



Operator Manual

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SF-Black Widow Absorber

Original Instructions

www.SuperFlow.com

**SF- Black Widow
Absorber**

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Please keep this manual for future reference.

This manual is intended to assist operating personnel in becoming familiar with the product and as guidance in ordering necessary parts inclusive of SuperFlow's warranty requirements. Maximum operating efficiency and life of any SuperFlow product will be attained through complete understanding of the instructions and recommendations contained within this manual.

 WARNING
Services performed beyond preventive maintenance by personnel other than SuperFlow Service Technicians on any SuperFlow products during the warranty period may void the warranty.

IMPORTANT
When available, please include the model number and serial number of the product in any correspondence.

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**INSTALLATION, OPERATION
AND
MAINTENANCE MANUAL
FOR**

**SH SERIES
SH 750 CURRENT DYNAMOMETER
(IM / 1244 / 06)**



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1. FORWARD

1.1 Compliance with Instructions

All personnel operating, maintaining or who are otherwise associated with this equipment MUST have read and fully understand the information given in this manual, and obtained the necessary authorization before using the equipment. Cautions and warnings are used in this manual to emphasize the important and hazardous instructions and it is imperative that they are read and understood before the operation they refer to be carried out.

Caution: A caution is typed in bold lower case to draw attention to a required procedure which, if not followed may result in damage to the equipment.

WARNING: A WARNING IS TYPED IN UPPER CASE TO DRAW ATTENTION TO A REQUIRED PROCEDURE WHICH IF NOT FOLLOWED MAY RESULT IN PERSONAL INJURY.

1.2 During Normal Use

Ensure that operators are:

- A. Are fully conversant with all controls, particularly those for emergency shut down.
- B. Are trained to recognize signs of malfunction and know what action to take in the event of problems.

1.3 During Maintenance

Ensure that only suitably skilled persons are permitted to carry out work and they should:

- A. Isolate the equipment completely, whenever possible, before starting work.
- B. Comply with all safety procedures.

1.4 First Aid

A sufficient number of qualified First Aiders should be available where there is equipment to be operated. However the following information provides essential First Aid instruction for attending to a victim of electrical shock.

1.5 In case of Electric Shock

- 1 Ensure that the electrical supply is disconnected.
- 2 Lay victim on his back.
- 3 Clear victim's mouth and throat.
- 4 Tilt the victim's head as far back as possible and raise his chest.



- 5 Pinch victim's nostrils.



- 6 Take a deep breath.
- 7 Cover the victim's mouth with your mouth and blow, watching his chest rise.



Note: Blow forcefully into adults, but gently into children.

- 8 Move your face away to allow victim to breath out.

- 9 Repeat steps 7 and 8 every four seconds.
- 10 Keep victim's head back as far as possible all the time. Have Someone else send for a doctor or ambulance. Keep patient Warm and loosen his clothing.

RECORD OF AMENDMENTS

Information in this manual will be subject to revisions in accordance with alterations made to the equipment described. Users of this manual should ascertain that they are in possession of the latest amendments of the issue.

Issue No.	Amendment	Date	Text affected
01	Original	Oct. 1985	-
02		Feb. 2003	Computerised



FIGURE 1.1
TYPICAL DYNAMOMETER

2. DESCRIPTION

2.1. CONSTRUCTION & PRINCIPLES OF OPERATION

The 'SH' range of hydraulic dynamometers is designed to absorb & measure the power developed by prime movers operating at low, medium & high speeds.

An arrangement of a typical dynamometer is shown in Fig. 1.1 & Fig. 1.2

Accessories of typical Dynamometer are shown in Fig. 2.

The power to be absorbed is transmitted through the dynamometer shaft to the rotor. The rotor / shaft assembly is enclosed in a casing which is mounted in trunnion bearings & prevented from rotating by means of a torque arm connected to a strain gauge load cell.

On either face of the rotor there is an annular recess, which is subdivided into a number of cups by radial vanes inclined at 45° to the central plane of the rotor.

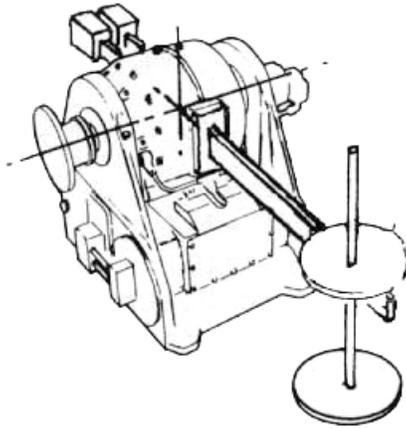
A section through a typical dynamometer is shown in Fig. 3.

Stators, which are, fitted in the stationary casing match the adjacent halves of the rotor. The stators have cups formed in an annular recess as on the rotor halves, but with the 45° vanes set in opposition to those in the rotor.

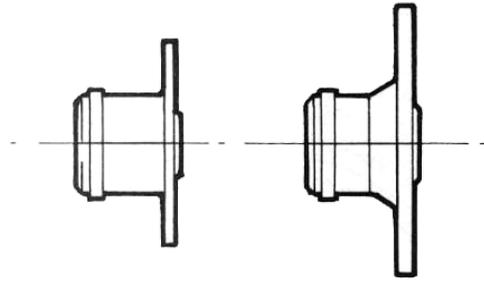
When the shaft assembly rotates, water flows readily outward around the rotor cups & into the adjacent stator. The stator cups return the flow to the root of the rotor cups. Each 'particle' of water, which enters & leaves the rotor cup, receives a large change in the component of its momentum tangential to the rotor, thus applying a resistive torque to the rotor. When operating, the resistive torque exerted on the rotor is balanced by the torque reaction on the stator. This torque is measured by means of the torque arm & a torque measurement system. Since the shaft bearings are mounted in the casing, all frictional torque except the small amount in the trunnion bearings is read out by the torque measurement system & very accurate measurement of the torque absorbed by the dynamometer is achieved.

The principles of operations are shown diagrammatically in Fig. 4.

Water is fed into the working compartments through holes in the center of the stator vane thickness while it leaves through holes in the back of



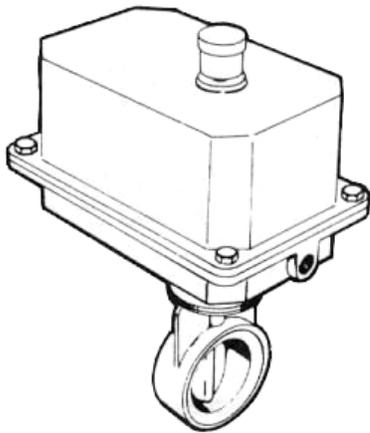
FIGUER 2.1
CALIBRATION EQUIPMENT



To suit 'Layrab'
70-6/6

To suit "Layrab"
100-6/6

FIGURE 2.2
ALTERNATIVE HALF COUPLING



FIGUER 2.3
REMOTE CONTROLLED WATER
INLET VALVE

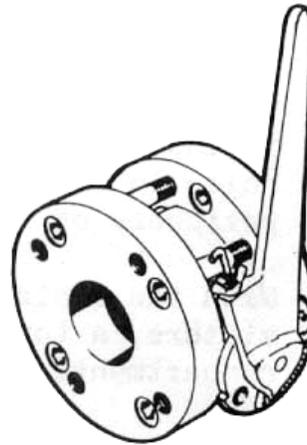
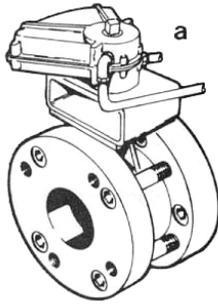


FIGURE 2.4
MANUALLY OPERATED WATER
INLET VALVE



FIGUER 2.5
LOAD THROW-OFF EQUIPMENT

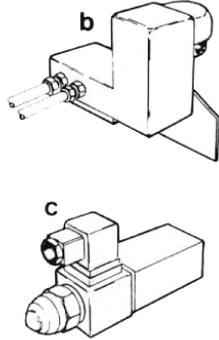


FIGURE 2.4
WATER INLET PRESSURE SWITCH
ASSLY.

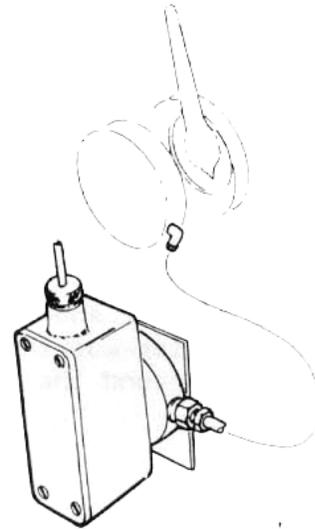


FIGURE 2
TYPICAL ACCESSORIES FOR DYNAMOMETER

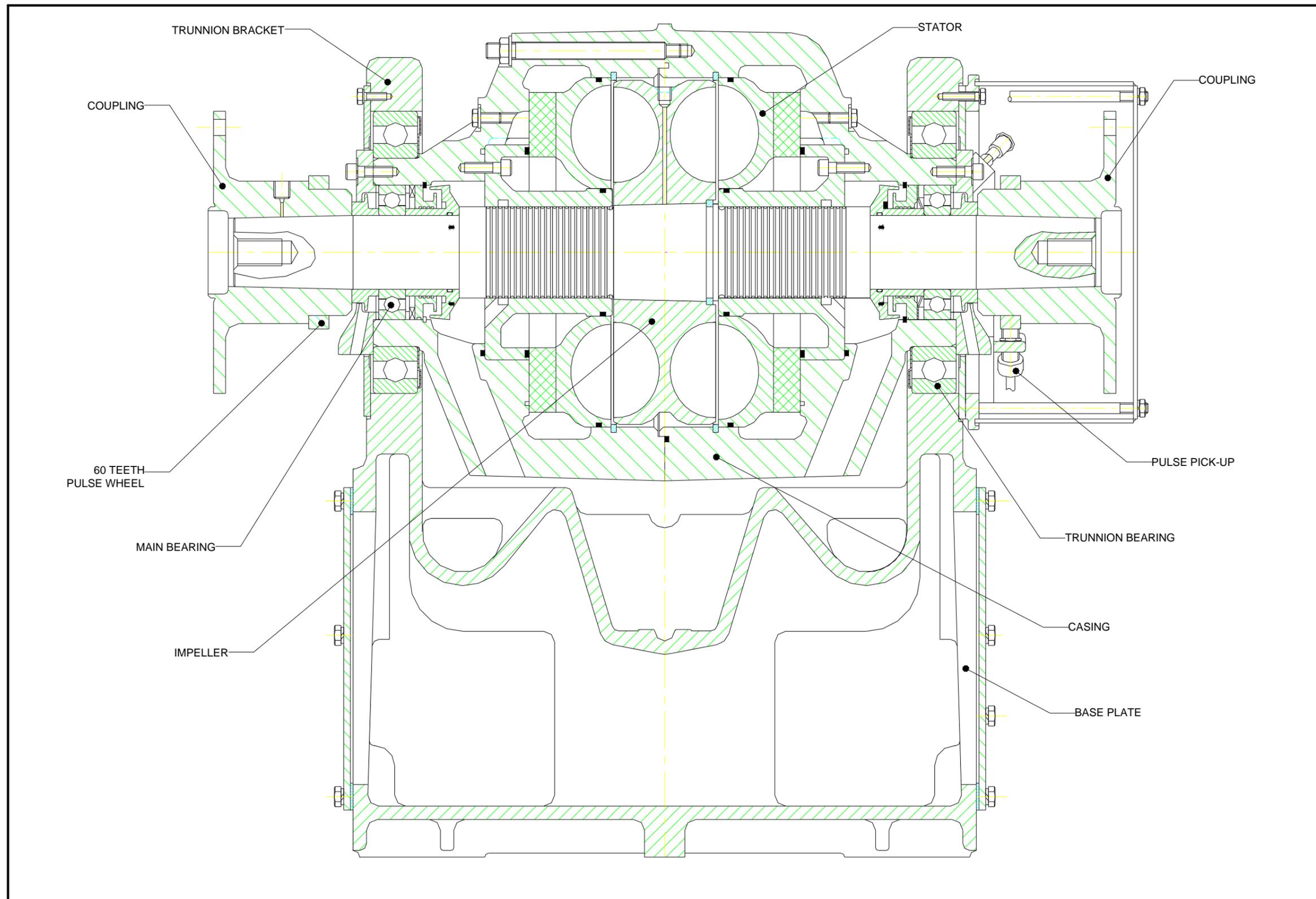


FIGURE 3
CROSS SECTION OF TYPICAL DYNAMOMETER

the stator cups to an annulus around the periphery of the working compartments

With the re-circulation of water between the moving rotor & the stators, a toroidal vortex is set up around the annular working compartments & a high 'vortex' velocity is set up round the working compartment cups. There is a corresponding high pressure round the cup periphery & a much lower (ideally atmospheric) pressure at the center of the cup, which is vented to atmosphere, again by means of passages through the center of the stator vanes.

The velocity of circulation of water around the working compartment cups & the depth of water in the cups determine the torque exerted by the dynamometer against the prime mover.

2.2. REGULATION OF POWER

As already stated the torque exerted by the dynamometer is dependent upon the velocity & mass of the cooling water circulating in the working compartments of the dynamometer.

Regulation of the cooling water flow rate is by means of the inlet valve although the conditions in the working compartments can have an effect.

Working compartment cup fill is controlled by the rotary valve (butterfly type) at the water outlet the position of which is controlled by an electro-hydraulic system.

Major control system elements are shown in Fig. 5.

2.3. REVERSIBILITY

The dynamometer shaft is normally fitted with a single half coupling for testing prime movers with clockwise rotation. Special versions with couplings at both ends of the shaft permit the testing of prime movers with either rotation.

