ENGINEERING MANUAL

PHARMA MANUFACTURING,

1.0 INTRODUCTION

This Engineering Manual has been prepared to provide information on facilities available in Engineering Department in respect of Utilities, like Steam, Water, Electricity and list out various systems used for Preventive Maintenance and Breakdown Maintenance of Plant and Machinery.

Company name and address, Industrial Area, covers approximately …….. sq. mtrs. and has manufacturing and packaging facilities for various Injectable products. The Plant has facilities for manufacturing of Oncology and Non Oncology products. The site has centralized utilities section with diesel generators, compressed air plants, air dryers, chilling plants and water systems.

Each equipment system is validated prior to use. Validation includes Installation Qualification (IQ), Operational Qualification (OQ) and Performance Qualification (PQ). IQ, OQ and PQ is done by a team consisting of Representatives from Production, Quality Assurance, Engineering and Validation Departments. Protocols for IQ and OQ check the compliance of installed equipment to the design specifications. These also ensure inspection of physical installation to ensure that they comply with cGMP's. Various parameters are checked as listed in the protocol.

Normal maintenance of premises is carried out by the Engineering and maintenance department but contractors are used in special cases and for major repairs. A calendar for preventive maintenance of equipment is available for carrying out preventive maintenance as per respective SOPs. These procedures give details of periodicity of preventive maintenance and special check/ replacement to be done. Details of such maintenance are recorded suitably.

2.0 DESCRIPTION OF PHYSICAL FACILITIES

2.1 GENERAL

This section provides a brief description of Engineering and Maintenance Department of …….. The Plant has centralized utility section consisting of two diesel generating power sets, Air Conditioning Plant, Air Compressors, purified water system, and pure steam generator. The department has self contained facility for any repair and modification jobs. It also has an instrumentation laboratory for calibration.

2.2 D.G. ROOM

This room house has two power generating D.G. Sets of capacity 320 KVA of Kirloskar Cummins Make Model KT-1150-G. The D.G. Sets are operated as per SOPs. The preventive maintenance of these equipment is carried as per the preventive maintenance schedules. These equipments are operated only during periods of power shortages.

The walls are constructed of brick, plastered to provide a hard, smooth finish and painted with plastic emulsion. The floor is concrete and the ceiling is concrete, plastered and painted with plastic emulsion.

2.3 POWER SUB-STATION

This room is consist of one Vacuum Circuit Breaker of capacity 630 Amperes and Eleven KV Voltage of Crompton Greaves Make. One transformer of capacity 1000 KVA is installed adjacent to the substation.

The substation consist of Power Control Centre having three numbers Air Circuit breaker of capacity 1600 Amperes and 800 Amperes(two). This feeds power supply to various M.C.C. Panels in the plant.

The walls are constructed of brick, plastered to provide a hard, smooth finish and painted with plastic emulsion. The floor is concrete and the ceiling is concrete, plastered and painted with plastic emulsion.

2.4 AIR CONDITIONING PLANT

Oncology Block

This consists of three compressors of Kirloskar Make, Model A.C.570 having capacity of 40 TR each. It also consist of one hot water generator of Thermax Make, Model ATW-01 with the capacity of 100000 K cal per hours. This system controls required temperature and relative humidity conditions.

Non Oncology Block

This consist of two compressors of Kirloskar Make, Model KC-II having capacity of 40 TR each. These equipments are operated as per SOPs. The preventive maintenace of these equipment is carried as per the preventive maintenance schedules.

2.5 AIR COMPRESSORS

The plant has two Air Compressors of ELGI Make, Model TC-1000 of capacity 50 m^3 / hour each and another air compressor of Ingersoll make, Model ESV 5x7 of capacity 100 cfm. The air compressor are provided with drying units of capacity 200 cfm. These equipment provide compressed and dried air supply to various equipments in the plant.

2.6 WATER SYSTEM

Natural Water is taken from the Bore Well and passed through Dual Media Gravity Filter. The resultant water is used as Raw Water for general use and as feed water to the Soft Water, Demineralised Water Plants.

Prior to the Softener Plant, the raw water is passed through an Activated Carbon Filter. The resultant Soft Water is used at various sites within the facility. The Soft Water and the Raw Water are stored in Tanks, each of 5000 Litres capacity.

2.6.1 Demineralised Water Plant

The Demineralised Water Plant also has the Raw Water as its feed. The Raw Water is filtered through a activated carbon filter, passed through a strong Acid Cation Exchange, next through a strong Base Anion Exchanger followed by a cation polisher, to give Demineralised Water. This demineralised water is stored in 4000 and 2000 litres tanks.

2.6.2 Water for Injection Plant

The Demineralised Water is used to feed the Multicolumn Distilled Water Still, for the manufacture of Water for Injection. The method is that of fractional distillation, by the use of baffles. This Water for injection is made as per USP specifications, and stored in a 500 and 1000 Litres capacity tanks, which has adequate insulation and heating facility to maintain the stored Water for Injection within 70-80°C. The Water for Injection is used for solution preparation, rubber plug washing and Vessels/ Equipment washing.

