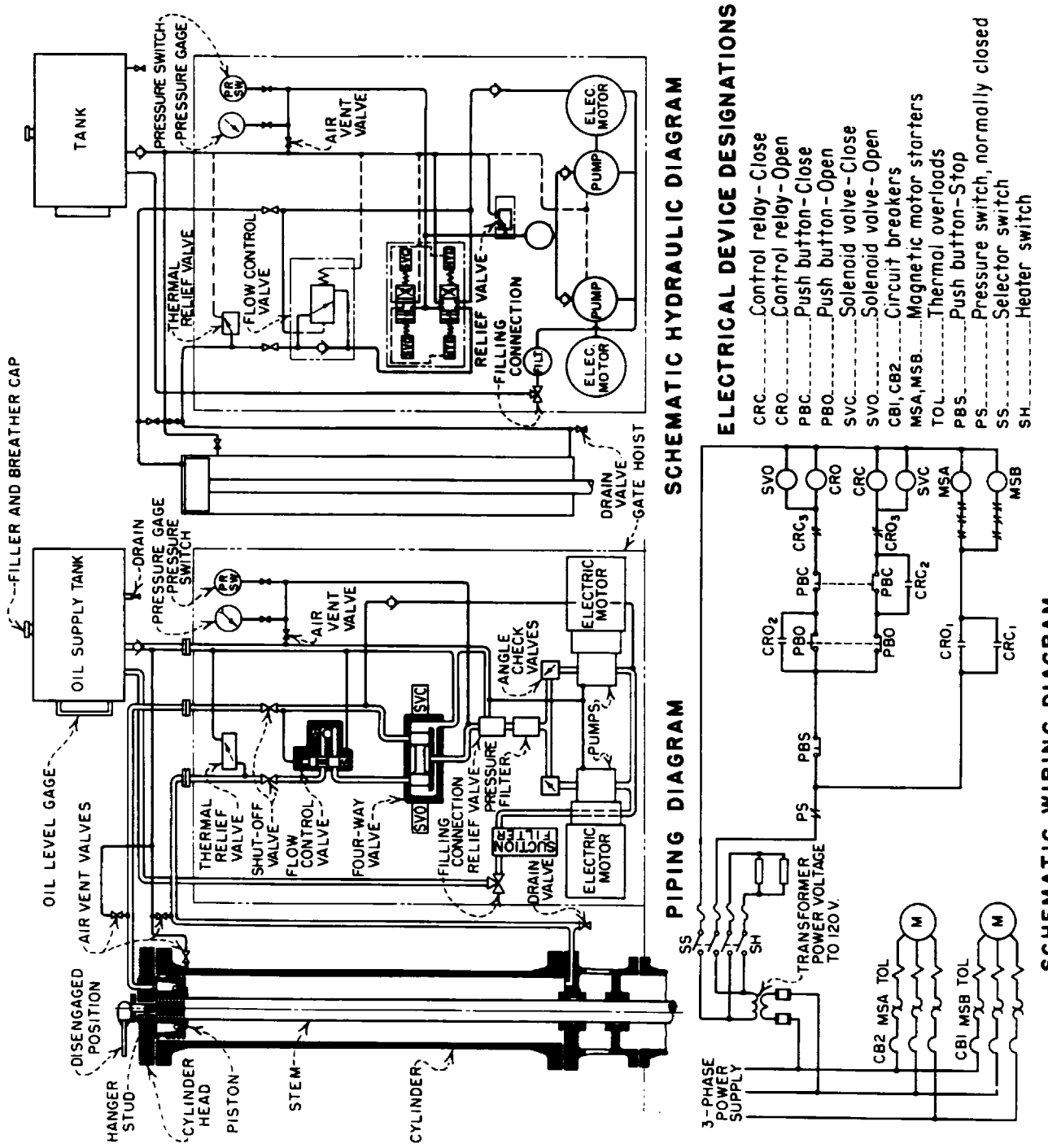

Figure 39. – Schematic hydraulic hoist system.

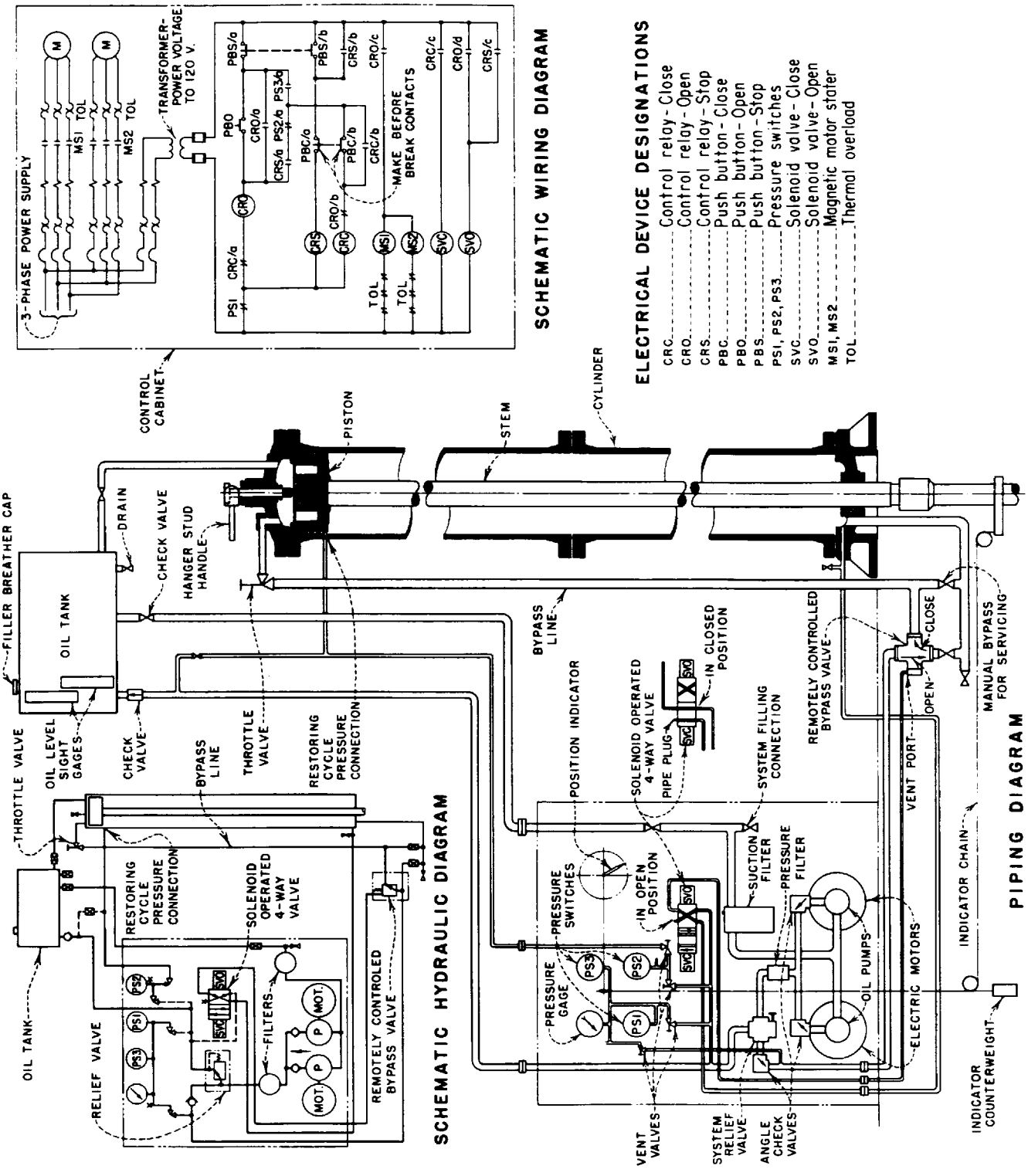

Figure 40. – Hydraulic hoist (gravity closing guard gate).

or ultrasonic tests, can be used to determine the condition of a piping system. Radiographs will not only show pipe wall thickness but also the amount of scale buildup inside the pipe.

Service air systems may also suffer corrosion damage if excessive moisture is allowed into the system. Scale and rust particles can damage pneumatic tools and cause pneumatic cylinders to stick. If moisture in air piping is a problem, a moisture separator or an air dryer should be installed.