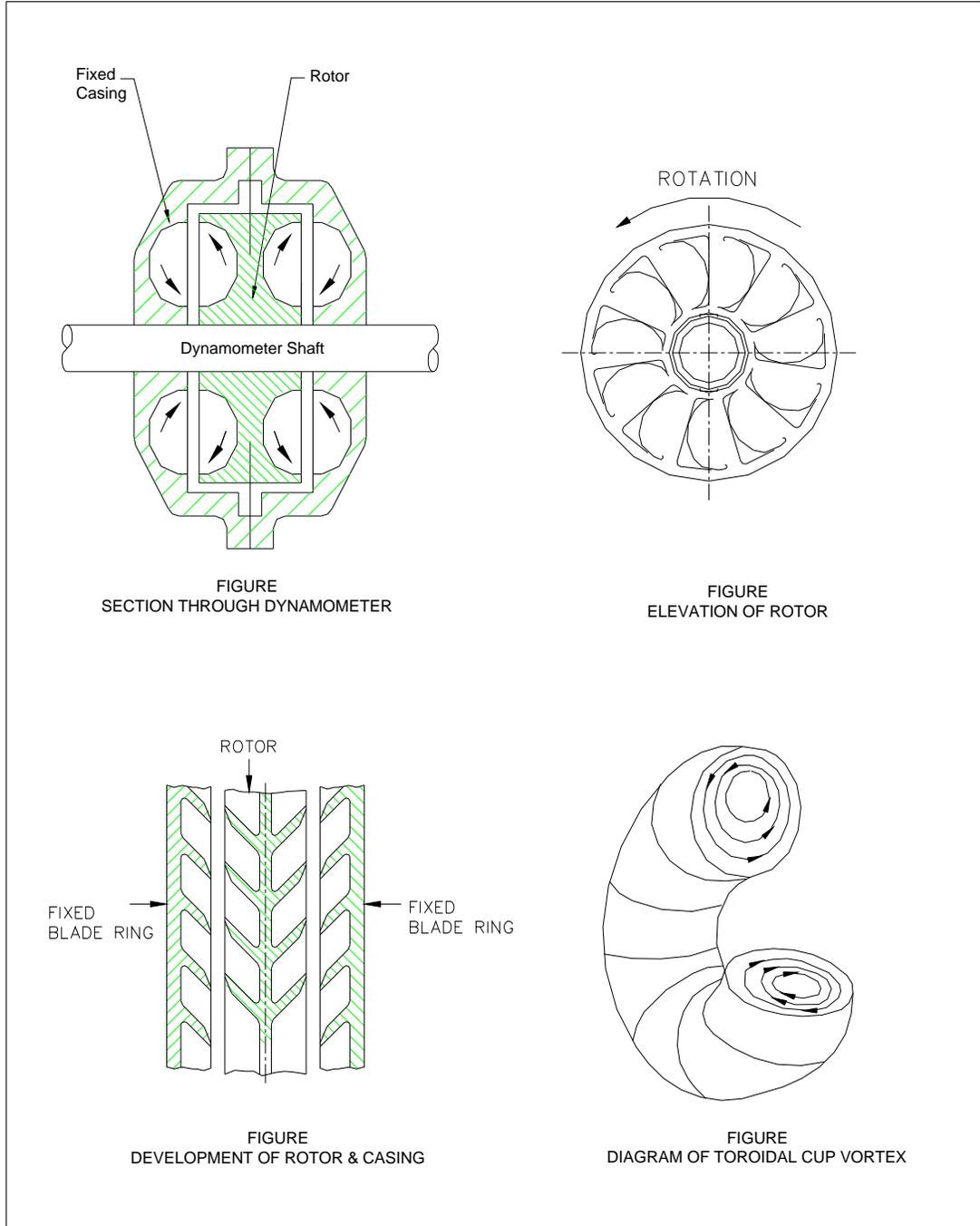


FIGURE 4
SCHEMATIC DIAGRAM OF PRINCIPLES OF OPERATION

2.4. TORQUE MEASUREMENT

The forces resisting rotation of the dynamometer shaft are the hydraulic resistance created by rotation of the rotor in water & the friction of the shaft bearings.

Both of these forces react upon the casing which being free to rotate within the anti-friction trunnion bearings transmits the whole of the forces to a strain-gauge load cell type of torque measurement system.

An arrangement of the torque measurement system is shown in Fig. 6.

An arm on the dynamometer casing operates directly on a load cell transducer in which sensitive elements translate changes in force into proportional changes in output voltage.

The weigher system is calibrated before delivery at an ambient temperature between 15° C (59° F) & 20° C (68° F). To ensure that accuracy remains within the guaranteed range it is important that the operating temperature of the load cell remains within a range from -5° C (23° F) to +40° C (104° F) & the indication equipment remains within a range from +5° C (41° F) to +30° C (86° F).

SH 750 HS HYDRAULIC DYNAMOMETER

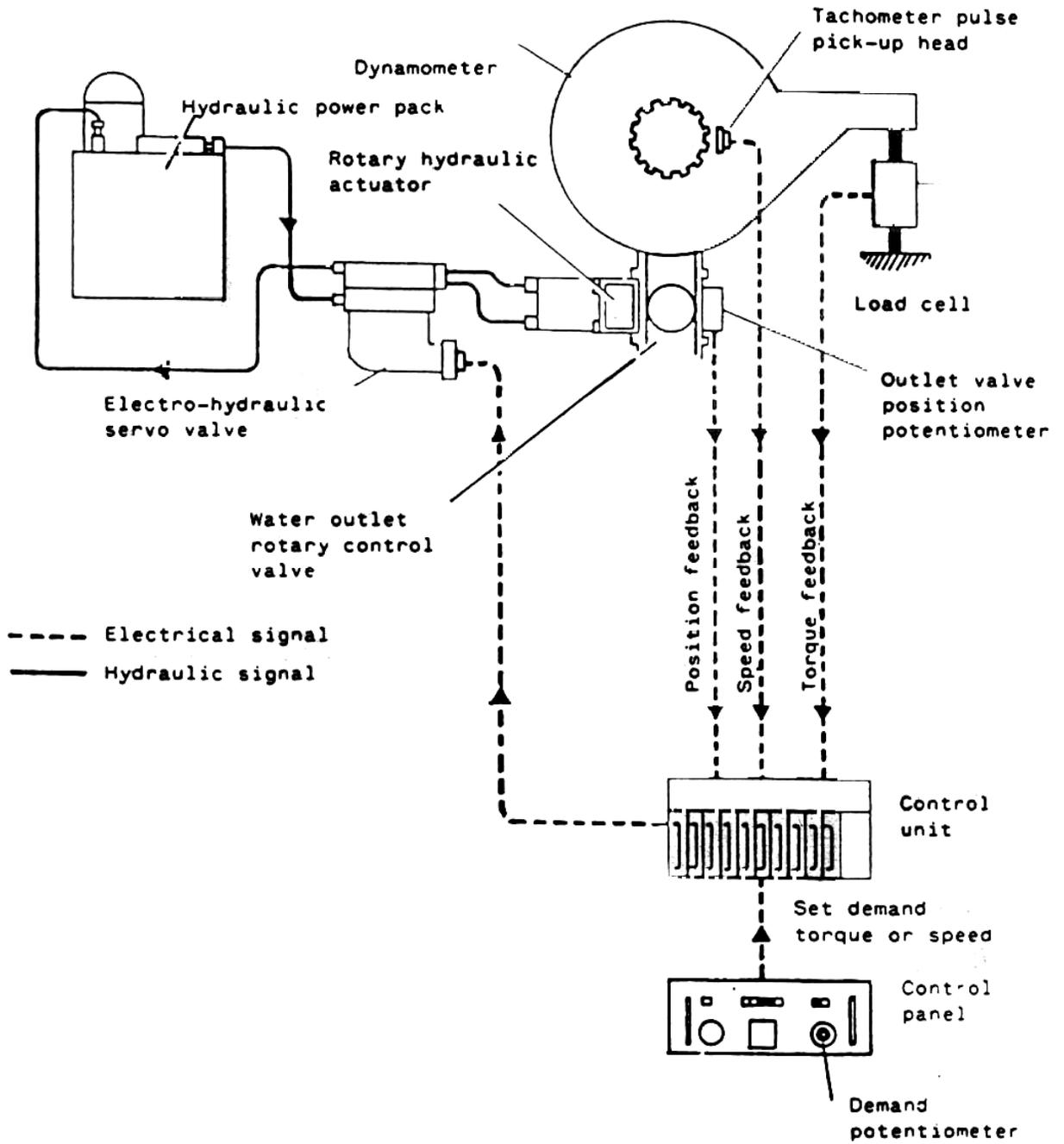


FIGURE 5
GENERAL ARRANGEMENT OF CONTROL SYSTEM

2.5. SPEED MEASUREMENT

The speed signal (the AC frequency of which is proportional to speed) required to operate the tachometer is generated by a pulse pick-up unit, which is mounted adjacent to a toothed wheel fixed to the rotating dynamometer shaft.

2.6. POWER-ABSORBING CAPACITY

The power-absorbing capacity diagram for the dynamometer shows the curves for maximum & minimum power that can be absorbed when the dynamometer is running at the speeds indicated.

Power capacity & torque capacity diagram of SH 750 HS are shown in fig. 7 & fig. 8 resp.

2.7. PROTECTION DEVICES

Protection devices fitted in the dynamometer are thermocouples, which bear against the outside diameter of each of the shaft bearings & a water outlet temperature thermocouple.

Optionally, a water inlet pressure switch can be fitted to provide indication of water supply failure.

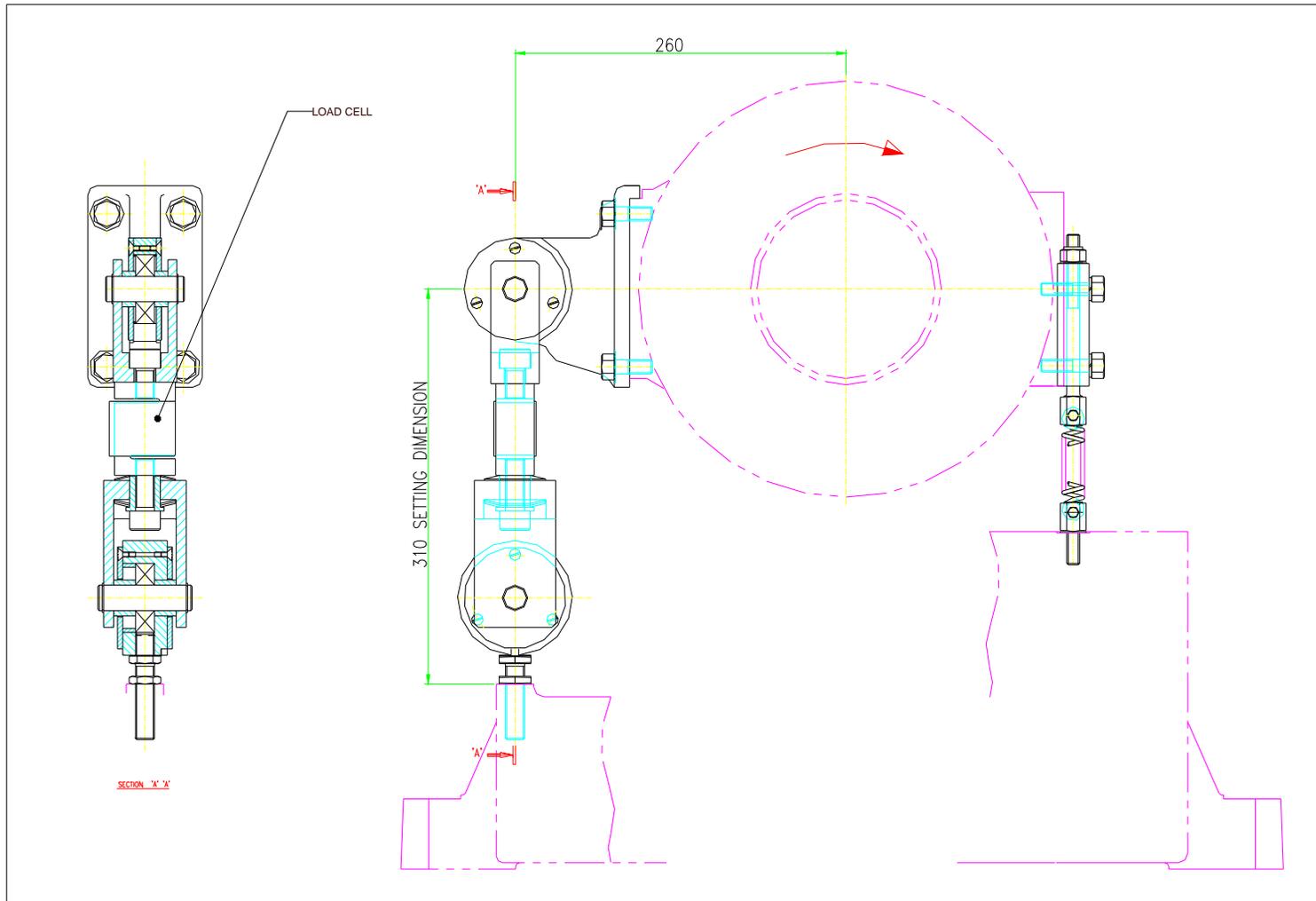
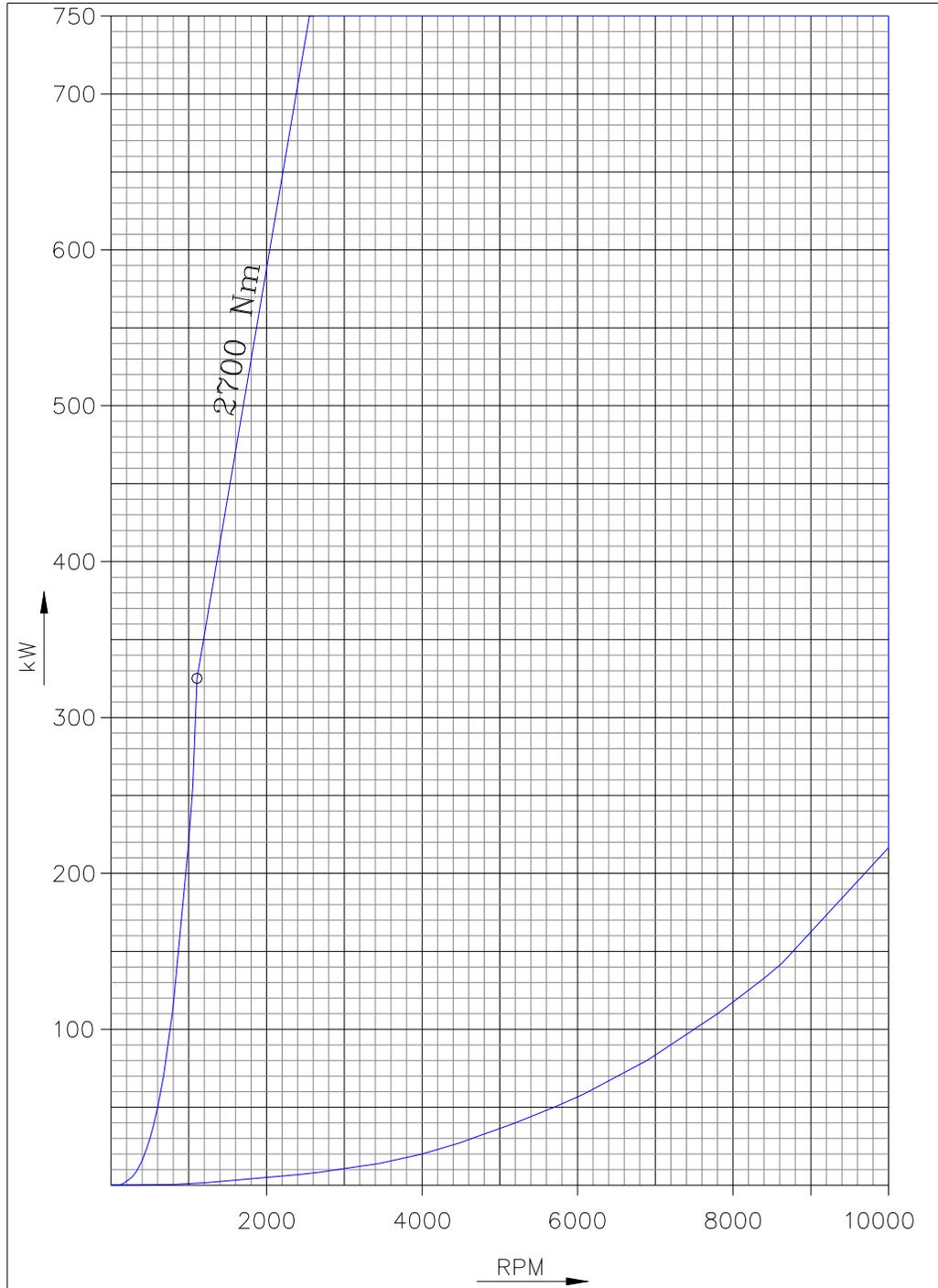


FIGURE 7
LOAD CELL TORQUE MEASUREMENT SYSTEM

SH 750 HS HYDRAULIC DYNAMOMETER



 SAJ Test Plant Private Ltd. 72/76, Mundhwa, Pune Cantonment, Pune 411 036. (INDIA)	SAJ HYDRAULIC DYNAMOMETER SH-750 (HS) POWER CAPACITY DIAGRAM SI UNIT	CURVE NO.		
		205 C 06		
		STANDARD	DRN	APPD
		DATE 04.02.03		