3.0 SAFETY

A number of solvents are used in our plant. Some of them are corrosive and hazardous in nature while the others are highly inflammable or explosive. If proper precautions are not taken during maintenance, many of these solvents can cause internal or external injuries or can start a fire and pose danger to life and property. Therefore, it is necessary to take all safety precautions before starting any work in the plant. All accidents and injuries can be prevented. Each of our employees have the responsibility to work safely and avoid injury to himself and fellow employees. Safety has its own important role to play whether one is on the job in the plant or off the job, at home.

3.1 ***Basic Safety Rules***

For the safety of the employees, basic safety rules have been framed and it is essential that all employees strictly adhere to these.

3.2 ***Personal Protective Equipment***

For doing specific operations in the plant, personal protective equipment have been made available to employees. It is necessary for employees to wear the personal protective equipment as per the job requirement. The equipment available for use include safety glasses, uniforms, helmets, hand gloves, shoes, gum boots, face-shields, ear muffs etc.

GENERAL SAFETY RULES

i) **HOUSE KEEPING**

a. Work place and surrounding areas shall be kept clean and free from all obstruction.

b. On completion of job all tools, equipment and leftover material shall be removed to the designated places of storage.

c. Waste, oily rags and other inflammable materials shall be removed and kept in proper receptacles.

d. Nails, planks tools with producing nails and such objects shall not be left on floor.

ii) **WEARING APPAREL**

No person working on or near moving machinery shall wear loose clothing. All persons engaged in oiling or cleaning of machinery shall put on tight fitting clothes (overalls). Shoes and boots must be properly laced. The safety apparel to be worn shall be specified in the work clearance by the Department concerned.

iii) **PERSONAL PROTECTIVE EQUIPMENT (PPE)**

PPE like goggles, face shields, aprons, gloves, safety shoes, helmets, etc. are issued for personal protection for jobs where special hazards exist.

iv) STACKING OF MATERIALS

All material shall be stacked tidily and upto a safe height to prevent them from falling or causing some other piles to fall. No material shall be stacked in passages, aisles and emergency exits. Bags containing solids/powders, cardboard boxes containing finished goods shall be stacked in a criss-cross fashion to have good stack stability.

v) EYE PROTECTION

a. Goggles or face shield must be used by all personnel engaged in operation involving hazards to eyes. These operations shall be identified by the respective departmental heads.

b. Keep the lenses clean, they should not develop scratches.

c. Safety goggles should never be left with the lenses in contact with hard surfaces such as table tops, tools etc.

vi) SAFETY BELTS

All employees working on elevated places, not adequately protected by railing or suitable enclosure shall wear Safety Helmet and safety belt with line line tied securely to a firm structure or other support independent of the equipment on which they are working.

vii) **DEFECTIVE TOOLS**

a. All defective tools e.g. chisels with mushroom heads, spanners with worn jaws, broken file handles, hammers with broken shaft etc. shall be brought to the notice of the Engineering In-charge and discarded. The Engineering In-charge shall inspect the tools and shall arrange appropriate replacement of the tools.

b. No tools shall be put to use for which they are not meant e.g. Hack-saw blade for tightening screws.

viii) **GUARDS**

a. Machine guards and other safety devices shall not be removed except for making repairs, lubricating or cleaning and that too only by authorised persons. These must be replaced before starting the machinery.

b. Willful defeating of safety devices such as limit switches is a punishable offence and attracts disciplinary action.

ix) **STARTING AND REPARING MACHINERY**

a. No person shall attempt to operate or set in motion any machine or equipment for which he is not authorised.

b. Oiling, cleaning or repairing of machinery shall not normally be carried out without first stopping the machinery completely. Where it is necessary to examine any part of the machinery, while it is in motion or to carry out lubrication or other adjustment operation, such work shall be done only by specially trained workers wearing tight fit clothing.

c. No person shall switch on electricity, turn on gas, steam/air/acid or set in motion any machinery without first making sure that no one is in a position to be injured.

d. All exposed moving parts of a machinery such as pulleys, belts, couplings, chains, Fly-wheels, rotating collars with projecting set screws etc. shall be properly guarded.

x) ELECTRICITY

a. No work shall be done on or in close proximity to electric supply line and apparatus without the approval of competent authority.

b. The use of defective plugs, sockets and flexible cables shall be avoided. All broken or missing covers of switches etc. shall be replaced.

c. No one except a person duly authorised by electrical section (Engg. Dept.) shall operate any switch gear or other electric equipment except for routine starting and stopping of motors and switching on or switching off lights and fans etc.

d. The repair to electrical apparatus and electric supply lines shall not be carried out by unskilled men and without effective isolation of supply. Necessary precautions to prevent accident or inadvertent charging are to be ensured.

e. The use of water or foam type chemical fire extinguishers for extinguishing electrical fires shall be strictly avoided and Co_2 type of fire extinguishers is used for dealing with electrical fires.

xi) **LADDERS AND SCAFFOLDS**

a. Ladders with broken and missing rungs or split side rails or otherwise defective shall not be used.

b. No metallic ladders shall be used for electrical work or any work to be executed in close proximity to the electric supply lines or apparatus.

c. Ladders shall rise sufficiently above the place of landing and shall be securely tied at the top with rope or held at the foot.

d. The use of defective scaffolds shall be strictly avoided. All scaffolds shall be inspected by the person in-charge of the work before commencement of work.

xii) HANDLING AND STORAGE OF GAS CYLINDERS

a. Cylinders of compressed gas either flammable or otherwise can be lethal if they are mishandled or misused.

b. Care must be taken in all aspects of their use, particular attention must be paid to the care of valves and regulators.

