



FIST 4-1

POWER O. AND M. BULLETIN

NO. 19

MAINTENANCE SCHEDULES AND RECORDS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DENVER, COLORADO

REVISED OCTOBER 1965

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DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
DIVISION OF POWER OPERATIONS
Denver, Colorado

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1. Maintenance Methods, Schedules, and Records

The apparatus, structures, transmission lines, etc., which are a part of the power system must be maintained in the best possible operating condition at all times. Following such a maintenance program will result in the best service to power customers, fewer emergency repairs, better working conditions for the maintenance men, and lower maintenance cost. Because of the great variety of equipment used on Bureau projects, it is obviously impractical to cover the subject in anything but a very general manner in this bulletin. This bulletin will, therefore, serve only as an outline or guide for the maintenance procedure which should be carried out.

General

It is believed that a continuous program of preventive maintenance, combined with equipment overhaul when required, will best suit the needs on Bureau projects. This method consists of continually doing routine maintenance and adjustment work to the critical items of a structure or facility in a scheduled and organized manner so as to make special inspection and heavy repairs less necessary. The maintenance is applied more specifically to the parts which are known to need repairs or replacement most often. The underlying theory is that proper lubrication, adjustment, and small repairs applied often enough to the critical parts will make it less necessary to undertake complete overhaul. Experience shows that breakdowns are reduced, outages shortened, and the frequency for overhaul of most facilities is lessened when preventive maintenance is followed. Depreciation and obsolescence of equipment may often be reduced by using improved repair materials and parts which are superior to the original. The success of preventive maintenance will depend largely on the alertness of the men who work around the equipment. They should be continually on the alert for things which need attention, such as loose bolts, vibration, leaks, wear, unusual noise, odor, etc.

Preventive maintenance

Maintenance crews should be limited to as few men on a particular job as practical. However, when working in hazardous locations, there must be a sufficiently large crew to provide safe working conditions as covered in the Safety Manual. The best maintenance men are those who lay out their work schedule in advance, work fast, and believe in keeping the equipment rolling.

Maintenance crews

Maintenance work should be done in accordance with prearranged schedules so as to make the best use of available men, to coincide with favorable weather so far as possible, and to

Work schedules

coincide with periods in which outages of the equipment can best be tolerated. In following the preventive maintenance method, the work to be done is spread out over the entire year, and there is a job to be done each day. This makes more efficient use of the men, creates better working morale, and makes it possible to maintain a nearly fixed number of men in the maintenance crews throughout the year. Outdoor work should be scheduled in the summer and indoor work in the winter, except on southern projects where weather may not be a governing factor. Better and faster work will be produced when working under favorable weather conditions. Maintenance work should also be divided into the group which can be done at any time and that which can be done only at times when the equipment can be taken out of service.

Inspection check lists Each piece of equipment should be inspected at specified intervals. In order to carry out such a program, it is necessary to follow an effective but simple method of scheduling the work and keeping records of inspections and repairs. The inspection check lists included in this bulletin should be used as a guide to proper maintenance by the operators and maintenance men. The time intervals shown represent the average intervals which the particular item should go without inspection. More or less frequent inspections may be necessary on some items as operating experience or accessibility for maintenance dictates. The lists are intended to cover all types of equipment, including the most complex. If the particular equipment is not provided with all the features listed under "Items of inspection," these items on the check list should be disregarded. The routine inspections are those which should normally be checked at attended stations by an operator while on his tour of duty or at unattended stations by a maintenance man. These routine checks and inspections should be of a visual nature not requiring the use of tools or equipment, and are intended to detect troubles in their early stages so that corrective measures can be applied before serious trouble develops. Anything unusual found on such inspections should be promptly referred to the maintenance department for proper action. The indexed paragraphs following the check lists are intended to give pertinent instructions on what to look for and what to do. However, it is not intended to duplicate instructions already covered in detail in other Power O&M bulletins, manufacturers' instruction books, or other available publications.

Inspection and maintenance record cards A card system should be kept for recording equipment rating data and is recommended for calling attention to the time when an inspection is due and for recording the data and brief description of the work done. A 5- by 8-inch card, Form PO&M 122, shown in Figure 1, is available at the Denver Office for this purpose.

The front of this card has spaces for recording the nameplate and other pertinent data for the equipment or line to which the card applies. The back of the card has spaces for recording the dates on which inspections and repair work were done, name of the inspector, a reference to the complete inspection and repair report, a brief description of the work done, and for costs of work done. The cost data need not be shown on this card if other means of cost recording are used. Another card, Form PO&M 123, has the "Inspection and Maintenance Record" on both sides and is used as a continuation of the original card when the latter is filled up. It should be stapled to the original card. Entries should be made on the "Inspection and Maintenance Record" for the detailed semiannual or annual inspection and repair work but not for the routine daily, weekly, or monthly inspections, unless some repair work is performed.

A card should be used for each piece of equipment or line section which is subject to a scheduled periodic inspection and maintenance. A rotating file system, illustrated in Figure 2, is suggested as a simple system for small plants. This entire file, including the index tabs, rotates forward as time goes on, with cards removed from the front as work is done being placed in the back so that for each year (or other inspection interval) the cards come up in the same order. Each day the file should be consulted to see what work is due. After the work is completed, the card should be filled in, signed by the maintenance foreman, and placed at the back of the file. The cards for annual and semi-annual inspections should be kept in separate stacks so that a complete cycle of rotation will occur in the inspection interval.

A suggested file numbering system for the cards is illustrated in Figure 2. The first symbol consists of the equipment designation originally assigned by the Division of Design for construction purposes and given in the Denver Office Design Standards, plus the unit number and part letter as needed for identification. The second symbol is the month in which the inspection is due. A third symbol representing the week of the month may be used if it is desired to confine the inspection intervals to narrower margins than 1 month. For a semiannual card file, the second symbol should show 2 months, one above the other, and the index tabs should be marked in a similar manner. This file will rotate twice in a year.

Since it may be desired at times to find a card applying to some particular piece of equipment which may be at some unknown place in the stack, a separate equipment list, illustrated in Figure 3 is needed. From this list, the card for any piece of equipment

can be promptly located from the card file number by the month in which it is filed. The list also serves as a check on file cards which may have been misplaced or lost. This list should be made up on letter size sheets and filed in a ring binder.

Some projects, particularly the large ones, may require other record cards and forms in order to carry out the maintenance program in an efficient manner. These should be provided by the project as needed.

Alternate method for maintenance scheduling

An alternate method for maintenance scheduling recommended makes use of a bar graph illustrated in Figure 4. This method uses the same equipment data cards, Forms PO&M 122 and 123, described above, for maintaining the equipment rating data and record of the work done. Instead of the rotating file system, the cards are kept in subject file arrangement, and the advance scheduling of work is laid out on the bar graph sheets, Figure 4. This graphical method has some advantage in that the scheduling over the entire year is visible at a glance, showing when each item is due for maintenance, length of time allowed for the work, and as a past record shows when work was started and finished. As soon as the work is completed, an entry of the work done should be made on the back of the equipment data card. Data on man-hours time required and cost can be placed on the bar graph if desired. The bar graph sheets should be made up, listing each item to be maintained during the year, and then place a bar for each item to show the time period in which the work is to be done. Several sheets will be required for most plants.

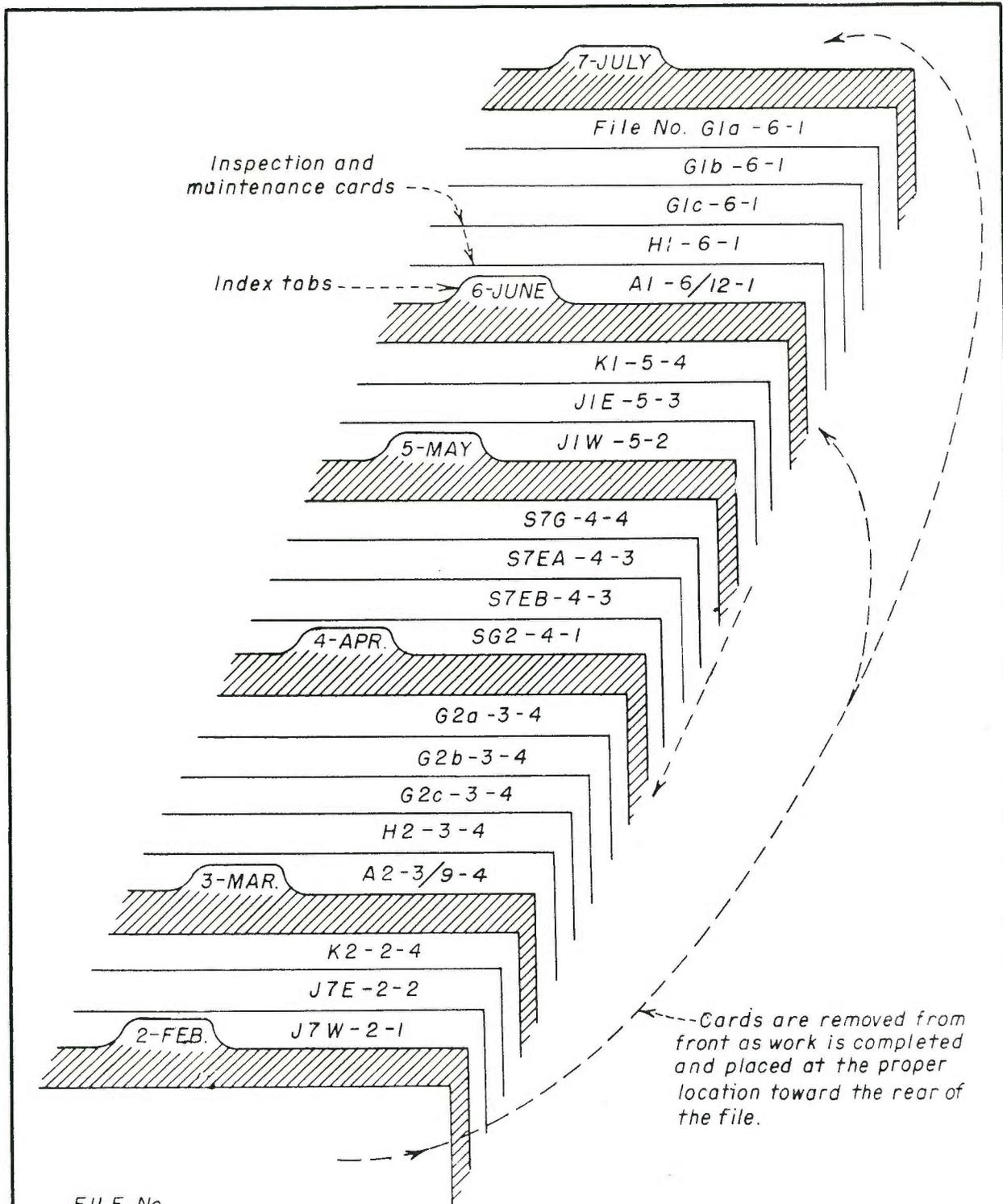
Records of inspections, maintenance, and tests

Keeping records of the inspections, repairs, and tests is an important part of preventive maintenance. It provides a means of recognizing chronic troubles and finding the causes and provides a basis for estimating what spare parts should be kept on hand and how often repairs will be necessary. The card described in paragraph "Inspection and maintenance record cards" above, when used in the rotating file system, is intended to serve primarily as an index and tickler system to call attention to when inspection should be made and with only a brief reference to what was done. A more detailed report should be made and filed elsewhere for future reference. After each inspection, a report of the inspection should be made out showing briefly what was found and what was done. The work involved in making such reports can be greatly simplified by using forms made out for the purpose. Forms available at the Denver Office, samples of which are enclosed herewith, are as follows:

Form No. PO&M 100 Overcurrent Relay Test Report
Form No. O&M 101 Differential Relay Test Report
Form No. O&M 102 Distance Relay Test Report
Form No. O&M 104 Switchboard Instrument Test Sheet
Form No. O&M 105 Watt-hour Meter Test Report
Form No. O&M 106 Miscellaneous Test Sheet
Form No. O&M 107 Bushing Power Factor Test Report
Form No. PO&M 109 Oil and Insulation Test Report--Insulation
Resistance Tests
Form No. PO&M 123 Inspection and Maintenance Record
Form No. PO&M 124 Equipment Failure Report
Form No. PO&M 133 Daily Battery Pilot Cell Readings
Form No. PO&M 134 Lead-acid Battery Cell Readings
Form No. O&M 150 Motor or Generator Inspection Report
Form No. O&M 151 Transformer Inspection Report
Form No. O&M 152 Circuit Breaker Inspection Report
Form No. O&M 153 Turbine Inspection Report
Form No. O&M 154 Pump Inspection Report
Form No. PO&M 155 High Voltage D.C. Insulation Test Record
Form No. PO&M 158 Nickel Cadmium Battery Cell Readings
Form No. PO&M 160 Runner Inspection Report







FILE No.

1st. Symbol group = Equipment designation symbol as established for construction purposes and shown on switching diagrams. G1a = generator No. 1. a, b, c, etc. represent parts such as exciters, etc. requiring separate cards. For old plant or equipment having no official symbol use word description such as Gen. 1, Line 1, etc.

2nd. Symbol = Month when inspection is due.

3rd. Symbol = Week when inspection is due.

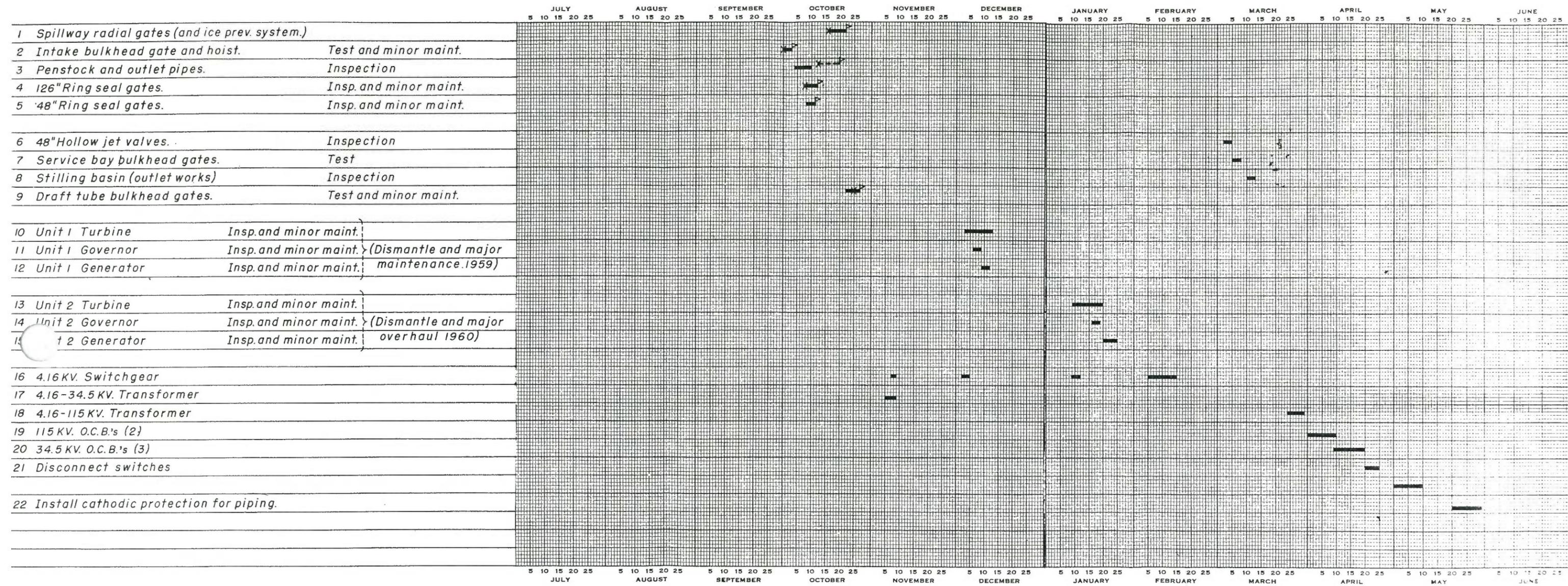
FIGURE 2
ROTATING CARD FILE SYSTEM FOR MAINTENANCE SCHEDULES

Equipment	Card File No.
Generators	
Unit No. 1 generator	G1a-6-1
Unit No. 1 main exciter	G1b-6-1
Unit No. 1 pilot exciter	G1c-6-1
Unit No. 2 generator	G2a-3-4
Unit No. 2 main exciter	G2b-3-4
Unit No. 2 pilot exciter	G2c-3-4
Turbines	
Unit No. 1 turbine	H1-6-1
Unit No. 2 turbine	H2-3-4
Governors	
Unit No. 1 actuator	A1-6-1
Unit No. 2 actuator	A2-3-4
Transformers	
Unit No. 1 main transformer	K1-5-4
Unit No. 2 main transformer	K2-2-4
Oil circuit breakers	
Unit No. 1 161-kv east bus	J1E-5-3
Unit No. 1 161-kv west bus	J1W-5-2
Line No. 2 161-kv east bus	J7E-2-2
Line No. 2 161-kv west bus	J7W-2-1
Disconnecting switches	
Line No. 1 ground switch	S7G-4-4
Line No. 1 OCB east bus switch	S7EA-4-3
Line No. 1 OCB east bus switch	S7EB-4-3
Unit No. 2 6.9-kv disc. switch	SG2-4-1

FIGURE 3
INSPECTION AND MAINTENANCE FILE INDEX

(To be made up on letter-size sheets and filed in ring binders)

FIGURE 4
MAINTENANCE SCHEDULE
BOYSEN UNIT - M.R.B.P. - POWER FEATURES
 F.Y. 1957



Work started - X Work completed - P
 Work rescheduled

(Graph sheet is K. & E. No. 359-141L)

The entries on this sheet are for illustration only and do not necessarily represent actual field data.

OVERCURRENT RELAY TEST REPORT

LOCATION _____ CIRCUIT _____ RELAY MFR. _____ TYPE _____ STYLE OR MODEL NO. _____

RELAY RATING.

TIME DELAY ELEMENT _____ TO _____ AMPERES _____ CHARACTERISTIC _____
 INSTANTANEOUS ELEMENT _____ TO _____ AMPERES _____
 DIRECTIONAL ELEMENT _____ AMPERES _____ VOLTS _____ DEGREES PHASE ANGLE _____

RELAY SERIAL NUMBERS. PHASE A _____ PHASE B _____ PHASE C _____

C. T. MARKED RATIOS _____ ACTUAL RATIO _____ P. T. MARKED RATIOS _____ ACTUAL RATIO _____

DATE	19__			19__			19__			19__		
	SETTING DESIRED	PHASE A	PHASE B	PHASE C	PHASE A	PHASE B	PHASE C	PHASE A	PHASE B	PHASE C	PHASE A	PHASE B

RELAY SETTING:

TIME DELAY ELEMENT - AMP. TAP															
- TIME LEVER															
- PRIMARY AMPS. KVA															
INSTANTANEOUS ELEMENT - AMPS. P. U.															
- PRIMARY AMPS. KVA															
DIRECTIONAL ELEMENT - AMPS. OR VOLTS															

RELAY TESTS:

A. TIME DELAY ELEMENT - MIN. PICK-UP AMPS															
INSTANTANEOUS ELEMENT - MIN. PICK-UP AMPS															
DIRECTIONAL ELEMENT - MIN. PICK-UP AMPS															
POLARIZING AMPS. OR VOLTS															
ANGLE OF MAX. TORQUE															
B. TIME DELAY ELEMENT - OPERATING AMPS															
POLARIZING AMPS. OR VOLTS															
OPERATING TIME - SECONDS															
C. TIME DELAY ELEMENT - OPERATING AMPS															
POLARIZING AMPS. OR VOLTS															
OPERATING TIME - SECONDS															
D. TIME DELAY ELEMENT - OPERATING AMPS															
POLARIZING AMPS. OR VOLTS															
OPERATING TIME - SECONDS															
E. INSTANTANEOUS ELEMENT - OPERATING AMPS															
OPERATING TIME - CYCLES															
DO TESTS AGREE WITH MFR S DATA ?															
DO RELAYS TRIP BREAKERS ?															
DO OPERATION INDICATORS OPERATE *															
DO AUXILIARY CONTACTS OPERATE *															

*RECORD MINIMUM PICK-UP AMPS.