If a piping system fails prematurely because of a corrosion problem, it may be beneficial to replace the piping with a nonmetallic material. Pipe constructed of fiberglass and PVC (polyvinyl chloride) as well as other plastics have been used successfully in corrosive environments. Before switching to one of these materials, give careful consideration to their temperature and pressure limitations. **Fiberglass and plastic piping should not be used in compressed air systems.**

5. Inspection Checklist

Items of inspection	
Penstocks and outlet pipes	
a. *Supports*	*A*
b. *Expansion joints*	*A NS*
c. *Exterior*	*A*
d. *Interior*	*A NS*
Gates and valves	
e. *General inspection (BH,BV,CG,CY,DG,FW,HJ,JF,RF,RG,RS,SG,TV)**	*A NS*
f. *Seals and seal seats (BH,BV,CG,CY,DG,FW,HJ,JF,RF,RG,RS,SG,TV)*	*A NS*
g. *Gate frames and tracks (CG,FW)*	*NS*
h. *Roller and wheel assemblies (CG,FW,RS)*	*NS*
i. *Pivot pins and hinges (DG,RG)*	*A*
j. *Gate frames and bonnets (JF,RF,RS,SG)*	*A NS*
k. *Gate leaf, skin plates, and structural members (BH,BV,CG,CY,DG,FW,JF,RF,RG,RS,SG)*	*A NS*
l. *Valve body (BV,HJ,TV) and valve needle or tube (HJ,TV)*	*A NS*
Gate and valve operators and hoists	
m. *Threaded-stem hoist and mechanical operators (CG,CY,FW,HJ,JF,RF,RS,SG,TV)*	*A NS*
n. *Chain hoists (CG,FW,RG)*	*A NS*
o. *Wire rope hoists (BH,CG,FW,RG)*	*A NS*
p. *Hydraulic hoists (BV,CG,CY,FW,HJ,JF,RF,RS,SG,)*	*A NS*
Power penstock guard gate and valve closure tests	
q. *Balanced closure tests (BV,CG,CY,FW,RF,RG,RS,SG)*	*A*
r. *Unbalanced, emergency closure tests (BV,CG,FW,RF,RG,RS,SG)*	*TY*
Auxiliary piping systems	
s. *Pipe and fittings — exterior surface*	*A*
t. *Pipe and fittings - interior surface*	*NS*
u. *Gate valves, globe valves, plug valves, etc.*	*A NS*
v. *Check valves*	*NS*
w. *Pressure-regulating and pressure-relief valves*	*A NS*

Abbreviations in parentheses refer to the following type of gate or valve:

*BH = Bulkhead gates/stoplogs	DG = Drum gate	RG = Radial gate
BV = Butterfly valve	FW = Fixed-wheel gate	RS = Ring-seal gate
CG = Coaster gate	HJ = Hollow-jet valve	SG = Slide gate
CY = Cylinder gate	JF = Jet flow gate	TV = Tube valve
	RF = Ring-follower gate	

A — Annual inspection.
NS — Not scheduled (extraordinary maintenance - usually 5-year or longer intervals).
TY — Ten-year (interval between tests not to exceed 10 years; actual interval should be between 5 and 10 years).

Penstocks and outlet pipes

a. *Supports.*-

Annual inspection.-Check concrete supports for cracks, spalling, or signs of movement. Check lubrication of sliding supports and clean exposed bearing surfaces. Make sure sliding surfaces are not obstructed.

b. *Expansion joints.*-

Annual inspection.-Check leakage past packing and tighten as necessary. Sliding surfaces should be clean of rust and scale. Clean as required.

Not scheduled.-Remove old packing; thoroughly clean packing area and sliding surfaces and install new packing.

c. *Exterior..*-

Annual inspection.-Inspect surface for deterioration of paint and for corrosion paying particular attention to rivets, bolts, and welds. Prepare corroded or deteriorated surfaces by sandblasting or other acceptable means and repaint. Steel pipe where it emerges from concrete is subject to galvanic corrosion. These areas should be repaired by thoroughly cleaning and sandblasting, and painting with a zinc rich primer. Look for leakage from gasketed joints such as mandoors or at drain or fill lines.

d. *Interior.*-

Annual inspection.-Inspect surface for paint deterioration, corrosion, and cavitation damage paying particular attention to rivet heads, and welded and bolted joints. Check condition of tie rods and supports at bifurcations. Prepare corroded or deteriorated surfaces by sandblasting or other acceptable means and repaint with an appropriate paint.

Not scheduled.-Sandblast and paint entire interior surface when condition of paint has reached the point that spot repairs are no longer adequate.

Gates and valves

e. *General inspection.*-(BH,BV,CG,CY,DG,FW,HJ,JF,RF,RG,RS,SG,TV)

Annual inspection.-Inspect exposed and accessible components for corrosion, deterioration of paint, or any other damage. Unwater penstock or water conduit and inspect downstream portion of gate or valve. Where guard gates are available, inspect upstream portion as well. If possible, operate gate through it full range of travel.

Not scheduled.-Install stoplogs or bulkhead gates to inspect gates or valves normally inaccessible. Remove or disassemble gate or valve as necessary to replace or renew seals or guides, to sandblast and repaint, or to repair any other damage.

f. *Seals and seal seats.*–(BH,BV,CG,CY,DG,FW,HJ,JF,RF,RG,RS,SG,TV)

Annual inspection.–Check for excessive leakage. Adjust seals or schedule maintenance as required. Leakage, especially through high-pressure gates or valves, can cause further damage if not corrected. Where accessible, check rubber seals for cracking or other signs of deterioration and bronze seals for wear, cavitation erosion, or galling.

Not scheduled.–Unwater as required and check for damaged or missing seals, seal retainers, and bolts. Check that water actuated seals are free to move and that waterlines and ports are clear. Check seal seats, wallplates, gate sills, and adjacent concrete for wear or other damage. Look for signs of misalignment such as uneven wear on the seals or seal seats.

g. *Gate frames and tracks.*–(CG, FW)

Not scheduled.–A thorough inspection of the tracks and gate frames in most cases will require the installation of bulkhead gates or stoplogs, or the use of divers or a remote controlled underwater vehicle. The tracks for the rollers or wheels should be checked for deformation, corrosion, and missing clamps or bolts. The gate frame should be checked for deformation, corrosion and cavitation damage, and for any missing bolts.

h. *Roller and wheel assemblies.*–(CG, FW, RS)

Not scheduled.–Removal or disassembly of the gate is usually required for inspection of roller and wheel assemblies. Roller assemblies should be checked for any damaged rollers, pins, or links. Rollers and wheels should be checked for free movement and for flat spots or other indications that the rollers or wheels have been sliding and not rolling. Antifriction bearings (roller or ball bearings) should be checked for free rotation, adequate lubrication, corrosion, and replaced as necessary. Bronze bushings should be checked for scoring or adequate lubrication. Bearing seals should be replaced if there is any sign of damage. The bearing journal should be checked for scoring, corrosion, or any other damage. The bearing journal of self-lubricated bushings can sometimes corrode due to a electrolytic reaction from the graphite in the bushing. If this is noted, the bushings should be replaced with a non-graphite, self-lubricated bushing or a plain bronze bushing with some type of lubrication system.

i. *Pivot pins and hinges.*–(DG, RG)

Annual inspection.–Check general condition of pivot pin or hinge, looking for bent or damaged parts. Check that pivot pins are properly lubricated. Inspect concrete adjacent to anchors or pivot pins for cracking or spalling.

j. *Gate frames and bonnets.*–(JF,RF,RS,SG)

Annual inspection.–If accessible, inspect interior of fluidway, checking for any cavitation erosion, corrosion, or other damage. Check bonnet cover for cracks or leaky gaskets. Check for excessive leakage past gate stem and position indicator rod packing and tighten as required. If equipped with a lower bonnet drain, flush silt from bottom of bonnet.

Not scheduled.–Disassemble gate and inspect for any cracks, corrosion, cavitation erosion, or any other damage. Sandblast or clean by acceptable method, and paint interior of bonnet as necessary.

k. *Gate leaf, skin plates, and structural members.*–(BH, BV, CG, CY, DG, FW, JF, RF, RG, RS, SG)

Annual inspection.–Accessible portions should be checked for corrosion, cavitation erosion, missing or damaged bolts or rivets, or any other damage. Check flexible drain hoses of drum gates to ensure they are clear and unplugged.

Not scheduled.–Disassemble gate or install bulkhead gates and unwater to allow inspection of entire gate or gate leaf. Check bottom of the gate leaf or gate for cavitation erosion. Sandblast or clean by acceptable method, and paint as necessary. Check structural members for cracked welds, missing or damaged bolts or rivets, or any other damage. On drum gates and some radial gates, check interior of gate for leaks, plugged drain holes and general condition. Drum gate flexible drain hoses should be cleaned with a rotary drain cleaner.

l. *Valve body.*–(BV, HJ, TV) *and valve needle or tube.*–(HJ, TV)

Annual inspection.–Exterior of valve should be checked for leakage, cracks, and corrosion. If accessible, interior of valve should be checked for corrosion, cavitation erosion, scale buildup that may interfere with valve movement or sealing, and any other damage. Check lubrication to bearings and oil level of gear boxes.