The following precautions are mandatory :

1. The oxygen and acetylene cylinders shall not be stored together.

2. Gas cylinders shall be stored upright.

3. The full and empty cylinder shall be kept apart to prevent confusion and mistake.

4. No valve or fitting on a gas cylinder shall be lubricated. The cylinders and fittings shall be kept away from oil and grease during storage and handling.

5. The LPG cylinders shall be stored under cover, away from the direct rays of the sun and the store room shall be properly ventilated.

6. Filled gas cylinders shall not be rolled on the ground. These shall be moved on cylinder carts or trolleys.

xiii) WELDING AND GAS CUTTING

Welding and gas cutting operations, soldering shall be prohibited in proximity to material and plant where inflammable liquids, gases etc. are likely to be present or given off, except with special precaution. No naked flame shall be introduced except in canteen, laboratory Bunsen flame and welding operations in the premises of Engg. Work-Shop.

xiv) VEHICLES

a. All vehicles shall comply with traffic regulations within the factory and they shall not exceed the speed limit of 20 km/hour.

b. Riding on hand trolleys, battery trucks strictly prohibited.

c. Riding on a running vehicle or any part of the vehicle except on a proper seat is strictly prohibited.

d. Sitting on the side flaps or standing in a truck while in motion is strictly prohibited.

xv) SMOKING

Smoking is strictly prohibited in the factory premises and any violation shall be a punishable offence. All the personnel shall deposit the match boxes and lighters at the gate with security. In case of visitors it is the persons/section visited, who shall ensure that the visitor does not error.

xvi) FIRST AID BOXES

First-aid boxes shall be provided in suitable places in every department.

xvii) HEALTH

Any contagious or communicable disease suffered by the employee shall be intimated to the Management by the Individual. Food, water and beverages shall be taken at designated places only.

xviii) REPORTING OF ACCIDENTS

Whenever an injured person is required to be sent to the hospital for treatment, the executive on duty should prepare a report and send it to security with a Tele-Communication to the Production Manager, Personnel Manager and Manager Security and Administration.

4.0 BASIC FIRE FIGHTING

In Chemical Industry like ours, using large quantities of solvents and other flammable materials, fire is a continuous potential hazard and all out efforts should be made to prevent its occurrence.

Definition of Terms

Flash Point : It is the lowest temperature at which a liquid gives off enough vapors which can catch fire if ignited. For example flash point of acetone is 0°F.

Explosive range or inflammability limits : Each material has lower and upper flammable limits which are minimum and maximum % volumes of the vapor in air which can be ignited. These are abbreviated as LEL (Lower Explosive Limit) and UEL (Upper Explosive Limit). Below LEL there is not enough air for the material to catch fire. Information about the flammability of various chemical compounds is available in literature but in its absence, the formula gives a clue to its fire hazard. For instance all material composed of solely carbon and hydrogen are combustible and those with low boiling points flammable.

Vapor Density : It is the ratio of density of vapor to the density of air. The vapor of most flammable liquids e.g. ether etc. are heavier than air, and therefore they can flow into low areas. Hence, ventilating outlets in a plant should be located near ground level. For flammable gases or vapor which are lighter than air, ventilating outlets should be near the ceiling.

PREVENTION OF FIRE

Earthing of Containers - Organic solvents develop electrostatic charges due to friction etc. and static spark can set the solvent on fire. This is particularly the case during low humidity condition. Therefore all organic solvent containers should be kept well earthen in order to minimize static sparks.

FIRE FIGHTING

The risk of fire can be minimized but cannot be totally eliminated. If a fire does occur, the employees should have adequate knowledge and training for fire fighting or extinguishing the fire. The four classes of fire and the ways to extinguish them are given below;

Class A Fires :

They involve combustion of materials like wood, paper, cloth, plastic and can be extinguished by water by combined effects of quenching and cooling.

a. Carbon-dioxide extinguisher gives out CO^2 to extinguish the flame.
b. Dry chemical extinguishers utilize a number of methods for excluding oxygen.

Class B Fires :

These involve combustion of flammable liquids. Such fires can be extinguished by spraying water if the burning liquid is miscible with water e.g. methanol, ethanol but for others, fire extinguishers to be used are :

Foam Type extinguisher spread a layer of durable foam over the burning material and exclude air (oxygen).

Dry Chemical extinguishers utilize a number of methods for excluding oxygen.

Suitable fire extinguisher have been placed at strategic locations for this purpose.

Class C Fire :

These are caused in live electrical systems and can be extinguished by Class B extinguishing agent given above. Water cannot be used on account of it being a conductor of electricity.

Class D Fires

These are caused by the reaction of water with active metal alloys or metals like Sodium, Potassium, Magnesium, Titanium and Lithium. Following agents are used to extinguish this class of fires.

i. Fine Sand is very effective for small metal fires which may take place in laboratory.

ii. Mixtures of salts(NaCl) and polymeric binder can also be used. When applied to the fire the plastic melts, sealing the fire in a thick layer of salt.

iii. If the metal fire is confined in a limited volume, displacement of oxygen with an inert gas like nitrogen is helpful.