FIGURE 7
POWER CAPACITY DIAGRAM

SH 750 HS HYDRAULIC DYNAMOMETER

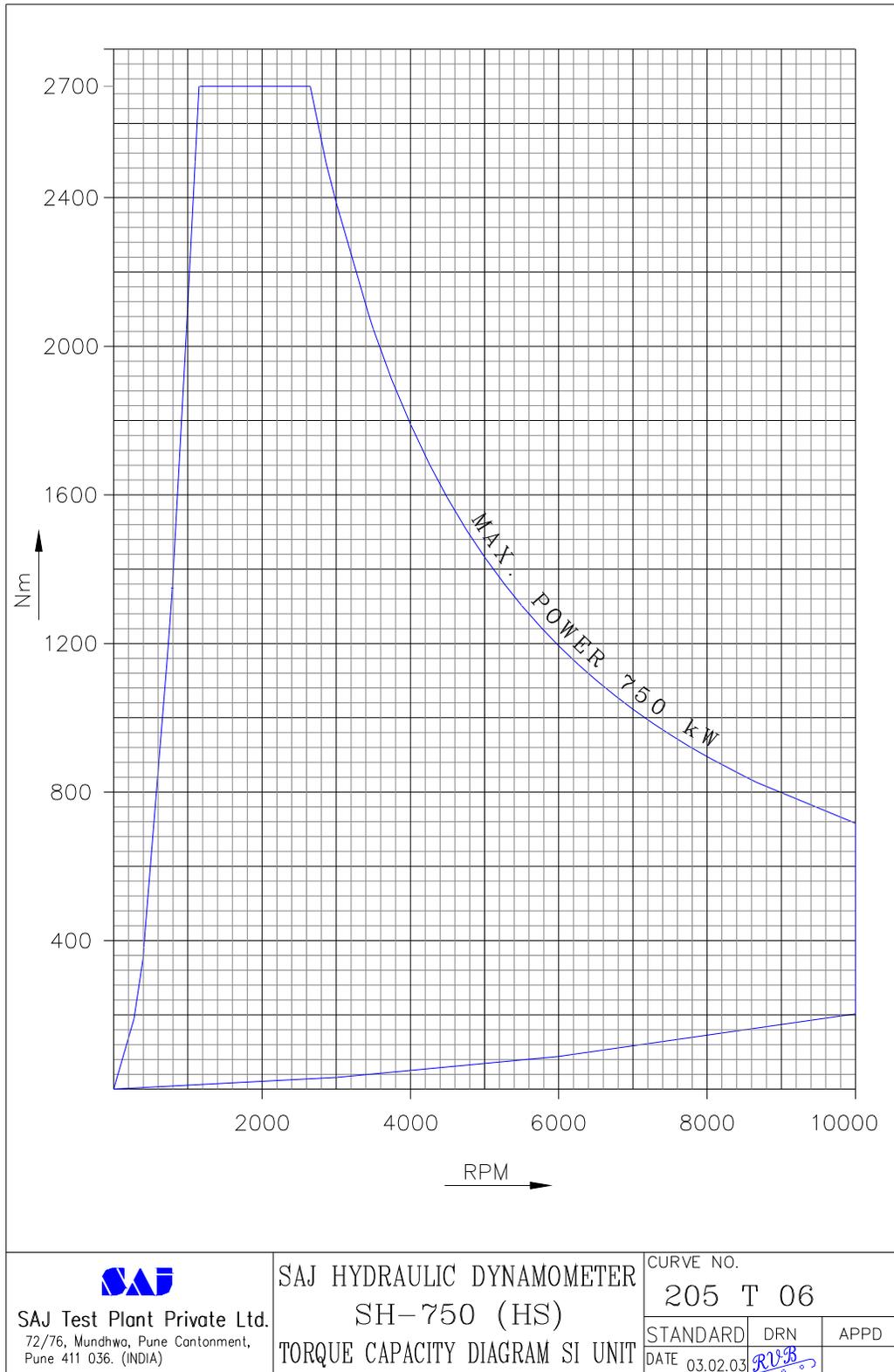


FIGURE 8
TORQUE CAPACITY DIAGRAM

3. INSTALLATION

3.1. FOUNDATIONS

An arrangement of the dynamometer is shown on a separate drawing, arrangement of Dynamometer. This includes overall dimensions & the position & size of the holding-down bolts.

When installing the dynamometer adequate space must be left for the attachment of the test arm, referred to in section 5.2.

The base plate or plinth must be horizontal, leveled & constructed so as to adequately support the dynamometer & transmitted torques & to minimize any vibration that may be transmitted from the prime mover or other machinery. Bending or twisting strains must not be imposed upon the bed-plate when it is bolted down & any base-plate should first be checked with a spirit level to ensure that it is not warped.

The holding down bolts should of the specified size & should be made perfectly secure. If the machine is set down on concrete foundations, the foundation block should be set down on a firm subsoil, & all concrete & grout should be of first-class mix. The grout should be allowed to set hard before running the machine.

CAUTION: Correct mounting is essential, as distortion of the bedplate may cause misalignment, rapid wear of bearings & mechanical failure.

3.2. COOLING WATER

3.2.1. WATER QUANTITY & PRESSURE:

The quantity of water supplied to the dynamometer should be sufficient to prevent the outlet temperature rising above 60°C (140°F). Higher temperatures than this could increase the rate of scale deposit on the internals and may affect the control stability. If the user is in any doubt they should consult SAJ Test Plant Pvt. Ltd. The amount of water required per horsepower absorbed depends on the water inlet temperature; where re-cooled water is used this may be quite high, where corresponding high water requirements. The table given on next page may be used as a guide

SH 750 HS HYDRAULIC DYNAMOMETER

Water inlet temperature °C (° f)	Water temperature rise for 60° C (140° f) outlet temperature	Water requirement 1/cv h (m3/kw h) (gal/bhp h)
16 (60)	44 (80)	14.39 (0.0194) (3.18)
21 (70)	39 (70)	16.23 (0.0220) (3.64)
27 (80)	33 (60)	19.18 (0.0260) (4.24)
32 (90)	28 (50)	22.61 (0.0306) (5.09)
38 (100)	22 (40)	28.77 (0.0390) (6.36)

The quantity of water required for the dynamometer may be calculated from the following formulae.

In English units -

$$Q = \frac{2545}{W (T_2 - T_1)}$$

Where Q = quantity of water in gallons per bhp per hour
 W = mass of one gallon of water in pounds (10 lb)
 T₂ = maximum water outlet temperature from dynamometer in ° F
 T₁ = water inlet temperature to dynamometer in ° F

In metric units -

$$Q = \frac{633}{W (T_2 - T_1)}$$

Where Q = quantity of water in litres per cv per hour
 W = mass of one litre of water in kilogrammes (1 kg)
 T₂ = maximum water outlet temperature from dynamometer in ° C
 T₁ = water inlet temperature to dynamometer in ° C

In SI units -

$$Q = \frac{3\,600\,000}{W \times 4200 \times (T_2 - T_1)}$$

Where Q = quantity of water in litres per kW per hour
 W = mass of one litre of water in kilogrammes (1 kg)
 T₂ = maximum water outlet temperature from dynamometer in ° C
 T₁ = water inlet temperature to dynamometer in ° C

It should be noted that at part load conditions the quantity of water required per unit of power may be higher than the rate required for maximum duty up to the maximum rate requirement.

The user's water system should be designed to provide the quantity of water sufficient for the maximum duty of the dynamometer at the minimum pressures specified below. Three types of valves can be provided for installation in the users water supply piping to the dynamometer to enable the water pressure & quantity to be adjusted to suite the engine being tested. These are:

1. A manual flow control valve to vary the flow rate to match the power to be absorbed by the dynamometer.
2. An electrically actuated remotely operated flow control valve to vary the flow rate to match the power to be absorbed by the dynamometer.
3. A pneumatically operated two position open & shut valve.
4. A servo controlled inlet valve. The actuation time for full travel is approximately 0.3 seconds. This valve will, if fitted, give a very fast response in load rate when used in combination with an electro-hydraulic water outlet valve.

These valves cannot be shut completely & are set to provide the quantity of water necessary for minimum load conditions. If necessary the user should provide a separate shut-off valve in their water supply piping.

The water inlet pressure required for maximum power absorption will depend upon the water inlet temperature & the consequent flow requirements.

To achieve a flow rate of 28.77 l/cv per h (0.0390 m³/kW per h) (6.36 gal/bhp per h) at maximum dynamometer hydraulic capacity, a mains supply pressure of not less than 2.5 kg/cm² (2.5 bar) (36 lbf/in²) is necessary. This should be measured at the dynamometer inlet connection with full water quantity flowing. The water inlet pressure required to meet the minimum flow requirements is 0.5Kg/cm² (0.5bar) (7.1lbf/in²). This should be measured at the dynamometer inlet connection with the full water quantity flowing. It is important that the size of feed pipe to the dynamometer is adequate to maintain this pressure.

Lower pressure and smaller total quantities are permitted if the maximum power to be absorbed is lower than the maximum hydraulic capacity of the dynamometer.

NOTE: All the above pressures are based on a cooling water temperature rise of 22°C with a flow rate of 0.039m³/kW per hour (6.36galls/bhp per hour).

For reduced powers or when testing smaller engines, the water inlet valve may be partly closed. This is subject to the water outlet temperature not exceeding 60°C (140° F)

The water quantity is controlled during operation by the valve fitted to the dynamometer inlet connection, as described in section 4.1 (4).

The water should be free from aeration, & for optimum control the variation in maximum pressure should not exceed +/- 0.07 kg/cm² (0.07 bar) (1lbf / in²). The number of pressure peaks must not exceed 12/min. It is advisable to employ a centrifugal pump with a flat-head characteristics which is fed from it's own sump.

3.2.2. WATER CONDITION & TREATMENT

The working life of the power absorbing elements of the dynamometer will be prolonged considerably if arrangements are made in the planning stage of the installation to provide a water supply, which is satisfactory in quality. The water should be free of sand or other mechanical abrasives & if it is taken direct from a river or other unfiltered source, it should be strained or filtered before entry into the system. Seawater should not be used. It is recommended that the solids in suspension should not exceed 1000 parts per million & that the filtration level should be 185 microns.

In general 'Soft' water is acid & is liable to cause corrosion, while 'hard' water is alkaline & may cause scaling. The pH value of acid water is below 7.07 & that of alkaline water is above 7.07.

Ideally the pH value should be between 7.4 & 8.4 and additives should be introduced into the supply to hold it within these limits. Conditions vary so widely that it is not possible to give precise information on how to do this. Users should, therefore consult a local water treatment expert, who will be aware of factors in the vicinity & will be able to advise on the type of test to made & how to implement its findings.

3.2.3. WATER PIPING

The water inlet piping to the dynamometer should be of ample dimensions, capable of supplying water in the quantities, & at the pressures, specified in section 3.2.1. Straight runs of piping with the minimum of bends (and no sharp elbows) are recommended.

The dynamometer casing drains into the bedplate the outlet from which should be taken directly into an open flow drain. The outlet water relies on gravity flow & therefore a pipe of ample dimensions & free from sharp bends should be provided from the outlet to lead the water to the nearest sump, drain or hot well. The outlet pipe should have a gradual fall & should be as short as possible to avoid flooding the test shop floor.

A diagrammatic layout of a suitable water system is shown in Fig.9.

3.3. ELECTRICAL SUPPLY

An AC electrical mains supply of 110 volt or 200-250 volt, 50-60 hertz, single phase is required for the dynamometer & control equipment. The supply should be switched & fused at 5 amperes.

Schematic diagram of Electrical Connection of terminal box, which is fitted on dynamometer, is shown on Fig. 10

Additional information with internal & external electrical wiring diagrams is included with the separate instructions for the control equipment.

3.4. AIR SUPPLY

If the dynamometer is fitted with the pneumatically operated inlet valve the user is responsible for a supply of clean dry compressed air at a pressure of approximately 5.6kg/cm² (5.5bar) (80lbf/in²). Only a small quantity is required for each operation.