Not scheduled.–Unwater water conduit or penstock or disassemble valve to allow inspection of all valve components. Check for parts damaged by cavitation erosion or corrosion. Check water and oil seals and replace as necessary. Polished surfaces of hydraulically operated hollow-jet valves should be checked for any damage and built up by welding or other process, re-machined, and re-polished if necessary. Check bearings, and bronze seal rings for wear or other damage and replace if necessary.

Gate and valve operators and hoists

m. *Threaded-stem hoist and mechanical operators.*–(CG, CY, FW, HJ, JF, RF, RS, SG, TV)

Annual inspection.–Inspect gear cases for leaks or other damage. Check motor coupling for misalignment. Check oil in gear boxes for water contamination and for proper level. Check grease-coated gears, stems, and stem nuts for dirt or dust contamination of grease. Check gears, stem, and stem nut for wear, galling, or other damage. Grease bearings or other components equipped with grease fittings being careful not to overgrease and damage grease seals. During operational test, check for unusual or excessive vibration or noise.

Not scheduled.–Drain gear boxes and refill with new oil. Grease-coated gears and stems should be cleaned and recoated with new grease. Disassemble as required to check condition of gears, bearings, or other components normally inaccessible.

n. *Chain hoists.*–(CG, FW, RG)

Annual inspection.–Inspect chain for corrosion, and deformed chain links or pins. Check sprocket for damaged teeth. Apply appropriate lubricant to chain. Check oil in gear boxes for water contamination and for proper level. Check condition of grease for dirt or dust contamination on grease-coated gears. Grease sheave, drum, and gear shaft bearings equipped with grease fittings being careful not to overgrease and damage grease seals. Check gears for uneven wear, galling, or signs of misalignment. Check brake shoes and brake drums for signs of overheating or other damage.

Not scheduled.–Drain gear boxes and refill with new oil. Grease-coated gears should be cleaned and recoated with new grease. Disassemble as required to check condition of gears, bearings, or other components normally inaccessible.

o. *Wire rope hoists.*–(BH, CG, FW, RG)

Annual inspection.–Inspect wire rope for broken wires, worn or abraded wires, corrosion, and crushed or flattened strands. See Chapter 6 (Cranes, Hoists, Rigging Equipment, and Elevators) for replacement requirements. Inspect rope drum and sheaves for wear and spooling characteristics of the drum. If possible apply lubricant to entire length of wire rope. Check oil in gear boxes for water contamination and for proper level. Grease sheave, drum, and gear shaft bearings equipped with grease fittings. Check gears for uneven wear, galling, or signs of misalignment. Check condition of brake shoes and brake drums for signs of overheating or other damage.

Not scheduled.–Drain gear boxes and refill with new oil. Grease-coated gears should be cleaned and recoated with new grease.

p. *Hydraulic hoists.*–(BV, CG, CY, FW, HJ, JF, RF, RS, SG)

Annual inspection.–Check entire hydraulic system for leaks, including piping, valves, and packing. Drain accumulations of water and sediment from oil reservoir and lower end of hydraulic cylinders. Add oil to system if necessary to bring oil to proper level, making sure oil added is exactly the same type and viscosity as the oil in the system. Clean or replace oil filters. Calibrate pressure gauges and pressure switches. Check setting and operation of pressure-relief valves. Operate gate or valve through a complete open-close cycle under balanced conditions, checking the opening or closing times, and noting any unusual or excessive noise or vibration. If there is a significant increase in either the opening or closing time, determine the reason for increase. Check surface condition of piston stem for rusting, scoring, or other condition that could impair operation or cause leakage. Check position indicators to ensure wire rope and sheaves or chains and sprockets move freely.

Not scheduled.–Drain system, filter oil, and clean oil reservoir with lint-free rags. Remove cylinder head and inspect cylinder wall looking for signs of corrosion pitting or scoring. Check condition of stems and stem couplings, applying a coating of waterproof grease to couplings normally submerged or exposed to moisture.

Power penstock guard gate and valve closure tests

q. *Balanced closure tests.*–(BV, CG, CY, FW, RF, RG, RS, SG)

Annual inspection.–Perform gate or valve closure test under balanced, no-flow conditions following test procedure for particular gate or valve being tested. Test procedure should be for the specific gate or valve being tested and not a similar one. Contact the appropriate personnel if a procedure is not available or if there is any uncertainty about the procedure that is available.

r. *Unbalanced, emergency closure tests.*–(BV, CG, FW, RF, RG, RS, SG)

Ten-year inspection.–Perform gate or valve closure test under full-flow conditions following test procedure for the gate or valve being tested. Test procedure should be for the specific gate or valve being tested and not a similar one. Contact the appropriate engineering personnel if a procedure is not available or if there is any uncertainty about the procedure that is available.

Auxiliary piping systems

s. *Pipe and fittings — exterior surface.*–

Annual inspection.–Visually inspect all threaded, welded, and flanged fittings checking for any leaks or corrosion. Replace or tighten fittings or pipe as required. Check pipe hangers and supports to make sure they are carrying their share of the load and that anchors are tight. Examine paint for cracking, chalking, or other deterioration. Remove corrosion by wire brushing, sandblasting, or other acceptable method and repaint.

t. *Pipe and fittings — interior surface.*–

Not scheduled.–Partially disassemble piping or utilize a non-destructive-test method to determine condition of interior surfaces. Measure pipe wall thickness and compare to original thickness.

u. *Gate valves, globe valves, plug valves, etc.*–

Annual inspection.–Check valve stem packing for leaks and tighten packing gland as required. Operate valve through its full range of movement several times. With valve closed under pressure, listen for leakage past valve and correct as required. Lubricate valve stems, plug valve seats, and other components as required with appropriate lubricant.

Not scheduled.–Disassemble valve and inspect condition of valve body, stem, and sealing surfaces and repair as required. Completely remove old valve stem packing and install new packing.

v. *Check valves.*–

Not scheduled.–Check for leakage past valve while under full-operating pressure. Disassemble and replace or regrind valve seats as required.

w. *Pressure-regulating and pressure-relief valves.*–

Annual inspection.–Check operation and setting of pressure-regulating and pressure-relief valves.

Not scheduled.–Disassemble valves and remove any scale buildup that interferes with the operation of the valve. Reassemble and check operation and settings of valves.

CHAPTER 4 — MECHANICAL GOVERNORS

1. General

Periodic maintenance of a governor is essential for reliability and to maintain optimum performance. When preparing a maintenance schedule for a mechanical governor, consult FIST Volume 2-3, Mechanical Governors for Hydroelectric Units, and the governor manufacturer's literature.

2. Inspection Checklist

Items of inspection						
Mechanical governors						
a. *Governor tests and adjustments*						*A*
b. *Governor ball head (vibrator type)*					*W*	*A*
c. *Governor ball head (strap-suspended type) and oil motor vibrator*					*Q*	*A*
d. *Pilot valve*						*A*
e. *Main distributing and auxiliary valves*				*NS*	*B*	*A*
f. *Dashpot*						*A*
g. *Linkage and pins*					*W*	*A*
h. *Restoring cable*					*NS*	*A*
i. *Hydraulic system*	*D*	*W*	*M*			*A*
j. *Generator air brake valve*					*B*	*A*
k. *Permanent magnet generator (PMG) or speed signal generator (SSG)*					*NS*	*A*
l. *Position and limit switches*						*A*
m. *Shutdown solenoids*						*A*
n. *Speed changer and gate limit motors and remote position indicators*						*A*
o. *Governor inspection report*						*A*

A — *Annual inspection.*
B — *Biannual inspection (every 2 years).*
D — *Daily inspection.*
M — *Monthly inspection.*
Q — *Quarterly inspection.*
W — *Weekly inspection.*
NS — *Not scheduled* (extraordinary maintenance, usually 5-year or longer intervals).

Mechanical governors

a. *Governor tests and adjustments.*–

Annual inspection.–Check wicket gate timing, speed droop calibration, speed changer adjustment, speed stability index, and governor time constant as described in FIST Volume 2-3, Section IV. These tests not only optimize a governor's performance, but

also can be very helpful in troubleshooting governor problems. The mechanical alignment of the governor should also be checked as described in FIST Volume 2-3, Section III. It is important to recheck governor settings with these tests after any major maintenance to a governor.

b. *Governor ball head (vibrator type).*–

Weekly inspection.–Oil ball head by applying a few drops of light machine oil to the top of the ball head motor shaft. See if a discernible motion can be felt with a finger between the main valve and base. If no motion can be felt, replace the vibrator and balls.