NOTE. ALL DATA ARE FOR CONDITION AS LEFT UNLESS OTHERWISE NOTED.

TRIP CIRCUIT MEASUREMENTS:

DATE :

19__

19__

19__

19__

19__

MINIMUM AMPS. TO TRIP
TOTAL RESISTANCE
RESISTANCE OF TRIP COIL ONLY
MAIN CONTACT GAP CLEARANCE

.....
OHMS AT °C
OHMS AT °C
..... INCHES

.....
OHMS AT °C
OHMS AT °C
..... INCHES

.....
OHMS AT °C
OHMS AT °C
..... INCHES

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OHMS AT °C
OHMS AT °C
..... INCHES

.....
OHMS AT °C
OHMS AT °C
..... INCHES

GENERAL CONDITION OF RELAYS AS FOUND

DUST OR DIRT INSIDE OF RELAYS?
CONDITION OF CONTACTS?
CONDITION OF PIVOTS?
STICKING OR BINDING OF MOVING PARTS?
MAGNETIC PARTICLES IN AIR GAP?
CONDITION OF COILS?

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WHAT MAINTENANCE OR REPAIR WAS FOUND NECESSARY?

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WHAT CHANGES WERE MADE IN SETTINGS AND C.T. RATIOS?

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REMARKS

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TESTED BY:

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ASSISTED BY

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DIFFERENTIAL RELAY TEST REPORT

LOCATION Elephant Butte Pr. Pl. CIRCUIT Gen. No. 3 DATE OF TEST 3/17/45
 RELAY MFR. G. E. Co. TYPE IJD ~~XXXXXX~~ MODEL No. 12IJD12B2
 RELAY RATING:
 TAPS None 5 AMPERES. % SLOPE 10 Min. P.U. 0.1 Amp.

C.T. MARKED RATIOS 1000/5 ACTUAL RATIOS 1000/5

	PHASE A	PHASE B	PHASE C
RELAY SERIAL No.	3 element	KT	

RELAY SETTING:

TAP - AMPERES <u>None</u>			
SLOPE - %	10	10	10

MINIMUM PICK-UP CURRENT TESTS:

RESTRAINING COIL No.1 AMPS.	.12	.11	.12
RESTRAINING COIL No.2 AMPS.	0	0	0
RESTRAINING COIL No.3 AMPS.			
OPERATING COIL AMPS.	.12	.11	.12

MEDIUM PICK-UP CURRENT TESTS:

RESTRAINING COIL No.1 AMPS.	5.0	5.0	5.0
RESTRAINING COIL No.2 AMPS.	5.64	5.62	5.63
RESTRAINING COIL No.3 AMPS.			
OPERATING COIL AMPS.	.64	.62	.63

HIGH PICK-UP CURRENT TESTS:

RESTRAINING COIL No.1 AMPS.	10	10	10
RESTRAINING COIL No.2 AMPS.	11.1	11.2	11.1
RESTRAINING COIL No.3 AMPS.			
OPERATING COIL AMPS.	1.1	1.2	1.1

OVERCURRENT OPERATING TESTS:

A. RESTRAINING COIL No. <u>1</u> AMPS.	5	5	5
OPERATING COIL AMPS.	1	1	1
OPERATING TIME - CYCLES	8	9	9
B. RESTRAINING COIL No. <u>1</u> AMPS.	10	10	10
OPERATING COIL AMPS.	2	2	2
OPERATING TIME - CYCLES	8	8	8

CURRENT BALANCE FOR THRU PRIMARY CURRENT:

CIRCUIT No.1 AMPS.	3.	3.21	3.13
CIRCUIT No.2 AMPS.	3.17	3.22	3.12
CIRCUIT No.3 AMPS.			

DO RELAYS TRIP ALL CONNECTED DEVICES?	Yes	Yes	Yes
DO OPERATION INDICATORS OPERATE?*	".2	".2	".2
DO AUXILIARY CONTACTS OPERATE?*	None	.2	.2

*RECORD MINIMUM PICK-UP AMPS

NOTE: ALL DATA ARE FOR CONDITION AS LEFT UNLESS OTHERWISE NOTED.

Note: Data entered on this form is for illustration only and is not necessarily actual field data.

TRIP CIRCUIT MEASUREMENTS:

MINIMUM AMPS. TO TRIP 11 TOTAL RESISTANCE 7.1 OHMS AT 23 °C
RESISTANCE OF TRIP COIL ONLY 5 OHMS AT 23 °C
MAIN CONTACT GAP CLEARANCE _____ INCHES

GENERAL CONDITION OF RELAYS AS FOUND:

DUST OR DIRT INSIDE OF RELAYS? No
CONDITION OF CONTACTS? Tarnished--poor contact
CONDITION OF PIVOTS? OK
STICKING OR BINDING OF MOVING PARTS? Aux. contactor tended to stick closed
MAGNETIC PARTICLES IN AIR GAP? No
CONDITION OF COILS? OK

WHAT MAINTENANCE OR REPAIRS WAS FOUND NECESSARY?

Polished contacts

Corrected sticking of aux. contactor

WHAT CHANGES WERE MADE IN SETTINGS AND C.T. RATIOS?

None

REMARKS:

TESTED BY: Joe Smith

ASSISTED BY: A. Jones

DISTANCE RELAY TEST REPORT

(For W. relays - Use other side for G.E.)

LOCATION Mt. Home Substation DATE 5/24/55
 CIRCUIT Mt. Home--A.R. 115 kv MILES 17.9 R. 4.21 X 13.8 ϕ 7.30
 RELAY STYLE NO. HZ AUX. DEVICES[†]
 RANGE 0.6 TO 6.0 L-N OHMS[†] AMPS 5 VOLTS 115
 ANGULAR DISPLACEMENT RANGE
 C.T. RATIO 80/1 FAULT R.C.F. MULT. TO CONVERT $\left(\frac{\text{C.T. RATIO}}{\text{P.T. RATIO}}\right) = 0.0667$
 P.T. RATIO 1200/1 R.C.F. PRI. TO SEC. OHMS

TRANS. DROP COMP. SETTING --
[†]Calibration includes 5:8.66 L-L ratio Y-Δ aux. c.t.s.

DESIRED CHARACTERISTIC	ZONE 1	ZONE 2	ZONE 3
REACH: % OF LINE... ETC.	100% of line	A.R. 115-kv Transf.	A.R. 115-kv Transf.
PRI. OHMS AND ANGLE	29.6	50.8	84.5
SEC. OHMS AND ANGLE	1.975	3.39	5.64
MAX. TORQUE ANGLE	60	60	60
CHAR. RADIUS OHMS (2)			
DISPLACEMENT OHMS (1-2)			
MAX. KVA @ UNITY P.F.			
TIME			

SETTINGS	CALC.	ACTUAL			CALC.	ACTUAL			CALC.	ACTUAL		
		A	B	C		A	B	C		A	B	C
RADIUS TS	19.75	19.75	19.75	19.75	33.9	33.9	33.9	33.9	97.7	97.7	97.7	97.7
TAP	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	60	60	60	60
SCREW (as left)	0.95	1.01	0.88	0.88	1.63	1.75	1.63	1.63	1.63	1.57	1.70	1.58
DISPLACEMENT Z _R **												
VERNIER A**												
ANGLE R OR ϕ												
TIMER (as left--cycles)	--	--	--	--	20	20	20	20	60	60	60	60

TESTS: BALANCE POINT	A	B	C	A	B	C	A	B	C
VOLTS XXXXXXXXXX	35.6	35.6	35.6	60.0	60.0	60.0	60.0	60.0	60.0
AMPS. XXXXXXXXXX	18.0	18.0	18.0	17.7	17.7	17.7	6.15	6.15	6.15
PHASE ANGLE	84	84	84	84	84	84	84	84	84
OHMS REACH CALC. (sec.)	1.975	1.975	1.975	3.39	3.39	3.39	9.77	9.77	9.77
TIME (@ 80% REACH) (cycles)							1.0	1.0	1.0
VOLTS XXXXXXXXXX							60	60	60
AMPS. XXXXXXXXXX							7.7	7.7	7.7
OHMS REVERSE REACH							7.8	7.8	7.8
CONTACT RESISTANCE	Not measured								
CONTACT GAP CLEARANCE	.015	.015	.015	.020	.020	.020	.020	.020	.020
D UNIT MIN. P.U. VOLTS	25	25	25						
AMPS	0.48	0.81	0.69						
POWER FACTOR	1.0	1.0	1.0						

REMARKS Core screw adjusted to obtain specified operating points.

** FORMULAS DIFFER WITH 60-90° AND 60-120° RELAY MODELS

* SETTING OF TEST REACTOR AND RESISTOR IF USED

TESTED BY J. Smith ASSISTED BY A. Jones

Note: Data entered on this form is for illustration only and is not necessarily actual field data.

DISTANCE RELAY TEST REPORT

(For G.E. relays - Use other side for W.)

LOCATION..... DATE.....
 CIRCUIT..... MILES..... R..... X..... φ.....
 RELAY MODEL NO..... AUX. DEVICES.....
 RATING: RANGE.....TO..... L-N OHMS AMPS..... VOLTS.....
 STARTING UNIT.....TO..... L-N OHMS AMPS..... VOLTS.....
 C.T. RATIO..... FAULT R.C.F..... MULT. TO CONVERT (C.T. RATIO) =
 P.T. RATIO..... R.C.F..... PRI. TO SEC OHMS (P.T. RATIO) =
 TRANS. DROP COMP. SETTING.....

DESIRED CHARACTERISTIC	ZONE 1	ZONE 2	ZONE 3
REACH: % OF LINE... ETC.			
PRI. OHMS			
SEC. OHMS (1)			
MAX. TORQUE ANGLE			
OFFSET: SEC. OHMS (2) ANGLE			
OHMIC SETTING (1+2)			
MAX. KVA @ UNITY P.F.			
TIME			

SETTINGS	CALC.	ACTUAL			CALC.	ACTUAL			CALC.	ACTUAL		
		A	B	C		A	B	C		A	B	C
INPUT %												
RESTRAINT %												
MAX. TORQUE ANGLE												
OFFSET TAP												
OFFSET ANGLE												
TIMER												

TESTS: BALANCE POINT	A	B	C	A	B	C	A	B	C
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
PHASE ANGLE									
OHMS REACH CALC.									
TIME (@ 80% Z REACH)									
VOLTS OR TEST BOX %									
AMPS OR TEST R+JX*									
OHMS REVERSE REACH									
CONTACT RESISTANCE									
CONTACT GAP CLEARANCE									

REMARKS.....

* SETTING OF TEST REACTOR AND RESISTOR
 TESTED BY..... ASSISTED BY.....

SWITCHBOARD INSTRUMENT TEST SHEET

KIND OF INSTRUMENT A. C. ammeter

LOCATION Green Mt. Pr. Pl. CIRCUIT Gen. No. 1 DATE OF TEST 8/10/44

INSTRUMENT MFR. WE & M Co. TYPE H STYLE ~~XXXX~~ NO. 106581

INSTRUMENT RATING: VOLTS _____ AMPERES 5 WATTS _____ FREQ. 60

ELEMENTS 3 SERIAL No. 6095891

SCALE RANGE 0 - 100 CHART No. _____

KIND OF CHART DRIVE _____

C.T. RATIO 100/5P.T. P.T. RATIO _____ SHUNT _____ AMPS. EXTERNAL RES. _____ OHMS.

TEST STANDARD USED: MFR. G. E. Co. TYPE P3 STYLE MODEL NO. _____

SCALE RANGE 0 - 5 SERIAL No. 219897

ZERO CHECK - ON STANDARD OK ON INST. ON TEST OK

READINGS OF INSTRUMENT ON TEST TO READINGS OF STANDARD

		PERCENT OF FULL SCALE READING			
		25	50	75	100
ELEMENT 1:					
	VOLTS				
	AMPERES	24.9/1.25	49.7/2.5	75.0/3.75	101/5.0
	WATTS				
ELEMENT 2:					
	VOLTS				
	AMPERES	25.0/1.25	50.1/2.5	75.2/3.75	100/5.0
	WATTS				
ELEMENT 3:					
	VOLTS				
	AMPERES	24.4/1.25	49.6/2.5	74.9/3.75	100.5/5.0
	WATTS				
3-PHASE WATTS					

NOTE: ALL DATA ARE FOR CONDITION AS LEFT UNLESS OTHERWISE NOTED.

Note: Data entered on this form is for illustration only and is not necessarily actual field data.

GENERAL CONDITIONS AS FOUND:

DUST OR DIRT INSIDE OF INSTRUMENTS? No

CONDITIONS OF PIVOTS? OK

STICKING OR BINDING OF MOVING PARTS? Slight sticking at half scale

MAGNETIC PARTICLES IN AIR GAP? No

CONDITION OF POINTER AND SCALE? Pointer bent

BALANCE OF MOVING ELEMENT? OK

CONDITION OF COILS? OK

CONDITION OF CHART DRIVE? _____

CONDITION OF INKING DEVICE? _____

IS TIMING OF CHART DRIVE CORRECT? _____

WHAT MAINTENANCE OR REPAIRS WERE FOUND NECESSARY? _____
Straightened pointer and spiral spring

WHAT ADJUSTMENTS WERE MADE TO CORRECT INDICATION? _____
Zero adjustment only

REMARKS: Cracked glass should be replaced

TESTED BY: Joe Smith ASSISTED BY: A. Jones

WATTHOUR AND DEMAND METER TEST REPORT

LOCATION.....CIRCUIT.....DATE OF TEST.....

WATTHOUR METER:

MFR.....TYPE.....STYLE OR MODEL No.....SERIAL No.....
 VOLTS.....AMPS.....ELEMENTS.....REG RATIO.....GEAR RATIO.....
 DISC. CONST: PRI.....SEC.....MULTIPLIER.....
 DETENT.....

DEMAND METER OR ATTACHMENT:

MFR.....TYPE.....STYLE OR MODEL No.....SERIAL No.....
 KW FULL SCALE.....DEMAND INTERVAL.....MULTIPLIER.....
 GEAR RATIO.....POINTS ON CONTACT CAM.....CHART No.....

C.T. RATIO.....P.T. RATIO.....

STANDARD METER:

MFR.....STYLE OR MODEL No.....SERIAL No.....

METER REGISTRATION "AS FOUND"

DIAL READING.....AT.....A.M.
 P.M.

UPPER ELEMENT:

REV. OF METER TO STANDARD.....
 % REGISTRATION OF ELEMENT.....

..... AMP LOAD AT 1.0 P.F. AMP LOAD AT 1.0 P.F. AMP LOAD AT + .5 P.F. AMP LOAD AT - .5 P.F.

..... ELEMENT:

REV. OF METER TO STANDARD.....
 % REGISTRATION OF ELEMENT.....

--	--	--	--

LOWER ELEMENT:

REV. OF METER TO STANDARD.....
 % REGISTRATION OF ELEMENT.....

--	--	--	--

OVERALL REV. OF METER TO STANDARD.....

OVERALL % REGISTRATION.....

DOES METER CREEP WITH POTENTIAL ONLY APPLIED?.....

METER REGISTRATION "AS LEFT"

DIAL READING.....AT.....A.M.
 P.M.

UPPER ELEMENT:

REV. OF METER TO STANDARD.....
 % REGISTRATION OF ELEMENT.....

..... AMP LOAD AT 1.0 P.F. AMP LOAD AT 1.0 P.F. AMP LOAD AT + .5 P.F. AMP LOAD AT - .5 P.F.

..... ELEMENT:

REV. OF METER TO STANDARD.....
 % REGISTRATION OF ELEMENT.....

--	--	--	--

LOWER ELEMENT:

REV. OF METER TO STANDARD.....
 % REGISTRATION OF ELEMENT.....

--	--	--	--

OVERALL REV. OF METER TO STANDARD.....

OVERALL % REGISTRATION.....

DOES METER CREEP WITH POTENTIAL ONLY APPLIED?.....

DEMAND METER TESTS:

DEMAND METER READING-KW'-----
 DEMAND INTERVAL - MINUTES-----
 WATTHOUR METER REGISTRATION
 FOR INTERVAL OF----- MINUTES-WHRS-----
 TRUE WATTHOUR METER WATTS-----
 DEMAND METER INDICATED WATTS-----
 % CORRECT INDICATION-----

AS FOUND		AS LEFT	
AT	A.M. P.M.	AT	A.M. P.M.