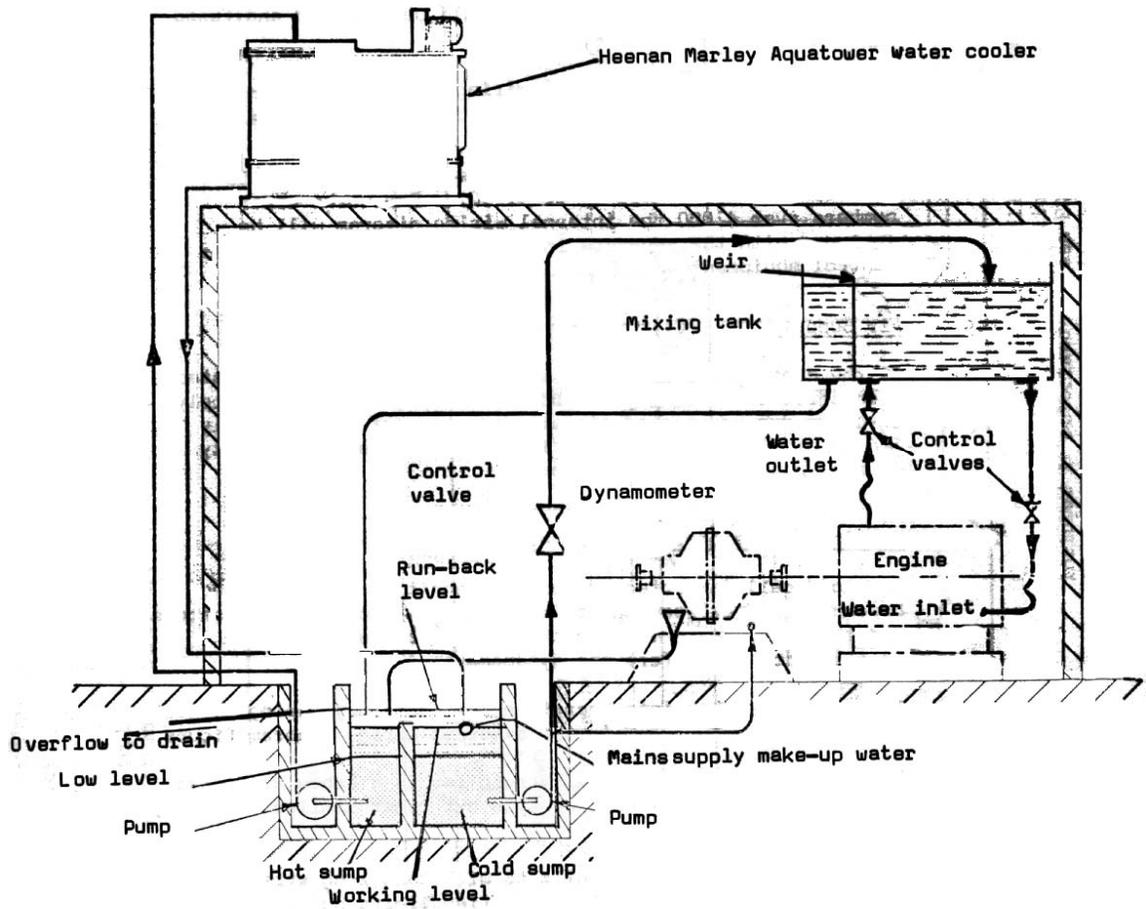


FIGURE 9
DIGRAMMATIC LAYOUT OF WATER SYSTEM

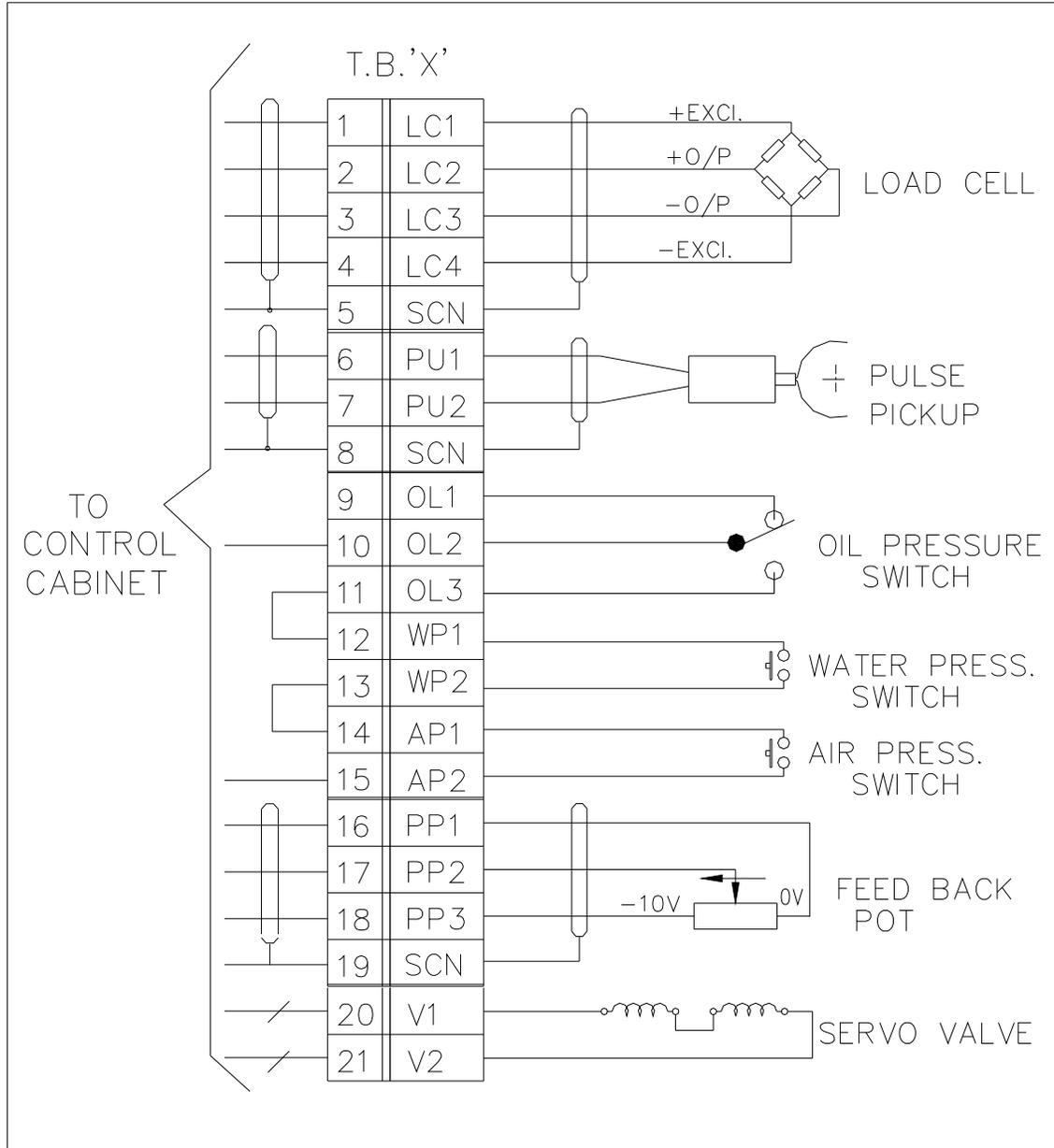


FIGURE 10
ELECTRIC CONNECTION ON DYNAMOMETER TERMINAL BOX

3.5. PUTTING THE TORQUE MEASUREMENT SYSTEM INTO OPERATION

The load cell is protected during transit by a red-painted bracket fixed between the calibration arm facing on the carcass & the bedplate. This bracket should be removed after installation & before the dynamometer is used.

To put the weigher into operation the necessary wiring connection should be made as shown in the external wiring diagram included with the separate instructions for the control equipment.

The type of load cell normally supplied is an elbow stainless steel precision model tension type but other similar types may be used.

These are rugged devices built to withstand long strenuous service when operation is within the specified limits but precautions must be taken to prevent damage, which can affect their operation & accuracy.

If the engine exhaust piping is mounted close to the dynamometer adequate arrangements must be made to protect the load cell from heat radiation, which could affect the indicator readings.

3.6. ENGINE SUPPORT STAND

The cradle or stand for supporting the engine should be of rigid design adequately bolted to suitable foundations, accurately leveled & positioned relative to the dynamometer. Flexible mountings must not be allowed to affect the alignment. They should not be used if the drive shaft is not fitted with universal joints. In cases where there are a variety of engines to be tested it is usually convenient to employ an adjustable type of cradle, of which we can supply several models. Whatever system is adopted for coupling the engine to the dynamometer, the shafts of both units should be accurately aligned.

For high speeds the dynamometer & prime mover should be lined-up using a clock gauge & any drive shafts should be of a high-class accurately - balanced type, as described in sections 3.7 & 3.8.

3.7. DRIVE SHAFTS

The dynamometer shaft is not designed to withstand heavy bending moments, which can be caused by the use of heavy couplings, flywheels & drive shafts or by misalignment between dynamometer & prime mover. For this reason, self-aligning or flexible couplings should be used; these should be of the lightest possible construction compatible with safety & in very good dynamic balance, preferably

consisting of a shaft with two universal joints, & of a design which prevents whirling.

If a single flexible joint is used it should not be fitted with a centering device, & the design should be such as to maintain dynamic balance while running. If a drive shaft is not used, alignment between prime mover & dynamometer shaft must be carried out with precision. Drive shafts or flexible coupling should be mounted in such a way as to reduce to a minimum any overhang from the bearings of the dynamometer shaft. Heavy or long face-to-face adaptors should not be used.

A diagram showing various combinations of shaft weights & distances from the coupling face & the resulting safe speed is available on application.

SAJ Test Plant Pvt. Ltd. cannot be held responsible for any vibrations or critical speeds caused by the prime mover or by the overall shafting system.

Any shaft (such as an in-line starting shaft) driving the dynamometer should be supported in its own independent bearings, & a flexible joint or disengaging clutch should be used to connect it to the dynamometer.

Heavy steel guards should be provided around the drive shafts & couplings. To prevent whirling in the event of breakage it is desirable that the inside of the guard should be made perfectly concentric & close fitting to the outside diameter of the drive shaft. The guard should be split along the horizontal center to facilitate examination & removal of the drive shaft.

3.8. LINING - UP

Dynamometers are normally very smooth running & any vibrations or mechanical failure during running are usually transmitted from the prime mover or caused by inaccurate lining-up of the prime mover & dynamometer.

Many troubles could be avoided if the users lining-up procedure includes attention to the following points.

1. If the dynamometer is coupled directly to the prime mover the lining-up must be exact & the coupling must have some flexibility such as that provided by a gear type unit.
2. If a drive shaft is used.

3.10 HYDRAULIC PUMP UNIT FOR ELECTRO-HYDRAULIC CONTROL

NOTE : The servo valve, which controls the actuator for the butterfly-type water outlet valve, is normally removed before delivery of the dynamometer & a flushing block fitted in its place. The servo valve must be fitted before the dynamometer can be used. The procedure for this is as follows:

1. Check the oil level in the tank incorporated in the bedplate. If necessary add sufficient Shell Tellus 68 oil, or its equivalent, to raise the level up to the mark on the sight indicator mounted on the side of the tank.

CAUTION: The operating life & efficient operation of the electro-hydraulic control system is dependent upon the cleanliness of the oil. The cleanliness of all oils should be considered suspect even when delivered in sealed cans.

2. Switch on the pump unit & run the oil through the system for at least two hours.
3. Taking care to keep all parts scrupulously clean, remove the flushing block. Remove the cover plate from the servo valve & fit the servo valve in place of the flushing block. Replace the cover plate on the flushing block.

3.11 MATCHING HALF COUPLING & ADAPTER PLATES

CAUTION: The dynamometer half couplings are not suitable for removal by the user & using as a jig when machining any matching half couplings or adapter plates.

The couplings are fitted by oil injection & an allowance is made during manufacture for the expansion caused by the high pressure used in this method. When the couplings are removed there will be a reduction in the spigot diameter & in the pitch circle diameter of the bolt holes.

3.12 SHAFT BEARING LUBRICATION

The dynamometer shaft is carried upon two anti-friction ball bearings. The machines are grease lubricated.

The correct grades of grease & oil are specified in section 5.3.5.

4. OPERATION

4.1 INITIAL START UP AND RUNNING

NOTE : The servo valve which controls the actuator for the butterfly-type water outlet valve is normally removed before delivery of the dynamometer. The servo valve must be fitted before the dynamometer can be used. See section 3.10.

1. Prepare the electronic control equipment. The position of the hand controls is included in the separate instruction manual for the control equipment.
2. With water flowing through the dynamometer check that the load indicator(s) read zero. If necessary adjust as described in the construction manual for the control system.
3. Start the motor for the hydraulic power system & observe the gauge mounted on the unit. This should indicate 35.0 kg/cm² (500lbf/in²). If necessary, reset the relief valve. The setting can be adjusted with a socket-type wrench after removing the cover nut from the relief valve.

The hydraulic power system motor should not be started before the control equipment panel is switched on. If possible this should be interlocked in the test bed wiring system.

The operation of the accumulator should be check by stopping the motor. The pressure should fall slowly over a period of approximately 10-20 seconds to 21.0kg/cm² (300lbf/in²) & then more rapidly to zero. If the changeover point is less than 21.0kg/cm² (300lbf/in²) the accumulator should be recharged as described in section 5.4.1.3.

4. The dynamometer water outlet temperature is controls by the setting of the water inlet valve. See sections 3.2.1 & 3.2.2 for water supply requirements.

The minimum flow requirement for the electro-hydraulic control system is 6800 l/h (1500gal/h). Extra water may be required to ensure that the outlet temperature does not exceed 71°C (160°F) when the dynamometer is absorbing the maximum power developed by the prime mover. This setting of the inlet valve should then be used for all operating conditions of the prime mover on test.

To attain the minimum capacity shown in the power absorption capacity diagram it will be necessary to reduce the water quantity from that required for maximum capacity. In certain circumstances it

may be difficult to start a high power prime mover under no-load conditions due to the high minimum absorption capacity of the dynamometer caused by the quantity of water in the casing.

It is therefore suggested that the user should incorporate a solenoid or actuator operated valve in their water supply piping. The piping should include a pipe & a smaller hand operated valve, which bypasses the main valve. The smaller valve should be set to pass the quantity of water necessary for starting.

If a water pressure switch is supplied it should be set to operate at 0.20kg/cm² (3lbf/in²) on falling pressure. It should be installed before the water inlet valve supplied with the dynamometer.

5. The prime mover may now be started. The method of control is specified in more detail in the separate manual for the control equipment.

4.2 BUTTERFLY VALVE PERFORMANCE TEST

This initial static test should also be performed as routine at the commencement of daily tests before the dynamometer is run & load applied thereto.

1. With the dynamometer & the control equipment prepared & switched on select a position mode of control for the butterfly valve & select maximum demand. The butterfly valve should now be fully open; as indicated by the position of the indicator slot in the end of the valve spindle & by water running out of the bottom of the dynamometer carcass, through the open butterfly valve, into the sump or drain.
2. Select minimum demand. This will cause the butterfly valve to close; as indicated by the position of the indicator slot in the end of the valve spindle & by the volume of water flowing past the butterfly valve being considerably reduced. After the carcass has filled up, water will flow down the plastic vent pipes of the carcass into the sump.
3. Check for dynamic stability with the engine running at approximately half maximum speed & torque, with the prime mover under dynamometer control in a speed mode of control. If speed holding is not adequate refer to section 5.4.6.
4. Select minimum demand &, if required, switch off the control system.

NOTE: This performance test should have been carried out on commissioning. For the positional setting procedure for the butterfly valve, when required, refer to section 5.4.5.1.

5. If the dynamometer control equipment does not include a position control mode the butterfly valve operation may be checked as follows:

Select a speed mode of control with minimum demand & check that the positional indicator meter pointer is at minimum position.

Select a speed mode of control with approximately 2% demand & check that the meter indicates its maximum position.

4.3 PREPARATION

For testing in any of the control modes prepare the test bed and the control equipment as follows –

1. Switch on the mains voltage supply to the control equipment at the isolator; the indicator lamp within the 'Stop' pushbutton (red) should illuminate.
2. Release the lock of 'Set Demand' control on the control panel by moving the locking lever situated on the side of the control counterclockwise.
3. Rotate the 'Set Demand' control counterclockwise until zero is indicated by both the engraved knobs and the digital indicator.
4. Switch on the hydraulic power system; indicated oil pressure should be 35.0 kg / m^2 (500 lbf / in^2). The starter for the hydraulic power pack should be interlocked with the isolator switch for the control equipment to ensure that the hydraulic power pack cannot be run until the control equipment has been switched on.
5. Turn on the water supply, open the water inlet valve to the dynamometer and, with the outlet control valve open, set the inlet pressure to required level.
6. Operate the 'Reset' pushbutton (green); the indicator lamp within the pushbutton should illuminate and remain illuminated. The indicator lamp within the 'Stop' pushbutton (red) should extinguish

Note : If any out - of - limit safety device fitted to the engine is dependent on the engine speed to close its contacts (e.g. oil pressure) and that device is connected in series with the shutdown interlock circuit then the 'Reset' pushbutton must be held in contact until the engine has been started and attained sufficient speed to close those contacts.

7. Prepare the engine for running; if its starting system, ignition or fuel pump is connected to the shutdown interlock circuit of the control equipment then the engine cannot be started until the preparation of the control equipment is completed.

4.4 TESTING OF ENGINE WITH 'SPEED' CONTROL'

1. Prepare the test bed and the control equipment
2. Ensure 'Set Demand' is fully counterclockwise.
3. Operate the 'Speed' pushbutton; the indicator lamp within the pushbutton should illuminate.
4. Start the engine.
5. Operate the 'Reset' pushbutton.
6. Open the throttle until speed in excess of that required is indicated.
7. Rotate the 'Set Demand' control in a clockwise direction until the required speed is attained; Lock the control if desired.
8. Adjust the engine throttle to achieve the desired load.

4.5 TESTING OF ENGINE WITH 'TORQUE' CONTROL

1. Prepare the test bed and the control equipment.
2. Ensure 'Set Demand' control is fully counterclockwise.
3. Operate the 'Torque' pushbutton; the indicator lamp within the pushbutton should illuminate.
4. Start the engine.
5. Operate the 'Reset' pushbutton.
6. Open the engine throttle until approximately half maximum speed is attained.

7. Rotate the 'Set Demand' control in a clockwise direction until load is just indicated.
8. Adjust the 'Set Demand' control for load and the engine throttle for speed to achieve the desired running condition.

4.6 TESTING OF ENGINE WITH 'POWER LAW' CONTROL

1. Prepare the test bed and the control equipment.
2. Ensure 'Set Demand' control is fully counterclockwise.
3. Operate the 'Power Law' pushbutton; the indicator lamp within the pushbutton should illuminate.
4. Start the engine.
5. Operate the 'Reset' pushbutton
6. Set the desired power law characteristics with the 'Set Demand' control and lock in position.
7. Open the engine throttle to accelerate up the preset torque / speed curve.

4.7 'POSITION CONTROL' (OPEN LOOP TESTING)

This mode is for limited applications only

1. Prepare the test bed and the control equipment.
2. Ensure 'Set Demand' is fully counterclockwise.
3. Operate the 'Position' pushbutton; the indicator lamp within the pushbutton should illuminate.
4. Start the engine.
5. Operate the 'Reset' pushbutton.
6. Open the throttle until approximately half maximum speed is attained.
7. Rotate the 'Set Demand' control in a clockwise direction until load is attained.