Annual inspection.–After shutdown, remove ball head and disassemble. Clean and inspect the slide blocks, flyball rod, and flyball rod bushings. Replace vibrators and vibrator balls if no discernible motion of the main valve was felt before shutdown or if there is any noticeable wear on the vibrators. If sliding surfaces of slide blocks are worn, rotate both blocks to new surface. Scribe an "X" or other mark on the worn slide block surfaces so they are not reused. Check flyball rod for wear and for straightness and replace as required. Check ball bearings in ball head motor and flyball arms and replace as required. Replace flyball rod bushings if worn or scored. Cover vibrator balls with a light grease and reassemble. Do not fill vibrator cup with grease as this can dampen the vibration. Check operation of pressure-type oilers if so equipped.

c. *Governor ball head (strap-suspended type) and oil motor vibrator.*–

Quarterly inspection.–Add dashpot oil to top of ball head motor to fill internal dashpot. Do not use lubricating oil.

Annual inspection.–Observe operation of ball head and check for any unusual vibration. If any abnormal vibration is noted, disassemble ball head and check condition of thrust bearing, ball head shaft bearings, and ball head motor bearings. Follow manufacturer's alignment and reassembly procedure. Check that oil motor vibrator is providing a 0.006- to 0.007-inch oscillation of the main valve and that motor is turning in the range of 400 to 600 r/min (7 to 10 Hz). Adjust the eccentric bushing in the pivot lever to change the magnitude of oscillation. Adjust the oil flow regulator to change the motor speed.

d. *Pilot valve.*–

Annual inspection.–Disassemble pilot valve and remove all rust spots and oil varnish with a fine-grade emery cloth (320 to 500) and crocus cloth. Any nicks or scratches should be removed by stoning with a very fine flat stone. Care must be taken not to round or break the edges of the valve lands. If wear is excessive or the plunger does not move freely in the bushing, replace with a new matched plunger-bushing set.

e. *Main and auxiliary distributing valves.*–

Annual inspection.–Check that main valve plunger is free. Shut off oil supply to pilot and main valves and disconnect the pressure supply to the pilot valve. With the oil

pressure relieved, lift main valve plunger until it hits the opening stop nuts and drop it so it hits closing stop nuts. If the plunger drops freely it is acceptable, but if there is any binding or if the plunger drops sluggishly, disassemble the valve to determine the problem. Check operation of transfer valve and auxiliary valve.

Biannual inspection.–Remove main and auxiliary valve plunger and remove all rust spots and oil varnish with a fine-grade emery cloth (320 to 500) and crocus cloth. Any nicks or scratches should be removed by stoning with a very fine flat stone. Care must be taken not to round or break the edges of the valve lands. Check ports in valve bushings for dirt or sludge and clean as required. Check that main valve plunger is free and can fall of its own weight after reassembly.

Not scheduled.–Completely disassemble main and auxiliary valves. Remove opening, closing, and pressure plungers and remove all rust spots and oil varnish with a fine-grade emery cloth (320 to 500) and crocus cloth. Check condition of main distributing valve plungers piston rings and replace as required.

f. *Dashpot.*–

Annual inspection.–Check dashpot oil level and add oil if necessary. Do not use lubricating oil. Check operation of solenoid operated bypass. If governor tests from item a. indicate a sticking dashpot, disassemble, inspect, and clean dashpot plungers. Before reassembly, check the setting of the small dashpot plunger. On Woodward governors, the distance from the center of the pivot pin to the top of the bonnet should be 2-7/8 inches. Turn the small plunger spring to adjust this distance. On other governors check the manufacturer's instruction book for adjustment procedure. To refill dashpot, reassemble except for the small dashpot plunger. Tip the dashpot so that the opening for the small plunger is higher than the large plunger and fill the dashpot through the small plunger opening. Move the large plunger occasionally during filling to allow air to escape. To check for trapped air once the dashpot is filled, install the small plunger, close the dashpot needle, and operate the large plunger. The small plunger should react instantaneously to any movement of the large plunger. Any lag in small plunger movement indicates there is air in the dashpot or a leak past the needle, solenoid bypass, or the plungers. To purge the air, open the needle, hold the small plunger in place, and operate the large plunger. After any maintenance on the dashpot it is important to perform the governor adjustment tests of item a. to bring governor back to optimum performance.

g. *Linkage and pins.*–

Weekly inspection.–Lubricate links and pivot pins with a light machine oil.

Annual inspection.–Check links and pins for wear or binding. Use a new pin to check holes in links for wear and use a new link with the proper sized mating hole to check condition of pins. Replace as required. Check bearings in linkage, on shafts, and in the control panel for any roughness and replace as required. Lubricate bearings as required. Check gears for wear and proper meshing.

h. *Restoring cable.*-

Annual inspection.-Lubricate restoring cable sheaves and rod ends at servomotor connection.

Not scheduled.-Disassemble sheaves and inspect sheaves and cable. Replace sheaves if pulley is worn or if bearings are rough.

i. *Hydraulic system.*-

Daily inspection.-Check level of oil in sump and actuator tank and add oil or charge pressure tank with air as required.

Weekly inspection.-Switch lead pump to lag and vice versa.

Monthly inspection.-Switch strainers and clean or replace filter element. If pumps are equipped with hour meters, note run time. Compare run time to previous months' readings and investigate any large deviation.

Annual inspection.-Prior to scheduled maintenance, send sample of governor oil to laboratory for analysis. If analysis shows filtration is required, drain and filter oil.

When oil is drained, clean oil sump and actuator tank with lint-free rags and squeegee; inspect and repaint as required. Check condition of float valve disk, seat, float and float arm for any damage or wear. Check condition of float, cable, and sheaves of level switches for wear and free operation. After system is refilled, check operation of pump unloader valve. Check operation of pressure-relief valves on pumps and actuator tank. Relief valves on the actuator tank should be set to operate at 10 percent higher than the working pressure. The pump relief valves should be set to operate at a slightly lower pressure than the actuator tank relief valve. This is to prevent the pumps from continuing to fill the actuator tank should a high-pressure condition in the system occur.

Check calibration and operation of pressure and level switches and reset as required. Check annunciation where applicable.

With wicket gates blocked, time pumping cycle for each pump, noting the length of time the pump is on, the rise of the oil level in the actuator tank, and the length of time between pumping cycles. Compare to previous readings. If pump is taking longer to reach operating pressure or is pumping more frequently, check for leaks in the system.

j. *Generator air brake valve.*-

Annual inspection.-Check manual and solenoid operation of valve. Lubricate pivot points with light machine oil. Clean airline filter.

Biannual inspection.-Disassemble and remove all rust spots with a fine-grade emery cloth (320 to 500) and crocus cloth. Lap valve seats if required.

k. *Permanent magnet generator (PMG) or speed signal generator (SSG).*–

Annual inspection.–Inspect speed switches and drive gears for wear. Lubricate pivot pins and check speed switch bearings. Check setting and operation of speed switches. Check insulation between PMG or SSG housing and the supporting frame by measuring the resistance from the housing to ground with a meggar. Replace or repair insulating gasket as required. Check voltage output of PMG.

Not scheduled.–Replace main drive bearings of PMG or SSG. If necessary, remagnetize PMG field following procedure in FIST Volume 2-3.

l. *Position and limit switches.*–

Annual inspection.–Check operation and settings of gate limit, speed changer position, and gate position switches. Adjust as required. Clean contacts as required. Check drive gears for wear and proper meshing. Check annunciation where applicable.

m. *Shutdown solenoids.*–

Annual inspection.–Check operation of solenoids for binding or sticking when tripped and reset. Check settings to ensure complete shutdown solenoid closes wicket gates completely and partial shutdown solenoid brings unit to speed-no-load. Inspect solenoid for any signs of any overheating or other damage. Check condition of electrical connections and auxiliary contacts.

n. *Speed changer and gate limit motors and remote position indicators.*–

Annual inspection.–Operate motors and check for excessive vibration or noise. Replace bearings as required. Check electrical connections and motor brushes. Check operation of position indicators for any sticking or binding and check correlation between transmitter and receiver. Check gears for wear and proper meshing.

o. *Governor inspection report.*–

Annual inspection.–An inspection report similar to figure 41 should be filled out annually to record data obtained during the annual inspection.