By way of training regular fire drills are held in the plant to sharpen workers reflexes and also to demonstrate operation of the fire extinguishers. The table On the next page shows which fire extinguisher should be used for a particular Fire situation.

SELECT THE RIGHT EXTINGUISHER

Type	Extinguishing Agent	Effect	Method	Suitability on the type of Fire				
				General	Inflam-able	Gaspeo-us LPG	Metal	Electri-cal
				Paper, wood, cloth & other organic matl.	Liquid, oil and gasoline chemical paint & solvents	Acetylene	Metals Sodium, Mg, K etc.	Electric fires motors, switch wires etc.
				A	**B**	**C**	**D**	**E**
Soda Acid	Liquid Soda, Solution / Water	Striking and cooling	Striking the plug knob against any hard surface & direct the jet at the base of the fire	Yes	No	No	No	No
Foam	Chemical Foam	Blanket ing	Unlock the bayonet & invert the extinguish er. Direct the jet at the base of fire.	No	Yes	No	No	No

Dry Chemical	Dry Chemical Powder	Blanketing	Remove the safety clip, strike the knob and direct the discharge at the base of the fire.	No	Yes	Yes	Yes	Yes
Carbon Dioxide	Carbon Dioxide Gas	Blanketing	Remove the locking pin, unscrew the valve and direct the discharge at the surface of the fire.	No However Can be used on small surface	Yes	Yes	No	Yes

5.0 MAINTENANCE SYSTEM

Maintenance of the utility systems and plant equipment is carried out as per written down Standard Operating Procedures and schedules i.e.

1. Running/breakdown maintenance of plant equipment and system as per job orders and work permit.
2. Preventive and routing maintenance/checks to be carried out as per schedule.
3. Major overhauls/servicing to be carried out as per requirement.

A. Breakdown maintenance is carried out whenever breakdown repair or any other work is required to be done in the plant. The occurrence or job is intimated to the Maintenance Department through a job order.

Job Order

The purpose of job order is:

i. To establish adequate and proper communication between the concerned departments regarding the job.

ii. To provide safe working conditions.

iii. To ensure that the job is completed in all respects and tried out to the satisfaction of plant personnel.

iv. A basis to get the equipment history cards updated and maintain other records.

v. To obtain feed back for breakdown/repair analysis and spare parts planning.

B. Preventive Maintenance

All equipment's require regular care and upkeep. A neglected equipment is prone to:

a. Frequent breakdowns
b. Poor performance

a. **Break downs result in :**

i. Unavoidable damage to the equipment.
ii. Excessive wear and tear
iii. Excessive down time
iv. Loss of production
v. Expensive repair

b. **Poor performance result in :**

i. Inadequate capacity utilization
ii. Energy loss.

To minimize breakdowns and maintain equipment in a healthy conditions, preventive maintenance system needs to be adopted. Dabur has a comprehensive and well defined preventive maintenance, program in which all the equipment's of the plant are required to be checked and lubricated periodically as per Standard Operating Procedures (SOP) on maintenance.

Preventive Maintenance is carried out to ensure uninterrupted optimum performance and to minimize downtime. It is also a base of a well planned maintenance system.

6.0 PROCEDURE TO TAKE UP MAINTENANCE OF AN EQUIPMENT

Following are various procedures which must be followed before starting any job.

1. Inspection

It is carried out to know about the defects in the equipment. The inspection of the equipment is carried out in three stages.

a. Initial Inspection

This checking of equipment is carried out before starting of any repair. This will help in finding fault/defect in the equipment. This will also help in as certaining the type of repair required and in planning the tool requirement.

b. Detailed Inspection

After dismantling the equipment all the parts should be cleaned and thorough inspection to be carried out for carrying out the repairs. This also establishes the condition of wear on the part and parts to be replaced. Each break down should be analyzed an steps to avoid the same should be chalked out and taken.

c. Final Inspection

This is done after the completion of the job. This is to ensure that job is completed in all respects.

Important : It should be ensured that all the dismantled parts especially small items like keys, nuts, bolts, O-rings, Mechanical Seals are stored in a container and at a proper place to avoid their mis-placement.

Following may be followed for all maintenance jobs :

Inspection - Inspection of equipment's should be carried out as above.

Cleanliness - A mechanic should keep his tools and area of work clean. During overhaul and repair the equipment should be cleaned so that the detailed inspection could be carried out.

Safety - While carrying out any job basic safety rules must be followed. It must be ensured that the job is carried out with proper tagging and isolation as per safety guidelines. Always use protective gears as specified.

Minor repairs/maintenance jobs are carried out at site only after proper tagging and electrical isolation.

In case of major fault and in case the equipment is to be shifted to workshop proper marking on matching parts should be put.

As pointed out earlier all the dismantled parts like keys, nuts and bolts etc. are to be stored in a container.

Proper tools must be used for dismantling of equipments

Immediately after dismantling a list of requisite spares should be made and drawn from store. Any non-available item to be brought to the notice of Engineer.

Any repair, which require outside facilities should be brought to the notice of the Engineer.

After all the items are available, the equipment should be assembled in a systematic way and with proper tools.

After fitment it must be ensured that the job is completed in all respects i.e.

a. Job repaired/equipment overhauled.

b. Proper installation and connections done.

c. Safety guards in position.

d. Equipment is cleaned.

Final trial to be taken in the presence of production officer/ supervisor.

