CHAPTER NINE
MAINTENANCE & TROUBLESHOOTING

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Because of the wide variation in pump types, ranges in sizes, differences in design, and materials of construction, these comments on maintenance are restricted to those types of pumps most commonly encountered. The manufacturer's instruction books must be carefully studies before any attempt is made to service any particular pump.

9.1 Maintenance Requirements for Pumps

9.1.1 Daily Observation of Pump Operation

When operators are on constant duty, hourly and daily inspections should be made, and irregularities in the operation of a pump should be reported immediately. This applies particularly to changes in the sound of a running pump, abrupt changes in bearing temperatures, and stuffing box leakage. A check of the pressure gages and of the flow meter, if installed, should be made hourly. If recording instruments are provided, a daily check should be made to determine whether the capacity, pressure, or power consumption indicate that further inspection is required.

9.1.2 Semi-annual Inspection

The free movement of stuffing box glands should be checked semi-annually, glands bolts should be cleaned and oiled, and the packing should be inspected to determine whether it requires replacement. The pump and driver alignment should be checked and corrected if necessary. Oil-lubricated bearings should be drained and refilled with fresh oil. Grease-lubricated bearings should be checked to see that they contain the correct amount of grease, and that it is still of suitable consistency.

9.1.3 Annual Inspection

A very thorough inspection should be made once a year. In addition to the semi-annual procedure, bearings should be removed, cleaned, and examined for flaws. The bearings housings should be carefully cleaned. Antifriction bearings should be examined for scratches and wear. Immediately after cleaning and inspection, antifriction bearings should be coated with oil or grease.

The packing should be removed and the shaft sleeves - or shaft, if no sleeves are used -should be examined for wear.

When the coupling halves are disconnected for the alignment check, the vertical shaft movement of a pump with sleeve bearings should be checked at both ends with the packing removed. Any vertical movement exceeding 150 percent of the original clearance required an investigation to determine the cause. The end play allowed by the bearings should also be checked. If it exceeds that recommended by the manufacturer, the cause should be determined and corrected.

All auxiliary piping, such as drains, sealing-water piping, and cooling-water piping should be checked and flushed. Auxiliary coolers should be flushed and cleaned.

The pump stuffing boxes should be repacked, and the pump and driver should be realigned and reconnected.

All instruments and flow-metering devices should be recalibrated, and the pump should be tested to determine whether proper performance is being obtained. If internal repairs are made, the pump should again be tested after completion of the repairs.

9.1.4 Complete Overhaul

It is difficult to make general rules about the frequency of complete pump overhauls, as it depends on the pump service, the pump construction and materials, the liquid handled and the economic evaluation of overhaul costs versus the cost of power losses resulting from increased clearances or of unscheduled downtime. Some pumps on very severe service may need a complete overhaul monthly, while other applications require overhauls only every two to four years, or even less frequently.

A pump should not be opened for inspection unless either actual or circumstantial evidence indicates that overhaul is necessary. Factual evidence implies that the pump performance has fallen off significantly, or that noise or driver overload indicates trouble. Circumstantial evidence refers to past experience with the pump in question or with similar equipment on similar service.

In order to insure rapid restoration to service in the event of an unexpected overhaul, an adequate store of spare parts should be maintained at all times.

The relative complexity of the repairs, the facilities available at the site, and many other factors enter into the decision whether the necessary repairs will be carried out at the installation or at the pump manufacturer's plant.

9.1.5 Spare and Repair Parts

The severity of the service in which a pump is used will determine, to a great extent, the minimum number of spare parts which should be carried in stock at the site of an installation. Unless prior experience is available, the pumps manufacturer should be consulted on this subject, as

an insurance against delays spare parts should be purchased at the time the order for the complete unit is placed. Depending upon the contemplated methods of overhaul, certain replacement parts may have to be supplied either oversized or undersized instead of the same size used in the original unit.

9.1.6 Record of Inspection and Repairs

The working schedules of the semi-annual and annual inspection programs should be entered on individual pump maintenance cards, which contain a complete record of all the items requiring attention, these cards should also contain space for comments and observations on the conditions of the parts before they are repaired.

In all cases complete records of the cost maintenance and repairs should be kept for each individual pumps, together with a record of its operating hours. A study if these records will be generally reveal whether a change in materials or even a minor change in construction may not be the most economical course of action.

9.1.7 Diagnosis of Pump Troubles

Pump operating troubles may be either of a hydraulic or of a mechanical nature. In the first category, a pump may fail to deliver liquid, it may deliver an insufficient capacity or develop insufficient pressure, or it may lose its prime after starting. In the second category if may consume excessive power, or symptoms of mechanical difficulties may develop at the stuffing boxes or at the bearings, or vibration, noise, or breakage of some pump parts may occur.

There is a definite interdependence between some difficulties of both categories. For example increased wear at the running clearance must be classified as a mechanical trouble, but it will result in a reduction

of the net pump capacity-a hydraulic symptom-without necessarily causing a mechanical breakdown or even excessive vibration. As a result, it is most useful to classify symptoms and causes separately.

As an insurance against and to list for each symptom a schedule of potential contrigutory causes. Such a diagnostic analysis is presented in the following sections for centrifugal, rotary, reciprocating and steam pumps, respectively.