GOVERNOR INSPECTION REPORT

PROJECT:_____ **POWERPLANT:**_____ **UNIT NO.**_____

DATE:_____ **GOVERNOR MANUFACTURER:**_____ **SERIAL NO.**_____

(Refer to Facilities, Instructions, Standards, & Techniques Volume 2-3, Mechanical Governors for Hydroelectric Units for test procedures.)

Data From Governor Adjustment Program Data Sheet

Wicket Gate Travel Time, Dry = _____Seconds Compensating Crank Setting = _____
Restoring Ratio Setting = _____ Gate Time Constant, TGATE = _____Seconds
Gate Time Constant, Dashpot Bypassed, TGATE2 = _____Seconds

WICKET GATE TIMING (Scroll Case Unwatered and Governor on Main Valve)
- Closing Time = (75% gate to 25% gate) X 2 = _____Seconds
- Opening Time = (25% gate to 75% gate) X 2 = _____Seconds
- Cushioning ---------- 10% gate to 0% gate = _____Seconds (Optimum -- 5 Seconds or More)

SPEED DROOP (With Unit On-line and Speed Droop Set at 5)
- Gate position with speed changer at +1 = _____% = GP1
- Gate position with speed changer at +2 = _____% = GP2
- Speed Droop = 100 X (1/(GP2 - GP1)) = _____ (Optimum -- 4.5 to 5.5)

OFF-LINE TESTS
- Speed Stability Index (SSI) = _____% (Optimum SSI = 0.3 %)
- Governor stability suitable for synchronizing? Yes No
- If no, determine problem and make necessary adjustments or repairs.
- Time required to synchronize? (Automatic Synchronizer) _____Minutes _____Seconds

ON-LINE TESTS
- As Left Gate Time Constant, TGate = _____Seconds
- As Left Gate Time Constant, Dashpot Bypass Energized, TGate2 = _____Seconds

MAIN VALVE DITHER

Vibrator Type Ball Heads
- Is there discernible motion of the main valve? Yes No
- If no, replace vibrator disks.

Oil Motor Vibrators
- Magnitude of main valve dither. _____Inches (Optimum - 0.006 to 0.009 Inches)
- Frequency of main valve dither. _____Hertz (Optimum - 7 to 10 Hertz)

PUMPING CYCLE

Pump 1 (Pump 1 Lead, Pump 2 Lag)
- Pressure Pump Turns On_____PSI Pressure Pump Turns Off_____PSI
- Length of Time Pump On_____Seconds Rise in Actuator Tank Level_____Inches
- Time between pumping cycles_____Minutes

Pump 2 (Pump 2 Lead, Pump 1 Lag)
- Pressure Pump Turns On_____PSI Pressure Pump Turns Off_____PSI
- Length of Time Pump On_____Seconds Rise in Actuator Tank Level_____Inches
- Time between pumping cycles_____Minutes

SHUTDOWN SOLENOIDS
- Does complete shutdown solenoid completely close wicket gates? Yes No
- Does partial shutdown solenoid bring unit to speed-no-load? Yes No
- If No, readjust solenoid.

Figure 41. – Governor inspection report.

GENERAL INSPECTION

Indicate condition of equipment, maintenance performed, and date inspected, or if not checked during this inspection, indicate condition and date when equipment was last serviced.

	Condition and Maintenance Performed	Date last Inspected
Governor Oil		
Laboratory Tests		
Filtered		
Sump		
Actuator Tank		
Actuator Tank Relief Valve		
Float Valve		
Level Switches		
Strainers		
Distributing Valve		
Auxiliary Valve		
Pilot Valve		
Ball Head		
Dashpot		
Linkage		
Restoring Connections		
Governor Oil Pump		
Bearings		
Packing or Seals		
Unloader		
Pump Relief Valves		
Permanent Magnet Generator or Speed Signal Generator		
Main Drive Bearings		
Speed Switch Bearings		
Coupling		
PMG Voltage		
Speed Switch Settings		
Pressure Switches		
Position and Limit Switches		

Remarks and Recommendations:

Inspection Made By

Figure 41 (Back)

CHAPTER 5 — AIR COMPRESSORS

1. General

Air compressors are a common piece of equipment found in most maintenance shops. There are a number of different types of compressors available, but the two most common types are the reciprocating and the rotary screw compressors.

2. Reciprocating Air Compressors

Reciprocating compressors have been available for many years in a variety of sizes and configurations and make up the majority of air compressors found in plants and maintenance shops. Reciprocating compressors are efficient and relatively simple to operate and maintain. Most reciprocating compressors can be completely overhauled with a minimum of tools and parts.

A reciprocating compressor compresses air in a cylinder, against a cylinder head, by a reciprocating piston. While all reciprocating compressors operate in basically the same manner, there are many variations in their construction. For example, a reciprocating compressor can be single- or multicylinder; single- or double-acting; single- or multistage; air- or water-cooled; and can have a horizontal-, vertical-, or angled-cylinder arrangement. Other variations are possible depending on the application.

Single-acting compressors utilize automotive-type pistons, connected directly to the crankshaft by connecting rods, and compress air on one side of the piston only. Double-acting compressors have a double-acting piston, compressing air on both sides, driven by a piston rod which extends through a packing box. The piston rod is connected to a crosshead which is connected to the crankshaft by a connecting rod. Both single- and double-acting compressors are available as single- or multistage. Multistage compressors develop their final pressure in steps by connecting the discharge of the first stage, through an intercooler, to the intake of the second stage. The intercooler removes the heat of compression of the first stage.

3. Rotary Screw Air Compressors

A rotary screw air compressor utilizes two meshing helical-shaped rotors to compress the air. As the rotors turn, air is compressed by the advancing helix. The rotor may either be oil flooded or dry. Dry rotor compressors require the use of timing gears to maintain the proper clearance between the rotors. The oil in the oil-flooded-type compressor lubricates and seals the rotors, and acts as a coolant to remove the heat of compression. The oil-flooded type does not require timing gears as the oil film prevents contact of the rotors, but an air-oil separator is necessary to remove the oil suspended in the compressed air as it leaves the compressor.

Rotary screw compressors have fewer moving parts than reciprocating compressors, and provide a smooth, nearly pulse free air supply. Rotary screw compressors are usually supplied in a "package" requiring only connection to electrical power and to air system. Since there is little vibration they do not require the massive foundation a comparable

reciprocating compressor would need. They are also very popular in trailer-mounted, internal-combustion engine-driven portable compressors.

The construction of a rotary screw compressor is such that little maintenance can be accomplished in the field by plant personnel. The lubricating oil filtration system must be maintained regularly as the tight tolerances make clean oil a necessity. The air end (i.e., the rotors and their housing) of the rotary screw compressor has no sacrificial components such as the piston rings of the reciprocating type. Since the air end is constructed with such high precision and tight tolerances, in most cases, the entire air end must be replaced as a unit.

4. Accessories

a. Inlet filters.–Inlet filters prevent dust and other particulates from entering the compressor. All compressors, especially rotary screw compressors, are susceptible to wear or other damage from dirt particles. A clogged system can cause a significant loss in compressor efficiency. To prevent damage and loss of efficiency, regular cleaning of filter elements or replacement of throwaway elements is required.

b. Aftercoolers.–Aftercoolers are installed on the discharge line to lower the compressed air's discharge temperature and to condense water from the air. Aftercoolers are usually installed with a separator and trap to handle the condensate.

c. Separators.–Separators are used to remove entrained liquids from the compressed air. This is usually accomplished by changing the direction of movement of the liquid particles so that they are removed from the air either centrifugally or through impingement against a separator element. The most common types of separators are impingement, centrifugal, and cyclone types. Separators should be equipped with a trap or drain.

d. Traps.–Traps collect liquid that has been removed from the air by separation or condensation and release it, either automatically or through a manual valve. Traps are installed with separators, filters, aftercoolers, receivers, and dryers. They should also be installed at the low points in distribution systems, especially on lines passing through a cold area. An in-line strainer is usually installed directly upstream of a trap to prevent sediment or other contamination from clogging the trap.

e. Dryers.–Dryers are used when drier air is required than can be provided by an aftercooler system. The most common are refrigerated dryers which condense the moisture from the air by reducing the air temperature. Deliquescent-type dryers absorb moisture into a deliquescent material which must be periodically replaced. Desiccant dryers use porous moisture adsorbing materials that hold the moisture in the pores until they are regenerated by electric heat, air purging, or both.

f. Pressure-regulating valves.–Pressure-regulating valves are used to supply small volumes of air to various pneumatic equipment at a pressure lower than the system pressure.

g. Pressure-relief valves.–As a safety precaution, a pressure-relief valve is required in every compressed air system ahead of the first point that could conceivably act

as an airflow restriction. This includes shutoff valves, check valves, and even in-line filters as they could clog. Receiver tanks should also have a relief valve installed on the tank with no restrictions between the tank and the valve. If there are no restrictions in the discharge line between the compressor and the receiver tank, the relief valve mounted on the receiver tank is sufficient to protect the system. The relief valve should be set to open at no higher than 10 percent above the maximum working pressure and periodically checked for proper operation. It should be noted that pressure regulators are not acceptable for protection against excessive system pressure as they do not vent air, but regulate pressure by restricting airflow.

h. Receiver tanks.–Receivers perform several functions in a compressed air system. The receiver dampens pulsations from reciprocating compressors, acts as a reservoir to take care of temporary demands in excess of compressor capacity, and prevents frequent loading and unloading of the compressor. The receiver may also act as a separator. Since the air is cooled and its velocity reduced, some of the moisture still in the air will condense and fall to the bottom of the receiver where it can be removed by a trap or manual valve.