All the surplus items, tools or removed parts, materials should be removed from the place of work after completion of the job.

Work Order format to be completed and handed over to Engineering In-charge.

7.0 REDUCTION GEAR BOXES

Reduction gear boxes are very important medium of transfer of power. With the gear boxes, number of RPM can be decreased or increase.

In our plant all worm shaft type gear boxes are being used. These gear boxes are available indifferent reduction ratios and are designed as under :

- Output shaft vertically downward.
- Output shaft vertically upward.
- Output shaft horizontal.

In these gear boxes, input is through worm shaft which transmit power to worm wheel which is keyed to output shaft.

Following type of breakdowns are mostly observed in these reduction gear boxes.

- Faulty bearings
- Worn out/damaged gears
- Gear mis-alignment
- Defective oil seals

Following are the precautions and maintenance checks, which should be carried out while checking the gear boxes.

- Oil Level
- Vent hole/breather hole
- Oil seal leakage
- Coupling bolt/bushes/coupling pad
- Alignment
- Foundation bolts/Coupling guard

Following minor repairs can be carried out at site only :

- Mis-alignment
- Coupling bushes replacement
- Air breather cleaning
- Foundation bolts tightening

For any major repair like changing of bearings, replacement of oil seals, worm wheel, worm shaft replacement etc. the reduction gear box is to be brought to the workshop. The gear box should be assembled after checking the axial float and backlash.

The axial float on the worm shaft and wheel should not exceed 0.15 mm This float can be adjusted by adding or removing shims in the end covers.

8.0 PUMPS

Pumps are the most important equipment for transfer of liquids. Following are the usual problems which are encountered in these.

- Bearing failure
- Gland leakage
- Coupling pad, bush damage
- Leakage from mechanical seal
- Foundation bolts tightness.

Mis-alignment

In the pumps some jobs can be carried out at site and for certain jobs the pumps are to be taken to the workshop.

i. Site Jobs

This consists of minor repair jobs which can be carried out at site. These jobs are :

Repackaging of the glands is done partially if the condition of existing packing is good i.e.

- Soft and lubricated.
- In case the packing have become hard and burnt then complete packing is to be renewed. For proper job, the following points are to be taken care.
- Complete old packing should be removed from stuffing box.
- Check condition of the sleeve of the shaft, in case shaft is worn out, it should be changed/repaired.
- Check cooling system of the stuffing box for proper circulation.
- The packing joints should be cut at 45°C.
- The packing joints should be staggered to ensure proper sealing.
- Right size of packing should be used.

Coupling pad/bush replacement

This job can be done at site. After the pad and bushes are replaced, the alignment of the coupling should be checked.

Foundation bolts tightness, Flange leakage's job can also be taken up at site. In addition to above, cleaning of cooling jackets, in case of jacketed pumps, cleaning of suction filters in the pipe lines can be carried out at site.

i. Workshop Job

For overhauling and all other major repair jobs pumps have to be dismantled and taken to the workshop for checking the following :

a. Impeller

Corrosion/Erosion of the impeller or damage to vanes of the impeller to be checked and rectified if possible. Condition of the impeller hub key way and key should also be checked properly.

b. Stuffing Box

Condition of gland bush, gland follower, holding down bolts and lantern ring condition, should also be checked and rectified.

c. Mechanical Seal

In case of mechanical seal the shaft sleeve seal faces, matching faces, spring condition and elastomers should be checked. The faces require lapping it should be carried out.

d. Shaft of the pump should be checked for straightness

In addition to the shaft, the sleeve portion of the shaft should be in healthy condition. The sleeve should have smooth finish and should be free of any grooves.

In addition to above, the portion of shaft where bearing or oil seal is fitted, should be checked. Bearing housings should also be checked for any damage or looseness. Threads on the shaft and lock nuts key way and key should be proper.

Important

- All parts should be cleaned before assembly. Any burrs on the shaft should be removed.
- All running clearance should be checked and maintained.
- Bearing should be of proper size and these should be press fit on the shaft as well as housings.
- Assembly should be done as per standard procedure.
- After installation of pump, all the spanners, bolt, nuts, old gaskets etc. should be removed from vicinity of the pump.

Alignment

For continuous and long life of any equipment, accurate alignment of drive and driven equipment is very important. With proper alignment, an equipment can give longer service without any problem. Mis-alignment results in short bearing life as well as frequent damage to coupling pad and bushes.

The pump and motor are placed on machined surfaces, shims are placed under the feet to facilitate adjustment. For alignment straight edge and feeler gauges are used. For proper and accurate alignments, dial gauges are used. Mis-alignment are :

Following procedure is followed for setting the alignment :

a. Both the coupling halves are disconnected. The bolts are removed.
b. Minimum gap of 3.0 mm is kept between the couplings.
c. Revolve the coupling by hand. Check whether faces and O.D. of the coupling are square and concentric.
d. Ensure that the coupling halves are properly fixed and locked with shafts.

i) For doing radial alignment, put straight edge on the coupling halves, revolve the coupling by hand and measure any gap at top, bottom and both sides. The straight edge should rest evenly on the coupling at all the positions. Correction of gap on top and bottom is done by providing or removing the shims under-neath feet of motor/pump.

ii) For doing the axial alignment, gap between the couplings is measured by the feeler guage the gap between couplings, while revolving the couplings at the top, bottom and side position should be same. The gap is adjusted while putting shims between front or rear feet of the motor/pump.