CONDITION OF METER:

AS FOUND

AS LEFT

GENERAL -----

 JEWELS -----

 BALL OR PIVOT -----

 UPPER BEARING -----

 REGISTER -----

 DEMAND CONTACTS -----

 DEMAND MECHANISM -----

ADJUSTMENTS MADE:

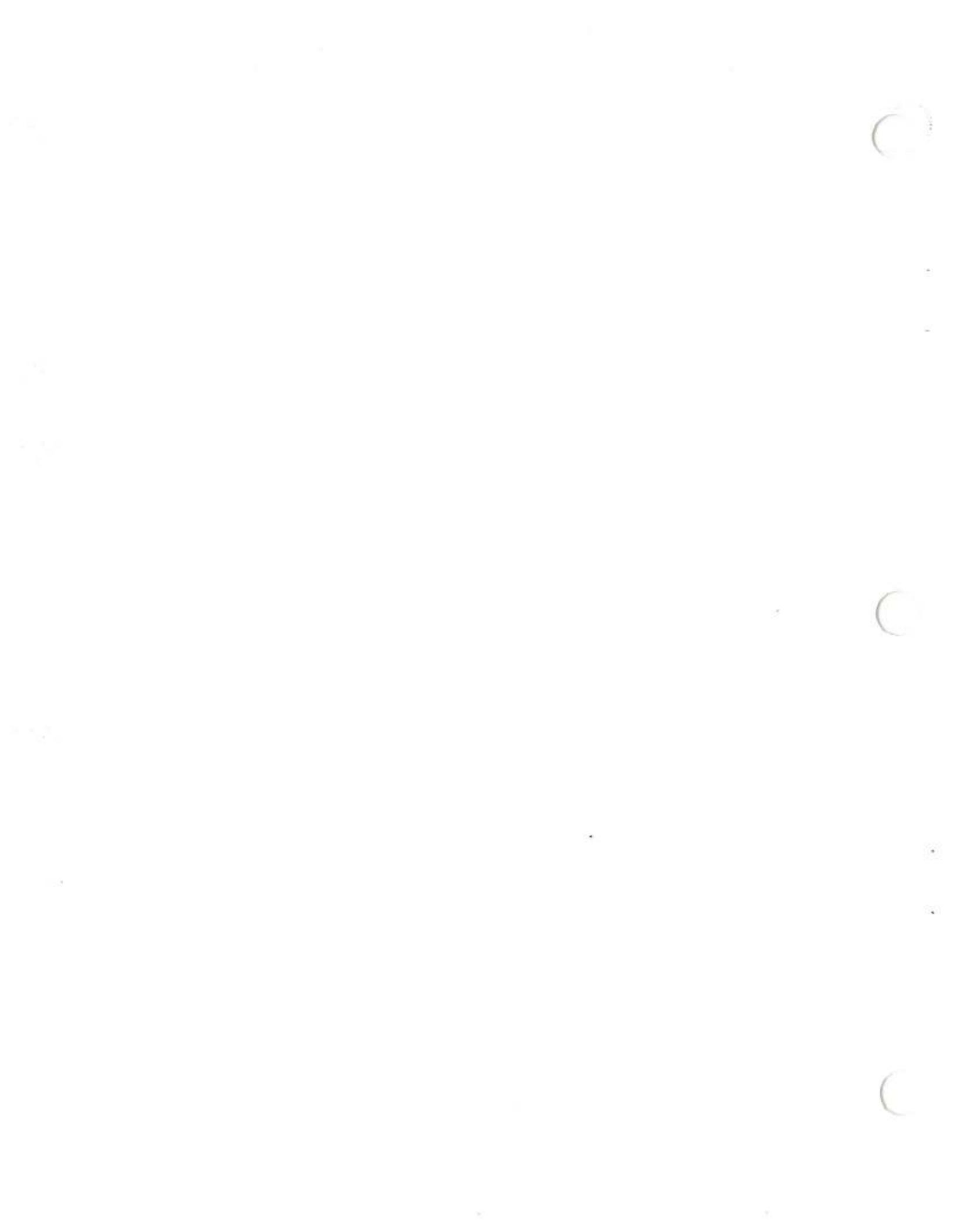
FULL LOAD -----

 LIGHT LOAD -----

 POWER FACTOR -----

 BALANCE -----

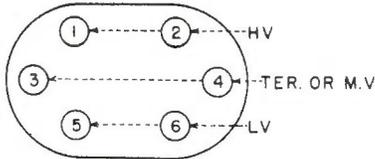
TESTED BY-----ASSISTED BY-----



BUSHING POWER FACTOR TEST REPORT

LOCATION Seminole Powerplant DATE OF TEST Sept. 10, 1943
 EQUIPMENT DESIGNATION Cheyenne Line Transformer - Phase A
~~XXXXXXXXXXXX~~ - TRANSFORMER
 MANUFACTURER American Transformer TYPE OLSC KVA 10,000
 SERIAL NO. 255134 KV 115 AMPS. _____
 AGE 3 yrs.
 BUSHING MFR. Ohio Brass KV 115 AMPS. _____
~~XXXX~~ Class G-40 ~~XXXX~~ Style B-JO
 DATES PREVIOUSLY TESTED Aug. 14, 1941

WEATHER CONDITION Clear
 AIR TEMP. 15°C OIL TEMP. 23°C



TRANSFORMER

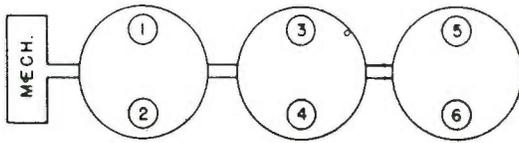
BUSHING	CAPACITANCE MMFD			POWER FACTOR %		
	DIRECT	REVERSE	AVERAGE	DIRECT	REVERSE	AVERAGE
HIGH TO LOW, GRD., TER.	5,030	5,040	5,035	1.00	1.02	1.01
LOW TO HIGH, GRD., TER.	5,180	5,160	5,170	0.80	0.80	0.80
LOW, HIGH TO GRD., TER.	5,000	5,000	5,000	1.06	1.04	1.05
TER. TO HIGH, LOW GRD.						

POS.	SERIAL NO.	COLLAR TESTS			(a)	(b)	(c)
		(a)	(b)	(c)			
1	168532	80	92	88	1.50	2.00	2.17
2							
3							
4							
5	168531	54	76	73	1.78	1.40	1.50
6							

REMARKS: (a) Below top skirt.
(b) Above bottom skirt.
(c) Above next to bottom skirt.

Note: Data entered on this form is for the purpose of illustrating the use of the form and is not necessarily actual field data.

OIL CIRCUIT BREAKER



BUSHING		CAPACITANCE			POWER FACTOR		
POS	SERIAL NO.	DIRECT	REVERSE	AVERAGE	DIRECT	REVERSE	AVERAGE
O.C.B. OPEN	1						
	2						
	3						
	4						
	5						
	6						
CLOSED	TANK 1						
	TANK 2						
	TANK 3						

COLLAR TESTS

1						
2						
3						
4						
5						
6						

REMARKS:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

TESTED BY:



EQUIPMENT FAILURE REPORT
DIVISION OF POWER OPERATIONS

- to:
- Office of Chief Engineer, Denver Attn: D-600
 - Reg. Office
 - Project Office

PROJECT M-0
REPORT NO. 8-56
DATE 4-7 19 56

EQUIPMENT Pacific Oerlikon Circuit Breaker No. 162--JY2A REGIONAL NO. 6
LOCATION Mount Vernon Substation
USED WITH Fort Randall 115-kv Line DATE OF FAILURE April 7 19 46
FURNISHED ON SPEC. OR INV. NO. DS-3424, Item 2 DATE INSTALLED September 25 19 52
MFG. OR MAKE Pacific Oerlikon TYPE TOFP-115.8
MODEL OR STYLE _____ SERIAL NO. 52000-22, -23, -24
VOLTS 115-kv AMPS. 800
H.P. _____ K.W. _____ K.V.A. _____ P.F. _____
R.P.M. _____ FREQ. 60 cycle PHASE 3 TEMP. RISE _____ °C
TAPS _____ % IMPEDANCE _____
INTERRUPTING RATING-KVA 3,500 MVA
OTHER NAMEPLATE DATA Operating Mechanism Type KL, Serial No. 52M04-8

CAUSE OF FAILURE Drive mechanism failed to reset closing spring trigger.
CONDITION OF EQUIPMENT WHEN REMOVED Repositioned the cam follower to obtain more clearance between the locking lever and the closing spring trigger when the closing springs are fully charged. Replaced equipment in service.

REPLACED WITH _____ DATE _____ 19 _____

MAKE _____ SERIAL NO. _____ REGIONAL NO. _____

DISPOSITION OF EQUIPMENT REMOVED _____ DATE _____ 19 _____

REMARKS _____

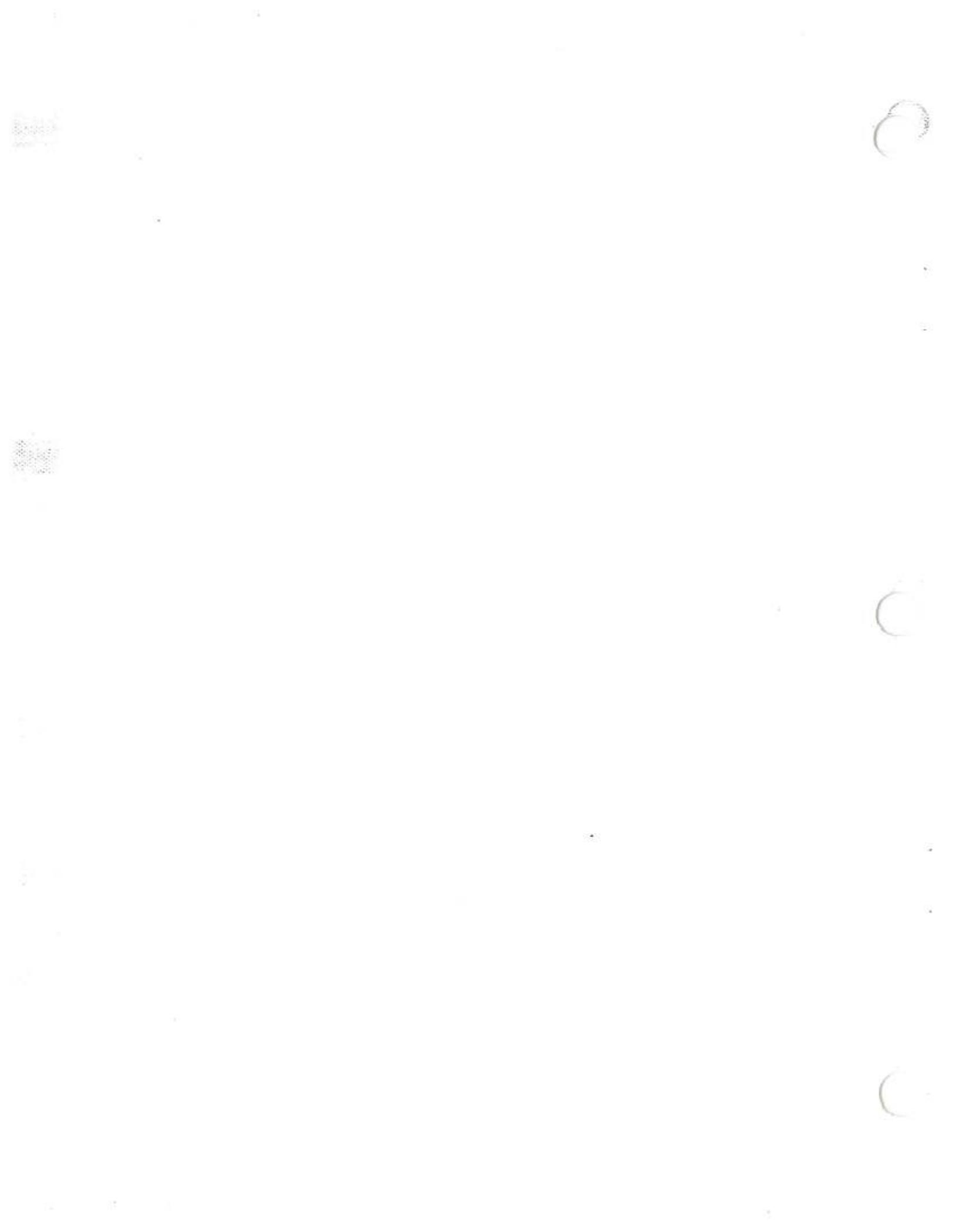
INSPECTED BY Stiever and Erling

Mr. Erling and I went to the Mount Vernon Substation to check the Dispatcher's
report that OCB 162 could not be closed. Arrived at the substation at 12:00 noon
4-7-56. Found OCB 162 open, closing springs fully charged, but could not close
breaker either electrically or with the mechanical push button. Discharged the
closing springs with the hand crank and allowed the motor to recharge the springs.
Then we successfully closed and tripped the breaker several times at the breaker
cabinet. However, the third attempt to close the breaker was from the control
board in the service building and this proved unsuccessful. Went out to the
breaker and was unable to close the breaker at the cabinet.

(Refer to Pacific Oerlikon Company Instruction Book for the Maintenance of 69-kv
and 115-kv Minimum-Oil Circuit Breakers No. 30001-1, or 466-M-602-551, Drawing
No. Z4-0096). Further investigation revealed that lever 32 had not cleared
lever 33 and trigger 35. Since cam follower 31, which controls lever 33, is
adjustable by means of slotted bolts holes, we attempted to lower cam follower 31
so that it would ride all the way out on shoulder 30. Cam follower 31 was
already butted against a projection on its lever arm, so we removed the cam
follower and filed about 1/16 inch off the bottom end and replaced it. All
subsequent operations were normal.

SIGNED _____

USE ADDITIONAL SHEETS IF REQUIRED





MOTOR OR GENERATOR INSPECTION REPORT

LOCATION Black Canyon Pr. Pl. DATE OF INSPECTION 6/6/44
 PURPOSE OF UNIT Main Unit UNIT No. 1
 MFR. OF UNIT Allis - Chalmers

RATING:

VOLTS 6600 AMPS 436 PHASE 3 FREQ. 60
 H.P. KW 4000 KVA. P.F. 80 %
 R.P.M. 225 TYPE Vertical Hydro
 FRAME SIZE SERIAL No.
 FIELD ~~66/574~~ AMPS. 96 VOLTS 250
 KIND OF BEARINGS.

MAIN EXCITER: KW. 35 VOLTS 250 AMPS. 140
 TYPE SERIAL No. 119500
 PILOT EXCITER: None KW. VOLTS AMPS.
 TYPE SERIAL No.

CONDITION OF UNIT AND AUXILIARY DEVICES:

COIL INSULATION Clean OK
 FIELD COIL RESISTANCE 1.90 OHMS AT 21 °C
 MAIN EXCITER FIELD COIL RESISTANCE 25.0 OHMS AT 21 °C
 PILOT EXCITER FIELD COIL RESISTANCE OHMS AT °C
 FRAME AND ROTOR Good
 STATOR AND ROTOR LAMINATIONS Good
 SHAFT Good
 COUPLING Good
 BEARINGS Good
 ANY OIL LEAKS? No
 BEARING OIL OK
 COLLECTOR RINGS OK
 COMMUTATOR Exciter commutator slightly grooved
 BRUSHES OK
 COLLECTOR RING OPERATION OK
 COMMUTATION OK

IF TROUBLE IS EXPERIENCED GIVE:

BRUSH GRADE SIZE NUMBER
 COLLECTOR-RING MATERIAL MAX. AMPS.
 SPRING PRESSURE LBS. RING OR COM. DIA. IN.
 MISALIGNMENT OR VIBRATION? Slight
 DOES END PLAY FLOAT FREELY?
 BEARING THERMOMETERS OR ~~TEMPERATURE~~ OK
 BEARING OIL GAGE ~~OK~~ OK
 BEARING COOLING-WATER PRESSURE GAGE OR SWITCH None
 STATOR TEMP. INDICATOR OR THERMOSTAT RTDs on swbd indicator OK
 FIRE PROTECTIVE EQUIPMENT None

Note: Data entered on this form is for illustration only and is not necessarily actual field data.

AIR GAP CLEARANCE (INCH)	XXXX NORTH	XXXX EAST	XXXX SOUTH	XXXX WEST
MAIN UNIT	.42	.44	.46	.45
MAIN EXCITER	.15	.18	.16	.14
PILOT EXCITER				

(MEASURE OPPOSITE SAME SPOT ON ROTOR FOR EACH POSITION IF PRACTICAL)

WAS INSULATION RESISTANCE MEASURED? See Form O&M 109

(REPORT DATA ON FORM O&M 109)

MAXIMUM LOADING AND TEMPERATURES OF UNIT (FROM ~~XXXX~~ TEST)

	6/6		6/6		6/7
DATE	6/6		6/6		6/7
HOUR	3P		11P		1A
A.C. AMPS.	410		272		80
A.C. KV.	6600		6600		6600
KW.	4900		3510		1600
KVAR. P.F.	99/ag		95/ag		95/ag
FIELD AMPS.	70		55		40
FIELD VOLTS	133		120		100
PILOT EXCITER AMPS.					
PILOT EXCITER VOLTS					
TURBINE GATE OPENING	.8		.6		.3
TURBINE NET HEAD	92		92		92
STATOR TEMP. °C.	78.5 by RTD		71 by RTD		65 by RTD
INLET AIR TEMP. °C.	30		22		20
THRUST BRG. TEMP. °C.	56		50		50
UPPER GUIDE BRG. TEMP. °C.	50		45		45
LOWER GUIDE BRG. TEMP. °C.	49		45		45
TURBINE GUIDE BRG. TEMP. °C.	44		40		40
COOLING WATER TEMP. °C.					
AMBIENT TEMP. °C.	30		22		20

REPAIRS OR CHANGES MADE AT TIME OF THIS INSPECTION.....

None

OTHER REPAIRS OR CHANGES RECOMMENDED.....

Respace exciter brushes and stone commutator

INSPECTION MADE BY: Joe Smith

NOTE: CROSS OUT ALL ITEMS WHICH DO NOT APPLY TO THE UNIT COVERED BY THIS INSPECTION.

TRANSFORMER INSPECTION REPORT

LOCATION Minidoka Pr. Pl. DATE OF INSPECTION 5/28/44
PURPOSE OF BANK Unit No. 6 BANK No. 6
MFR. OF TRANSFORMERS Packard Electric Co.

RATING:

HIGH VOLTAGE 19050/33000Y. taps 20955-20478-20002-19526-19050
MEDIUM VOLTAGE _____
LOW VOLTAGE 2300 delta
(UNDERLINE TAP OR VOLTAGE USED)

KVA PER TANK 1000
PERCENT IMPEDANCE 5.4
TYPE A COOLING Oil - self
FREQ. 60 CYCLES. PHASE 1 TEMP. 55 °C.
SERIAL NUMBERS 79511-09-10-12

BUSHINGS:	TYPE	MFR.	C.T. RATIOS	P.D. RATIOS
H.V.	<u>X</u>	<u>OB</u>	<u>100/5 delta</u>	
M.V.				
L.V.	<u>Y</u>	<u>OB</u>		

(UNDERLINE RATIO USED)

CONDITIONS OF TRANSFORMERS AND AUXILIARY DEVICES:

TANK AND ~~ACCESSORIES~~ OK
ANY OIL LEAKS? Slight
COOLING FANS _____
BUSHINGS OK
GROUND CONNECTIONS OK
GROUND RESISTANCE Station ground 1 ohm.
ARE TRANSFORMERS NOISY? No.
THERMOMETERS OK except 0 A sticks
TEMPERATURE RELAYS None
OIL-LEVEL GAGES OK
OIL-LEVEL ALARM RELAYS None
COOLING WATER SIGHT FLOW None
TAP CHANGERS "
AUTO-LOAD RATIO CONTROL "
IS PRESENT RANGE ADEQUATE? "
NITROGEN PURITY, % OXYGEN "
NITROGEN PRES. IN TRANSFORMER None
NITROGEN TANK PRES. "
PRESSURE RELIEF OK
CONSERVATOR "
CORE Transformer not untanked for this inspection
ARE ALL CLAMPING BOLTS TIGHT? _____
COIL INSULATION _____
COOLING COILS _____

Note: Data entered on this form is for illustration only and is not necessarily actual field data.

CONDITION OF INSULATING OIL Good
 WAS OIL TESTED? Yes - See Form O & M 109
 WAS INSULATION RESISTANCE TESTED? _____
 (RECORD OIL AND INSULATION DATA ON FORM O & M 109)

MAXIMUM LOADING AND TEMPERATURES OF TRANSFORMERS (FROM LOG SHEETS OR TESTS)

DATE	5/28				
HOUR	10A				
AMPS.	625				
KV.	2280				
KW.					
KVAR. P.F.					
KVA.	2470				
Φ A OIL TEMP. °C.	44				
Φ A RTD TEMP. °C.					
Φ B OIL TEMP. °C.	45				
Φ B RTD TEMP. °C.					
Φ C OIL TEMP. °C.	48				
Φ C RTD TEMP. °C.					
AMBIENT TEMP. °C.	18				
COOLING WATER IN - TEMP. °C.					
COOLING WATER OUT - TEMP. °C.					

REPAIRS OR CHANGES MADE AT TIME OF THIS INSPECTION _____

None

OTHER REPAIRS OR CHANGES RECOMMENDED _____

None

INSPECTION MADE BY: Joe Smith

NOTE: CROSS OUT ALL ITEMS WHICH DO NOT APPLY TO THE TRANSFORMERS COVERED BY THIS INSPECTION.