5. Inspection Checklist

Items of inspection			
General			
a. *Foundation*			*A*
b. *Frame*			*A*
c. *Compressor drive*		*W*	*A*
d. *Cooling system*		*W*	*A*
e. *Air intake and filter*		*W*	*M*
f. *Piping and valves*			*A*
g. *Aftercoolers*			*NS*
h. *Separators*			*NS*
i. *Traps*		*W*	*A*
j. *Dryers*			*A*
k. *Pressure-regulating valves*			*A*
l. *Pressure-relief valves*			*A*
m. *Receiver tanks*	*NS*	*W*	*A*
n. *Gauges*		*W*	*A*
o. *Pressure and temperature switches*		*M*	*A*
p. *Unloader*		*M*	*A*
q. *Bearings*		*NS*	*W*
Reciprocating compressors			
r. Lubrication		*W*	*A*
s. Packing gland		*NS*	*W*
t. Crosshead		*W*	*A*
u. Cylinder			*NS*
v. Piston			*NS*
w. Connecting rod			*NS*
x. Intake and discharge valves			*NS*
Rotary screw compressors			
y. *Air end*			*NS*
z. *Oil reservoir and separator*		*M*	*A*
aa. *Oil filter*			*A*

A — *Annual inspection.*
W — *Weekly inspection.*
M — *Monthly inspection.*
NS — *Not scheduled* (extraordinary maintenance; usually 5-year or longer intervals).

General

a. *Foundation.*–

Annual inspection.–Check foundation with level for settling. Examine concrete for cracks and spalling.

b. *Frame.*-

Annual inspection.-Examine metal for corrosion and cracks. Clean and paint as required.

c. *Compressor drive.*-

Weekly inspection.-Check V-belts for slippage, chains for looseness, and shaft couplings for excessive runout or vibration. Dress or tighten V-belts as required. Tighten and lubricate chains as required. Tighten coupling bolts and lubricate coupling as required.

Annual inspection.-Check V-belts for signs of wear or aging and replace as needed. Check chain and sprocket for wear or distortion and replace as needed. Check shaft runout of direct coupled machines with dial indicator and check shaft alignment if runout is excessive.

d. *Cooling system.*-

Weekly inspection.-Check flow of water or coolant through compressor and aftercooler. Check for accumulation of dirt and lint on cooling fins of air-cooled compressors.

Annual inspection.-Flush and clean all water lines and repair any leaks. Check for corrosion and scale buildup and clean as required. Thoroughly clean cooling fins of air cooled compressors.

e. *Air intake and filter.*-

Weekly inspection.-Check condition of filter and intake for obstructions.

Monthly inspection.-Remove intake filter and clean or replace. Filter may require cleaning more or less frequently depending on location of the intake.

f. *Piping and valves.*-

Annual inspection.-Clean and repaint piping as required. Repack and reseat valves as required.

g. *Aftercoolers.*-

Not scheduled.-Check for leaks and for adequate waterflow. Disassemble and check for internal corrosion and scale buildup. Clean as required.

h. *Separators.*-

Not scheduled.-Check for leaks. Disassemble and check for corrosion and scale buildup. Clean as required.

i. *Traps..*-

Weekly inspection.-Operate manual drains.

Annual inspection.–Check automatic traps for leaks and proper operation. Clean strainer and check for corrosion or scale buildup.

j. *Dryers.*–

Annual inspection.–Replace dryer elements as required on deliquescent dryers. Check operation of refrigerated and desiccant types.

k. *Pressure-regulating valves.*–

Annual inspection.–Check operation and verify that regulating valves are providing correct pressure downstream from valve.

l. *Pressure-relief valves.*–

Annual inspection.–Remove and test to verify operation and setting.

m. *Receiver tanks.*–

Weekly inspection.–Open the receiver drain valve and blowdown until water is removed from tank. Check for leaks.

Annual inspection.–If equipped with inspection door, open and clean all rust and sludge from interior of tank. Inspect interior of tank for corrosion or other damage and repaint as required. Make thorough inspection of exterior of tank paying close attention to joints, seams, and fittings.

Not scheduled.–All receiver tanks are to inspected in accordance with the National Board Inspection Code (ANSI-NB-23), published by The National Board of Boiler and Pressure Vessel Inspectors. The inspector shall meet the qualification requirements of this code. If the State or other organization is responsible for pressure vessel inspections, the inspector shall be an employee of that organization or authorized by that organization.

n. *Gauges.*–

Weekly inspection.–Check operation of gauge. Look for loose or stuck pointer. If there is any doubt about the accuracy of gauge, remove and check calibration or replace with new gauge.

Annual inspection.–Remove gauge and calibrate. Make any necessary repairs or replace with new gauge if gauge is not repairable.

o. *Pressure and temperature switches.*–

Monthly inspection.–See that pressure switches cut in and out at proper pressures. Check setting of temperature switches.

Annual inspection.–Check and clean switch contacts. Check switch calibration and set points. Clean and adjust moving parts.

p. *Unloader.*-

Monthly inspection.-Check that compressor is not being loaded until operating speed is reached in starting and that it unloads at the proper pressure.

Annual inspection.-Inspect valves and air lines for leaks and valves for proper seating. Lap valves if required. Examine solenoid for deteriorated insulation or loose connections.

q. *Bearings.*-

Weekly inspection.-Check antifriction bearing for excessive vibration or noise and schedule replacement as required. Check for adequate lubrication.

Not scheduled.-Disassemble compressor and inspect condition of all bushings and babbitt-lined bearings. Repair or replace as required.

Reciprocating compressors

r. *Lubrication.*-

Weekly inspection.-Check that oil or grease cups are full and that crank case oil is at proper level. Replace or add the correct lubricant to bring to proper levels in crankcase or oil reservoir. Check oil feed rate to cylinder. Check forced oil systems for proper operation. Note any leaks and repair if excessive.

Annual inspection.-Clean oil or grease cups and piping. Check condition of lubricant and change if required. Repair any leaks.

s. *Packing gland.*-

Weekly inspection.-Check for excessive leakage and for scoring on piston rod. Adjust packing as necessary.

Not scheduled.-Replace packing as necessary.

t. *Crosshead.*-

Weekly inspection.-If visible, check fit and lubrication.

Annual inspection.-Check bearing shoes for scoring and wear, and fit to crosshead. Shim shoes if necessary to obtain proper fit. Check pin and bushing for wear and replace or refit as required.

u. *Cylinder.*-

Not scheduled.-Check cylinder walls for wear and scoring. Measure inside diameters at top, bottom, and middle in two directions, 90 degrees apart. If cylinder is out-of-round or oversized, rebore cylinder.

v. *Piston.*-

Not scheduled.-Check piston for wear. Check clearance with micrometer. Examine rings for tightness and fit. Replace if necessary. Check piston rod for trueness and scoring or wear. Renew or replace as required.

w. *Connecting rod.*-

Not scheduled.-Check for distortion or bending. Check bearing bolts and nuts for damage and replace as required.

x. *Intake and discharge valves.*-

Not scheduled.-Inspect valves and seats for scoring and proper seating. Clean any deposits off of seats and valve plates being very careful not to scratch the surfaces. Lap valve seats if there are any imperfections. Deposits on the valves indicate a dirty intake, the wrong type or excessive oil, or a leaking valve or valve gasket.

Rotary screw compressors

y. *Air end.*-

Not scheduled.-Check condition of rotors and bearings. Replace if worn or if compressor efficiency has decreased noticeably.

z. *Oil reservoir and separator.*-

Monthly inspection.-Drain condensation from bottom of oil reservoir.