For accurate alignment, dial gauge with magnetic base can be used. For specific requirements, clamps can be made and dial guage can be used with clamps. The magnetic base is mounted on the pump and half of the coupling. The pointer is adjusted so that indicator rests on driver half. Ensure that fixing is rigid and needle is square.

Set the dial to zero. Mark the pointer touching with chalk. Rotate both the halves of coupling together with pointer button resting on the chalk mark.

- Mount the magnetic base on the pump half of the coupling.
- Adjust the pointer so that indicator rests on driver half.
- Ensure fixing is rigid and needle square.
- Set the dial to Zero.
- Mark the pointer touching with chalk.
- Place both halves of coupling together with pointer resulting on chalk mark.

Take the reading of the dial at every 90° of rotation, note this down.

The maximum deflection is adjusted while putting shims under underneath the motor/pump. This is done till reading is within tolerable limit. For parallel alignment, base of dial indicator is mounted on vertical face and pointer rests on face of other coupling. Again the readings are taken till the same is within tolerable limit.

9.0 V.BELT

V. Belts are very important media of transmission of power. The V-Belts are available in Sections A, B, C and D. Following must be taken care of while fitting V-Belts :

a. Select a proper size of V-Belt. For larger sizes, match nos. are usually put on the V-Belts. These match number should be taken into consideration while putting a set of V-Belts in a multi-grooved pulley. The V-Belts should have three consecutive match numbers otherwise one belt will get tightened, other will sag.

b. Correct tension should always be maintained. Loose belts will slip and cause excessive wear on sheaves.

c. Loose fitted V-belts also result in excessive power consumption.

d. V-grooved pulleys should be properly aligned. Improper alignment also causes excessive wear on sheaves and reduces life of V-belts.

e. Belt tension is checked by pressing belt. A correct tension belt can be pressed equal to belt thickness for each 1.25 mt. Center to center distance or should deflect 16 mm for every meter of center to center distance.

f. For checking the alignment, the distance between equipment and motor shaft should be same. That means shafts should be parallel. The drive and driven sheaves are properly aligned by help of a string. When fully tight the string will touch at two points across the face of the sheaves.

g. The sheaves groves should be smooth and uniform. The sheaves/groves must be free from oil.

h. For fitting V-belts, the motor or prime move should be moved towards the driven unit so that V-belts may be placed in their respective grooves by hand. The motor or prime mover is then moved to apply uniform tension to the belts.

i. Under no circumstances should V-belts be forced on to pulleys with crowbars, wedges, screw drivers etc. Such procedure would tend to damage the V-belts thereby reducing their life.

j. A new belt tension should be rechecked after the drive has been running for a few days as the belt tend to become loose after acquiring proper tension.

k. Make adequate provision for tensioning of belts periodically.

10.0 LUBRICATION

When two surfaces having motion come in contact, the frictional force is generated which generates heat. With lubrication, the heat is dissipated. The function of lubrication is to decrease friction by preventing direct contact of rubbing surface. A lubricant creates a fluid film which separates the surfaces in contact.

The lubricants like lubricating oil, grease etc. are chosen depending upon the various working conditions e.g. speed, load, temperature etc. It is very important to use right kind of lubricant for any service. Proper lubrication is essential and most important for trouble free operation of any machinery.

For lubrication following must be taken care of :

- For any new machine always check with Engineering In-charge which lubricant is to be used and the quantity.
- Never mix two grades of lubricants.

- Always fill right quantity of oil in the equipment. Normally all the equipment come with level indicator. In case these indicators are not available dip stick arrangement should be provided.

- Excess oil filling will lead to oil seal damage whereas less oil will damage the bearings.

- Level sight glass should be cleaned regularly.

- While overhauling, the oil or grease parts of any equipment should be cleaned.

The lubrication of all equipment in our plant is to be carried out strictly as per SOP.

11.0 VALVES

A valve is a device by which flow of a liquid or gas in pipeline is regulated or isolated. The valves are available of different design and types.

- Where flow is required to be regulated globe valves or diaphragm or butterfly valves are used.
- Where flow is required to be completely on or completely off, gate valves, Ball valves are used.

Following main type of valves are being used in our plant for different services.

- Forged steel valves : These valves are used for steam and hot services.
- G.M. Valve : These valves are being used for service water, chilled water, brine service and air service.
- S.S.Ball valve : These valve are used for water lines.
- Diaphragm valve : These valves are used for water lines.
- C.I or Carbon Steel Valves : These valves are bigger in size and used for any liquid services.

In addition to above following valves are also available ;

- S.S/G.M –NRV's
- Pressure relief valve

Gate Valves : These are used for fully opened or closed non throttling service and in frequent operations. Its feature are minimum resistance to flow with less turbulence within the valve and very little pressure drop and fluid trapped in line.

Globe valve, Angle valves, Needle valves : Are used primarily for throttling services to control flow and where the service is frequent. Needle valves are normally used in instruments where very accurate throttling is required. The features are efficient flow control with minimum seat erosion.

Ball valve : Are primarily designed for on-off service for minimum resistance to flow, quick opening and frequent operations. Its feature are same as gate valve.