CIRCUIT BREAKER INSPECTION REPORT

LOCATION Cheyenne Substation DATE OF INSPECTION 8-11-52
CIRCUIT DESIGNATION Seminos line BREAKER No. Ch 364
BREAKER DATA:
MFR. Pacific Electric TYPE P.O. KV. 115 AMPS 600
INTERRUPTING KVA. 250,000 INTERRUPTING TIME 8 cycles
RECLOSING TIME No recloser SERIAL No. 6678
CLOSING MECHANISM TYPE Solenoid 125V.DC
TRIPPING MECHANISM TYPE Solenoid 125V.DC

INSPECTION: (CHECK IF SATISFACTORY OR NOTE CONDITION)

OPERATION COUNTER READING - AS FOUND 241 AS LEFT 245

FOUNDATION OK

TANKS OR FRAME:

ALINEMENT OK PAINT needs repainting GROUNDING OK

OPERATING MECHANISM:

CLOSING SOLENOID OK TRIPPING SOLENOID OK

~~CLOSING SPRING MECHANISM~~

~~CLOSING AIR BRIDGE CYLINDER~~

~~AIR COMPRESSOR~~ ~~AIR TANK~~

LATCHES OK RELAYS OK

TRIP-FREE MECHANISM OK

AUXILIARY SWITCHES Contacts pitted POSITION INDICATOR OK

CABINET HEATERS OK CABINET DOOR GASKETS OK

LUBRICATION OK

MAIN CONTACTS:

ALINEMENT OK ADJUSTMENT Ø A readjusted

CONDITION - MOVING slightly pitted FIXED slightly pitted

~~SPRINGS~~

~~RESISTORS~~

OPERATING RODS AND SHAFTS OK

BUSHINGS:

PORCELAIN OK Slightly chipped OIL OR COMPOUND LEAKS None

OIL LEVEL OK OIL CONDITION* OK Tested

TERMINALS OK

INSULATORS:

INSULATING OIL:

LEVEL OK LEAKS slight at B Ø drain valve

CONDITION* OK 28 - 30 - 27 kv See report

Potential Device - Connection loose in C Ø terminal box

*REPORT OIL TESTS ON FORM O & M 109
USE SPARE LINES FOR OTHER ITEMS AS NEEDED

Note: Data entered on this form is for purpose of illustration only and is not necessarily actual field data.

OPERATING TESTS:

NORMAL CLOSING SOLENOID VOLTS 125 AMPS 30 TIME* 12 cycles
 MINIMUM CLOSING SOLENOID VOLTS 70 AMPS 17 TIME* 20 "
 NORMAL CLOSING CONTROL RELAY OR VALVE VOLTS 125 AMPS 5
 MINIMUM CLOSING CONTROL RELAY OR VALVE VOLTS 60 AMPS 2.5
 NORMAL TRIPPING VOLTS 125 AMPS 10 TIME* 8 cycles
 MINIMUM TRIPPING VOLTS 70 AMPS 8.7 TIME* 10
 CLOSING SOLENOID RESISTANCE 4.2 OHMS AT 25 °C
 CLOSING RELAY OR VALVE RESISTANCE 25 OHMS AT 25 °C
 TRIP COIL RESISTANCE 10 OHMS AT 25 °C
 TOTAL TRIP CIRCUIT RESISTANCE 12.5 OHMS AT _____ °C
 CLOSING AIR PRESSURE - NORMAL _____ PSI - MINIMUM _____ PSI
 AVERAGE PRESSURE DROP PER HOUR _____ PSI
 READING OF COMPRESSOR OPERATION COUNTER _____
 TIME TO PUMP UP AIR PRESSURE _____ PSI TO _____ PSI _____ MINUTES
 COMPRESSOR CONTROL SWITCH CUT-IN _____ PSI - CUT-OUT _____ PSI
 NUMBER OF CLOSURES WITHOUT RECHARGING VALVE _____
 SAFETY VALVE SETTING _____ PSI

CLOSING SPRING MOTOR LOAD VOLTS _____ AMPS _____
 TIME TO CHARGE CLOSING SPRING _____ MINUTES _____

REPAIRS OR CHANGES MADE AT TIME OF THIS INSPECTION

Auxiliary switch contacts cleaned
AØ main contacts readjusted
Main contacts dressed slightly
stopped BØ oil leak
Tightened potential device connection

INSPECTED BY Joe Smith
A. Jones

USE SPARE LINES FOR OTHER ITEMS AS NEEDED
 * OVERALL TIME FROM CLOSING OF CONTROL SWITCH CONTACTS

TURBINE INSPECTION REPORT

PROJECT Central Valley POWERPLANT Shasta UNIT NO. 1 DATE 4-7-56

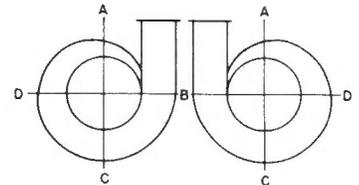
CLEARANCES BETWEEN UPPER AND LOWER CURB PLATES AND WICKET GATES			CLEARANCES BETWEEN WICKET GATES, CLOSED POSITION WITH PRESSURE RELEASED*			CLEARANCES BETWEEN UPPER AND LOWER CURB PLATES AND WICKET GATES			CLEARANCES BETWEEN WICKET GATES, CLOSED POSITION WITH PRESSURE RELEASED*		
GATE	UPPER	LOWER	TOP	MIDDLE	BOTTOM	GATE	UPPER	LOWER	TOP	MIDDLE	BOTTOM
1	.008	.005		.038		13	.003	.015		.042	
2	.006	.015		.031		14	.006	.012		.040	
3	.005	.012		.034		15	.006	.012		.042	
4	.008	.015		.038		16	.008	.014		.040	
5	.007	.012		.039		17	.005	.015		.038	
6	.004	.015		.037		18	.004	.015		.042	
7	.005	.015		.034		19	.008	.012		.048	
8	.006	.012		.031		20	.004	.012		.043	
9	.010	.015		.032		21	.008	.008		.045	
10	.006	.012		.037		22	.007	.008		.048	
11	.005	.015		.036		23	.005	.010		.043	
12	.005	.015		.039		24	.005	.010		.040	

* CONSIDER CLEARANCE BETWEEN GATES NO. 1 AND 2 AS NO. 1, ETC.

PART	POSITION			
	A	B	C	D
UPPER WEARING RING	N.E. .031	S.E. .041	S.W. .050	N.W. .040
LOWER WEARING RING	N.E. .030	S.E. .046	S.W. .051	N.W. .043
TURBINE GUIDE BEARING, LOWER END) By	N. .004	E. .003	S. .014	W. .013
TURBINE GUIDE BEARING, UPPER END) jacking				
POSITION** OF CROWN AND CURB PLATE	1/16" Low	1/16" Low	1/16" Low	1/16" Low
POSITION*** OF BAND AND CURB PLATE	OK	OK	OK	OK

*** HIGH OR LOW WITH RESPECT TO CURB PLATE

Discharge edge of No. 14 bucket was in line with east draft tube door



CONDITIONS OF:

PAINT AND KIND, OR IF BARE, METAL SURFACES OF, INCLUDING LOCATION OF PITTING AND EROSION AREAS AND SIZE AND DEPTH OF DAMAGED AREAS

SCROLL CASE: CA-50 Good

PENSTOCK: Coal tar enamel excellent. Very few bare areas. Most patched with two coats CA-50

SPEED RING, WICKET GATES, CURB PLATES: Stay ring - paint chipped off leading edges. Wicket gates paint O.K. on outside, smooth inside. Facing plates - bare and smooth

DRAFT TUBE: Not completely unwatered - some bare areas on top portion.

RUNNER: Type 4 red lead surface good. Runner in good condition. Some slight cavitation action occurring near discharge edge of all vanes on low pressure side about 15 sq in per vane and 1/4" to 1/8" deep. Runner seal clearance O.K.

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CONDITION OF

OIL PUMP... OK

GAGES... Calibrated

SHAFT PACKING

LEAKAGE... 5+ GPM, TYPE Braided Asbestos, NEED REPACKING? No

GATE STEM PACKING

LEAKAGE... 0 GPM, TYPE Flax, NEED REPACKING? Adjusted glands

HEAD GATE

LEAKAGE... 50+ GPM, LOCATION Top seal base, TYPE Coaster

GLANDS AND LANTERN RING: Not inspected

SHAFT AT GLAND: Not inspected

SHIFTING MECHANISM:

THRUST COLLARS 4 halves inspected. Nos. 1, 7, 14, and 18, and found OK.
These are bronze.

PINS AND JOURNALS: Not inspected

GATE STEMS AND BUSHINGS: Not inspected

LIST ALL BUSHINGS WITH EXCESSIVE CLEARANCE: None noted

SHIFT RING: Not inspected

TURBINE GUIDE BEARING:

BEARING: Not inspected

JOURNAL: Not inspected

OTHER ITEMS: Repaired tubo-vent--Used new packing & cup leathers.
Renewed gaskets in servo-motor cushion valves.
Checked wicket gate closure and calibration.
Checked functioning of centralized greasing system.

NAME, MANUFACTURER AND VISCOSITY OF OIL USED: Associated (2110-2135) 250 SSU at 100° F.

NAME, MANUFACTURER AND GRADE OF GREASES USED: Tycol-Ambercup-Associated-Federal Specification
Item 14-G-1173. Type B, Grade 1, soft calcium

REMARKS AND RECOMMENDATIONS 150 lbs. 5/32 18-8 stain weld
A5-Cb rod used on runner

140 lbs. 3/16" rod same as above also used on runner.
All runner cavitated areas were repaired.

INSPECTION MADE BY John Rose

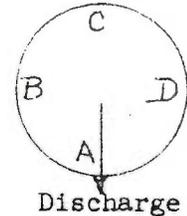
PUMP INSPECTION REPORT

PROJECT: Colo-Big Thompson PUMPING PLANT: Granby UNIT NO. 1 DATE: 3-12-56
 MANUFACTURER: N. N. Shipbuilding & Dry Dock Co. MODEL NO.: None
 TYPE: Centrifugal Vertical Pump SERIAL NO.: 10
 CAPACITY: 200 c.f.s. HEAD: 186 feet

PART	CLEARANCES			
	POSITION **			
	A	B	C	D
WEARING RING, MOTOR END	.015	.014	.014	.015
WEARING RING, PUMP END	.014	.015	.015	.014
PUMP GUIDE BEARING, MOTOR END	.016	.017	.015	.017
PUMP GUIDE BEARING, INTERMEDIATE	.018	.016	.017	.016
PUMP GUIDE BEARING, PUMP END	.014	.016	.015	.015
*IMPELLER				
*OTHER CLEARANCES				

*EXPLAIN AND GIVE REFERENCE POINTS IN REMARKS IF NECESSARY.

** SHOW SKETCH



CONDITION OF:

PAINT AND KIND, OR IF BARE, METAL SURFACES OF, INCLUDING LOCATION OF PITTING AND EROSION AREAS AND SIZE AND DEPTH OF DAMAGED AREAS:

CASING: CA50 paint condition good except for small shipped areas covering approximately 5 square feet in area.

DISCHARGE PIPE: Short metal section good--Concrete section good.

IMPELLER, DIFFUSER: Bronze impeller not painted. Some cavitation on shroud band. Cracks occurring in previous welded vanes. (See impeller report 4-5-56)

SUCTION PIPE: Did not check

SEAL AND WEARING RINGS: Slight scoring of wearing ring motor end considered satisfactory for further operation. Wearing ring pump end OK.

Note: Data entered on this form are for illustration only and is not necessarily actual field data.

CONDITION OF:

OIL PUMP: D.C. Pump OK--A.C. Pump noisy bearing

GAGES: OK Checked and calibrated 2-5-56.

INTAKE GATE:

LEAKAGE, 20 GPM, DESCRIPTION OF LEAKAGE: Leakage right hand bottom side

DISCHARGE GATE:

LEAKAGE, 25 GPM, DESCRIPTION OF LEAKAGE: Leakage along center at top

SHAFT PACKING:

LEAKAGE, 0 GPM, TYPE Garlock G44, NEED REPACKING? No

GLANDS AND LANTERN RING: Condition good

SHAFT SLEEVE: Slight scoring servicable after filing

PUMP BEARINGS:

MOTOR END: Surface OK

INTERMEDIATE: Surface OK

PUMP END: Slight wiping in center of bearing. Bearing OK after scraping.

JOURNALS: OK

OTHER ITEMS:

NAME, MANUFACTURER AND VISCOSITY OF OIL USED: Standard Oil Stan - oil 31

NAME, MANUFACTURER AND GRADE OF GREASES USED: Texaco No. 1

DATE LAST OVERHAUL: 2-5-55

REPAIRS MADE: Impeller removed and reconditioned. See Unit 1 overhaul report 3-6-55.

REMARKS AND RECOMMENDATIONS:

Repair damage paint area in pump casing.

Investigate repair of cracked runner vanes by chain lock method.

Replace A.C. oil pump bearing.

INSPECTION MADE BY: John Rose

HIGH VOLTAGE D.C. INSULATION TEST RECORD

PROJECT Columbia Basin PLANT Grand Coulee UNIT NO. L-3
WINDING TEMP. 31.2 °C R.H. 40% DATE OF TEST 5/12/56
EQUIPMENT INCLUDED IN TEST Each phase of stator separately with transformer bus to potential cubicle and idconnects including main and neutral CTS.

TIME min.	KV.	MICRO-AMPS	MEG-OHMS	TIME min.	KV.	MICRO-AMPS	MEG-OHMS	TIME min.	KV.	MICRO-AMPS	MEG-OHMS
* A ∅				* B ∅				* C ∅			
1	5.0	37.0		1	5.0	36.0		1	5.0	36.0	
3	"	19.0		3	"	17.2		3	"	17.3	
6	"	12.5		6	"	11.4		6	"	11.5	
10	"	9.4		10	"	8.4		10	"	8.9	
15	"	7.3		15	"	6.8		15	"	6.9	
20	"	5.2		20	"	5.9		20	"	5.8	
25	"	5.5		25	"	5.0		25	"	5.0	
30	"	5.0	1000	30	"	4.6	1082	30	"	4.6	1082
34	9.3	45.0		34	9.3	42.5		34	9.3	42.0	
37	"	19.9		37	"	17.9		37	"	18.0	
40	"	15.5		40	"	14.1		40	"	14.4	
45	"	12.7		45	"	11.4		45	"	11.7	
50	"	11.0	845	50	"	10.0	930	50	"	10.0	930
54	13.0	39.0		54	13.0	36.0		54	13.0	36.5	
57	"	22.0		57	"	20.0		57	"	20.2	
60	"	18.7		60	"	17.0		60	"	17.0	
63	"	16.8		63	"	15.0		63	"	15.2	
66	"	15.3	839	66	"	13.9	935	66	"	14.0	930
68	15.3	38.0		68	15.3	35.0		68	15.3	35.0	
71	"	23.5		71	"	21.2		71	"	21.4	
75	"	19.8	772	75	"	18.0	850	75	"	18.0	850
77	17.0	32.0		77	17.0	29.0		77	17.0	29.5	
80	"	23.1		80	"	21.9		80	"	21.9	
83	"	20.6	825	83	"	19.4	875	83	"	19.5	870
85	19.0	42.5		85	19.0	41.0		85	19.0	41.0	
87	"	29.7		87	"	28.0		87	"	28.5	
90	"	25.5	746	90	"	24.0	790	90	"	24.4	780
92	21.0	39.0		92	21.0	37.0		92	21.0	37.8	
94	"	30.1		94	"	28.8		94	"	29.2	
96-1/2	"	27.2	775	96-1/2	"	25.9	820	96-1/2	"	26.2	800
97-1/2	22.2	43.5		97-1/2	22.2	41.5		97-1/2	22.2	42.0	
98-1/2	"	34.1		98-1/2	"	32.3		98-1/2	"	32.9	
100-1/4	"	30.2	770	100-1/4	"	28.5	780	100-1/4	"	29.1	767
101-1/4	23.0	45.5		101-1/4	23.0	43.3		101-1/4	23.0	44.0	
102-1/4	"	36.9		102-1/4	"	34.8		102-1/4	"	45.3	
103-3/4	"	32.2	710	103-3/4	"	30.3	762	103-3/4	"	30.9	745
104-3/4	24.0	41.0		104-3/4	24.0	38.6		104-3/4	24.0	39.4	
106	"	35.0		106	"	32.8		106	"	33.3	
107	"	32.9	730	107	"	30.9	770	107	"	31.5	762
108	25.0	48.0		108	25.0	45.0		108	25.0	45.5	
109	"	38.6		109	"	35.9		109	"	36.9	
110-1/4	"	35.0	715	110-1/4	"	32.8	762	110-1/4	"	33.2	750

* Identify phase, coil No. etc. at head of column

Polarization Index 3.95

4.29

4.04





Remarks:

Maximum depth of pitting - inches _____

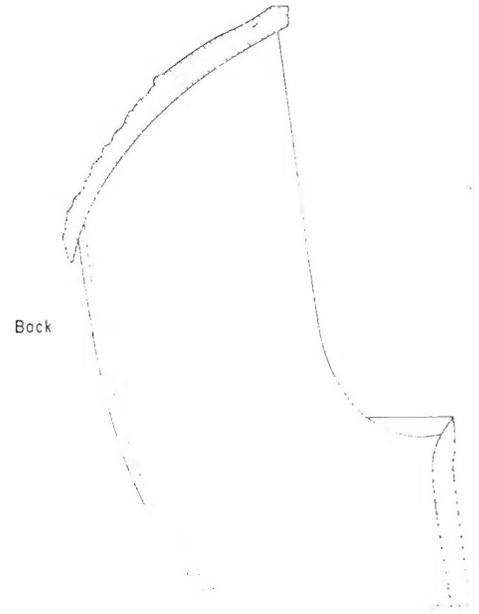
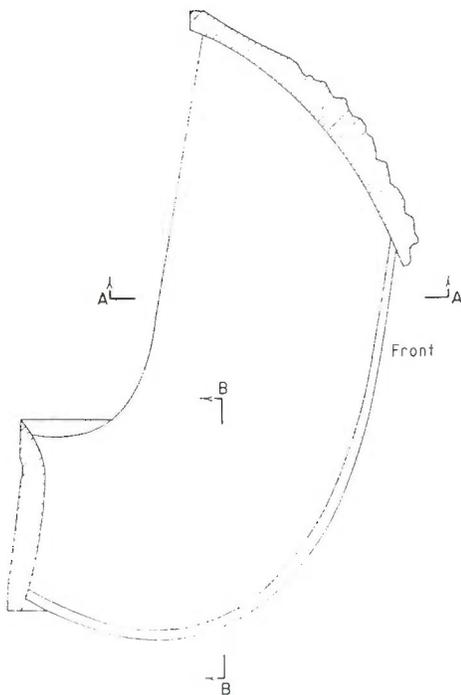
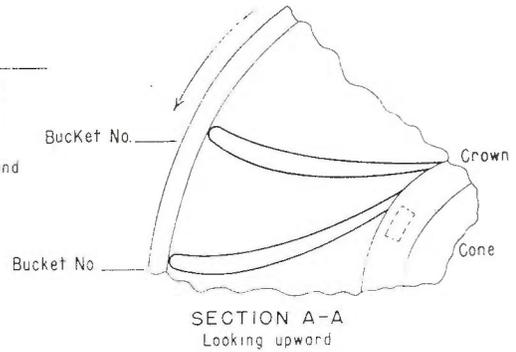
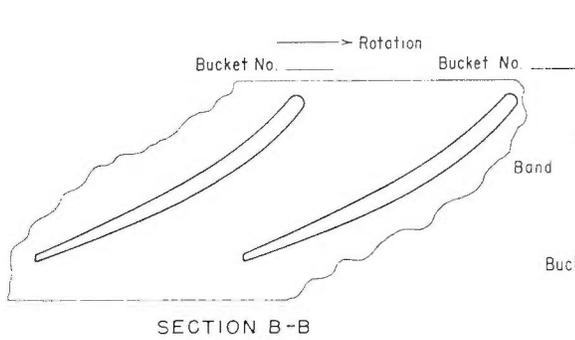
Unit No. _____ Bucket No. _____

Bucket _____
 Band _____
 Crown _____
 Cone or vent _____

Area repaired (this sheet) - sq. in. _____ Date _____
 Bucket _____
 Band _____
 Crown _____
 Cone or vent _____

Note:

Other Runner Inspection Report Forms are available
 PO&M 161--Long Bucket--Counterclockwise Rotation
 PO&M 162--Short Bucket--Clockwise Rotation
 PO&M 163--Short Bucket--Counterclockwise Rotation
 PO&M 164--Impulse Runner



Method of repair and material used _____

 Presently pitted
 Presently patched

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION		
PLANT		
RUNNER INSPECTION REPORT LONG BUCKET - CLOCKWISE ROTATION		
UNIT No. _____	BUCKET No. _____	
INSPECTOR _____	SHEET _____	OF _____ SHEETS
APPROVED _____	DATE _____	



2. Power Dams and Canals

INSPECTION CHECK LIST

<u>Item of inspection</u>	<u>Inspection interval</u>	<u>Procedure reference</u>
<u>Power Dams and Canals (In General)</u>	D	2.01
Concrete and masonry	D	2.02
Earth embankments or fills	A	2.03
Canal lining and riprap	A	2.04
Expansion joints	A	2.05
Roadways and walks	A	2.06
Railings and miscellaneous metalwork	A	2.07
Stairways and ladders	M A	2.08
Cranes, hoists, and elevators		See Section 5
Gates and valves		See Section 4
Trashracks	D	2.11
Trash-removing facilities	A	2.12
Ice prevention and removing facilities	A	2.13
Galleries and shafts	W A	2.14
Fish ladders and screens	W A	2.15
Conduit and fittings	A	2.16
Wiring and wiring devices	A	2.17
Lighting and power	W	2.18
Floating boom	D A	2.19
Reservoir or forebay	A	2.20

D--Routine daily inspection.
W--Routine weekly inspection.
M--Routine monthly inspection.
A--Annual inspection.