Annual inspection.-Check condition of separator element and service or replace if oil consumption is excessive.

aa. *Oil filter.*-

Annual inspection.-Replace or clean oil filter as required.

CHAPTER 6 — CRANES, HOISTS, RIGGING EQUIPMENT AND ELEVATORS

1. Crane and Hoists

Due to the potential for injury to personnel and damage to equipment, periodic inspection and maintenance of cranes and hoists is very important. A preventive maintenance and inspection program based on the manufacturer's recommendations should be established for all cranes, hoists, or other lifting devices. This program should be well documented with detailed records of the inspections and maintenance performed on the equipment.

The American National Standards Institute (ANSI) publishes the following standards that may be useful in setting up an inspection and maintenance program for cranes and hoists: B30.2, "Safety Standard for Overhead and Gantry Cranes"; B30.5, "Safety Code for Crawler, Locomotive, and Truck Cranes"; B30.10, "Hooks"; B30.11, "Monorails and Underhung Cranes"; and B30.16, "Overhead Hoists (Underhung)."

2. Ropes, Slings, Chains, and Rigging Hardware

The standards designated for use by the Bureau of Reclamation are contained in the *Rigging Manual* published by the Construction Safety Association of Ontario, 74 Victoria Street, Toronto, Canada, M5C 2A5. This publication provides information on safe rigging, load capacities of slings and other rigging equipment, and the inspection of wire rope and slings. The Bureau's *Construction Safety Standards* and ANSI standard B30.9, "Safety Standard for Slings," may be helpful in the use and inspection of slings.

Prior to any lift, all of the rigging should be checked to ensure that it is safe to use. Defective equipment that is repairable should immediately be clearly marked as unsafe and removed from service. Defective equipment that is not repairable should be cut in half or otherwise rendered unusable to ensure it will not be used. Capacity charts should be consulted and all variables, such as sling angle, should be considered to assure that the rigging hardware's rated capacity is not exceeded by the load being lifted.

3. Shop-Fabricated Lifting Devices and Rigging Hardware

Shop-fabricated lifting devices or rigging hardware, including supports or components of a hoist or lifting device, shall not be used unless designed and certified by an engineer qualified in this field and tested at 125 percent of the rated safe working load. All lifting devices and rigging hardware shall be designed with a 5:1 factor of safety and in accordance with any applicable ANSI standard.

4. Elevators

Passenger and freight elevators are to be inspected and tested in accordance with ANSI A17.1, "Safety Code for Elevators and Escalators," and ANSI A17.2, "Inspector's Manual for Elevators and Escalators." The inspector shall meet the qualification requirements of ASME/ANSI QEI-1, "Standard for the Qualification of Elevator Inspectors," and shall be certified by an organization accredited by the American Society of Mechanical Engineers (ASME) in accordance with the requirements of ASME/ANSI QEI-1. If the State or other organization is responsible for elevator inspections, the inspector shall be an employee

of that organization or authorized by that organization. Periodic maintenance should be in accordance to the elevator manufacturer's recommendations and any recommendations of the elevator inspector.

5. Inspection Checklist

The items listed on the inspection checklist that are listed as daily inspections should be inspected prior to use each day a crane or hoist is used. Regardless of whether or not a crane or hoist has been used, all of the monthly and daily inspections should be performed at least semiannually; and if the crane or hoist has been idle for more than 6 months, the daily, monthly, and the annual inspections should be performed before the equipment is used. For a more complete description of inspection techniques and equipment requirements, refer to the above mentioned ANSI standards, the *Rigging Manual*, the Bureau's *Construction Safety Standards*, and manufacturers' recommendations.

Items of inspection		
Cranes and hoists		
a. *Operating mechanisms*	*D*	*A*
b. *Limit switches*	*D*	*A*
c. *Hooks*	*D*	*A*
d. *Braking systems*	*D*	*A*
e. *Wire rope or load chain*	*D*	*A*
f. *Crane rails, supports, and stops*		*A*
g. *Hoist and bridge framework*		*A*
h. *Bumpers*		*A*
i. *Bridge and trolley conductors and collectors*		*A*
j. *Gears, shafts, bearings, and wheels*	*M*	*A*
k. *Catwalks, access ladders, and handrails*		*A*
l. *Cab*		*A*
m. *Hoist drums and sheaves*		*M*
n. *Hydraulic systems*	*M*	*NS*
o. *Inspection report*		*A*
Slings and rigging hardware		
p. *Slings (wire rope, chain, synthetic web, etc.)*		*D*
q. *Rigging hardware (eye bolts, shackles, etc.)*	*D*	*A*
r. *Lifting beams and specialized lifting devices*	*D*	*A*
Elevators		
s. *Routine and periodic inspections*	*S*	*A*

A — *Annual inspection.*
S — *Semiannual inspection.*
M — *Monthly inspection.*
D — *Daily inspection* (prior to use, each day equipment is used).
NS — *Not scheduled* (extraordinary maintenance; usually 5-year or longer intervals).

Cranes and hoists

a. *Operating mechanisms.*–

Daily inspection.–Check control levers and pushbuttons for free movement and for any obstruction that could interfere with proper operation.

Annual inspection.–Check controller contacts for signs of pitting or any other deterioration. Check for excessive wear or looseness of control levers.

b. *Limit switches.*–

Daily inspection.–Check operation of hoist and travel limit switches, without load, by carefully inching into limit switch.

Annual inspection.–Check electrical contacts for signs of pitting or any other deterioration. Check levers and cams for adequate lubrication and excessive wear.

c. *Hooks.*–

Daily inspection.–Visually inspect hook for cracks, nicks, gouges, or deformation. Check hook latch operation, hook attachment, and securing means. Check that swivel hooks are free to rotate. Hooks having any of the following deficiencies shall be removed from service:

(1) Cracks
(2) A throat opening of more than 15 percent in excess of normal
(3) A bend or twist of more than 10 degrees from the plane of the unbent hook
(4) Wear exceeding 10 percent of the original dimension
(5) Inoperable hook latch

Annual inspection.–Perform magnetic particle, die penetrant, or other nondestructive test in addition to visual inspection. Lubricate swivel and sheave bearings as required.

d. *Braking systems.*–

Daily inspections.–Check operation of bridge and trolley brakes and look for leaks in hydraulic lines. Before proceeding with a lift, lift load a few inches and check that hoist brakes are holding. Refer to the Bureau's *Construction Safety Standards* for information on brake tests for mobile cranes.

Annual inspection.–Check brake lining for excessive wear and oil contamination. Check brake drums for scoring. Check operating mechanisms for wear or damage, adequate lubrication, and proper adjustment. Repair or replace parts as required. Check operation of load control braking system.

e. *Wire rope or load chain.*–

Daily inspection.–Check wire rope to ensure there is no slack in drum or load block and that reeving is proper. Check load chains for worn or damaged links. Check that chain feeds into and away from sprockets smoothly.

Annual inspection.–Check wire rope for reduction of diameter, broken wires, wear, corrosion, kinking, crushing, unstranding, and other damage. Pay close attention to end connections and sections normally hidden. Refer to the *Rigging Manual* or the rope manufacturer for recommendations for replacement of the wire rope. Apply lubrication, if required, according to manufacturer's recommendations. Examine chain for gouges, nicks, weld splatter, corrosion, wear, and distorted links. Refer to the Rigging Manual or the chain's manufacturer for guidelines on the replacement of the chain.

f. *Crane rails, supports, and stops.*–

Annual inspection.–Check rails for alignment and level. Check concrete rail supports for cracking or spalling and steel supports for corrosion and loose bolts or rivets. Repair concrete as required. Tighten loose bolts and rivets. Check that rail stops are securely fastened.

g. *Hoist, trolley, and bridge framework.*–

Annual inspection.–Check bolts and rivets for tightness. Check all framework for deformation, cracks, and corrosion, paying close attention to load-bearing members and welded joints. Clean and repaint as required.

h. *Bumpers.*–

Annual inspection.–Check for looseness and proper positioning. Check for leaking of hydraulic bumpers and fill to proper level. Check rubber or plastic bumpers for cracks or other damage. Replace or repair as required.

i. *Bridge and trolley conductors and collectors.*–

Annual inspection.–Check the contact surfaces of open conductors and collectors for signs of arcing damage, pitting, and corrosion. Check condition of insulators. Clean as required. Check that festoon-type conductor cable moves freely with bridge and trolley movement. Check the condition of insulation and for kinking in cable.

j. *Gears, shafts, bearings and wheels.*–

Monthly inspection.–Check lubrication and look for excessive wear.