8. Adjust the 'Set Demand' control for load and engine throttle for speed to attain the desired conditions.

4.8 TO CLOSE DOWN THE PLANT

1. Reduce the engine speed to idling speed.
2. Rotate the 'Set Demand' control fully counterclockwise to zero; if in torque mode the engine and demand should be reduced together to prevent over-speeding.

Note : If power law control has been performed immediately prior to closing down the plant and it is desired to use that mode of control with the next test, then the setting of the 'Set Demand' control should not be disturbed.

3. Stop the engine by operating 'Stop' (red) pushbutton; the shutdown system will operate.
4. Stop all supplies to the dynamometer, engine and auxiliaries.
5. Switch off the mains supply voltage to the control equipment at the isolator.

Note : If testing is conducted intermittently throughout the day then it is only necessary to perform operations 1 & 2. The operation of the 'Stop' pushbutton or switching of mains voltage supply will cause the shutdown system to operate, which will necessitate resetting the equipment and re-starting the engine before the tests can be continued. The engine may be stopped by operation of the ignition switch.

4.9 EMERGENCY SHUTDOWN

In the event of emergency requiring a complete shutdown this may be affected by any one of the following actions.

1. Operation of an emergency stop pushbutton; where one is connected in the shutdown interlock circuit.
2. Operation of the 'Stop' (red) pushbutton in the control panel.
3. Disconnecting the mains supply to the control equipment at any point.

All the preceding operations will de-energize the shutdown relay which, provided that either the ignition circuit or the fuel pump interlock have

been correctly connected to the circuit of the control system, will stop and electrically isolate both the engine and the dynamometer.

When it is desired to return the same torque / speed condition after the engine has been restarted the 'Set Demand' control should not be adjusted after effecting a shutdown.

4.10 CALCULATION OF POWER

The dynamometer is normally calibrated before leaving our works with the torque measuring system indicating torque in Newton meters (Nm units) so that the power developed may be calculated from one of the following formulae.

$$\text{S.I. units} \quad \text{KW} = \frac{\text{Nm x rev/min}}{9549.305}$$

$$\text{Imperial units} \quad \text{bhp} = \frac{\text{Nm x rev/min}}{7121}$$

$$\text{Metric units cv or PS} = \frac{\text{Nm x rev/min}}{7023.746}$$

The indicators can also be calibrated in lbf ft or kgm units, which enables the power developed to be calculated from one of the following formulae.

$$\text{bhp} = \frac{\text{lbf ft x rev/min}}{5252}$$

$$\text{cv or PS} = \frac{\text{Kgm x rev/min}}{716.197}$$

Conversion factors into other units are as follows:

$$1\text{kW} = 1.341\text{bhp} = 1.360\text{cv or PS}$$

$$1\text{Nm} = 0.7376\text{lbf ft} = 0.1020 \text{kgm}$$

4.11 LOAD – CELL TORQUE MEASUREMENT SYSTEM

The load cell with its associated readout instrument is calibrated at our works before delivery. This calibration is carried out by adding known weights to the end of an arm which is attached to the dynamometer carcass, any adjustment to bring the load readings within the guaranteed range of accuracy are made on the associated control equipment. The method for making those adjustments is described in the separate manual for the control equipment.

Although the load cell may be used over a wide temperature range its actual operation must be restricted to a range from -5°C (23°F) to $+40^{\circ}\text{C}$ (104°F) in order to ensure that its accuracy remains within the guaranteed limits.

5. MAINTENANCE

5.1 WATER SUPPLY

To maintain the necessary quality of the circulating water & thereby secure the maximum working life of the power-absorbing elements.

1. Ensure, by regular inspection, that the water supply is free from dust, sand, grit or other impurities, bearing in mind the fact that water, which was satisfactorily clean at the time of installation, may deteriorate in quality if building or roads making operations are carried out in the vicinity.
2. Keep all piping clean & flushed out regularly.
3. Ensure that any filters or strainers incorporated in the system are inspected at frequent intervals and cleaned as necessary.
4. If the water is re-circulated through a cooler, drain the system once a month and clean the cooler thoroughly, scraping it free of all sediment.
5. At regular intervals, & when refilling the system after cleaning, check the pH value of the water & take any action necessary to bring it within the approved limits of 7.4 & 8.4 recommended in section 3.2.2.

5.2 TORQUE MEASUREMENT SYSTEM CHECKS & ADJUSTMENTS

5.2.1 CHECK FOR ACCURACY

All dynamometer are calibrated for accuracy before dispatch.

Test arms can be supplied to enable the user to check the accuracy of their dynamometer whenever this is considered necessary. Space must be left when installing the dynamometer for the attachment of the test arm. The space required is shown in Fig. 11.

The procedure for using the test equipment is described in section 5.2.2.

SH 750 HS HYDRAULIC DYNAMOMETER

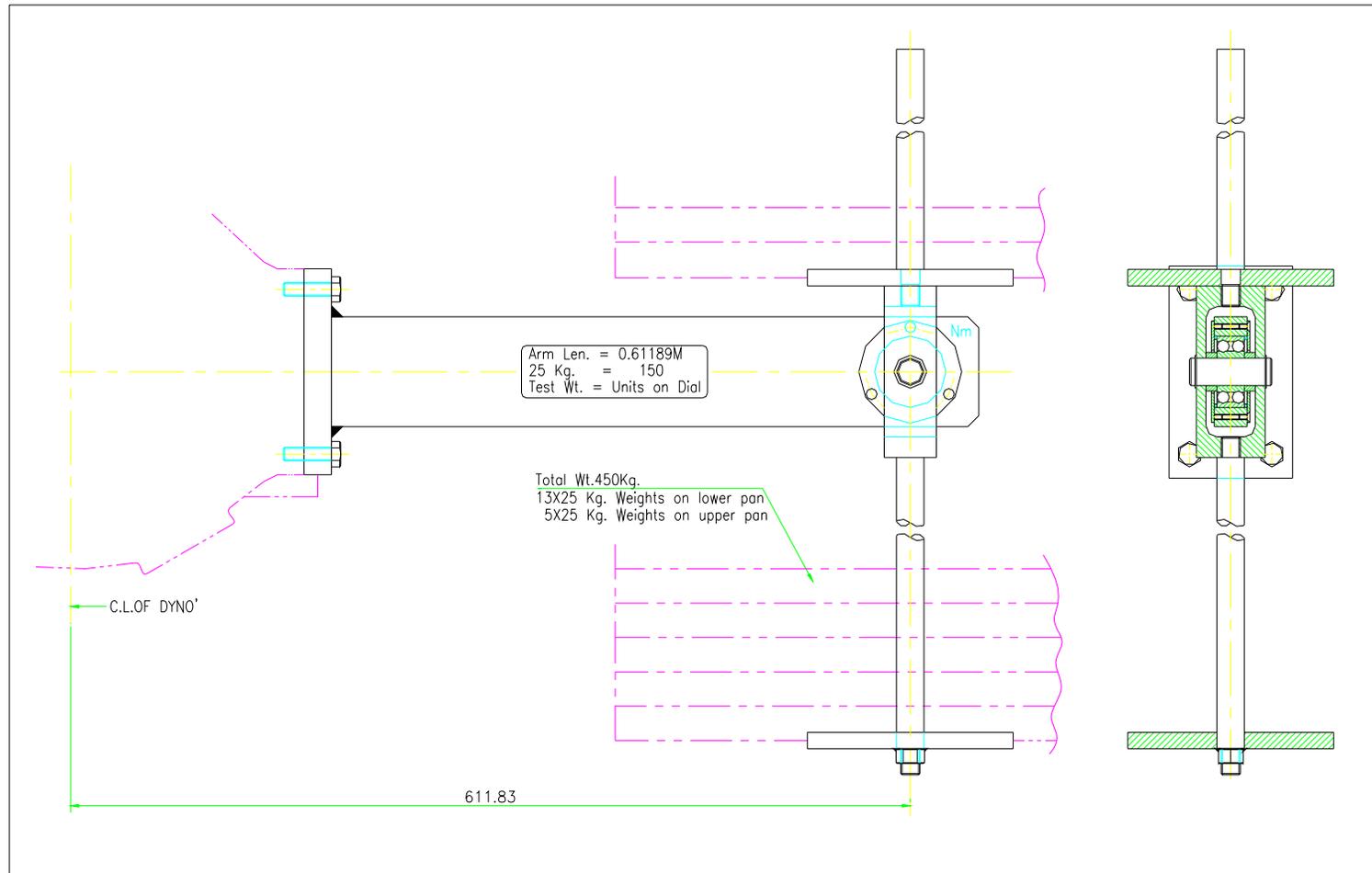


FIGURE 11
TEST A

5.2.2 INSTALLATION OF TEST EQUIPMENT

1. Switch on the electrical supply to the load indication equipment at least 30 minutes before starting the calibration check.
2. Disconnect any drive shafts or couplings from the dynamometer half couplings, allowing the shaft to rotate freely.
3. Turn on water supply & allow water to flow through the dynamometer.
4. Ensure that the torque indicator reads zero. If necessary adjust as described in the instruction manual for the control equipment.
5. Fit the test arm to the carcass at the opposite side to the load cell, as shown on a separate drawing. Ensure that the weight pan is in position. Fit the counterbalance arm & rider weight to the load cell torque arm.
6. Adjust the position of the rider weight to return the torque indicator reading to zero & secure in position.
7. Place the appropriate weights on the weight pan & check that the indicator readings are correct. The ratio of check weights to indicated readings is stated on a plate fixed to the test arm. The distance from the centerline of the dynamometer carcass to the centerline of the test weights is 0.61183m. A 25kg test weight at this distance will show 150Nm on the indicator.

The method of making adjustment to the zero & span to bring the load readings within the guaranteed range of accuracy is described in the instruction manual for the control equipment.

8. Remove test arm & counterbalance arm.

5.2.3 FAULT FINDING

To determine the cause of erratic or incorrect operation, the following checks should be made.

1. Check that power is available to the equipment & that all fuses are intact.
2. Check that connections to the load indicator are correct & secure.
3. Check the electrical continuity of the interconnecting cable leads using an ohmmeter.

4. Check the security of all connections in any junction box.
5. With the leads disconnected measure the resistance between the input leads & between the output leads. The lead colours & expected resistance value for the various types of load cell fitted are shown in the following tables.

CAUTION : The ohmmeter used to measure these resistances must not apply more than 10 V to the load cell; high voltage insulation testers will damage the load cell by destroying the strain gauges.

Load cell Specification

Non-linearity	% FSO	± 0.03
Hysteresis	% FSO	± 0.03
Operating Temp. Range	Deg. C	- 20 to + 80
Compensated Temp. Range	Deg. C	0 to 60
Thermal Zero Shift	% FSD/Deg C	± 0.002
Thermal Sensitivity Shift	% Reading/Deg C	± 0.002
Input Resistance	Ohms	375 nominal.
Output Resistance	Ohms	350 nominal
Overload Capacity	% FSO	150
Maximum Side Load	% FSO	50
Barometric Effect	None	
Environmental Protection Level	1 P51	

Load cell- cable colour code details as per Mfg.

<i>Function</i>	<i>Ferrules</i>	<i>Load Cell Manufacturer</i>			
		<i>Maywood</i>	<i>HBM</i>	<i>IPA</i>	<i>Sensotronics</i>
Excitation (+)	LC1	Red	Black	Green	Red
Output (+)	LC2	Green	White	Red	Green
Output (-)	LC3	White	Red	Black	White
Excitation (-)	LC4	Blue	Blue	White	Black
	SCN	SCN	SCN	SCN	SCN

Resistance readings other than those specified in this Section indicate a failure within the load cell. The customer should not attempt to repair the load cell, which must be returned to the manufacturer for service. In the unlikely event of this being necessary the customer should first contact the Engineering Services Department at SAJ Test Plant Pvt. Ltd. to ascertain the correct procedure.

5.3 LUBRICATION

5.3.1 SHAFT BEARINGS

The shaft bearings fitted to these machines are lubricated with grease.

Grease lubricated shaft bearings have a Kluber replenishable system with Rotherham grease cups.

After each 100 hours running time, rotate the grease cup cover one full turn clockwise. When the cover is fully tightened, remove it, refill it with grease as specified in section 5.3.5 & refit it one full turn.

When the dynamometer is dismantled it is advisable to clean, inspect & repack the bearings as described in Appendix A/1 at the back of this manual. If there is any doubt concerning their condition the bearings should be replaced. The grease passages & grease cups should be thoroughly cleaned & repacked with grease.

A kluber lubrication leaflet entitled "The treatment of newly mounted roller bearings or first treatment with kluber lubrication high temperature, low temperature & permanent lubricants" & a list of kluber Lubrication companies; European branch offices & representatives are included in Appendix A/1.

The quantity of grease in each of the bearings is 16gramme/bearings.

5.3.2 HYDRAULIC POWER PACK

In case Dynamometer having integral oil tank in the bedplate should be filled with oil to the top level mark on the sight indicator. The level should be checked daily & any oil lost should be replenished.

Generally we provide separate Hydraulic Power Pack for ease of maintenance.

The recommended grade of oil is specified in section 5.3.5.

5.3.3 TRUNION & TORQUE MEASUREMENT SYSTEM BEARINGS

The trunion & torque measurement system bearings are lubricated before delivery. They should be cleaned out & a small quantity of fresh grease inserted whenever the dynamometer is dismantled. No grease nipples are provided.

The recommended grade of grease is specified in section 5.3.5.

5.3.4 TORQUE MEASUREMENT SYSTEM OPERATING LINKS, FORKS & PINS

The torque measurement equipment should be given a light protective coating of oil at approximately monthly intervals.

The recommended grade of grease is specified in section 5.3.5.

5.3.5 RECOMMENDED LUBRICANTS

	Shaft Bearings	Oil System	Trunnion & Load cell rod end bearings	Operating Links & pins
Lubrication Interval	See section 5.3.1	Check level daily. See section 5.3.2	See section 5.3.3	See section 5.3.4
Lubricant	Grease	Oil	Grease	Oil
Shell		Tellus 68	Alavinia R3 Or RA	Tellus68
Mobil		DTE26	Mobilux Grease 3 Or Mobiplex 48	DTE 26
Burmah Castrol		Hyspin AW68	Spheectrol AP 3	Hyspin AWS 68
			B.P. Enererease LS 3	Enerpol
				HLP 100
Esso		Nuto H68	Beacon 3	Nuto H54
Gulf		Harmony 68AW		Harmony 54 AW
Kluber	Isoflex Topas NB 52			

5.4 LOAD CONTROL VALVE

5.4.1 PUMP UNIT & CONTROL CIRCUIT

5.4.1.1. OIL CONDITION & QUANTITY

Keep the oil in the tank topped up to the mark on the sight indicator mounted on the side of the bedplate / tank. Always use clean oil as recommended in section 5.3.5 & replace the filler cap immediately afterwards. The pump should then be run for two hours to ensure that all impurities have been removed.

5.4.1.2. FLUSHING PROCEDURE

If the hydraulic circuit in the dynamometer has been broken for any reason, the system must be thoroughly flushed before the machine can be used.

1. Remove the servo valve. Bolt the flushing block, supplied with the dynamometer, in place of the servo valve & immediately bolt the cover plate removed from the flushing block onto the bottom of the servo valve. Pay particular attention to cleanliness to ensure that no dirt enters the valve.
2. Switch on the pump unit for a period of at least four hours.
3. Remove the flushing block & replace the servo valve. Replace the cover plate on the flushing block.