References

Bureau Paint Manual and Field Painting of Metalwork
Power O&M Bulletin No. 3, Testing Electrical Equipment Insulation
Power O&M Bulletin No. 25, Corrosion Protection of Buried and Submerged Metals

- 2.01 Dam and power canal (in general) Daily inspection. Visual inspection by any operator, caretaker, or maintenance man who has occasion to be at or near the dam or canal, for signs of anything unusual such as leaks, ice formation collecting of debris, earth or rock slides, safety hazards, presence of unauthorized persons, etc.
- 2.02 Concrete and masonry Daily inspection. Visual inspection to detect signs of deterioration of concrete or masonry, movement of earth embankments or fills, leaks or improper drainage, etc.
- 2.03 Earth embankment or fills Annual inspection. Close inspection of concrete and masonry or earth embankments or fills for cracks, movement, deterioration, leaks, improper drainage, etc. Make repairs as necessary to maintain normal life and safety of structures.
- 2.04 Canal lining and riprap Annual inspection. When canal can be drained, check concrete or other lining for movement, cracks, leaks, and deterioration, and repair as necessary. Check riprap on earth embankments.
- 2.05 Expansion joints Annual inspection. See that expansion joints are kept free of gravel, ice, or other material which might obstruct movement of mass concrete. Check rubber or metal joint filler strips.
- 2.06 Roadways and walks Annual inspection. Check roadway and walk surfaces for holes, bumps, ruts, etc., and resurface as necessary.
- 2.07 Railings and miscellaneous metalwork Annual inspection. See that all stair and guardrailings are securely fastened and rigid. Check metalwork for corrosion, rusting, or other damage, and repaint as necessary.
- 2.08 Stairways and ladders Monthly inspection. Visual inspection to detect failures, obstructions, slipperiness, or other safety hazards.
Annual inspection. Check and tighten bolts and screws. Correct slipperiness and other safety hazards. Check metalwork for corrosion or rusting and repaint as necessary.
- 2.11 Trashracks Daily inspection. Check for trash and remove as necessary.
- 2.12 Trash-removing facilities Annual inspection. Check trashracks, including underwater portion, so far as possible, and remove lodged debris not removed on routine cleaning. Check condition of metalwork

and repair as needed. See that trash-removing facilities are adequate and in good repair.

Annual inspection. Check operation of electric heaters, air bubbling system, or other ice-prevention devices at trash-racks, spillway gates, etc., during mild weather to see that the system is in working order. Check again for adequacy of the system during coldest weather. See that ice formation against dam or at spillway gates is not endangering the structure or preventing movement of the gates. 2.13
Ice prevention and removal facilities

Weekly inspection. Visual inspection to detect excessive leakage, stopped drains, and anything unusual. 2.14
Galleries and shafts

Annual inspection. Make close inspection of leaks, drains, and cracks. Clean drains and direct drainage so as to keep it off walkways, stairways, ladders, and equipment. Check ventilation through galleries. See that adequate guard-rails or enclosures are provided at head of shafts. Check for excessive corrosion of metalwork, and apply protection as necessary.

Weekly inspection. Visual inspection to see that fish ladders are in service during fish migrating season and that screens are in place where required and kept free of debris. 2.15
Fish ladders and screens

Annual inspection. Check condition of fish ladders and screens and repair as necessary. These facilities are sometimes operated and maintained by the Fish and Wildlife Service, in which case inspection by the Bureau is not necessary except as it affects Bureau operations.

Annual inspection. Inspect conduit, condulets, outlet, and switchboxes, etc., for rust or deterioration from moisture or alkali. Check conduits for proper drainage. Arrange to keep such metalwork as dry as possible. 2.16
Conduit and fittings

Annual inspection. Inspect and tighten connections at terminal points. Check for presence of moisture. Inspect insulation. Test insulation resistance. 2.17
Wiring and wiring devices

Weekly inspection. Try out lights to see that they are in operating condition, and replace burned-out lamps. Try out power-driven equipment to see that power is available and equipment operable. See also Sections 4 and 5 of this bulletin. Check power and lighting outlets. 2.18
Lighting and power

2.19
Floating
boom

Daily inspection. Visual inspection to see that boom protecting penstock or canal intake or spillway is intact.

Annual inspection. See that boom timbers are sound and that floats and drums are free of leaks and adequately painted. Check boom chains or cables and shore anchors. Remove debris collected in front of boom.

2.20
Reservoir or
forebay

Annual inspection. Inspect shoreline of reservoir or forebay at low-water stage. Collect and burn debris to reduce accumulation in front of boom or trashracks.

3. Powerplant Buildings

INSPECTION CHECK LIST

Item of inspection	Inspection interval	Procedure reference
Doors and windows	M A	3.06
Stairways and ladders	M A	2.08
Railings and miscellaneous metalwork	A	2.07
Elevators, cranes, and hoists	See Section 5	
Electric space heaters	D	3.10
Ventilating fans	A	3.11
Water supply and drain piping	A	3.12
Water heaters and coolers	W A	3.13
Wash basins, sinks, showers, toilets, etc.	W	3.14
Water supply	W A	3.15
Conduit and fittings	A	2.16
Wiring and wiring devices	A	2.17
Lighting	W	3.18
Fire protection	M A	3.19

D--Routine daily inspection
W--Routine weekly inspection
M--Routine monthly inspection
A--Annual inspection

References

Power O&M Bulletin No. 23, Fire--Fighting, Cause, and Prevention
Bureau Paint Manual and Field Painting of Metalwork

- 3.06
Doors and windows
Monthly inspection. Check for general condition of windows, door locks, etc. Keep window glass clean. Replace broken glass.
- Annual inspection. Check windows and window operators, latches, etc. Check doors, hinges, lock operators, etc. Repaint frames, doors, and sash as necessary.
- 3.10
Electric space heaters
Daily inspection. Visual inspection to see that heaters and ventilating fans are functioning properly in their respective seasons of use.
- 3.11
Ventilating fans
Annual inspection. Check control thermostats, contactors, and fans for proper operation. Check heating elements of heaters for open circuits, short circuits, and damaged insulation. Check air-circulating ducts. Check for adequacy of the heating and ventilating facilities during cold and hot weather, respectively. See also Section 8 for motors and Section 14 for control equipment.
- 3.12
Water supply and drain piping
Annual inspection. Check for leaks and repair as necessary. Check for obstructions in supply and drain piping and remove as necessary.
- 3.13
Water heaters and coolers
Weekly inspection. Visual inspection to see that water heaters and coolers are functioning properly.
- Annual inspection. Check electric water heaters for burned-out or grounded elements. Flush from bottom of tank and observe for signs of rust. Check thermostat operation and clean contacts. Check water cooler refrigerating element. Lubricate if required.
- 3.14
Wash basins, sinks, showers, toilets, etc.
Weekly inspection. Check for dripping faucets and valves and other leaks, and repair as necessary. See that all equipment is maintained in clean and sanitary condition.
- 3.15
Water supply
Weekly inspection. Check purity and cleanliness of drinking water. Check operation of purifying equipment. Check amount of drinking water in storage and see that supply pumps are in operating condition.
- Annual inspection. Check and clean water storage tanks. Check supply intake for cleanliness and freedom from

obstruction. Check purifying equipment. Check and overhaul water supply pumps, float switches, pressure switches, pressure reducers, etc. Check motors and control equipment. (See Sections 8 and 14.)

Weekly inspection. Try out normal and emergency lights to see that they are in operating condition, and replace burned-out lamps. 3.18
Lighting

Monthly inspection. Visual inspection of sprinkler system, water-supply control, and fire doors. Flush sprinkler-system branch lines. Check fire extinguishers as follows and see that they are kept in specified locations: 3.19
Fire protection

15-pound and similar portable CO₂, weigh monthly
75- and 100-pound wheel-type portable CO₂, weigh quarterly

Fixed CO₂ cylinders (usually 50 pounds), weigh semi-annually

Soda-acid (all water-solution types), inspect quarterly

Flush fire hydrants and inspect hose carts, hose, nozzles, etc., quarterly. Review fire-fighting procedure with all personnel concerned two to four times annually.

See Power O&M Bulletin No. 23 for detailed fire-protection instructions.

Annual inspection. Test a few sprinkler heads at random for correct operation. Test operation of fire doors.

4. Penstocks, Gates, and Valves

INSPECTION CHECK LIST

Items of inspection	Inspection interval	Procedure reference
<u>Penstocks</u>		
Foundation	Q A	4.01
Sliding supports	Q A	4.02
Slip joints	Q A	4.03
Rivets, welds, and bolts	Q A	4.04
Exterior paint and surface	A	4.05
Interior paint and surface	A	4.06
<u>Gates and Valves (In General)</u>		
	A	4.07
Seals and guides	NS	4.08
Seat, disk, or needle ring and spider	NS	4.09
Stems	A	4.10
Lubrication	NS A	4.11
Spring and cushioning mechanism	NS	4.12
Journals, bearings, and bushings	NS	4.13
Wheels, pins, and rollers	NS	4.14
Operating cylinder or gear mechanism	NS	4.15
Control piping	A	4.16
Packing glands	W A	4.17
Operation	NS A	4.18
Gate hoist or crane	See Section	5
Electric motors	See Section	8
Electrical control equipment	See Section	14

W--Routine weekly inspection.

M--Routine monthly inspection.

A--Annual inspection.

NS--Not scheduled, frequency as required to maintain equipment and assure its function.

Q--Quarterly inspection.

Note: In the absence of specific maintenance instructions on valves and gates, Items 4.08 through 4.18 should be carried out.

References

Bureau Paint Manual and Field Painting of Metalwork

Power O&M Bulletin No. 21, Lubrication of Powerplant Equipment

- Quarterly inspection. Visual inspection for cracks, settling, and spalling. 4.01
Foundation
- Annual inspection. Make careful check on alinement of penstock and foundation. Settlement or breakage of the foundation may stress the penstock joints beyond their breaking points.
- Quarterly inspection. Visual inspection for lubrication and for obstructions. 4.02
Sliding supports
- Annual inspection. Check lubrication. Flush grease fittings if not self-lubricating with fresh lubricant, clean all exposed bearing surfaces of rust, scale, paint, or other material, and sludge with suitable grease. See that sliding members are not obstructed. Obstruction of sliding members may cause buckling and weakening of the penstock joints.
- Quarterly inspection. Visual inspection for leaks and corrosion. Tighten adjusting bolts as necessary and clean sliding surface. 4.03
Slip joints
- Annual inspection. Repack as necessary. Clean and lubricate sliding surface. See that penstock is not obstructed and is free to move at slip joint.
- Quarterly inspection. Visual inspection of all welds, rivets, and bolted flanges for leaks and corrosion. 4.04
Welds, rivets, and bolts
- Annual inspection. Make careful visual examination of all welds, rivets, and bolts for leaks and corrosion. Calk rivets or replace where necessary, spotweld leaky welds with penstock drained. Tighten or renew bolts and studs where necessary.
- Examine paint for cracking, chalking, or other deterioration. Examine surface for corrosion, paying particular attention to welded joints, rivet heads, and bolts and nuts at flanged joints. Prepare corroded or deteriorated surfaces with sandblasting or other recommended methods and repaint with suitable materials. 4.05
Exterior paint and surface
- Inspect for deterioration of the paint in the form of scales, looseness, tubercles, dissolution, cracks, etc. Pay particular attention to rivet heads and welded and flanged joints. Prepare surfaces where paint has failed by sandblasting or other recommended means and repaint with suitable paint. 4.06
Interior paint and surface

- 4.07 Gates and valves (in general) Inspect exposed metal parts of valves and gates for corrosion, cracking, deterioration of paint, and other damage. For spillway and intake gates, this should be done during low water so that as much of the surface as possible can be observed. Check rivets, bolts, and welds and repair as necessary. Clean corroded surfaces by sandblasting or other approved means and repaint or apply cathodic protection as necessary. See Power O&M Bulletin No. 25.
- 4.08 Seals and guides Not scheduled. Check seals and guides for wear and deterioration. Renew seals and build up guides where scored, as necessary. Remove accumulated mineral deposit. Check alignment. Check slot heaters if installed.
- 4.09 Seat, disk or needle ring, and spider Not scheduled. Examine for mineral deposit and remove as necessary. Inspect seat and disk or needle ring for scoring, pitting, and abrasion. Regrind or remachine as necessary.
- 4.10 Stems Annual inspection. Clean off all grease and dirt, and inspect for wear and breakage of the threads, scoring, and wear of the sliding surface. Renew or repair as necessary by building up scored surfaces and broken threads. Relubricate.
- 4.11 Lubrication Not scheduled. Lubricate all underwater fittings with suitable underwater grease.
- Not scheduled. Lubricate all fittings exposed to the atmosphere. Flush out fittings on such items as rollers on coaster gates, and wheels on fixed-wheel gates. See that they are free and turn easily.
- Annual inspection. Examine all grease grooves to see that they are not obstructed with hardened grease. Remove any hard deposit. See that all grease supply pipes are clear. Flush all old grease from fittings and refill with fresh lubricant.
- 4.12 Springs and cushioning mechanism Not scheduled. Inspect springs in relief valves for proper tension and for corrosion. Examine oil dashpots where used for tightness of plunger, scoring on cylinder walls and plunger. Examine foot valves if used. Renew oil if sludged or contaminated with water.
- 4.13 Journals, bearings, and bushings Not scheduled. Disassemble and check clearance. Examine bearing surfaces and journals for scoring and wear. Replace bronze bushings, rebabbitt and rebores babbitt bearings, build up journals with welding or metalizing and machine to proper dimensions as necessary.

- Not scheduled. Check to see that all moving parts are free to move. Examine for corrosion and deterioration 4.14
Wheels, pins,
and rollers
- Not scheduled. Check for alinement of rollers and wheels. Check pins for bending and scoring. Check rollers for wear and corrosion. Check bearing surfaces under linkage. Check linkage for cracks, bending, or weakening.
- Not scheduled. Check hydraulic operating cylinders, pistons, rods, guides, bellcrank bearings, etc., for wear. See also Section 5. Check motor-driven reduction gears for wear. Flush out and relubricate gear boxes. See that lubricant used is suitable for coldest weather encountered. Check torque limit device if used. 4.15
Operating
cylinder or
gear mechanism
- Annual inspection. Check for leaks and repair as necessary. Examine for corrosion and need of paint. Repaint as necessary. Replace gaskets and renew or tighten bolts as necessary. 4.16
Control piping
- Weekly inspection. Inspect for leaks and adjust gland as necessary. 4.17
Packing glands
- Annual inspection. Clean gland and nuts. Measure clearance between gland and stuffing box. Renew packing when clearance between gland and stuffing box becomes so small there is doubt as to whether the gland may be adjusted and kept tight until the next outage.
- Annual inspection. Make an annual operation check under balanced conditions of penstock gates having emergency closing facilities and are depended upon for closing in case of a broken penstock or similar failure, to insure the equipment will operate when called upon. Other gates and valves should be given an annual operation check if conditions will permit. 4.18
Operation
- Not scheduled. Initial simulated emergency closure tests should be made after requesting test procedure from this office. Frequency of additional similar tests will be determined from initial test results.

5. Cranes, Hoists, and Elevators

INSPECTION CHECK LIST

Items of inspection	Inspection interval	Procedure reference
Crane, rails, supports, and stops	A	5.01
Crane bridge and carriage	A	5.02
Hoist framework	A	5.03
Trucks	A	5.04
Bumpers	A	5.05
Trolley rails or wire and supports	A	5.06
Trolley shoes or wheels	A	5.07
Runways and catwalks	A	5.08
Ladders and handrails	A	5.09
Cab	W A	5.10
Driving gears, shafts, bearings, and wheels	W A	5.11
Brakes	M A	5.12
Cable drums and sheaves	M A	5.13
Cables or chains	M A	5.14
Lifting beams	A	5.15
Counterweights	A	5.16
Blocks and hooks	M A	5.17
Electric motors and motor-generator sets	See Section 8	
Electrical control equipment	See Section 14	
Electrical wiring	A	5.20
Hydraulic-hoist cylinder, piston, and rod	NS	5.21
Hydraulic pump	M NS	5.22
Hydraulic control valves and piping	M NS	5.23
Hydraulic oil reservoir tank	M	5.24
Guide rails and shoes	M A	5.25
Safety devices	M A	5.26
Operation	W	5.27
State elevator inspection	A	5.28

W--Routine weekly inspection.

M--Routine monthly inspection.

A--Annual inspection.

NS--Frequency as required to maintain the equipment and assure its operating functions.

Note: Always make detailed operation and maintenance checks of cranes and hoists prior to lifting heavy loads.

<p><u>Annual inspection.</u> Check rails for alinement and obstructions. Check supports for cracks and spalling of concrete and for corrosion and loose rivets and bolts if steel. Repair concrete as necessary. Tighten or calk loose rivets and bolts. Check stops for security to building or rails.</p>	<p>5.01 Crane rails, supports, and stops</p>
<p><u>Annual inspection.</u> Check framework for looseness and cracks. Check rivets and bolts for tightness. Check girders for alinement. Examine girders for corrosion. Clean and paint as necessary. Check trucks for skew.</p>	<p>5.02 Crane bridge and carriage</p>
<p></p>	<p>5.03 Hoist framework</p>
<p></p>	<p>5.04 Trucks</p>
<p><u>Annual inspection.</u> Check for looseness. Examine bumpers to see that they are properly positioned. Tighten or adjust as necessary. Check hydraulic bumpers for leaks and fill to proper level.</p>	<p>5.05 Bumpers</p>
<p><u>Annual inspection.</u> Check rails and wires for alinement. Check supports for tightness. Adjust as necessary. Check contact surfaces of wire or rails for corrosion and arc burning and clean as necessary. Check and clean insulators.</p>	<p>5.06 Trolley rails or wire and supports</p>
<p><u>Annual inspection.</u> See that contact shoes or wheels are tight and make good contact with rails or wires. Clean as necessary. Check contact spring pressure.</p>	<p>5.07 Trolley shoes or wheels</p>
<p><u>Annual inspection.</u> Check runways and catwalks for obstructions, broken floor material, or other safety hazards.</p>	<p>5.08 Runways and catwalks</p>
<p><u>Annual inspection.</u> See that handrails and ladders are firmly secured and rigid. Check ladder rungs for corrosion and weakening. Clean and paint as needed.</p>	<p>5.09 Ladders and handrails</p>
<p><u>Weekly inspection.</u> Check cab for loose articles which would interfere with operation and for general housekeeping. Check for broken windows or doors. Check doors and safety gates. See that lighting is sufficient. Check seats, if fitted, for security.</p>	<p>5.10 Cab</p>
<p><u>Annual inspection.</u> Check for security to bridge girders.</p>	

- 5.11 Driving gears, shafts, bearings, and wheels. Weekly inspection. Check lubrication. Examine for excessive wear.
- Annual inspection. Check bearing clearances. Refit as needed. Examine gears for broken teeth or rough or sharp edges. Misalignment or improper meshing will cause rough edges at the tip of the teeth. Check shafts for alignment and coupling for alignment and lubrication if oil filled. Check wheels for flat sides and wear. Rebuild or machine as needed.
- 5.12 Brakes Monthly inspection. See that braking surfaces are free from oil and grease. Check spring tension.
- Annual inspection. Check brake lining to see that it has not hardened or worn excessively. Renew as necessary. See that brake drums are not scored. Check spring tension. Adjust brake with adjustment nuts. Adjust spring tension if needed or renew if fatigued.
- 5.13 Cable drums and sheaves Monthly inspection. Check sheaves for broken or chipped wheels. Lubricate.
- Annual inspection. With cable removed, check all cable grooves for wear, chipping, and corrosion. Check bearings for clearance and refit if needed.
- 5.14 Cables or chains Monthly inspection. Visual inspection for broken or frayed strands or broken or elongated chain links.
- Annual inspection. Run cable or chain out and inspect carefully for frayed or broken strands, stretched or weakened links. Examine for wear and corrosion, especially down between the cable strands. Lubricate.
- 5.15 Lifting beams Annual inspection. Check beams for alignment, corrosion and tightness of rivets. See that members have not been stressed beyond their elastic limits.
- 5.16 Counterweights Annual inspection. Check counterweights to see that they are secure to the cables or chains and to the guides.
- 5.17 Blocks and hooks Monthly inspection. See that the blocks have sufficient lubrication. Note hook for bending, cracking, stretching, and condition of safety latch.

