pressure Hydraulic Rubber hose

19. Temperature Sensors

Resistance Temperature Detectors (RTDs), are sensors used to measure temperature. Many RTD elements consist of a length of fine wire wrapped around a ceramic or glass core but other constructions are also used. The RTD wire is a pure material, typically platinum, nickel, or copper. The material has an accurate resistance/temperature relationship which is used to provide an indication of temperature. As RTD elements are fragile, they are often housed in protective probes.RTDs, which have higher accuracy and repeatability, are slowly replacing thermocouples in industrial applications below 600℃.

Figure 19.1: Temperature Sensor

20. Temperature Controller

Controllers are widely used in industrial control systems to adjust or maintain desired outputs of specific processes within a desired range. As the name implies, a temperature controller - often called a PID controller is an instrument used to control temperature. The temperature controller takes an input from a temperature sensor and has an output that is connected to a control element such as a heater or fan.

To accurately control process temperature without extensive operator involvement, a temperature control system relies upon a controller, which accepts a temperature sensor such as a thermocouple or RTD as input. It compares the actual temperature to the desired control temperature, or set point, and provides an output to a control element.

There are three basic types of controllers: ON-OFF, Proportional and PID. Depending upon the system to be controlled, the operator will be able to use one type or another to control the process.

Figure 20.1: Temperature Controller

21. Pilot Operated Check Valve

If dual station steering is required, then it is necessary to install this block, or to use two steering pumps with built in non-return valve. These valves allow oil flow from inlet port to outlet port of one steering station at a time. The free flow from outlet port to inlet port is strictly possible when the pilot pressure in the opposite way is strong enough to open the valve poppet.

Figure 21.1: Pilot Operated Check Valve

22. Rudder Feed Back Unit

Rudder feedback unit reports back information about the position of the rudder to the Rudder position indicator. The rudder feedback unit is installed in such a way that the arm of the feedback unit will accurately follow the rudder arm.

Figure 22.1: Rudder Feed Back Unit

23. Rudder Indicator Display Unit

The electronic Rudder Indicator Display Unit will display the rudder position over a range of 40 degrees both port and starboard side. A complete installation consists of following components

- Display instrument
- A Rudder feedback unit with connection cable.
- An operating Rod with ball joints.

Figure 23.1: Rudder Position Indicator

24. OIL Level sensor

Magnetic Float Switches are mainly available for Single Level Sensing and Two Level Sensing type. Magnetic Float Switch contacts are SHORT when float is at lowermost level and OPEN when float moves up (towards fixing). As per the level of liquid, float position changes and corresponding output is used for automation Control Unit is also available for automatic functioning of Pump or Feeder with supply 220 volts AC and offers relay output. Relay is ON when level of liquid reaches lower level and gets OFF when level of liquid reaches upper level.

- Supply Voltage: 10-24 Volts DC/AC
- Output Current: 100 mA max
- Stem Mounting : Stainless Steel
- Float : Stainless Steel
- Stem Mounting : Stainless Steel

Figure 24.1: Oil Level Sensor

25. Preventive Maintenance and Trouble shooting

25.1. Trouble Shooting

- The vessel is not turning Starboard side / Port side.
  - Check if Motor is running.

    IF YES
    - Check if any oil leakage from the pipe connectors hoses etc. since the oil pumped from power pack have to reach the actuator for the vessel to turn starboard to port side
    - Check if 24VDC solenoid coils are working properly. The LED indicators are there to conform the working of coil.

    IF NO
    - Check if alternator is generating power. Switch the Star Board side Alternator with Port side alternator to check the functions.

- The rudder angle indicator not showing the angle of turning.
  - Check if the power source from the battery connection is OK.
  - Check for any Physical damages are there at the rudder feedback unit.
  - Check if any connection cables from Rudder Feedback Unit are cutoff

25.2. Preventive Maintenance

- Daily
  - Keep the Control panel area Clean of Oil, Dust, Moisture etc.
  - Avoid Hot objects from direct contact with cables and seamless steel tubes.
  - Check the belt Tension of the Alternator and do not allow it to run in slack.

- Weekly
  - Oil topping with clean oil should be done if the oil Level Indicator is showing Low oil Level. **Preferred Oil SERVO System 32 (IOC) , Enklo 32(HP), Hydrol 32(BPCL).**
  - Observe for any oil leakage: Excessive oil drain in indicator means loosened Nut/ ferrule Connection. This should be tightened before working.

- Check the tightness of the V belt of the Alternator, always maintain an optimum tightness in the V belt.

- Yearly
  - Complete Oil change with clean oil.**Prefered Oil SERVO System 32 (IOC) , Enklo 32(HP), Hydrol 32(BPCL).**
  - Seals of Hydraulic Actuator Can be changed.

25.3. DO'S and DONT'S

- DO'S
  - Oil top up Should be done With clean and Fresh Oil.
  - Keep the Steering control panel Area Free of Dust, Oil, Moisture etc.
  - Cover the power pack properly before doing any overhead Cutting or Welding works

- DON'TS
  - Never remove or connect the wire from socket while the engine is running.
  - Do not keep any tools or heavy objects on top of the Power Pack while running.
  - Never run the Alternator V belt in slack, it will decrease the life of the V belt.
  - Do not expose the hydraulic oil to naked flame.
  - Do not open the Control panel Unit While Working.
  - Rudder feed back unit is a fragile equipment, do not step on it while entering the rudder compartment.