Annual inspection.–Listen for excessive noise or vibration from bearings. If possible, check clearances of journal bearings. Replace or refit as required. Examine gears for signs of abnormal or excessive wear. Check lubricant levels and check the oil of enclosed gear cases for metal filings. Check drive shafts and couplings for signs of misalignment. Check wheels for excessive wear or other damage. Repair or replace as required.

k. *Catwalks, access ladders, and handrails.*–

Annual inspection.–See that handrails and ladders are firmly secured and rigid. Check catwalks for obstructions, damaged floorway, or other safety hazards. Walking surfaces of catwalks and ladder landings should be an anti-skid type. Check all steel members for corrosion. Clean and paint as required.

l. *Cab.*-

Annual inspection.-Check cab for loose articles which would interfere with operation and for general housekeeping. Check for broken windows or doors. Check guard rails and doors. Check bolts and rivets for tightness. Check welded joints for cracks. Look for corrosion of steel member. Clean and paint as required.

m. *Hoist drums and sheaves.*-

Monthly inspection.-Visually inspect drums and sheaves for cracks or other damage. Check bearings for wear and proper lubrication. Check grooves of drums and sheaves for wear with sheave gauge. Repair or replace as required.

n. *Hydraulic systems.*-

Monthly inspection.-Check that pump delivers full pressure. Check piping and cylinder packing for leaks. Check condition of oil filters. Clean or replace as required.

Not scheduled.-Inspect cylinder walls and piston for scoring and wear. Check condition of pump. Inspect valve seats for wear. Repair or replace as required.

o. *Inspection report.*-

Annual inspection.-An inspection report similar to figure 42 should be filled out annually to record data obtained during the annual inspection.

Slings and rigging hardware

p. *Slings (wire rope, chain, synthetic web, etc.).*-

Daily inspection.-Check all slings for any damage or defects prior to use. Immediately remove any damaged sling(s) from service and cut in half to ensure it will not be used. One or more of the following conditions shall be sufficient reason for removing a sling from service:

Wire rope slings.-

(1) Six randomly distributed broken wires in one rope lay, or three broken wires in one strand in one rope lay.

(2) Wear or scraping of one-third the original diameter of outside individual wires.

(3) Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure.

(4) Evidence of heat damage.

(5) End attachments that are cracked, deformed, or worn.

(6) Corrosion of the rope or end attachments.

OVERHEAD CRANE INSPECTION REPORT

PROJECT_____ CRANE LOCATION_____ _____ CRANE RATING_____ DATE_____

GENERAL COMMENTS

Note condition of each item and any maintenance performed. Check structural components for loose bolts or rivets, deformation, cracks, or other damage. Report any deficiencies to Supervisor immediately and tag main breaker for crane so that it is not used until a determination is made as to whether the deficiencies constitute a safety hazard.

CONTROLS

Lever Operated Controls_____

Pushbutton Pendant Controls_____

Radio Operated Controls_____

BRIDGE

Motor_____

Drive Shaft, Gearing, and Protective Guards and Covers_____

Wheels, Rails and Bumpers_____

Brakes_____

Conductors_____

Bridge Framework_____

TROLLEY

Motor_____

Drive Shaft, Gearing, Bearings, and Protective Guards and Covers_____

Wheels, Rails and Bumpers_____

Brakes_____

Conductors_____

Bridge Framework_____

MAIN HOIST

Motor_____

Holding Brake_____

Load Control Braking System_____

Rope Drum_____

Gearing, Bearings and Protective Guards and Covers_____

Load Blocks, Sheaves, and Equalizers_____

Hook_____

Limit Switch_____

Figure 42. – Overhead crane inspection report.

AUXILIARY HOIST

Motor_____

Holding Brake_____

Load Control Braking System_____

Rope Drum_____

Gearing, Bearings and Protective Guards and Covers_____

Load Blocks, Sheaves, and Equalizers_____

Hook_____

Limit Switch_____

MAIN HOIST ROPE

Date Rope In Service---------- _____
Total Number of Broken Wires ---------- _____
Maximum Number of Broken Wires in One Rope Lay ---------- _____
Condition of Rope at End Connections_____

Kinking, Crushing, Wear, Reduction in Diameter, or Other Damage_____

Lubrication, Date Last Lubricated_____

AUXILIARY HOIST ROPE

Date Rope In Service---------- _____
Total Number of Broken Wires ---------- _____
Maximum Number of Broken Wires in One Rope Lay ---------- _____
Condition of Rope at End Connections_____

Kinking, Crushing, Wear, Reduction in Diameter, or Other Damage_____

Lubrication, Date Last Lubricated_____

MISCELLANEOUS

Ladders, Walkways and Handrails_____

Cab_____

Capacity Markings_____

Warning Bell_____

OTHER COMMENTS AND RECOMMENDATIONS_____

Inspection Made By_____

Figure 42 (Back)

(7) Fiber core rope slings shall be permanently removed from service if exposed to 200 °F plus temperatures. Non-fiber core rope temperatures shall not exceed 400 °F or minus 60 °F without the manufacturer's recommendation.

Chain slings.–

(1) If wear at any point of any chain link or the depth of gouge or rounded out portion exceeds the values in the table below, the assembly shall be removed from service.

Chain sizes inches	Maximum allowable wear — inches	Chain sizes inches	Maximum allowable wear — inches
1/4	3/64	1	3/16
3/8	5/64	1-1/8	7/32
1/2	7/64	1-1/4	1/4
5/8	9/64	1-3/8	9/32
3/4	5/32	1-1/2	5/16
7/8	11/64	1-3/4	11/32

(2) Sharp transverse nicks shall be rounded by grinding.

(3) Assemblies with deformed master or coupling links or cracked hooks or attachments shall be removed from service.

(4) Alloy steel chains shall be permanently removed from service if heated above 1,000 °F and capacities reduced if exposed to 600 °F temperatures.

Natural and synthetic fiber rope slings.–

(1) Slings shortened with knots, bolts, or other unapproved methods.

(2) Damaged slings.

(3) Rope less than 1/2-inch diameter.

(4) Slings subjected to a sustained load equal to the rated capacity for more than 3 days.

(5) Slings made from old rope.

(6) Slings subjected to chemically active environments unless permitted by the rope manufacturer.

(7) Frozen rope slings or rope slings subjected to temperatures below minus 20 °F or above 180 °F shall be removed from service or have capacities reduced in accordance with manufacturer's requirements.

(8) Visual indication of ultra-violet degradation such as:

(a) Bleaching out of sling color
(b) Increased stiffness of sling material
(c) Surface abrasion in areas not normally in contact with the load

Synthetic webbing slings.–

(1) Acid or caustic burns.

(2) Melting, charring, or weld spatter of any part of the sling.

(3) Holes, tears, cuts, or snags or embedded particles.

(4) Broken or worn stitches in load-bearing splices.

(5) Wear or elongation exceeding the amount recommended by the manufacturer.

(6) Distortion, excessive pitting or corrosion, or broken fittings.

(7) Frozen slings or slings subjected to temperatures below minus 20 °F or above 180 °F shall be removed from service or have capacities reduced in accordance with manufacturer's requirements.

(8) Knots in any part of the sling.

(9) Visual indication of ultra-violet degradation such as:

(a) Bleaching out of sling color
(b) Increased stiffness of sling material
(c) Surface abrasion in areas not normally in contact with the load

q. *Rigging hardware (eye bolts, shackles, etc.)*.–

Daily inspection.–Check all rigging hardware for damage or defects prior to use. Damaged hardware should be removed from service and cut in half, or rendered useless by other means to ensure it cannot be used.

Annual inspection.–Inspect rigging hardware thoroughly for any damage such as nicks, gouges, or deformation. Refer to the *Rigging Manual* and the Bureau's *Construction Safety Standards* for more information on removal from service requirements.

r. *Lifting beams and specialized lifting devices*.–

Daily inspection.–Check for any sign of deformation or other damage. All specialized devices should be designed and certified for use by an engineer competent in the field. Lifting devices designed for a specific operation should not be used for any other operation unless approved by a competent engineer.

Annual inspection.–Check for deformation, lubricate bearings and bushings. Check that all pivot points and level indicators are free to move. For rarely used lifting devices, apply a protective coating to areas prone to corrosion. Clean and paint as required.

Elevators

s. *Routine and periodic inspections.*–

Semiannual inspection.–Perform routine inspections and tests in accordance with ANSI A17.1, Part X, Section 1001, on all electric passenger and freight elevators.

Annual inspection.–Perform periodic inspections and tests in accordance with ANSI A17.1, Part X, Section 1002, on all electric passenger and freight elevators.

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Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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