Diaphragm valves : Are recommended for fully opened, fully closed or throttling service, handling of slurries, highly corrosive material, high purity, fluids and low pressure service.

Non-return or check valve : To prevent the reversal of flow in a piping system. These valves are activated by the flowing material in the pipe line.

Maintenance Checks :

All the types of valves are checked as under :

a. Operation of the valve should be smooth and easy.
b. Spindle wheel should properly fit on the spindle and should be locked.
c. Gland packing should be done properly and adequately.

d. Lubrication of valve spindle and threads should be regularly carried out.

e. Check the valve whether this is holding or not. In case it is not holding, seats can be placed.

For doing above job valve should be dismantled and the internal parts should be cleaned thoroughly. The valve after lapping etc. should be assembled.

f. Apply only adequate pressure while shutting the valve. Excessive pressure or over tightening will damage the spindle. Do not fully open the hand wheel of a gate valve to avoid jamming in open position.

Important

Before dismantling any valve from line, the line must be isolated and properly tagged.

12.0 MECHANICAL SEALS

Mechanical seal is an efficient way of sealing any liquid from a moving part. The sealing is done with the help of two anti-frictional matching rings. One ring rotates with the rotating part whereas the stationary face is fitted on stationary part. The two faces are held together with the help of springs.

Mechanical seal eliminates leakage's which normally occur in gland packed equipment. Because of this, these seals are extremely used in chemical/process industry. These seals can be designed to suit vacuum service also. With the help of seal, wastage of expensive chemicals, solvents etc. could be avoided.

For long and trouble free service of the seal, following should be taken care of while installation of any seal;

a. Shaft straightness must be thoroughly checked.
b. Shaft sleeve on which seal is fitted should have very good smooth finish.
c. Before installation, the pump or equipment should be overhauled.
d. Run out the shaft on the seal portion should be measured and should be less than 0.08 mm.
e. After the seal is installed on the equipment, the equipment should be put on foundation. Proper alignment with dial gauge should be done to avoid vibrations.
f. The seal lubricant should always be there in the seal. The seal must have a constant oil level indication to show the level of seal liquid.

Installation and Maintenance of Mechanical Seals

A major role is played by the installation procedures and equipment condition in deciding the life of a particular mechanical seal. The first stage in installation of a mechanical seal is equipment inspection.

Equipment Inspection

With the help of a dial indicator check the following :

a. The radial reunite of shaft in seal area should not exceed 0.003 inch or 0.08 mm.

b. Axial end play of the shaft should not exceed 0.005 inch or 0.125 mm.

c. The stuffing box face should be square (at right angle) with the shaft within 0.002 inch or 0.05 mm.

d. Stuffing box bore should be concentric with the shaft within 0.002 inch or 0.05 mm.

The above check points usually decide the seal life and hence they should be observed strictly.

In actual practice there can be deviations due to any of the following reasons :

A bent shaft: Mount the shaft between centers on a lathe machine and check with dial indicator. If found bent, replace it.

Worn out bearing: It is usually practice to replace the bearings before installing a mechanical seal. The shaft may run out giving excessive vibrations resulting into face separation and subsequent leakage if the bearings are worn-out.

Improper fitment of bearings: If the shaft is not properly locked in both axial as well as radial directions, it may give excessive run out. It is important to adopt correct fitment procedure of bearings to avoid excessive radial or end play.

Apart from above, following checks should be made regarding general conditions of the equipment.

a. Stuffing box must be clean of foreign matter that might harm the seal.

b. The stuffing box face must be free of sharp edges and the surface capable of being sealed by a gasket of 'O' ring.

c. Shaft/sleeve must be free of sharp edges or burrs. If there are any, polish them with emery cloth until smooth.

d. Deep scratches on shaft or sleeve should not be in the area over which the secondary seal will travel during installation.

e. A gradual chamber should be provided at the corners so the elastomer is not damaged while it is pushed on to the shaft or sleeve.

f. When a sleeve is used, there should not be any radial play between the shaft and the sleeve bore. Excessive clearance between the two will give rise to radial run out of the sleeve.

Installation :

Following are the general guidelines for proper installation of mechanical seal.

a. Installation drawing of the seal is most important. Always insist on a proper assembly drawing as a quick reference guide before starting the installation of any mechanical seal.

b. Study the drawing carefully, understand the basic design and materials of the seal and look out for special instructions regarding installation, lubrication, auxilliary arrangement like flushing, quenching, cooling, heating etc. Decide a tentative action plan to carry out the installation in all respects with a special attention on sequence of assembly and provision of auxillary systems.

c. Check the mechanical seal and make sure it is as per the drawing supplied by the manufacturer.

For final fitment of the mechanical seal on the equipment following are the generalized steps for fitment of seal.

a. Assemble the pump with shaft sleeve, stuffing box, impeller in position and mark the reference point on the shaft/sleeve as shown in the reference drawing.
b. Dismantle the pump.
c. Measure back from reference mark the required length of the seal assembly as per the assembly drawing and mark there.
d. Place stationary face into the gland. If it is press in type, apply lubrication to the elastometer and press the seat into the gland.
e. Lubricate the shaft and secondary seal.
f. Slide the rotary unit on shaft until back of the seal is in line with the second marking line on the shaft/sleeve.
g. Reassemble the pump
h. Bring stationary seat and gland into position and bolt it to the stuffing box
i. When seal assembly is complete, connect all the pipings.