NOTE : Failure to carry out the correct flushing procedure, or the use of dirty oil in the control system at any time, will result in failure of the servo valve. This is an expensive component & the need for cleanliness cannot be overemphasised.

5.4.1.3. ACCUMULATOR

The operation of the accumulator fitted in the electro-hydraulic control system should be checked at monthly intervals in the following manner.

Stop the pump unit motor & observe the pressure gauge fitted on the unit.

The pressure should fall slowly for approximately 10-20 seconds & then more rapidly. The change from slow to rapid rate of fall

should occur at 21.0 kg/cm² (300lbf/in²). This is the pressure of the nitrogen in the accumulator.

If the change over point is below 21.0 kg/cm² (300lbf/in²) the accumulator should be recharged. The recharging can be carried out by either removing the accumulator & taking it to a company, which specializes in this type of equipment or charging it in place on the pump unit. The charging equipments & procedures are included in Fig. 12.

5.4.2 VALVE ACTUATOR

Because the actuator is controlled by oil it should require very little maintenance. If, after a long period of use, the seals have worn, then the actuator should be replaced or new seals should be fitted. The procedure for replacing the seals is as follows :

1. Ensure that a complete set of replacement seals in Viton rubber is available before starting to dismantle the unit.
2. Clamp the mounting pads, or feet, in a vertical position in a vice, (Do not clamp the body of the unit.)
3. Remove all bolts securing one head & remove head. The shaft should be taken out of the body by carefully rotating it by hand until the bearing diameter is clear of the bearing in the opposite head.

CAUTION: The interior of the body, head, or any finished surfaces, must not be damaged.

4. Before the new seals are fitted any burrs, particularly round the "O" ring grooves, must be carefully removed. All parts must be clean & a light coating of oil applied to the seals & bearings before assembly commences.
5. Care must be taken to avoid damaging the unit during reassembly. The shaft must be rotated into the bearing diameter by hand & the shoe, with seal assembled, can be fitted over the dowels after the shaft is in position. The head that was removed should then be replaced over the shaft extension & located on the dowels.

The bolts should be replaced & tightened evenly, opposite to each other & then made uniform tight. Care must be taken to avoid distortion.

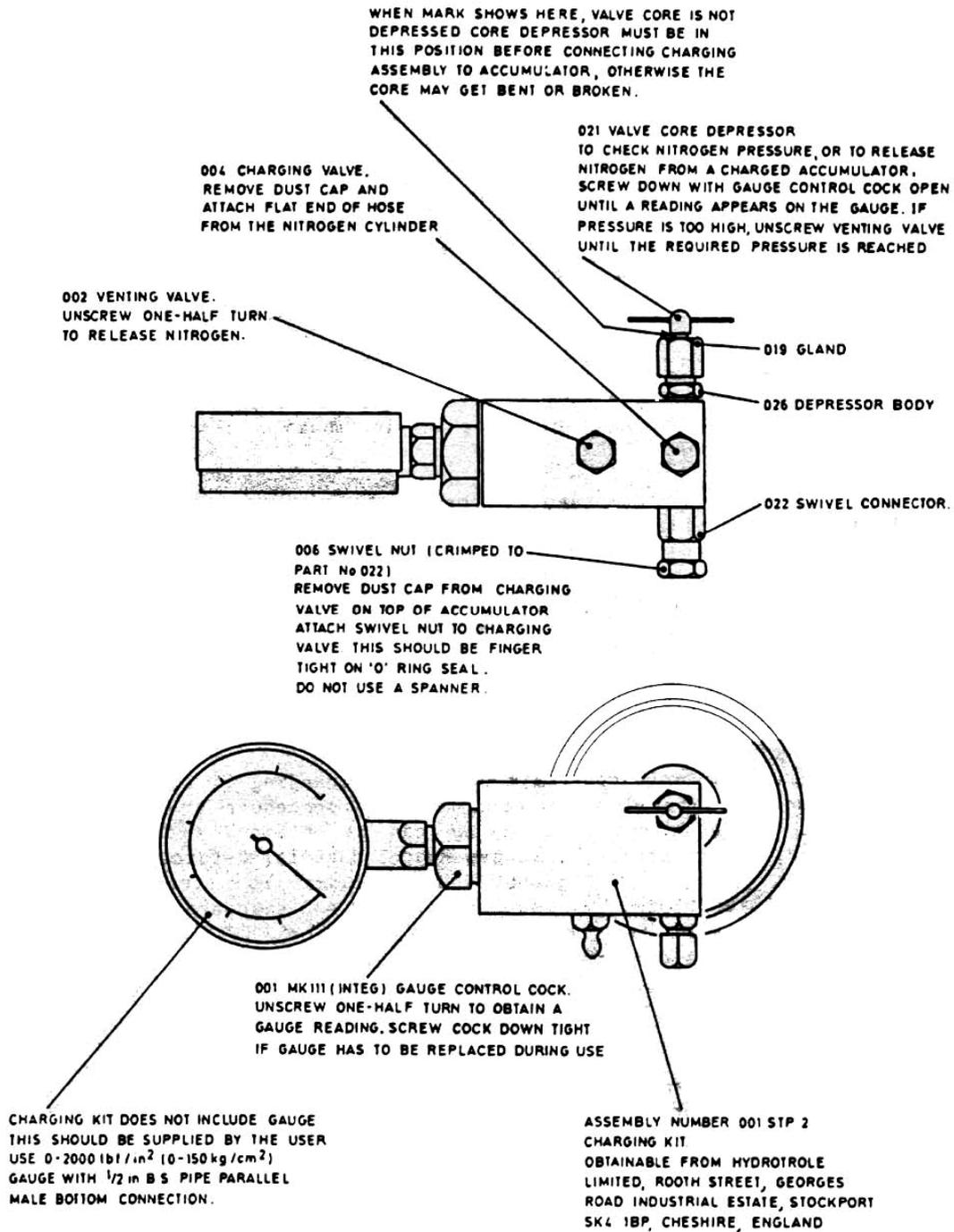


FIGURE 12
METHOD OF CHARGING ACCUMULATOR

5.4.3 POSITIONAL POTENTIOMETER

As this is a precision instrument with a long operating life no routine maintenance is necessary. Accidental mechanical damage however, may make it necessary to replace the potentiometer. This should be done in accordance with the following procedure; refer to Fig.13.

1. Switch off the hydraulic power system motor & the mains isolator for the control equipment.

Disconnect the lead to the servo valve by turning the knurled locking ring counterclockwise & withdrawing the plug from the socket.

2. Remove cover over potentiometer.
3. Disconnect the three leads soldered to the terminals on the potentiometer. These are numbered 1,2 & 3 or 10,11 & 12 dependent upon the type of potentiometer.

NOTE : Ensure that these leads are still legibly labeled before disconnecting & note the relative position of the terminals.

4. Remove the two non-captive retaining clips & screws(C).
5. Manually rotate the butterfly valve to the fully open position.
6. Release the two grub screws (G) in the spindle coupling.
7. Withdraw the damaged potentiometer from the coupling & mounting plate then clean around the locating hole & the potentiometer seating area as necessary before replacing with a new potentiometer. Ensure that this is set with the terminals in approximately the same position as before.
8. Replace the two retaining clips & screws (C) & tighten securely.
9. Reconnect the correct potentiometer leads to the solder terminals 1,2 & 3 or 10,11 & 12 dependent upon the type of potentiometer.
10. Switch on the control equipment. If the hydraulic power system motor starter is interlocked in this system it will be necessary for this test to isolate the motor.
11. Select position mode of control.
12. Select minimum demand.
13. Connect an AVO or similar Voltmeter on the maximum/minimum position test point & the system common test point on the

“position” module. For details see the instruction manual for the control equipment.

14. With a voltage of 10volts negative on PP1 with respect to PP3 manually rotate the potentiometer spindle(s) until the voltage at PP2 with respect to PP1 is 1.5volts negative (+/-50mV).

NOTE : If the required setting cannot be precisely obtained by the above method, trimming may be accomplished by slacking the clamps (C), rotating the potentiometer body to achieve the required setting then tightening the clamps.

15. Tighten the two grub screws.
16. Turn the control equipment off.
17. Replace the electrical connector plug on servo valve.
18. Repeat section (10).
19. Switch the hydraulic power system motor on.
20. Transfer the meter lead to the second test point on the same module; the meter indication should be exactly the voltage (measured on the lowest possible range) specified in the instruction manual for the control equipment.

Should there be any deviation from this figure, adjust the minimum position preset control to reset to exactly the correct voltage.

21. Check that the groove in the end of the butterfly valve spindle is in line with the “open” position groove in the valve body. If there is any misalignment repeat the lining-up procedure to attain accurate alignment.
22. Disconnect the voltmeter.
23. Select maximum demand.

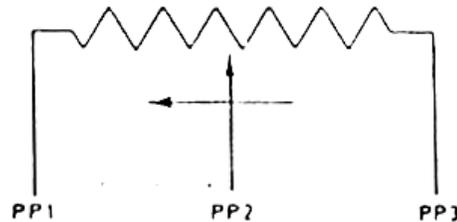
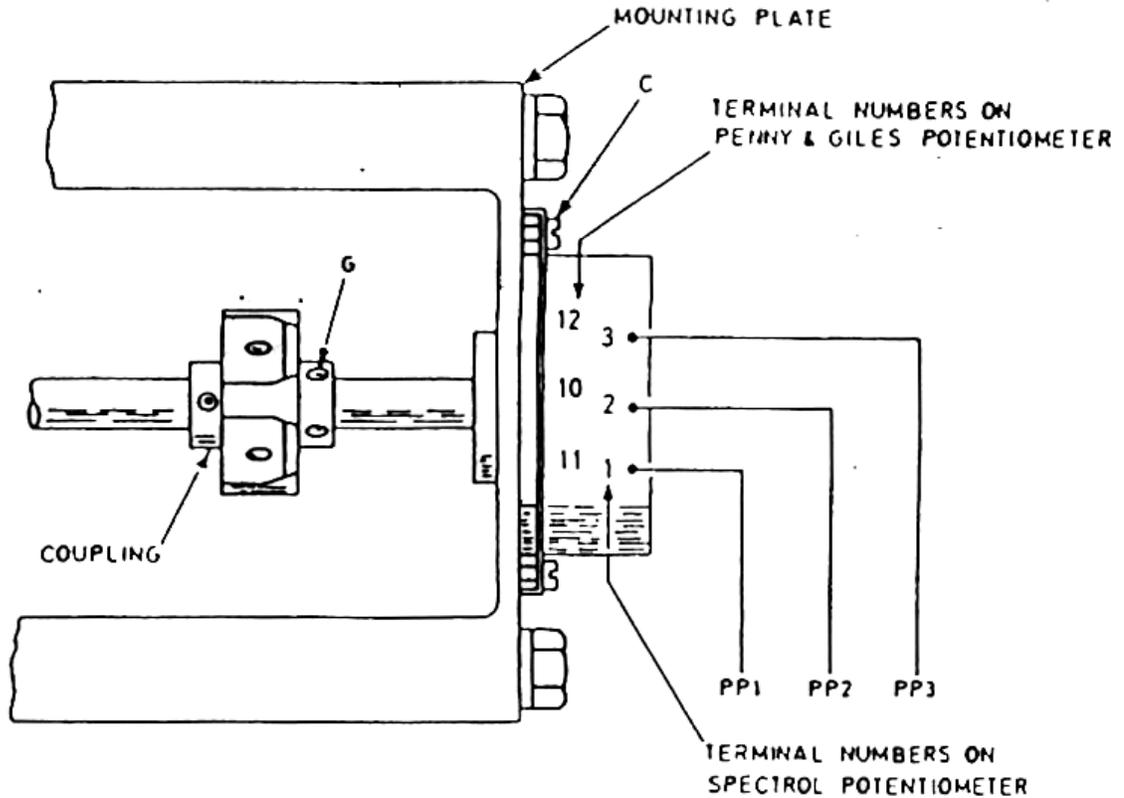


FIGURE 13
POSITION POTENTIOMETER

NOTE: The fixing screws(C) & (G) must be perfectly tight and should be secured by loctite 241 or some similar adhesive
The Penny & Giles and Spectrol potentiometers are alternative types

24. Check that the groove in the end of the butterfly valve spindle is in line with the "closed" position groove in the valve body. If necessary re-align by adjusting the maximum position preset; refer to section 5.4.5.1 & the position mode setting procedure in the instruction manual for the control equipment.

5.4.4 ELECTRO-HYDRAULIC SERVO VALVE

5.4.4.1. HYDRAULIC SYSTEM – STATIC CHECK

The dynamometer must be stationary for this check.

To check the hydraulic system only, independent of the electronic controls refer to the appropriate separate drawing & proceed as follows

1. Disconnect the lead to the servo valve (3) by turning the knurled locking ring (4) counterclockwise & withdrawing the plug (5) from the socket.
2. Switch off the hydraulic power system motor then temporarily release but do not remove, one of the special connectors at the bedplate to release any residual oil pressure; this will ensure that the rotation of the butterfly valve will not be restricted by a hydraulic lock. Tighten connector.

Check the static friction of the butterfly valve assembly by manually rotating the spindle clockwise then counterclockwise. The torque required to overcome the resistance of the oil & water seals on the spindle & the trapped oil in the actuator should be approximately 0.48Kgm (3.5lbf.ft).

NOTE : If a hard & untreated water supply is being used for the installation it may be found, after a long period in service, that the butterfly valve, seals, & housing are coated with lime scale deposits thus increasing the torque required to move the butterfly valve & so reducing the efficiency & the time response of the system. Under these conditions the butterfly valve should be periodically removed & decaled. Refer to section 4.4.5 for procedure.

3. Switch on the hydraulic power pack; the indicated oil pressure should be 35.0kg/cm² (500lbf/in²).
4. The actuator spindle (8) should not oscillate & there should be no vibration transmitted through the oil pipes connected to the servo valve. These indicate a faulty servo valve which should be adjusted as follows :

5. Reduce the oil pressure to the servo valve to between 3.5 & 7.0kg/cm² (50-100lbf/in²); a few minutes will be required for the pressure to decay.
6. Use a 3.2mm (0.125in) across flat socket wrench to turn the mechanical null adjuster pin (6), slightly clockwise. Allow the actuator spindle (8) to rotate slightly counterclockwise, then reverse the procedure & turn the pin slightly counterclockwise to allow the spindle to rotate slightly clockwise before reversing the procedure again until a stable stationary position of the spindle is attained.

NOTE : Only a fraction of a turn of the null adjuster pin, depending on the oil supply pressure, is required to cause movement of the actuator spindle.

7. Reconnect the plug & socket (5) & tighten the locking ring (4).
8. Reset the pressure of the hydraulic power pack to indicate 35.0kg/cm² (500lbf/in²).

5.4.4.2. ELECTRO – HYDRAULIC SYSTEM – STATIC CHECKS

The dynamometer must be stationary for these checks.

1. Switch on control equipment.
2. Switch on the hydraulic power system motor; refer to section 4.1 (3).
3. Either, Select a position mode of control with approximately 50% demand. Rapidly increase & decrease the demand level backwards & forwards; the actuator spindle (8) & the valve position indicator meter pointer should follow these rapid demand signal reversals. Maintain a steady demand; the actuator spindle & the pointer should also stop.

OR,

Select "speed" mode of control with approximately 2% demand. Alternatively select a torque mode & a speed mode without varying the demand level. The butterfly valve will move rapidly between minimum & maximum positions. This is shown by the pointer of the valve position indicator meter.

4. Should one actuator spindle continue to oscillate or show any sign of instability after performing section (3) switch off

the control equipment; if the instability still persists the servo valve should be suspected as being faulty & the hydraulic system check performed as described in section 5.4.4.1.