9.2 Check Chart for Centrifugal Pump Troubles

Symptoms	Possible cause of trouble (each number is defined in the list below)
Pump does not deliver water:	1,2,3,4,6,11,16,17,22,23
Insufficient capacity delivered:	2,3,4,5,6,7,8,9,10,11,14,17,20,22,23,29,30,31
Insufficient pressure developed:	5,14,16,17,20,22,29,30,31
Pump loses prime after starting:	2,3,5,6,7,8,11,12,13
Pump requires excessive power:	15,16,17,18,19,20,23,24,26,27,29,33,34,37
Stuffing rebox leaks excessively:	13,24,26,32,33,34,35,36,38,39,40
Packing has short life:	12,13,24,26,28,32,33,34,35,36,37,38,39,40
Pump vibrates or is noisy:	2,3,4,9,10,11,21,23,24,25,26,27,28,30,35, 36,41,42,43,44,45,46,47
Bearings have short life:	24,26,27,28,35,36,41,42,43,44,45,46,47
Pump overheats and seizes:	1,4,21,22,24,27,28,35,36,41

9.2.1 Suction Troubles

1. Pump not primed.
2. Pump or suction pipe not completely filled with liquid.
3. Suction lift too high.
4. Insufficient margin between suction pressure and vapor pressure.
5. Excessive amount of air or gas in liquid.
6. Air pocket in suction line.
7. Air leaks into suction line.
8. Air leaks into pump through stuffing boxes.
9. Foot valve too small.
10. Foot valve partially clogged.
11. Inlet of suction pipe insufficiently submerged.
12. Water-seal pipe plugged.
13. Seal cage improperly located in stuffing box, preventing sealing fluid from entering space to form the seal.

9.2.2 System Trouble

14. Speed too low.
15. Speed too high.
16. Wrong direction of rotation.
17. Total head of system higher than design head of pump.
18. Total head of system lower than pump design head.
19. Specific gravity of liquid different from design.
20. Viscosity of liquid different from that for which designed.
21. Operation at very low capacity.
22. Parallel operation of pumps unsuitable for such operation.

9.2.3 Mechanical Troubles

23. Foreign matter in impeller.
24. Misalignment.
25. Foundations not rigid.
26. Shaft bent.
27. Rotating part rubbing on stationary part.
28. Bearings worn.
29. Wearing rings worn.
30. Impeller damaged.
31. Casing gasket defective, permitting internal leakage.
32. Shaft or shaft sleeves worn op scored at the packing.
33. Packing improperly installed.
34. Incorrect type of packing for operation conditions.
35. Shaft running off center because of worn bearings or misalignment.
36. Rotor out of balance, causing vibration.
37. Gland too tight, resulting in no flow of liquid to lubricate packing.
38. Failure to provide cooling liquid to water-cooled stuffing boxes.
39. Excessive clearance at bottom of stuffing box between shaft and casing, causing packing to be forced into pump interior.

40. Dirt or grit in sealing liquid, leading to scoring of shaft or shaft sleeve.
41. Excessive thrust caused by a mechanical failure inside the pump or by the failure of the hydraulic balancing device, if any.
42. Excessive grease or oil in antifriction-bearing housing or lack of cooling, causing excessive bearing temperature.
43. Lack of lubrication.
44. Improper installation of antifriction bearings (damage during assembly, of stacked bearings, use of unmatched bearings as a pair, etc.).
45. Dirt in bearings.
46. Rusting of bearings from water in housing.
47. Excessive cooling of water-cooled bearing, resulting in condensation of moisture from the atmosphere in the bearing housing.

9.3 Check Chart for Reciprocating Pump Troubles

Symptoms	Possible cause of trouble (each number is defined in the list below)
Liquid end noise:	
Power end noise:	
Overheated power end:	
Water in crank case:	
Rapid packing or plunger wear:	
Fitted valves or seats:	
Valves hanging up:	
Leak at cylinder-valve hole plugs:	
Loss of prime:	

9.3.1 Suction troubles

1. Insufficient suction pressure.
2. Partial loss of prime.
3. Cavitation.
4. Life too high.
5. Leaking suction at foot valve.
6. Acceleration head requirement too high.

9.3.2 System problems

7. System shocks.
8. Poorly supported piping, abrupt turns in piping, pipe size too small, piping misaligned.
9. Air in liquid.
10. Overpressure or overspeed.
11. Dirty liquid.
12. Dirty environment.
13. Water hammer.

9.3.3 Mechanical Troubles

14. Broken or badly worn valves.
15. Packing worn.
16. Obstruction under valve.
17. Loose main bearings.
18. Worn bearings.
19. Low oil level.
20. Plunger loose.
21. Tight main bearings.

9.4 Check Chart for Rotary Pump Troubles

Symptoms	Possible cause of trouble (each number is defined in the list below)
Pump fails to discharge:	1,2,3,4,5,6,8,9,16
Pump is noisy:	6,10,11,17,18,19
Pump wears rapidly:	11,12,13,20,24
Pump not up to capacity:	3,5,6,7,9,16,21,22
Pump starts, then loses suction:	1,2,6,7,10
Pump takes excessive power:	14,15,17,20,23

9.4.1 Suction Troubles

1. Not properly primed.
2. Suction pipe not submerged.
3. Strainer clogged.
4. Leaking foot valve.
5. Suction lift too high.
6. Air leaks in suction.
7. Suction pipe too small.

9.4.2 System Problems

8. Wrong direction of rotation.
9. Low speed.
10. Insufficient liquid supply.
11. Excessive pressure.
12. Grit or dirt in liquid.
13. Pump runs dry.
14. Viscosity higher than specified.
15. Obstruction on discharge line.

9.4.3 Mechanical Troubles

16. Pump worn.
17. Bent drive shaft.
18. Coupling out of balance or alignment.
19. Relief valve chatter.
20. Pipe strain on pump casing.
21. Air leak at packing.
22. Relief valve improperly seated.
23. Packing too tight.
24. Corrosion.