<u>Annual inspection.</u> Check block pins for wear and distortion. Renew or machine pins as needed. Check blocks for weakening. Measure hook for distortion. If distorted more than the allowable set of the metal, renew.	
<u>Annual inspection.</u> Check and tighten connections at terminal points. Check for damaged insulation or broken or overheated conductors. Check insulation resistance of wiring and connected devices and equipment.	5.20 Electrical wiring
<u>Not scheduled.</u> Inspect cylinder walls for scoring and piston for wear and fit. Check rod for wear and alignment. Refit or aline if necessary.	5.21 Hydraulic hoist cylinder, piston, and rod
<u>Monthly inspection.</u> Test pump to see that it delivers full pressure.	5.22 Hydraulic pump
<u>Not scheduled.</u> Inspect pump working parts for wear and fit. Renew if needed. Test pump.	
<u>Monthly inspection.</u> Inspect piping for leaks. Test control valves.	5.23 Hydraulic control valves and piping
<u>Not scheduled.</u> Check valve seats for wear and refit as needed.	
<u>Monthly inspection.</u> See that oil in tank is sufficient for emergency operation. Keep sight glass cocks turned off to prevent loss of oil if glass is broken when not attended. Check for leaks.	5.24 Hydraulic oil reservoir tank
<u>Monthly inspection.</u> Check guide rails and shoes for proper lubrication.	5.25 Guide rails and shoes
<u>Annual inspection.</u> Check rails for alignment and scoring. Check and tighten supports. Check shoes for fit and scoring. Refit as needed.	
<u>Monthly inspection.</u> See that all safety devices are in service and functioning properly.	5.26 Safety devices
<u>Annual inspection.</u> Check all mechanical and electrical safety devices for worn or broken parts and proper operation. Renew and refit as needed.	

5.27 Weekly inspection. Operate all idle equipment for a few
Operation minutes weekly to insure that it is in operating condition
 and ready for service.

5.28 Annual inspection. In states where elevator inspection is
State elevator available, it should be obtained for all elevators. Where
inspection state inspection is not available, the inspections and
 tests shall be made by a certified inspector of an elevator
 or insurance company.

6. Miscellaneous Station Auxiliaries

INSPECTION CHECK LIST

Item of inspection	Inspection interval	Procedure reference
<u>Air Compressors</u>		
Foundation	M A	6.01
Frame casting	A	6.02
Belt, chain, or gear drive	D A	6.03
Belt pulleys and idler or coupling	D A	6.04
Crankshaft	NS	6.05
Connecting rod	NS	6.06
Crosshead	D A	6.07
Piston and piston rod	NS	6.08
Cylinder	NS	6.09
Valves	NS	6.10
Bearings	NS	6.11
Packing gland	D A	6.12
Lubricating system	D A	6.13
Cooling system	D A	6.14
Receiver tank	D W A	6.15
Air intake and cleaner	D M	6.16
Gages	D A	6.17
Pressure switches	M A	6.18
Unloader	M A	6.19
Piping and valves	A	6.20
Safety valve	M	6.21
Guardrails or grills	A	6.22
Electric motor	See Section 8	
Electrical control equipment	See Section 14	
Operation	W	6.25
Cleaning		6.26
<u>Water or Oil Pumps</u>		
Foundation	M A	6.01
Frame casting or casing	A	6.02
Belt, chain, or gear drive	D A	6.03
Belt pulleys and idler or coupling	D A	6.04
Crank or rotor shaft	NS	6.05
Connecting rod	NS	6.06
Crosshead	D A	6.07
Piston and piston rod	NS	6.08
Cylinder	NS	6.09
Valves	NS	6.10
Impeller or rotor	NS	6.30
Bearings	NS	6.11
Packing gland	D A	6.12
Lubricating system	D A	6.13

INSPECTION CHECK LIST--Continued

Item of inspection	Inspection interval	Procedure reference
<u>Water or Oil Pumps--Continued</u>		
Storage tanks	D A NS	6.31
Intake strainer	W A	6.32
Piping and valves	A	6.20
Gages	D A	6.17
Pressure or float switches	M A	6.18
Guardrails or grills	A	6.22
Electric motor	See Section 8	
Electrical control equipment	See Section 14	
Operation	W	6.25
<u>Storage Batteries</u>		
Battery room and ventilation	D A	6.40
Base or rack	A	6.41
Base pad	A	6.42
Cell jars and covers	M	6.43
Plates--Sediment	M	6.44
Separators	M	6.45
Electrolyte	M	6.46
Intercell connectors and terminals	A	6.47
Hydrometers and thermometers	A	6.48
Sink, funnels, and fillers	A	6.49
Water still	A	6.50
Distilled water storage	M	6.51
Acid storage	M	6.52
Operation		6.53
<u>Battery Chargers</u>		
Motor and generator	See Section 8	
Switchboard and control equipment	See Section 14	
Transformer or reactor	M	6.62
Dial switch or rheostat	M	6.63
Bulb or dry rectifier element	D M	6.64
Instruments	See Section 14	

D--Routine daily inspection
W--Routine weekly inspection.
M--Routine monthly inspection.
A--Annual inspection.
NS--Not scheduled, frequency based on equipment operating history (1 to 5 years).

References

Power O&M Bulletin No. 12, Storage Battery Maintenance and Principles
Power O&M Bulletin No. 21, Lubrication of Powerplant Machinery

<u>Monthly inspection.</u> Visually inspect foundation for cracking, spalling, or settling.	6.01 Foundation
<u>Annual inspection.</u> Check foundation carefully with a level for settling. Examine concrete for cracks and spalling.	
<u>Annual inspection.</u> Tap casting lightly with a hammer. A flat sound indicates a crack. Examine metal for corrosion. Clean and paint as needed.	6.02 Frame casting
<u>Daily inspection.</u> Note belt for slippage, chain for looseness, and gears for lubrication, excessive noise, vibration, or overheating. Dress and tighten belt as needed. Tighten chain as needed.	6.03 Belt, chain, or gear drive
<u>Annual inspection.</u> Check belt splices for weakening. Renew if needed. Check chain for wear or distortion. Replace when distorted or worn excessively. Examine gears for wear or sharp edges, reface, and refit or replace if needed.	
<u>Daily inspection.</u> See that bearings are getting sufficient lubrication. Note for looseness, excessive wear, or misalignment.	6.04 Belt pulleys and idlers or coupling
<u>Annual inspection.</u> Check wheels for broken rims. Check axles for wear. Build up and machine or replace as needed. Refit bushings as needed. Check weights or springs on idlers for security or proper tension. Check alignment at coupling and wear of flexible coupling.	
<u>Not scheduled.</u> Check crank for alignment. Check journals for scoring, signs of overheating, and wear. Build up and machine as needed.	6.05 Crankshaft
<u>Not scheduled.</u> Inspect for distortion or bending. Examine bearing nuts and bolts for distortion and wear. Replace as needed.	6.06 Connecting rod
<u>Daily inspection.</u> If visible, note for looseness, noise, overheating, and sufficient lubrication.	6.07 Crosshead
<u>Annual inspection.</u> Examine shoes for scoring and wear. See that they are tight to the crosshead body if shoes are removable. Check pin for wear and bushings for looseness. Refit if needed. Adjust shoes with additional shims if needed. Note guides for scoring or excessive wear.	

- 6.08
Piston and
piston rod
- Not scheduled. Check piston for wear. Check clearance with micrometer. Examine rings for tightness and fit. Renew if necessary. Check rod for trueness. See that rod is not bent or distorted. Examine bushings for wear and fit. Renew parts as needed.
- 6.09
Cylinder
- Not scheduled. Check cylinder walls for wear and scoring. Measure inside diameters at top, bottom, and sides on two directions 90° apart. If out of round or oversize, rebore cylinder.
- 6.10
Valves
- Not scheduled. Inspect valves and seats for scoring and proper seating. Lap valves if needed. See that stems and guides are not bent or cocked. See that springs have proper tension. Check feather valves for proper operation.
- 6.11
Bearings
- Not scheduled. Check bearings for fit, scoring, signs of overheating, and proper lubrication. Renew or refit as needed.
- 6.12
Packing gland
- Daily inspection. Note for leakage or scoring of shaft or rod, and adjust as necessary.
- Annual inspection. Renew packing as needed.
- 6.13
Lubricating
system
- Daily inspection. See that oil and grease cups are full or crankcase oil is at the proper level. Replace as needed using approved-type compressor lubricants. See that forced-oil system is working properly. Note leaks in piping.
- Annual inspection. Clean oil pipes and crankcase or cups. Repair leaks. Examine pump and strainer. Clean strainer and refit or renew pump parts as needed.
- 6.14
Cooling
system
- Daily inspection. See that air is not too hot when delivered to the receiver. Check flow of cooling water. Note any leaks in cooling-water piping. Note accumulation of dirt and lint on air-cooling fins.
- Annual inspection. Flush and clean out all water lines. Repair leaks. Clean air-cooling fins. Paint fins with aluminum paint. Clean and paint as needed.
- 6.15
Receiver
tank
- Daily inspection. Note joints and seams for leaks.
- Weekly inspection. Open the receiver drain valve and blow down until water is removed. This includes receivers equipped with automatic discharge valves.

Annual inspection. Open and clean all rust and sludge from interior of all receivers having a volume of more than 1-1/2 cubic feet. Repaint as required using compatible paint. Examine all fittings for tightness. Inspect manhole gasket and seating surfaces. Reface surfaces and renew the gasket if needed. If receiver shell deterioration exists, it should be hydrostatic tested to 1.50 times the maximum allowable working pressure. Air receivers without manholes should be subjected to a similar hydrostatic test every 5 years. Hydrostatic tests are not required on receivers associated with circuit breakers.

Daily inspection. See that screen and intake are not obstructed.

6.16
Air intake
and cleaner

Monthly inspection. Remove intake cleaner and clean the screen. If compressor is in a dusty location, it may be necessary to clean the intake screen at more frequent intervals.

Daily inspection. Note operation of gages and pressure being held. Check for loose or stuck pointer. Do not operate the compressor without a good pressure gage.

6.17
Gages

Annual inspection. Remove all gages and calibrate. Renew defective parts and reinstall.

Monthly inspection. See that all pressure or float switches cut in and out at proper pressure or liquid level.

6.18
Pressure or
float switches

Annual inspection. Check and clean switch contacts. Check spring tension. Clean and adjust moving parts.

Monthly inspection. See that compressor is not being loaded until operating speed is reached in starting and is unloaded when the pressure switch breaks circuit to the motor and unloads at the proper pressure.

6.19
Unloader

Annual inspection. Inspect valves and air lines for leaks and valves for proper seating. Lap valves if needed. Check weights for security to lever arm and all springs for proper tension. Examine solenoid for deteriorated insulation or loose connections. Examine dashpots for excessive play and refill with oil if needed.

Annual inspection. Renew valve packing as needed. Reseat valves as needed. Repair leaks. Clean piping and repaint.

6.20
Piping and
valves

- 6.21 Safety valve Monthly inspection. Test safety valves to make sure that they operate on an increase of pressure of 10 to 15 psi above maximum normal system pressure or maximum allowable working pressure whichever is lower.
- 6.22 Guardrails or grills Annual inspection. See that guardrails and grills are tightly secured to foundations. See that guards and grills are adequate and give complete protection to both compressor and personnel.
- 6.25 Operation Weekly inspection. Operate all idle equipment for a few minutes weekly to insure that it is in operating condition and ready for service.
- 6.26 Cleaning Air piping, compressor cylinders, air cleaners, or the receivers shall not be cleaned using kerosene, gasoline, or other inflammable products.
- 6.30 Impeller or rotor Not scheduled. Inspect impeller or rotor for erosion of vanes. Rebuild with suitable material and machine if necessary. Measure seal-ring clearances. Refit if necessary. Balance impeller or rotor after test run if needed.
- 6.31 Storage tanks Daily inspection. Note amount of oil or water available in tanks when in continuous use. Check for leaks. Clean up leaking oil which might be a fire hazard. Keep sight-glass cocks turned off to prevent loss of liquid if glass is broken.
- Annual inspection. Check and repair leaks.
- Not scheduled. Clean inside of tanks used for storage of clean oil or drinking water. Clean and repaint as necessary.
- 6.32 Intake strainer Weekly inspection. Flush or remove and clean strainer. Utilize differential gage if so equipped to determine cleaning frequency.
- Annual inspection. Replace strainer when corroded badly or broken.
- 6.40 Battery room and ventilation Daily inspection. See that battery room entrance doors are kept closed and that ventilators to outside air are open and air is circulating.
- Annual inspection. Check metal in room for corrosion and clean and paint as necessary. Check ventilating system, fans,

etc., for proper operation. Make sure that no explosive gases are being accumulated in the battery room due to excessive gassing or poor ventilation.

<u>Annual inspection.</u> Inspect concrete base or wooden racks for deterioration. Repair and repaint with acid-resisting paint as necessary.	6.41 Base or rack
<u>Annual inspection.</u> Check base pad of sheet rubber, sand, or other material for deterioration from acid or other causes.	6.42 Base pad
<u>Monthly inspection.</u> Check for cracked or leaking jars or covers and replace as necessary. Keep jars and covers clean.	6.43 Cell jars and covers
<u>Monthly inspection.</u> Inspect plates carefully for signs of deterioration due to improper charging. Note amount, color, and texture of sediment. Follow instructions in Power O&M Bulletin No. 12, <u>Storage Battery Maintenance and Principles.</u>	6.44 Plates
<u>Monthly inspection.</u> See that separators are remaining in place and keeping plates properly spaced.	6.45 Separators
<u>Monthly inspection.</u> Check electrolyte level and add distilled water as necessary.	6.46 Electrolyte
<u>Annual inspection.</u> Clean acid corrosion from connectors and terminals. Tighten terminals.	6.47 Intercell connectors and terminals
<u>Annual inspection.</u> Check condition of hydrometers and thermometers. Check hydrometers and thermometers used for daily and monthly readings against spare units held in reserve.	6.48 Hydrometers and thermometers
<u>Annual inspection.</u> See that the sink, funnels, fillers, and other distilled water and acid-handling facilities are kept clean and in good usable condition.	6.49 Sink, funnels, and fillers
<u>Annual inspection.</u> Check still for proper operation and adequacy and purity of distilled water delivered. See that equipment is kept clean.	6.50 Water still
<u>Monthly inspection.</u> See that enough distilled water and acid are kept in storage to meet current needs. Check containers for cleanliness. Provide separate water containers	6.51 Distilled water storage

- 6.52 Acid storage and equipment for serving nickel-cadmium and lead-acid batteries.
- 6.53 Operation Check charging rate hourly. Check and record pilot cell specific gravity, temperature, and floating voltage daily. Check and record specific gravity and voltage of each cell monthly.
- See Power O&M Bulletin No. 12, Storage Battery Maintenance and Principles, and Operators Lesson No. 18, Electrolytic Cells and Storage Batteries, for developing a battery operation and maintenance program.
- 6.62 Transformer or reactor Monthly inspection. Check general condition and operating temperature of transformer or reactor used in bulb- or dry-type rectifiers.
- 6.63 Dial switch or rheostat Monthly inspection. Check general condition of dial switch or rheostat contacts and operating mechanism. Check contact heating and spring pressure. Clean contacts.
- 6.64 Bulb or dry rectifier element Daily inspection. Check for burned-out bulb and replace as necessary. See that adequate stock of spare bulbs is kept on hand.
- Monthly inspection. See that copper oxide or selenium rectifier elements are not operating too hot; this will shorten their life.

7. Hydraulic Turbines, Governors, and Large Pumps

INSPECTION CHECK LIST

Items of inspection	Inspection interval	Procedure reference
<u>Turbines and Large Pumps</u>		
Runner or impeller	A	7.01
Seal rings	NS A	7.02
Scrollcase or pump casing	A	7.03
Wicket gates	NS A	7.04
Curb plates	A	7.05
Thrust collars	A	7.06
Gate linkage	D A	7.07
Draft tube	A	7.08
Shaft and coupling	D A	7.09
Shift ring and bearing surfaces	NS	7.10
Bearings	D A NS	7.11
Servomotor cylinder, piston, and rod	D NS	7.12
Packing glands	D NS	7.13
Lubrication		7.14
Thermometers and gages	D A	7.15
<u>Governors</u>		
Electric control devices		See Section 14
Ball head, bearings, and motor	SA A	7.17
Speeder rod and vibrator disk	A	7.18
Pilot and relay valves and strainers	W SA A	7.19
Compensating dashpot assembly	A	7.20
Oil piping and pressure tank	D A	7.21
PMG assembly	A	7.22
Belt and drive	D A	7.23
Controls and indicators	D A	7.24
Linkage and pins	D A	7.25
Oil pump		See Section 6
Safety valve		See Section 6

D--Routine daily inspection.

W--Routine weekly inspection.

SA--Semiannual inspection

A--Annual inspection.

NS--Not scheduled, frequency as required to maintain equipment and assure its function.