5.4.5 BUTTERFLY VALVE

The butterfly valve should be removed for inspection.

Repair should only be necessary if the bushes need replacing after a long period of use.

If the valve becomes stiff & slow to operate this may be caused by deposit of scale. Examine the valve &, if necessary, scrape the valve gently to remove the scale.

5.4.5.1. POSITIONAL SETTING OF THE BUTTERFLY VALVE :

1. Prepare the control equipment as described in the instruction manual for the control equipment.
2. Select maximum demand.
3. Initially set the maximum position preset control fully clockwise & the minimum position preset control fully counterclockwise. Refer to the instruction manual for the control equipment for the position of these controls.
4. Switch on the control equipment.
5. Slowly rotate the minimum position preset control clockwise until the groove in the end of the butterfly valve spindle is in line with the "open" position groove in the valve body.
6. Select minimum demand.
7. Slowly rotate the maximum position preset control counterclockwise until the groove in the end of the butterfly valve spindle is in line with the "closed" position groove in the valve body.
8. Repeat section (2) & (6) to check the accuracy of alignments; adjust the presets if necessary.
9. Switch off the control equipment.

The butterfly is now set for the fully closed position when the demand is at maximum & fully open position when the demand" is at zero.

5.4.6 INSTABILITY OF THE DYNAMOMETER

Instability of the dynamometer is either "Speed" or "Torque" control modes.

First check that instability is not caused by any malfunction of the engine.

1. Check that there are no variations present in the inlet water pressure to the dynamometer.
2. Run the dynamometer using the position control mode. If the instability is still present inspect the positional potentiometer for rigid location also the spindle coupling for secureness & the absence of any slip. See Fig.9 & separate drawing. Inspect the potentiometer for any damage & check the smoothness of the output in relation to rotation. Details regarding the voltage variation of the potentiometer are included in the instruction manual for the control equipment. If necessary replace with a new potentiometer in accordance with section 5.4.3.
3. Check that the butterfly valves assembly responds smoothly to, & accurately follows, the demand control signal. Ensure that there is no static friction of the butterfly valve owing to excessive lime scaling.
4. With speed control mode selected run the dynamometer & check for positional stability by observing the spindle of the hydraulic actuator driving the butterfly valve & the position sensing potentiometer. This spindle will usually be "lively"; the "dither" amplitude & frequency of any oscillations being dependent on the characteristics of the engine under test, the particular dynamometer being used, & the degree of inertia damping in the complete system. This amplitude is directly proportional to the signal to the servo valve windings & is typically +/-1% of the total movement of the spindle with occasional larger amplitudes triggered by random disturbances generated within the system; the frequency is the product of all the various parameters of the test plant at any given time & speed.

Should the degree of speed stability be too low, proceed as follows :

- i. By equal increments concurrently rotate both the integral time constant & the proportional gain preset controls in a clockwise direction until maximum stability is restored.
- ii. Should this adjustment have made the control sluggish, rotate the integral time constant preset control slightly

counterclockwise until optimum control response is achieved. Check by varying the demand control.

iii. Repeat section (i) as necessary.

5.5 WATER INLET VALVES

5.5.1 MANUALLY OPERATED VALVE

The valve should be inspected for wear & damage at approximately yearly intervals. Any lime deposits should be carefully scraped off. An arrangement of the valve is shown in Fig.14.1.

5.5.2 REMOTELY OPERATED VALVE

If the dynamometer water inlet valve is fitted with a electrically operated actuator a copy of the suppliers instruction literature for the actuator will be provided. An arrangement of the valve is shown in Fig. 14.2. The butterfly valve should be inspected for wear & damage at approximately yearly intervals. Any lime deposits should be carefully scraped off.

5.5.3 TWO POSITION VALVE

If the dynamometer is fitted with a pneumatically operated valve at the water inlet position a copy of the supplier's instruction literature will be provided. The butterfly valve should be inspected for wear & damage at approximately yearly intervals. Any lime deposit should be carefully scraped off. An arrangement of the valve is shown in Fig.14.3.

5.5.4 SERVO OPERATED INLET VALVE

If the dynamometer is fitted with a servo operated inlet valve the actuation time for full travel should be approximately 0.3 seconds. The valve should be inspected at yearly intervals & any lime deposit carefully scraped off.

5.6 WATER PRESSURE SWITCH

No maintenance is required to this unit.

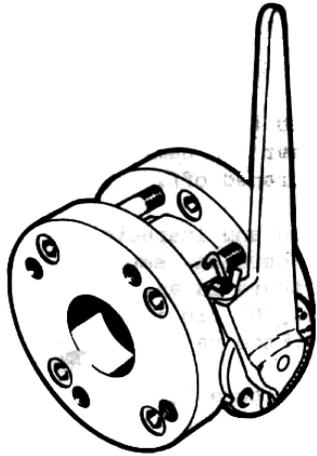


FIGURE 14.1
MANUALLY OPERATED VALVE

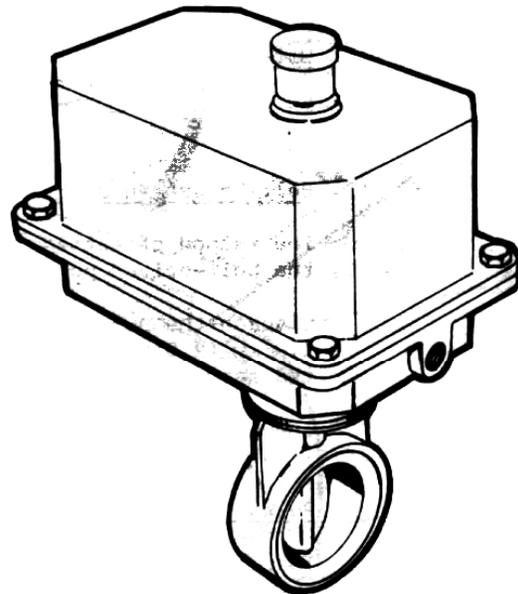


FIGURE 14.2
REMOTELY OPERATED VALVE

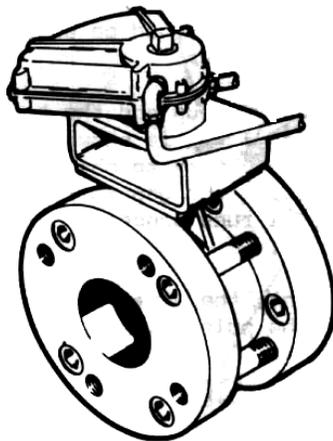


FIGURE 14.3
TWO POSITION VALVE

URE 14
ARRANGEMENT OF WATER INLET VALVES

FIG

5.7 PULSE PICK-UP UNIT :

There are no day-to-day adjustments to be made to this equipment, but the accuracy of the tachometer equipment should be checked periodically against a reliable hand tachometer.

The setting of the gap between the pulse pick-up & the toothed wheel is extremely important. The nominal gap is shown in Fig.11 but small adjustments may be necessary to obtain steady or accurate readings. When setting the gap it is essential to check that the toothed wheel runs concentrically within a tolerance of $\pm 0.025\text{mm}$ (0.001in).

If results are inaccurate or inconsistent, the waveform should be checked.

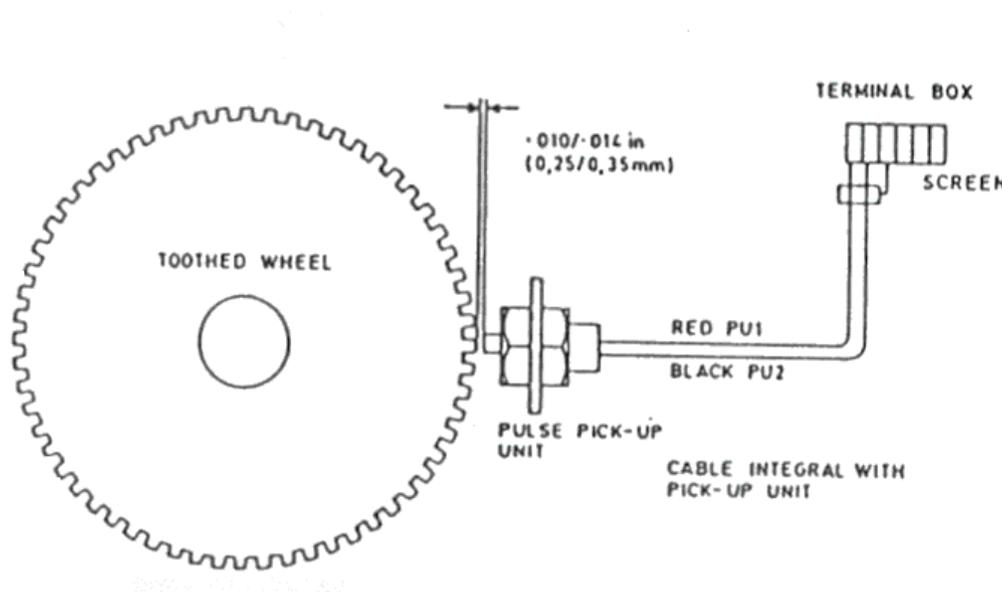


FIGURE 15
SETTING DIMENTION FOR PULSE PICK-UP

5.8 ELECTRONIC CONTROL EQUIPMENT

Because of the inherent reliability of present-day components & solid-state devices no preventative maintenance is required for this equipment. In case of difficulty circuit analysis details will be found in the separate instruction literature for the control equipment.

5.9 ELECTRICAL EQUIPMENT

The control cabinet should be cleaned & the condition of cables & cable terminations checked at three monthly intervals.

Maintenance is not required to any item of electrical equipment other than that referred to in the maintenance section of this manual.

5.10 OIL INJECTION

For the equipment necessary to provide expansion & drive-up pressure when assembling the rotor & half couplings on the dynamometer shaft, & the manner in which it should be used, refer to Appendix C/1. Oil injection data for the F24M dynamometer is give in the table below.

Detail	Maximum oil injection pressure (lbf/in ²)	Maximum drive-up force (tonf)	Minimum drive-up distance (mm)	Maximum drive-up distance (mm)
Rotor	31000 (12 tonf/in ²)	8.0	3.20	4.53
Half Coupling	44800 (20.2 tonf/in ²)	10.0	3.30	4.57
Pump Drive Sleeve	25800 (15 tonf/in ²)	6.0	2.55	3.82

5.11 SERVICE INTERVALS

This facility has been designed to operate with the minimum of maintenance. However, in order to ensure maximum reliability & life of components, the following recommended schedule of inspection & lubrication should be adopted.

INTERVAL	ITEM	SECTION
100 Hours	Shaft bearings (grease lubrication)	5.3.1.1
		5.3.5
Daily	Electro-hydraulic control system oil tank	5.3.2
		5.3.5
Weekly	Electro-hydraulic control system butterfly valve static check	5.4.5.1
Monthly	Water system cooler	5.1
Monthly	Torque Measurement System operating links forks & pins.	5.3.4 5.3.5
Monthly	Hydraulic unit power pack accumulator	5.4.1.3
3 Monthly	Electro-hydraulic control system static check	5.4.4.2
3 Monthly	Weigher equipment calibration	5.2.1
3 Monthly	Control Cabinet, cable terminations & cables	5.9
Yearly	Trunnion bearings	5.3.3
		5.3.5

6. TROUBLESHOOTING LOGIC

It is very important to know the existence of any problem while using / operating a dynamometer. All the parameters such as torque reading, vibrations, water inlet / outlet temperature, water inlet pressure, bearing temperature etc are constantly watched and noted periodically for monitoring the undesirable variations for timely corrective action.

No catastrophic failure occurs all of a sudden but there is always an indication prior to that. By taking an immediate corrective action on a small problem, catastrophic failures can be arrested and high cost of repairs & downtime can be avoided.

It is a good practice to maintain a logbook in which the preventive / periodic maintenance carried out from time to time will be noted for future reference. Sometimes the cause of a problem may be related to a maintenance carried out earlier.

Correct diagnosis of the fault and appropriate timely corrective action is a matter of experience & discipline.

Lack of maintenance or carrying out improper maintenance, both can cause the occurrence of faults and should be avoided. A proper and timely maintenance as per the recommendations only can give the specified life of a dynamometer before first overhaul.

While troubleshooting, always start checking from the simplest thing. It is also very important to find out the root cause of the problem / fault and take corrective action to arrest the problem once for all.

The troubleshooting logic explains the cause of a problem and the appropriate corrective action in the entire system of operation. The end users are requested to carry out installation as per the recommendations. SAJ Test Plant is not responsible for the problems emerging due to improper corrections. The corrections on the installation side beyond the scope of SAJ Test Plant is entirely the responsibility of the end user. Also replacement of components due to lack of or improper maintenance will be on chargeable basis.

In the following pages some common problems, their causes and corrective action are discussed.

1. Erratic indication of torque		
Cause		Corrective action
Carcase fouling within the bed plate	→	Remove the cause of fouling such as wire, pipe etc.
OK ↓		
Load cell links not free	→	Make load cell links free
OK ↓		
Inadequate lubrication of bearings	→	Lubricate bearings adequately
OK ↓		
Restriction to load cell assembly	→	Make load cell assembly free of restriction
OK ↓		
Water inlet pipes tight	→	Make water inlet pipes free to move
2. Load cell indication drifting		
Rapid changes in temperature of load cell	→	Ensure that there are no rapid changes in temp. of load cell
OK ↓		
Cell ventilation system blowing directly on load cell	→	Divert cell ventilation away from towards load cell
OK ↓		
Load cell is subjected to radial heat from exhaust system	→	Ensure that load cell is not subjected to radial heat by inserting a heat barrier
OK ↓		
Trunnion bearings causing restriction	→	Lubricate trunnion bearings
OK ↓		
Long term brinelling	→	Rotate or replace bearings

3. Step change in torque reading		
Cause		Corrective action
Broken load cell pre-tension spring	→	Replace the spring
OK ↓		
Part of dynamometer carcass has come loose or fallen off	→	Set right properly
OK ↓		
External object fallen onto carcass	→	Remove the object
OK ↓		
Broken pipe attached to carcass	→	Replace
OK ↓		
Faulty load cell	→	Check for linearity & replace if necessary
4. Control instability – Erratic indication of water outlet valve position		
Pulsing oil supply from power pack	→	Restore oil supply by removing cause
OK ↓		
Low oil level in tank	→	Fill oil to sufficient level
Condition 1 or 2 above will cause the pressure switch to open		
OK ↓		
Aeration in oil	→	Remove air from oil
OK ↓		
Poor contact in positional potentiometer	→	Check wiring and establish firm contact
OK ↓		
Faulty accumulator – punctured bag or blockage	→	Check and correct for low charge problem or replace

4. Control instability -Erratic indication of water outlet valve position (Contd)		
Cause		Corrective action
Restriction in flexible oil supply or return pipe	→	Clean pipe lines & refit
OK ↓		
Loose coupling between potentiometer and butterfly valve	→	Adjust coupling firmly
OK ↓		
Scaled butterfly valve or its bearings seized	→	<i>Repair by de-scaling</i>
OK ↓		
Faulty actuator	→	Replace
OK ↓		
Wiper of potentiometer is lifted off due to vibrations	→	Set properly & eliminate vibrations
OK ↓		
Faulty servo valve due to a break in the system or due to contaminated oil	→	Flush the system completely & replace servo valve, if necessary
OK ↓		
Water in gravity drain blocking up & flooding the outlet valve	→	Remove the blockage