Equipment Start-Up

a. Observe safety precautions.

b. After installation, check the shaft for free movement. Manually rotate shaft several turns.

c. Before start-up all auxiliary systems for seal protection should be connected. These auxiliary systems can be flush, quench, cooling, heating etc. During start up, first activate these systems and then start the shaft drive.

d. For liquids that solidify when exposed to atmosphere start heating/cooling prior to start up.

e. There should be no noise coming from the stuffing box.

f. Excessive heat should not be generated. This can happen due to metallic contact. Stop the pump immediately and reassemble the pump.

g. Observe and correct vibration and any other equipment abnormality.

h. If any thing appears abnormal, stop equipment and take corrective action.

Trouble Shooting of Mechanical Seals

The operating life of a mechanical seal is completed when either face has worn entirely. Whenever a seal has failed, irrespective of the length of its services, the seal faces and elastomers must be inspected thoroughly to ascertain the cause of failure. Following are the steps of trouble shooting procedure.

Inspect the seal faces :

Examine the seal face wear pattern. A normal mechanical seal has a wide and a narrow seal face. The narrow seal face forms a wear pattern on the wider face.

Normal wear pattern : If the wear pattern is equal to the width of the narrow face and is concentric with the outer and inner diameters, the seal leakage is unlikely to be related to face.

Narrow wear pattern : If the wear pattern is narrower than the narrow face, it indicates that the thinner seal face was distorted by pressure causing an inadequate film between the faces. In this case pressure on the seal should be reduced or seal with higher pressure capability should be used.

Wider wear pattern: If the wear pattern is wider than the narrow face, it indicates that opening of the faces created excessive film between the faces. This can be caused by cocked seal, pump misalignment, pipe strain or pump cavitation. The pump misalignment or vibration can cause the rotary face to move back and this face may remain open due to secondary seal hang-up on the shaft. A wide wear pattern is also indicative of excessive shaft movement in this case pump should be aligned and bearings replaced.

No wear pattern: If there is no wear pattern, there are chances that the seal faces are moving together instead of rubbing against one another. This may happen due to improper tightening of set screw of breakage of drive pin and slippage of rubber below.

Intermitted wear pattern: This type of wear pattern is generated when the faces touch each other intermittently. This can happen due to inflate faces, distortion of clamp type seat, uneven tightening of gland bolts or cocking of stationary seat. The faces should be replaced in this case and care should be taken to avoid distortion of the seal face. If possible stationary seat should be flexibly mounted.

Uneven wear pattern: The wear pattern can be elliptical or eccentric with the face diameter. This can be mainly due to misalignment. The pump should be aligned properly.

Heat Checking: Radial, multiple cracks on the seal face are called heat checks. This happens due to inability of the seal face to conduct away the heat. This heat can come from product temperature, friction or intermittent vaporization of the product. In this case proper cooling or flushing should be provided in the seal area or the material of seal face be changed or face design be changed to avoid the problem.

Cracked or broken hard face ; Cracking may occur in case of ceramic faces due to thermal shocks. The problem can be avoided by cautions handling of the pump or by changing to a better material

1. Chipped edges : The causes of the chipping is separation of the seal faces and subsequent breaking when they slam back against each other. This is common with fluids that change from liquid to gas when pump experiences severe cavitation. Proper product flushing should be provided in this case. Also steps should be taken to avoid cavitation by providing adequate volume of liquid to the pump.

2. Pitting, Blistering, Corrosion : If the seal faces are found with these damages, it should be changed and replaced with better corrosion resistant material.

3. Deep wear in hard face : This often happens in abrasive slurries and in crystallizing products. The particles embedded in carbon face grind away the hard face. In such cases, crystallization should be avoided by heating. Also slurry particles can be avoided in seal area by providing external flushing.

- **Inspect the elastomer**

   a. Swollen elastomer : The cause of swelling is chemical attack. Check the compatibility of the elastomer and replace it with better material.

   b. Extruded elastomer : This can happen due to excessive pressure and/or large clearances. The remedy is to provide back up rings or change the seal design.

   c. Hard or cracked elastomer : The usual cause here is high temperature. This can also be due to chemical attack. Change the elastomer and reduce the heat.

   d. Compressed or set elastomer : An excessive compression set can be due to too high a temperature. He cure for this is to have better cooling and/or selection of better elastomer.

   e. Cuts or nicks on elastomer : This means that the shaft or sleeve was not properly polished prior to installation.

- **Inspect Springs**

If the springs are found to be with reduced free length they are fatigued. Use better material with superior mechanical properties. If the springs are found to be broken, it is due to stress or impact. If cracks and corrosion is observed on the springs the spring material should be changed or the seal design should be changed to keep the spring away from the liquid.

- **Inspect Seal Drive**

Seal design use some way to transmit tore from the shaft to rotary face. Quite often it is done with pins, set screws, lugs, spring or metal bellows. Check whether the drive system has failed in the seal, Replace it and eliminate the cause of such damages in consultation with the seal manufacturer.

CONCLUSION:

As said earlier , a failed seal should always be inspected and after every failure efforts should be directed towards elimination of repetitive cause of failure. If necessary, seal design, installation procedure, materials of construction, auxiliary environment control system etc. can be changed to get maximum seal life.

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