References

Operators Lesson No. 16, Hydraulic Turbines

Operators Lesson No. 17, Governors for Hydraulic Turbines

Power O&M Bulletin No. 13A, Field Balancing of Large Rotating Machinery

Power O&M Bulletin No. 18, Remagnetizing Rotor of Woodward Permanent-Magnet Generator

Power O&M Bulletin No. 21, Lubrication of Powerplant Equipment

Power O&M Bulletin No. 24, Repair of Cavitation Damage of Hydraulic Turbines and Pumps

Bureau Paint Manual and Field Painting of Metalwork

- 7.01
Runner or
impeller
- Annual inspection. Examine runners for cavitation pitting, sand, or other forms of erosion, and cracked vanes, blades, or crowns. If crack welding is required, notify this office, attention D-610, so repair method can be suggested. Repair pitted areas, cleaning damaged area with a gouging rod and build up steel runners with mild steel welding rod, bronze runners with bronze rod, cast iron runners with "Ferroweld" rod, and stainless steel runners with stainless steel rod. Other approved type rods may also be used. Bronze and stainless steel runners should be built up to the original surface and ground smooth. Cast iron and cast steel runners should be built up and ground to a surface about 1/8-inch low to the original. Then 18-8 stainless steel should be used as a final coating over the mild steel inlay on steel runners and should be 1/8-inch thick. 25-12 stainless steel should be used over "Ferroweld" inlays on cast iron runners. In grinding the stainless steel coatings, a high-speed grinder should be used, and a permanent bar magnet or a commercial copper sulphate solution should be used to check the thickness of the stainless. Stainless steel is nonmagnetic and too much pull on the magnet indicates that the stainless has been ground away or applied too thinly. Some work has been done with metallizing surfaces subject to cavitation with stainless steel, but until further information as gathered from experience is available, it is advisable to continue to weld or braze. See Power O&M Bulletin No. 24 for details on welding. After assembly, check vibration of unit with vibrometer and balance if necessary.
- 7.02
Seal rings
- Annual inspection. Check the seal-ring clearances. Check to see that seal-ring cooling-water lines are clear.
- Not scheduled. Remove the runner, replace or build up with suitable material and machine seal rings to original clearances as listed on manufacturer's blueprints.
- 7.03
Scrollcase or
pump casing
- Annual inspection. Examine surface for corrosion and failure of paint. Check rivets for tightness. Inspect for leaks. Calk leaks and rivets as necessary. Prepare surfaces and paint with a recommended material. Inspect manhole door gaskets and bolts, and renew as necessary. Smooth up seating surfaces on door and case.
- 7.04
Wicket gates
- Annual inspection. Measure clearance between gates when nearly closed. Adjust openings as necessary. Examine body of gates for pitting. Examine sealing surfaces and grind or file rough or wire-drawn portions to a smooth surface. Check clearance at stem bushings by jacking.

Not scheduled. Raise cover plate and inspect stem bushings, journals, and shaft sleeve at packing gland for scoring, improper lubrication, and corrosion. Clean all hard grease from grooves and pockets. Refit bushings as necessary. Build up stem at packing gland and at journal areas using stainless steel if they are mild steel or repair is needed. At this time, also inspect baffle plates for deterioration and tightness. Clean and paint baffle plates and underside of cover plate.

Annual inspection. Examine facing plates for scoring and corrosion. Check clearance between facing and wicket gates. See that the facing plates are tight to the head cover and bottom ring. 7.05
Curb plates

Annual inspection. Examine three or four thrust collars and plates as examples for scoring, corrosion, and proper lubrication, taking different ones each year until all are examined. If excessive scoring or corrosion is noted, examine the remainder and repair as necessary. Obtain proper clearances between wicket gates and upper and lower curb plates with the thrust collars, placing or removing shims as needed. 7.06
Thrust collars

Daily inspection. Note linkage for excessive backlash. 7.07
Gate linkage

Annual inspection. Measure the backlash in linkage and refit pins and bushings as needed.

Annual inspection. Inspect metal liner for cavitation pitting. Weld and grind as necessary. Inspect concrete for failure and repair as necessary. Test for voids between liner and concrete by striking the liner with a hammer. A "drummy" sound indicates a void at that point. Grout if necessary. Inspect manhole door gaskets and bolts. Replace where needed. Smooth up seating surfaces on door and case. Prepare bare or corroded surfaces and paint with suitable material. 7.08
Draft tube

Daily inspection. Check shaft visually and by hand for wobble or runout. Note coupling for apparent misalignment or signs of loose coupling bolts. 7.09
Shaft and coupling

Annual inspection. Check shaft with oscillograph or dial indicator for excessive runout. Check coupling for runout. Check alignment of shaft at coupling and inspect coupling bolts for tightness. Inspect shaft sleeve at packing gland. Replace or build up and machine as necessary.

7.10
Shift ring and
bearing
surfaces

Not scheduled. Lift shift ring and inspect bearing surfaces for wear and proper lubrication. Check scoring and for out-of-round condition. If fitted, inspect patch bolts on cover plate bearing surface for tightness. Smooth up or build up and machine bearing surfaces as needed. Replace bearing plates on cover plates if needed.

7.11
Bearings

Daily inspection. Check bearings for overheating and to see that an ample supply of lubrication is being furnished.

Not scheduled. Inspect babbitt or bronze bushings for wiping or scoring. Inspect journals for scoring, wear, and discoloration which may be due to excessive heat, acidity of the oil, or shaft current.

Annual inspection. Refit or rebabbitt and machine bearings as necessary. See that all oil or grease grooves are clear. Check oil for dirt, sludge, and acidity and filter or replace as necessary. See that bearing temperature bulbs and alarms are functioning properly.

7.12
Servomotor

Daily inspection. Note glands for leakage. Adjust as necessary. Listen for "groaning" noises indicating misalignment.

Not scheduled. Examine plunger, rings, and cylinder for scoring. If scored, examine for possibility of misalignment and realine if needed. Repair by reboring or polishing cylinder, renewing rings, or machining piston. Inspect packing and repack as necessary.

7.13
Packing gland

Daily inspection. Check packing gland and seals for excessive heat and see that a slight flow of water is coming from between the gland and the shaft or the gland and stuffing box. Adjust gland as necessary.

Not scheduled. Inspect packing rings for wear. See that lantern ring is in proper place and cooling water lines are clear. Repack as necessary, staggering adjacent rings so that the points where ends meet do not coincide. See that the lantern ring is in its proper place and that the cooling water lines and drains are not obstructed. The gland should be adjusted so that a slight leak occurs rather than complete stoppage of waterflow. A gland too tight to allow a flow of water will wear the shaft sleeve unduly. The purpose of a gland is to control the flow rather than to stop it.

Routine inspection. Lubricate underwater fittings once daily where the unit regulates frequency or every other day where load is constant. Cycle gates to distribute grease if load is constant. Above-water fittings should be lubricated twice weekly where the unit regulates frequency or once weekly otherwise. On pumps or turbines which are fitted with babbitted bearings which are submerged in water containing abrasive material, it may be necessary to lubricate every 5 minutes or less with a solenoid-operated grease gun or similar equipment. Replenish oil in reservoirs as necessary. Check automatic greasing system to see that all fittings are receiving grease and that system is functioning properly. See Power O&M Bulletin No. 21. 7.14
Lubrication

Annual inspection. Clean and flush out all fittings with fresh grease. Check each fitting for adequate grease quantity where automatic greasing system is used. Test oil in large bearings for acidity prior to overhaul. If neutralization number is within limit specified by oil manufacturer, and has not taken a sudden increase since the last test, centrifuge and filter oil and clean out all bearing reservoirs and sumps. If neutralization number is above limits set by manufacturer, discard and refill system with new oil. In small bearings where the cost of testing is approximately equal to or more than the cost of new oil to refill the system, the oil should be drained and the system refilled with fresh oil.

Daily inspection. See that gages and thermometers have no visible signs of breakage. See that all dial-type needles are free to move by tapping the case gently with the fingers. 7.15
Thermometers and gages

Annual inspection. Remove all gages and thermometers and calibrate. Reinstall.

Semiannual inspection. Flush out and relubricate all bearings. Check springs for proper tension. Replace as necessary. Check travel of flyballs and adjust as necessary by means of laminated shim washers under vibrator cup. 7.17
Ball head, bearings, and motor

Annual inspection. Repeat semiannual inspection. Check pivot pins and bushings. Replace as necessary. Examine ball-head motor for damaged winding. Check winding insulation resistance.

Annual inspection. Remove speeder rod and check for wear and scoring. Examine all bushings and bearings for excessive wear. Examine vibrator disk for wear. Replace as necessary. 7.18
Speeder rod and vibrator disk

- 7.19 Pilot and relay valves and strainers
- Weekly inspection. Open drain cock on strainer assembly and flush off foreign matter collected on screen.
- Semiannual inspection. Clean strainers. Check frequency of operation of oil pump. Too frequent operation of oil pump indicates leaks in relay valve.
- Annual inspection. Clean strainers. Open and inspect pilot and relay valves. Check lap and adjust as necessary. Examine plungers, cylinder, and parts for excessive wear or scoring. Examine hand valves for leaks at seat and disk. Repair or replace as necessary.
- 7.20 Compensating dashpot assembly
- Annual inspection. Inspect valve plungers and cylinders and seats and disks for leaks or scoring. Repair or replace as necessary.
- 7.21 Oil piping and pressure tank
- Daily inspection. Note level of oil in sump and pressure tank. Charge pressure tank as necessary, bringing oil to proper level, using air compressor or air cock on suction side of oil pump. Replenish oil as necessary. Examine oil pipes for leaks. If too frequent air charging is necessary, check air fittings with soapsuds for leaks. Repair as necessary.
- Annual inspection. Check air fittings with soapsuds for leaks. Wipe and examine oil piping for leaks. Repair as necessary. Test oil and renew if neutralization number is high. Clean and wipe out pressure tank and sump when oil is changed. Drain oil, open sump and tank, clean, inspect, and repaint as required using compatible paint. Tanks without manholes having a pressure-air volume of over 3 cubic feet should be filled with oil and tested to 1.5 times working pressure every 5 years.
- 7.22 PMG assembly
- Annual inspection. Disassemble and inspect bearings for lubricant. Relubricate as necessary. Examine PMG for damaged winding. Check winding insulation resistance. Check speed switch contacts and speed indicator generator. Inspect over-speed device pivot pins, flyball arms, and driving gear. Check spring tension and renew as necessary. Reassemble and remagnetize PMG. (See Power O&M Bulletin No. 18.)
- 7.23 Belt and drive
- Daily inspection. Note belt for slippage. Adjust idler wheels and dress belt as necessary. Watch for loosening or failure of splices. Note drive wheel and shaft for loose bushings and bearings. Lubricate daily.

Annual inspection. Renew belt or splices as necessary. Refit bearings or bushings in the drive shaft or wheel as needed.

Daily inspection. Note daily operation of all controls and indicators. Investigate any unusual conditions. Lubricate moving parts. 7.24 Controls and indicators

Annual inspection. Check pointers on indicators for correct setting. Check control moving parts for wear. Check remote controls for proper indication. Repair or renew as necessary. Calibrate gages.

Daily inspection. Note linking arms and pivot pins for excessive backlash due to wear and vibration. Lubricate as necessary. 7.25 Linkage and pins

Annual inspection. Refit or replace bushings and pins as needed.

8. Generators, Motors, and Synchronous Condensers

INSPECTION CHECK LIST

Item of inspection	Inspection interval		Procedure reference
Foundation, base, or support	M	A	8.01
Frame		A	8.02
Laminations and pole pieces		A	8.03
Armature or rotor		A	8.04
Airgap		A	8.05
Air fans		A	8.06
Windings	M	A	8.07
Banding and lashing		A	8.08
Slot wedges		A	8.09
Cummutator or collector rings	Do	A	8.10
Brushes		A	8.11
Brush rigging		A	8.12
Shaft and bearings	D	A	8.13
Couplings, gears, and pulleys		A	8.14
Cooling coils and air coolers	Do	A	8.15
Hydrogen cooling equipment	Do	SA	8.16
CO ₂ fire protection	W	SA	8.17
Temperature indicators and relays		A	8.18
Water and oil flow gages and relays		A	8.19

Do--Routine daily inspection by operators.

W--Routine weekly inspection.

M--Routine monthly inspection.

SA--Semiannual inspection.

A--Annual inspection.

References

How to Maintain Electric Equipment, GET-1125, General Electric Company

Modern Pyramids or Carbon Brushes by National Carbon Company

Operators Lesson No. 8, Direct Current Machinery

Operators Lesson No. 9, Alternating Current Machinery, Generators, Motors, and Synchronous Condensers

Power O&M Bulletin No. 13A, Field Balancing of Large Rotating Equipment

Power O&M Bulletin No. 3, Testing Electrical Equipment Insulation

Power O&M Bulletin No. 3, Keeping Small Motors Dry

Power O&M Bulletin No. 21, Lubrication of Powerplant Machinery

Power O&M Bulletin No. 23, Fire Fighting, Cause and Prevention

Power O&M Bulletin No. 7, Permissible Overloading of Generators, Synchronous Condensers, and Large Motors

<u>Monthly inspection.</u> Visual inspection to see that machine foundation, base, or support is in good condition.	8.01 Foundation, base, or support
<u>Annual inspection.</u> Check concrete foundation for cracks. Check base or support for broken, loose, or weakened parts. Check and tighten anchor bolts. Check sound-absorbing base for adequacy.	
<u>Annual inspection.</u> Check for cracks, loose, or broken parts. Clean and repaint as necessary. Check frame ground connection.	8.02 Frame
<u>Annual inspection.</u> Check for loose laminations and tighten clamping bolts. If laminations vibrate and cannot be stopped by tightening clamping bolts, force some quick-drying varnish or shellac between the loose laminations while the machine is out of service. Check for damaged laminations at airgap due to rubbing or objects caught in airgap. Check and tighten field pole piece clamping bolts.	8.03 Laminations and pole pieces
<u>Annual inspection.</u> Check squirrel-cage rotor bars or amortisseur windings for loose or broken bars or end connections. Check field circuit connections and tighten if necessary. Check voltage drop across each pole by applying alternating current at the collector rings. This will show up a turn-to-turn short better than direct current. Check pole keys for tightness. Rebalance armature or rotor if vibration is objectionable. (See Power O&M Bulletin No. 13A.)	8.04 Armature or rotor
<u>Annual inspection.</u> Check airgap at four quadrature positions and recenter rotor if necessary. On horizontal machines, the bearings may need replacing if the bottom airgap is appreciably smaller than the top.	8.05 Airgap
<u>Annual inspection.</u> Check rotor air fans for fatigue cracks. Check and tighten holding bolts or screws.	8.06 Air fans
<u>Monthly inspection.</u> Visual inspection for damaged insulation and dirt, oil, or moisture on winding.	8.07 Windings
<u>Annual inspection.</u> Blow out dust with clean dry air at pressure not exceeding 40 pounds per square inch. Clean exposed parts of windings thoroughly with a noninflammable solvent, using suitable brushes for inaccessible places. The use of carbon tetrachloride is not recommended because of the toxic hazard. A number of good commercial solvents	

such as "Turco-Solv" are satisfactory. Revarnish windings if insulation is becoming hard, brittle, or dull. Check for insulation deterioration such as tape separation, cracking, brittleness, or evidence of corona. Check insulation with megger or high-voltage direct-current method. (See Power O&M Bulletins No. 3 and 9.)

- 8.08 Annual inspection. Check wire and string banding on direct-current armature windings. Check end-turn lashing of alternating-current stator coils. Apply lashing if end turns vibrate excessively.
- 8.09 Annual inspection. Check slot wedges and replace loose ones. Tighten coils in slots by rewedging if necessary.
- 8.10 Daily inspection. Check commutation or collector ring and brush operation. Wipe commutator or rings if needed. Have collector rings brushes replaced if worn too short.
- 8.11 Annual inspection. Turn down, stone, or polish commutator or collector rings if grooved, rough, or eccentric. Undercut mica if high. If commutator or rings have a good polish, they should not be disturbed. Check brush spring tension and brush fit. Tighten bolts, screws, and connections. Reset brush holders if not properly spaced. Check brush neutral position. Replace and sand in new brushes if needed. Clean up carbon or metallic dust.
- 8.12 Annual inspection. Turn down, stone, or polish commutator or collector rings if grooved, rough, or eccentric. Undercut mica if high. If commutator or rings have a good polish, they should not be disturbed. Check brush spring tension and brush fit. Tighten bolts, screws, and connections. Reset brush holders if not properly spaced. Check brush neutral position. Replace and sand in new brushes if needed. Clean up carbon or metallic dust.
- 8.13 Daily inspection. Check bearing temperature, lubrication and oil level. (See Power O&M Bulletin No. 21.)
- Annual inspection. Check bearing clearances. Check oil for dirt, sludge, and acidity, and filter or replace as necessary. Check end play on horizontal machines. Replace or refinish rough bearings. Inspect bearing oil piping and cooling water piping for leaks. Check shaft for wobble and alinement. Check for shaft currents through bearings on large machines. Check insulation of insulated bearings. Check oil film resistance occasionally with machine in operation with ohmmeter of 6 volts or less on thrust bearings provided with test terminals.
- 8.14 Annual inspection. See that keys, setscrews, and coupling bolts are tight. Check parts of flexible couplings for wear or fatigue. Adjust belt or silent chain tension. Flush out and renew grease in gearboxes. Inspect belts, chains, or gears. Check alinement between driving and driven machine.

Daily inspection. Check for water leaks in bearing cooling coils and surface air coolers. Check cooling water flow.

8.15
Cooling coils
and air
coolers

Annual inspection. Check external supply and drain piping for leaks. Flush out cooling coils with air and water. Test bearing cooling coils for leaks by applying air pressure to coils and observe for air bubbles rising in oil and drop in air pressure with supply valve closed, or use hydrostatic pressure test. Use hydrostatic pressure test on air coolers. If water scale is present, circulate a solution of 25 percent hydrochloric acid and water through the coils until clean. Then flush out thoroughly. Clean external surfaces of coils if practical. A pressure of 75 pounds per square inch is recommended.

Daily inspection. Visual check of hydrogen pressure in machine and gas supply remaining in tanks. Check gas purity.

8.16
Hydrogen
cooling

Semiannual inspection. Check for gas leaks if excessive amount of hydrogen is being used. Replace supply tanks as necessary. Check valves, piping, gages, and alarm relays.

Weekly inspection. Visual check of control devices to see that CO₂ system is in operating condition. Check the electrical control features by means of the test devices where these are provided.

8.17
CO₂ fire
protection

Semiannual inspection. Check weights of CO₂ supply cylinders and replace as necessary. Check piping and valves for leaks.

Annual inspection. Actuate routing valves to see that they are in operating condition. Check operation of system by closing actuating contacts by hand but with detonators disconnected from all but one cylinder discharging CO₂ into the generator or other protected area. (See Power O&M Bulletin No. 23.)

Annual inspection. Check bearing and stator temperature indicators and relays for sticking, dirty contacts, etc. Check calibration if in doubt. Check water and oil flow or pressure gages and relays for proper operation.

8.18
Temperature
indicators and
relays

8.19
Water and oil
flow gages and
relays

9. Low-voltage Switchgear, Buses, and Cables

INSPECTION CHECK LIST

Items of inspection	Inspection interval	Procedure reference
Oil and air circuit breakers		See Section 10
Disconnecting switches and fuses		See Section 11
Bus bars, joints, and connections	A	9.03
Bus insulators and supports	A	9.04
Bus enclosures and barriers	A	9.05
Switchgear panels and enclosures	W	A 9.06
Locks and interlocks	W	9.07
Warning and safety signs	W	9.08
Current and potential transformers		A 9.09
Meters, instruments, and relays)		
Control devices		See Section 14
Panel wiring		
Power cables	A	9.13
Potheads	A	9.14

W--Routine weekly inspection.

A--Annual inspection.