5. Butterfly valve blocked & is immovable		
Cause		Corrective action
Incorrect position of valve relative to potentiometer	→	Position the valve properly, check for faulty coupling, loose clamps holding the potentiometer housing
OK ↓		
Shorting of supply wires to the wiper connection of potentiometer	→	Connect wires properly
OK ↓		
Failure of electric supply to hydraulic valve or faulty lock valve	→	Restore the supply or replace hydraulic valve
<p>Note : 1. Manual checking of butterfly valve movement should only be carried out with all systems switched off and a period of time allowed for the accumulator to be empty.</p> <p>2. Operation of servo system requires the control system to be in 'RUN' condition.</p>		
6. Hot shaft bearings		
Inadequate lubrication of bearings	→	Ensure adequate lubrication of bearings
OK ↓		
No grease present in grease cups	→	Fill grease in grease cups
OK ↓		
Overgreasing	→	Avoid over-greasing
OK ↓		
Wrong grade of grease used	→	Use correct grade of grease
OK ↓		
Mixing of two grades of grease	→	Use only recommended grade & brand of grease

7. Machine failure due to ' pick - up '		
Cause		Corrective action
Contaminated water supply	—————→	Ensure clean water supply by maintaining filter / strainer in condition
OK ↓		
Scale formation	—————→	Use soft water by proper treatment
Due to a very small clearance along parts of the shaft assembly, 'pick-up' can occur. Machine failure is possible due to poor condition of the water supply.		
8. Shutdown associated with shaft assembly		
High bearing temperature	—————→	Check as above and rectify
OK ↓		
Oil supply failure	—————→	Correct oil level, remove aeration
OK ↓		
Water supply failure	—————→	Maintain appropriate water supply
OK ↓		
Failure of pressure switches and / or wiring associated with oil, air or water supplies	—————→	Check and correct as necessary

7. OVERHAUL OF DYNAMOMETER

7.1 GENERAL

If the installation, operation & use, periodic maintenance and Do's & Don'ts are followed as per the recommendations, the dynamometer should give an approximate life of 5000 hours before first overhaul. A dynamometer should be due for overhaul because of its extensive use or in case of a breakdown of some internal components. Due to long use of the dynamometer, the internal moving parts wear out, bearings get worn and clearances / plays increase. Under such circumstances the operation of the dynamometer is not satisfactory and the dismantling, inspection of components, replacement of damaged / worn components becomes necessary. It is not recommended to overhaul a dynamometer, which is in good running condition and is giving trouble free service. Some of the unaccepted reasons for overhauling a dynamometer are –

- **To train the staff on overhauling procedure**
- **To engage the idle staff in some work**
- **To reduce excess inventory**

Overhauling of a dynamometer should be avoided for such reasons.

Downtime during the overhaul :

It is recommended to undertake the overhauling work when there is less workload in the slack period on production & testing. It is also recommended to ensure that the other dynamometers can take the load of dynamometer under overhaul. In order to finish the job in reasonable timeframe, the spares that need 100 % replacement such as bearings, seals, "O" rings, gaskets etc should be procured in advance and kept in stock. Also ensure that the necessary parts list applicable to the model is available to refer the correct part numbers to place order on SAJ. If the replacement of any critical part is known in advance it is better to confirm the availability of such components with SAJ.

Use of Replacement parts :

SAJ advises the end users to use only genuine SAJ parts for reliable & satisfactory performance of the dynamometer after overhaul. While ordering for the spare parts inform the factory following details –
Dynamometer Serial Number
Dynamometer model
Year of manufacture
Part No & quantity.

Note : It is better to consult or take the help of authorised Service Engineer of SAJ for the job of rebuilding.

The process of rebuilding of a dynamometer may be divided into five steps as below (refer fig. 2) :

- 1) Disassembly of the dynamometer
- 2) Observation & Cleaning of components
- 3) Inspection of the components
- 4) Decision regarding reuse, replacement or salvage of components
- 5) Assembly of the dynamometer

7.2 REMOVING CARCASE FROM BEDPLATE

1. Remove all water inlet piping to bedplate.
2. Remove the circlip & retaining bush from the bedplate water inlet.
3. Withdraw the transfer pipe through the bedplate water inlet.
4. Disconnect pipes between oil lubricator reservoir units & the carcase (oil mist lubricated machines only).
5. Remove the closing plate from the water outlet chamber.
6. Disconnect the hydraulic pressure pipe & the hydraulic drain pipe from the outlet valve. Plug the pipes to prevent contamination & loss of fluid.
7. Release the securing screws & withdraw shaft-bearing thermocouples (if fitted).
8. Remove outlet water temperature sensor (if fitted).
9. Un-screw pulse pick-up bracket & both trunnion bearing retaining rings.
10. Remove the trunnion bearing caps.
11. Screw two eyebolts (M12 X 1.75) into the two tapped holes in the top of the carcase.
12. Remove the circlips & pin from the top link of the load cell, & allow the load cell to swing down, ensuring that it is not damaged.
13. Remove the bearing spacers from the weigher arm.

14. Remove the carcass from the bedplate, paying attention to the hydraulic pump feed & pressure pipes.
15. Plug the hydraulic pressure & hydraulic drain tapping on the bedplate to prevent contamination.

7.3 DISMANTLING CARCASE

1. Remove the weigher arm.
2. Remove the backpressure valve. For overhaul of the valve see section 5.4.5.
3. Remove the outlet manifold.
4. Remove the inlet manifold.
5. Remove the retaining screw from the half coupling at the end of the shaft.
6. Mark the position of the half coupling in relation to the shaft.
7. Remove the oil injection fitted half coupling using the equipment described in section 5.10.
8. Remove the trunnion bearing retaining ring.
9. Remove the spacer from the shaft & attach it to the half coupling.
10. Remove the retaining screw from the half coupling.
11. Mark the position of the half coupling in relation to the shaft.
12. Remove the trunnion bearing retaining ring.
13. Remove the spacer from the shaft & attach it to the half coupling.
14. Undo the nuts around the periphery of the carcass.
15. Separate the two casings.
16. Remove the rotor & shaft from the casings.
17. Remove the wasted studs from the free-end casing.
18. Remove the bearing retainer & trunnion bearing.

19. Remove the shafts bearing, wave washer, catchment plate, circlip & thrower.
20. Turn the casing over & remove the stator retaining ring.
21. Turn the casing over & remove three sealed screws from the casing. Insert suitably long forcing off screws in the three tapped holes, gradually tightening each screw to push the stator from the casing.
22. Turn the casing over & remove the seal housing by unscrewing the three stainless steel screws.
23. Take the fixed-end casing & remove the bearing retainer & trunnion bearing. Label the bearing retainer "FIXED END".
24. Remove the shim pack from the bearing. Protect & label "OUTER".
25. Remove that shaft bearing.
26. Remove the shim pack from the bearing. Protect & label "INNER".
27. Remove the catchments plate, circlip & thrower. Label the components "FIXED END".
28. Turn the casing over & remove the stator retaining ring.
29. Turn the casing over & remove the stator as previously described in paragraph (21).
30. Remove the seal housing by unscrewing the three stainless steel screws.

7.4 CLEANING & INSPECTION

For grease lubricated machines all grease passageways & grease cups are to be packed with grease as specified in section 5.3.5.

1. Remove all the built-up deposits from the components, ensuring that all mating surfaces are clean.
2. Inspect components for wear & damage & replace as necessary.

3. Wash the trunnion bearings & inspect the races for damage. Replace if necessary. Repack the bearing with grease (see section 5.3.3) & protect.
4. Replace the shaft bearings. Pack the bearings with grease (see section 5.3.1) & protect. Pre-packed bearings can be obtained from SAJ Test Plant Pvt. Ltd. (Grease lubricated machines only).
5. If the rotor is to be replaced, see Appendix C for oil injection procedure, & section 5.10 for recommended oil injection pressure & drive-up force.

7.5 ASSEMBLING THE CARCASE

1. Take the fixed end casing (holes around the circumference) & place it such that the inside is uppermost.
2. Lightly grease & fit the "O" ring in the inner groove. Fit the seal housing, ensuring that the water inlet hole is aligned & the seal drain is to the bottom of the machine. Fit the three stainless steel screws & secure.
3. Lightly grease & fit the three "O" rings to the casing & seal housing.
4. Take the A vane stator (upper vane tips pointing to the left) & fit the lightly greased "O" ring to its periphery.
5. Align the dowel holes & lower the stator into position.
6. Fit the stator retaining ring. This will probably require the stator to be slightly pushed into the casing, to compress the "O" rings.
7. Take the free end casing & place it such that the inside is uppermost.
8. Lightly grease & fit the "O" in the inner groove. Fit the seal housing, ensuring that the water inlet hole is aligned & the seal drain is to the bottom of the machine. Fit the three stainless steel screws & secure.
9. Lightly grease & fit the three "O" rings to the casing & seal housing.
10. Take the B vane stator (upper vane tips pointing to the right) & fit the lightly greased "O" ring to its periphery.
11. Align the dowel holes & lower the stator into position.
12. Fit the stator retaining ring. This will probably require the stator to be slightly pushed into the casing, to compress the "O" rings.

13. Fit the twelve wasted studs in the periphery of the casing, the two longer studs are fitted next to the water inlet face.
14. Orientate the rotor & shaft such that the rotor vanes are in the same plane as the stator vanes. Lower the shaft through the casing.
15. Fit the lightly greased "O" ring & lower the fixed end casing over the studs onto the free end casing. Fit the washers & nuts, & tighten down.
16. Lightly grease the "O" ring & fit into the groove in the thrower labeled "FIXED END". Slide the thrower over the fixed end of the shaft.
17. Fix the three sealing screws in each casing.
18. Fix the circlip & catchments plate labeled "FIXED END" to the fixed end casing.
19. Lightly tap the thrower & catchments plate to ensure they are positioned correctly.
20. If any of the following parts have been replaced the rotor will require centralising; see section 4.10.6 & then move on to paragraph (24).
 - Rotor
 - Stator
 - Shaft
 - Thrower
 - Catchments Plate
 - Casing
 - Bearing Retainer
21. Fit the shim packed labeled "INNER".
22. Fit the shaft bearing, pre-packed with the required grease quantity, see section 5.3.1.
23. Fit the shim pack labeled "OUTER".
24. Fit the trunnion bearing shield & the trunnion bearing, pre-packed with the required grease, see section 5.3.3.
25. Fit the bearing retainer & secure.
26. Turn the carcass over.

27. Lightly grease the "O" ring & fit into the groove in the thrower. Slide the thrower over the free & shaft.
28. Fit the circlip & catchments plate.
29. Fit the wave washer.
30. Fit the shaft bearing, pre-packed with the required grease quantity, see section 5.3.1.
31. Fit the trunnion bearing shield & the trunnion bearing, pre-packed with the required grease, see section 5.3.3.
32. Fit the bearing retainer & secure.
33. Turn the machine so that the shaft is horizontal.
34. Place the trunnion bearing retaining ring over the fixed end shaft.
35. Tap the shaft as far as possible towards the fixed end.
36. Fit the spacer on the shaft, tapping it to ensure contact with the inner race of the bearing.
37. Slide the half coupling onto the shaft until it stops, ensuring its position marks align.
38. Measure the clearance between the spacer & half coupling. Ensure that the clearance lies between the minimum & maximum drive up distances (see section 5.10) & adjust if necessary. Normally this is only required when any components have been changed.
39. Fit the half coupling as described in section 5.10.
40. Fit the retaining screw to the end of the shaft.
41. Place the trunnion bearing ring over the free end.
42. Tap the free end bearing to ensure that it is in contact with the thrower.
43. Fit the sleeve over the fixed end shaft, tapping it to ensure contact with the inner race of the bearing.
44. Slide the half coupling onto the shaft until it stops, ensuring its position marks align.

45. Measure the clearance between the spacer & half coupling. Ensure that the clearance lies between the minimum & maximum drive up distances (see section 5.10) & adjust if necessary.
46. Fit the half coupling as described in section 5.10.
47. Fit the retaining screw to the end of the shaft.
48. Fit the outlet manifold to the carcass, using LOCTITE 504 SEALANT or equivalent.
49. Fit the gasket & butterfly valve assembly.
50. Fit the inlet manifold to the carcass, using LOCTITE 504 SEALANT or equivalent.
51. Fit the weigher arm.

7.6 REPLACING CARCASS IN BEDPLATE

1. Remove the trunnion bearing caps & all pipe plugs.
2. Lower the carcass into the bedplate, ensuring that the hydraulic pump feed & pressure pipes align.
3. Insert the bearing spacers. Swing the load cell up to the weigher arm & push the pin through the fork & arm. Fit the circlip.
4. Replace the trunnion bearing caps.
5. Remove the eyebolts from the top of the carcass.
6. Fit the pulse pick-up bracket & both trunnion bearing retaining rings.
7. Fit the outlet water temperature sensor (if fitted).
8. Insert the shaft bearing thermocouples & tighten the securing screws (if fitted).
9. Connect the hydraulic pressure pipe & the hydraulic drain pipe to the outlet valve.
10. Fit the closing plate to the water outlet chamber.
11. Reconnect pipes between the oil lubricator reservoir units & the carcass (oil mist lubricated machines only.).
12. Lightly grease the "O" rings of the transfer pipe. Insert the transfer pipe into the water inlet manifold through the bedplate water inlet.

13. Fit the retaining bush & the circlip in the bedplate water inlet.

7.7 CENTRALISING THE ROTOR

See separate drawing.

1. Position the carcass, with the shaft vertical & the fixed end to the top.
2. Ensure that the thrower & catchments plate are securely down by lightly tapping.
3. Ensure that the shaft is in its lowest position with the rotor touching the lower stator.
4. Measure the distance between the end face of the casing & the bearing face of the catchments plate (Dimension A).
5. Measure the distance between the end face of the casing & the bearing face of the thrower in this lower position (Dimension B).
6. Raise the shaft until resistance is felt. That is the rotor is touching the upper stator.
7. Measure the distance between the end face of the casing & the bearing face of the thrower in this upper position (Dimension C).
8. The required shim between the catchments plate & rotor is :

$$\frac{B+C}{2} - A = D \text{ the required inner shim thickness.}$$

9. The shim packs are 1mm thick, consisting of ten 0.1mm laminations. Measure & adjust the shim pack to suit. The tolerance on the shim thickness, D, is +/- 0.05mm.
10. Fit the inner shim pack.
11. Lower the shaft to its lower position.
12. Fit the shaft bearing pre-packed with the required grease quantity, see section 5.3.1, ensuring it is completely down.
13. Measure the distance between the end face of the casing & the outer race of the shaft bearing (Dimension E).
14. Measure the length of the spigot of the bearing retainer (Dimension F)

15. The required shim between the bearing & retainer is :

$E - F = G$ the required outer shim thickness.

The tolerance on the shim thickness, G, is +/- 0.05mm.

8. SERVICE

All communications concerning spares or service should state the order number stamped upon the dynamometer nameplate.

When ordering spares, as much information as possible should be given to ensure correct identification &, if possible, the part numbers on the illustrations should be specified.

If a dynamometer is returned to our works for repair, it must be clearly labeled so that it may receive prompt attention. The label should state the name of the customer, the nature of the work required & the number of the customer's official covering order. It is recommended that the Engineering Services Department of SAJ Test Plant Pvt. Ltd. Should be notified prior to the return of a dynamometer for repair.

Service Engineers, specialising in the mechanical or electrical aspects of this equipment, are available by arrangement to visit installations & undertake repair or adjustment at site. The customer is expected, in these circumstances, to provide rough labor & lifting facilities &, if necessary, to place the equipment in an accessible position. It is important to state clearly the nature of the service required so that the appropriate specialist(s) may be sent. Weekends & holiday periods should be avoided whenever possible.

All requests for assistance should be directed to the following address:

**SAJ Test Plant Pvt. Ltd.
72/76 Mundhwa,
Pune Cantonment,
Pune - 411036 (INDIA)**