References

How to Maintain Electric Equipment, GET-1125 by General Electric Company

Power O&M Bulletin No. 9, Dependable Electrical Contacts

Power O&M Bulletin No. 3, Testing Electrical Equipment Insulation

<p><u>Annual inspection.</u> Check bus bars, joints, and connections for overheating. Tighten joint and connection bolts. Refinish joint contact surfaces if annealed from overheating. (See Power O&M Bulletin No. 9.)</p>	<p>9.03 Bus bars, joints, and connections</p>
<p><u>Annual inspection.</u> Inspect and clean insulators or insulating block supports. Paint chipped spots on porcelain with red glyptal lacquer. Tighten bolts. Check supports for strength and rigidity. Inspect tape insulation on bus bars and revarnish if dull.</p>	<p>9.04 Bus insulators and supports</p>
<p><u>Annual inspection.</u> Check metal or transite bus enclosures and interphases, barriers, tightness, and adequate ventilation. Clean as needed.</p>	<p>9.05 Bus enclosures and barriers</p>
<p><u>Weekly inspection.</u> See that interior and exterior of enclosures are kept clean and free of oil, insect webs, etc.</p>	<p>9.06 Switchgear panels and enclosures</p>
<p><u>Annual inspection.</u> Clean inside and outside of enclosures. Use solution of mild soap and water to remove dirt and grease from panels. Many cleaning compounds are harmful to the painted surfaces and should not be used. Clean out-control wiring and hard-to-reach places with an industrial-type vacuum cleaner (with nonmetallic hose and nozzle), or clean, dry compressed air.</p>	
<p><u>Weekly inspection.</u> See that all keyed locks and mechanical interlocks provided to prevent unauthorized operation of equipment or for personnel safety are in place and locked.</p>	<p>9.07 Locks and interlocks</p>
<p><u>Weekly inspection.</u> See that adequate warning and safety signs are in place around live parts or other safety hazards.</p>	<p>9.08 Warning and safety signs</p>
<p><u>Annual inspection.</u> Check oil level and oil leaks in oil-filled transformers. Check for leaking compound from dry-type transformers. Clean insulators. Check and tighten primary and secondary connections. See that short-circuiting device on current-transformer secondary is secured in the open position and that protector tubes or thyrite protectors are not bypassing current at normal loads. Check potential transformer fuses. Check insulation resistance of windings.</p>	<p>9.09 Current and potential transformers</p>
<p><u>Annual inspection.</u> Check visible portions of cable braid, rubber, or lead sheath for signs of cracking, deterioration,</p>	<p>9.13 Power cables</p>

or corrosion. Check for signs of moisture at entrance to conduits or ducts. Check cable terminals and tighten connections. Check for proper support. Check insulation resistance. (See Power O&M Bulletin No. 3.)

9.14
Potheads

Annual inspection. Check for oil or compound leaks, and stop as necessary. See that potheads are filled to the proper level with oil or compound. Clean insulators. Repair chipped spots on porcelain with lacquer such as red glyptal. Tighten connections, bolts, and screws.

10. Oil and Air Circuit Breakers

INSPECTION CHECK LIST

Items of inspection	Inspection interval			Procedure reference
	Attended station	Nonattended station		
Foundation		A	A	10.01
Frame and tanks	D	A	W A	10.02
Oil valves and plugs	D	A	W A	10.03
Oil levels and gages	D	A	W A	10.04
Breathers and vents	D	A	W A	10.05
Panels and cabinets		A	A	10.06
Bushings or insulators	W	A	W A	10.07
Bushing current transformers and potential devices		A	A	10.08
Main terminals and ground connections	D	A	W A	10.09
Main contacts		A	A	10.10
Contact pressure springs		A	A	10.11
Flexible shunts		A	A	10.12
Magnetic, air, or oil blowout device		A	A	10.13
Crosshead		A	A	10.14
Lift rods and guides		A	A	10.15
Operating rods, shafts, and bell-cranks		A	A	10.16
Closing solenoid, air cylinder, motor, or spring		A	A	10.17
Manual operating device	W	A	W A	10.18
Air compressor and air tank			See Section 6	
Latch and trip mechanism	W	A	W A	10.20
Tripping solenoid	W	A	W A	10.21
Control and protective relays			See Section 14	
Solenoid valves		A	A	10.23
Auxiliary switches		A	A	10.24
Operation counter	M	A	M A	10.25
Position indicator		A	A	10.26
Dashpots or snubbers		A	A	10.27
Mechanism cabinet		A	A	10.28
Cabinet lights and heaters	W	A	W A	10.29
Power supplies and wiring	W	A	W A	10.30
Oil dielectric test		A	A	10.31
Filter oil		NS	NS	10.32
Operation		NS	NS	10.33

D--Routine daily inspection.
W--Routine weekly inspection.
M--Routine monthly inspection.

A--Annual inspection.
NS--Not scheduled.

References

- How to Maintain Electric Equipment, GET-1125, General Electric Company
Operators Lesson No. 12, Oil Circuit Breakers
Power O&M Bulletin No. 14, Painting of Transformers and Oil Circuit Breakers
Power O&M Bulletin No. 10, Retaining Glaze-Burned Insulators in Service
Power O&M Bulletin No. 11, Maintenance of Mineral Insulating Oils

- 10.01 Foundation Annual inspection. Check foundation for cracks and settling. A shift of the breaker tanks may break bushings or cause mis-alinement of contacts or binding of operating mechanism.
- 10.02 Frame and tanks Daily or weekly inspection. Check for oil leaks and note tank temperature by touch.
- 10.03 Oil valves and plugs Annual inspection. Check condition of paint and repaint as necessary. Inspect oil valves and plugs and stop oil leaks. See that oil drain valves which can be operated without wrenches are plugged or locked to prevent unauthorized opening. Tighten bolts. Clean interior of tanks. Inspect underside of cover for moisture and rust, and clean and repaint as necessary. Check tank liners and interphase barriers.
- 10.04 Oil levels and gages Daily or weekly inspection. Check oil level in gages of the tanks and oil-filled bushings. Replenish oil if below normal.
Annual inspection. Clean dirty gage glasses and connections into tank. Drain out and replace bushing oil if dirty or discolored.
- 10.05 Breathers and vents Daily or weekly inspection. Check for external obstructions to breakers and vents.
Annual inspection. Check to see that screens and baffles in vents or breathers are not obstructed or broken.
- 10.06 Panels and cabinets Annual inspection. Check air circuit breaker or other panels of insulating material for cracks and cleanliness. Check condition of enclosing cabinets including hinges, latches, locks, door gaskets, and paint.
- 10.07 Bushings or insulators Weekly inspection. Check for chipped or broken porcelain, excessive dirt film, oil level, and oil or compound leaks.
Annual inspection. Clean porcelain with water, chlorothene, or other suitable cleaner. Repair chipped spots by painting with lacquer such as red glyptal. Inspect gaskets for leaks. Tighten bolts. Check insulation resistance with contacts closed and power factor. Check oil sample from bottom of bushing for dielectric strength and presence of water and dirt which may be entering at top. Replace or replenish oil if necessary. Check and clean interior at least once every 5 years.

- Annual inspection. Check tap settings and adjustments at terminal board to see that they agree with diagrams. Check insulation resistance of wiring with devices connected. Check ratio and phase-angle adjustments of potential devices if changes have been made in secondary connections or burden. Tighten connections, including potential device tap into bushing. 10.08
Bushings
current
transformers
and potential
devices
- Daily or weekly inspection. Check for presence of foreign materials, birds' nests, etc., in or near connecting bus work; loose or heating connections; and loose or broken frame ground connections. 10.09
Main terminals
and ground
connections
- Annual inspection. Tighten all bus and ground connections. Refinish joint contact surfaces if they have been overheating. Inspect ground cable to see that it is not loose or broken.
- Annual inspection. Remove the tanks or drain out oil so that the contacts can be inspected. Dress contacts, if rough, with a fine file. It is necessary to remove only the projecting beads. Pits in a flat, smooth surface are not objectionable. Check contact drop with "ducter" or by direct-current millivolt drop. Frequency of breaker contact maintenance should be based on number and severity of faults interrupted rather than a definite time period. Experience will tell how many faults can be interrupted before contact repairs are necessary. Data should be kept on each breaker to guide future maintenance. Inspection schedules might be extended further as oil-handling methods, methods for determining oil condition, and other improvements are made. The following factors should be established before intervals between inspections can be extended: 10.10
Main contacts
- a. All new breakers must have a complete inspection at the end of 1 year.
 - b. Only breakers having field experience to support the program should be scheduled for extended inspection periods.
 - c. Breakers used on special applications, such as capacitor and reactor switching, should be considered separately.
 - d. If recurring troubles are found on a certain type of breaker, the inspection schedules should be adjusted until the trouble is eliminated.

e. Breakers interrupting a large number of faults should be given special attention to determine whether or not early internal inspection is required.

f. When oscillographs indicate abnormal breaker operation, an immediate inspection of the breaker should be made.

- 10.11 Annual inspection. Check springs for loss of temper, breaks, Contact pressure springs or other deterioration.
- 10.12 Annual inspection. Check flexible shunts at contact hinges Flexible shunts for overheating and fraying. Tighten connections.
- 10.13 Annual inspection. Check arc-rupturing blowout coils, magnetic Magnetic, air, or oil blow-out devices circuit, arc chutes, deion grids, oil blast, or other interrupters for proper operation.
- 10.14 Annual inspection. Check contact crosshead for misalignment, Crosshead breaks, bends, or looseness on lift rod.
- 10.15 Annual inspection. Check contact lift rods for breaks, Lift rods and guides weakening or warping, and pulling out at ends. Check adequacy of guides.
- 10.16 Annual inspection. Check for loose locknuts, setscrews, keys, Operating rods, shafts, and bell-cranks bearings, bent rods or twisted shafts, etc. Clean moving parts of rust, dirt, and accumulated grease and oil. Wash out bearings, pivots, and gears with chlorothene or other suitable cleaner and operate breaker several times to work out dirt and old lubricant. Lubricate with new grease or oil. In cold climates, it is important to use lubricant which will not stiffen too much when cold. Wipe off excess oil. Enclosed dust-tight bearings should require less servicing.
- 10.17 Weekly inspection. Visual inspection to see that equipment Closing solenoid air cylinder, motor, or spring is in operating condition. Drain condensation from air cylinder.
- Annual inspection. Observe mechanism during several closing operations to see that everything is in proper working order. Check solenoid plunger for sticking in guides. Check coil resistance and insulation resistance. Dismantle air cylinder and clean and relubricate. Check motor as covered in Section 8. Check closing springs for proper tension and closing energy.

<u>Annual inspection.</u> See that manual operating lever or jack is kept on hand and in usable condition. See that breaker is closable with it.	10.18 Manual operating device
<u>Weekly inspection.</u> Visual inspection to see that mechanism is in operating condition.	10.20 Latch and trip mechanism
<u>Annual inspection.</u> Observe mechanism during several tripping operations to see that everything is in working order. Check pins, bearings, and latches for wear, binding, and misalignment. Clean and relubricate as in Section 10.16. Check latch carefully to see that it is not becoming worn so as to unlatch from vibration or stick and fail to trip. Tighten bolts and screws.	
<u>Weekly inspection.</u> Visual inspection to see that solenoid trip device is in operating condition.	10.21 Tripping solenoid
<u>Annual inspection.</u> Observe operation during electrical tripping. See that full energy, snappy action of plunger is obtained. Check plunger for sticking in guides. Check coil and insulation resistance.	
<u>Annual inspection.</u> Check for condition of valve seat, and refit as necessary. See that moving parts are free to operate. Check resistance and insulation resistance of solenoid coil.	10.23 Solenoid valves
<u>Annual inspection.</u> Check condition of contacts and refinish with fine file if burned or corroded. Check contact springs, operating rods, and levers. Check closing and opening position with respect to main contacts while breaker is being slowly closed and opened manually. Certain auxiliary contacts used for special purposes may require close adjustment in this respect.	10.24 Auxiliary switches
<u>Monthly inspection.</u> Observe and record reading of operation counter.	10.25 Operation counter
<u>Annual inspection.</u> See that operation counter is properly registering the breaker operations.	
<u>Annual inspection.</u> See that position indicator or semaphore is properly indicating the breaker position. Check operating rods or levers for loose parts.	10.26 Position indicator

- 10.27
Dashpots
or snubbers Annual inspection. Check for proper setting and adjust as necessary. Clean out and replenish liquid in liquid dashpots.
- 10.28
Mechanism
cabinet Annual inspection. Check condition of metal and hardware. Repaint as necessary. See that door gaskets are tight and properly exclude dust and dirt.
- 10.29
Cabinet
lights and
heaters Weekly inspection. Check cabinet heaters and see that they are in service during cold weather. Replace burned-out lamps.
- Annual inspection. Check heating elements and replace if in poor condition.
- 10.30
Power supplies
and wiring Weekly inspection. See that all power and control circuit switches are closed and fuses in place.
- Annual inspection. Inspect fuses or circuit breakers in all power and control supply circuits. Check and tighten wiring connections at terminal points. Inspect wiring for open circuits, short circuits, and damaged insulation. Check insulation resistance of wiring with devices connected.
- 10.31
Oil dielectric
tests Annual test. Check dielectric strength of the insulating oil in the main tanks and oil-filled bushings.
- 10.32
Filter oil The necessity for filtering the insulating oil will depend on the results obtained from the oil dielectric tests and the amount of carbon in the oil. The oil should be filtered if the dielectric strength is below 25 kilovolts or if there is a noticeable amount of carbon in suspension or in the bottom of the tanks. Refer to Power O&M Bulletin No. 11 for detailed test information.
- 10.33
Operation Some breakers, particularly those carrying high values of current, have a tendency to develop contact heating if left closed for long periods. Opening and closing breakers several times at intervals, as system operation will permit, may alleviate the heating by wiping the oxide from the contact surfaces, as well as demonstrate that the breaker is in operating condition.

11. Disconnecting Switches and Fuses

INSPECTION CHECK LIST

Items of inspection	Inspection interval	Procedure reference
Base and mounting	A	11.01
Insulators	W	A 11.02
Line and ground connections	A	11.03
Blades and contacts	W	A 11.04
Contact and hinge springs and shunts	A	11.05
Arcing horns	A	11.06
Blade latches and stops	W	A 11.07
Operating rods, levers, and cranks	A	11.08
Gearboxes	A	11.09
Operating motor and mechanism	A	11.10
Auxiliary and limit switches	A	11.11
Locks and interlocks	W	A 11.12
Switch sticks	W	A 11.13
Fuse tubes	A	11.14
Fuse links	A	11.15
Multiple-shot reclosing fuse	W	A 11.16

W--Routine weekly inspection.

A--Annual inspection.

Reference

Power O&M Bulletin No. 10, Retaining Glaze-burned Insulators in Service

- 11.01 Annual inspection. Check for loose bolts and insecure or inadequate supporting structure.
Base and mounting
- 11.02 Weekly inspection. Check for chipped or broken porcelain and excessive dirt film.
Insulators
- Annual inspection. Clean porcelain with water, chlorothene, or other suitable cleaner if subject to excessive dirt or smoke. Repair chipped spots by painting with lacquer such as red glyptal. Replace broken insulators. Check insulators at 5-year intervals with an insulator tester if a reliable tester is available. Tighten base and cap bolts.
- 11.03 Annual inspection. Check and tighten line terminals and base and operating handle ground connections. See that ground cable is not broken.
Line and ground connections
- 11.04 Weekly inspection. See that blades are properly seated in the contacts.
Blades and contacts
- Annual inspection. Operate switch several times and see that blades are properly alined to engage contacts. Clean contact surfaces if corroded. Tighten bolts and screws.
- 11.05 Annual inspection. Check pressure springs in contact and hinge and replace if not adequate. Replace flexible shunts if frayed.
Contact and hinge springs and shunts
- 11.06 Annual inspection. Check arcing horns of air-break switches to see that they are not bent out of shape. Clean up if burned.
Arcing horns
- 11.07 Weekly inspection. See that blade latches, where provided, are engaged.
Blade latches and stops
- Annual inspection. Check latches for proper engaging and holding blade against opening force. See that stops are in place and tight.
- 11.08 Annual inspection. Check and tighten bolts, screws, and locknuts. See that rods, levers, and cranks are in serviceable condition and repair as necessary. Lubricate pivots and bearings. (See Section 10.16.)
Operating rods, levers, and cranks

<u>Annual inspection.</u> Check gears and bearings. Flush out oil or grease and relubricate. (See Section 10.16.)	11.09 Gearboxes
<u>Annual inspection.</u> Check motor as per Section 8. Check adjustment of brake.	11.10 Operating motor and mechanism
<u>Annual inspection.</u> Check condition of contacts and refinish with fine file if burned or corroded. Check contact springs, operating rods, and levers. Check closing and opening positions with respect to main switch contacts or travel or motor mechanism.	11.11 Auxiliary and limit switches
<u>Weekly inspection.</u> See that switches are properly locked in the open or closed position as required by padlocks or other key-type locks or interlocks.	11.12 Locks and interlocks
<u>Annual inspection.</u> See that locks and keys operate as intended. Check mechanical interlocks, such as between main disconnecting switch and ground switch, for foolproof operation.	
<u>Routine inspection.</u> See that wooden switch-operating sticks are in good condition and are kept in a dry place.	11.13 Switch sticks
<u>Annual inspection.</u> Inspect wooden operating sticks for cracks, splinters, loose heads, and checked varnish. Broken or badly checked high-voltage sticks should be destroyed, as splicing or repairing may result in low dielectric strength. Good sticks should be revarnished frequently. Care must be exercised in revarnishing to see that stick is thoroughly dry and that varnish does not contain moisture or other foreign conducting material. Check varnish with an oil test set before use. See that means for keeping sticks dry is adequate.	
<u>Annual inspection.</u> Check fuse tubes for carbonizing or other deterioration.	11.14 Fuse tubes
<u>Annual inspection.</u> See that fuse links are secure at the terminals and are not overheating. See that extra links or new fuses are kept on hand.	11.15 Fuse links
<u>Weekly inspection.</u> Note whether operation has occurred and replace blown fuse.	11.16 Multiple-shot reclosing fuse
<u>Annual inspection.</u> Check fuse latching and tripping mechanism for proper operation.	

12. Transformers and Regulators

INSPECTION CHECK LIST

Item of inspection	Inspection interval						Procedure reference
	Large units			Small units			
	Attended	Un-attended		Attended	Un-attended		
Foundation, rails, & trucks		A	A	A	A	A	12.01
Tanks & radiators	D	A W	A W	A M	A	A	12.02
Oil & water piping	D	A W	A W	A M	A	A	12.03
Valves & plugs	D	A W	A W	A M	A	A	12.04
Oil levels, gages, & relays	D	A W	A W	A M	A	A	12.05
Breathers & vents	D	A W	A W	A M	A	A	12.06
Relift diaphragm	D	A W	A W	A M	A	A	12.07
Water-cooling coils & piping		A	A	A	A	A	12.08
Flow indicators & relays	D	A	A D	A	A	A	12.09
Heat exchangers		A					12.10
Oil pumps	D	A	See Section 6				12.11
Cooling fans	D	A	D	A			12.12
Temperature indicators & relays	D	A W	A W	A M	A	A	12.13
Inert gas tanks	D		W				12.14
Gas regulator, gages, & relays	D	A W	A				12.15
Gas piping and valves		A	A				12.16
Gas analysis		Q	Q				12.17
Bushings	W	A W	A W	A M	D		12.18
Bushing current transformers & potential device		A	A				12.19
Main terminal & ground connections	D	A W	A W	A M	A	A	12.20
Core & coils		NS	NS	NS	NS	NS	12.21
Internal inspection		A	A	A	A	A	12.22
Terminal board & connections		A	A	A	A	A	12.23
Ratio adjuster	W	A W	A W	A M	A	A	12.24
Tap changer or regulator	D	A W	A				12.25
Motor & drive		A	A				12.26
Auxiliary & limit switches		A	A				12.27
Position indicators		A	A				12.28
Operation counter	W	A W	A				12.29
Power & control relays			See Section 14				
Operation		A	A				12.30

INSPECTION CHECK LIST--Continued

Item of inspection	Inspection interval						Procedure reference
	Large units			Small units			
	Attended	Un-attended	Un-attended	Attended	Un-attended	Un-attended	
Power supplies & wiring	D	A	W	A			12.31
Insulation resistance		A		A	A	A	12.32
Oil dielectric		A		A	A	A	12.33
Oil acidity		5 yr		5 yr	5 yr	5 yr	12.34
Filter & reclaim oil		NS		NS	NS	NS	12.35
Fire protection	M	A					12.36

D--Routine daily inspection.
W--Routine weekly inspection.
M--Routine monthly inspection.
Q--Quarterly inspection.
A--Annual inspection.
NS--Not scheduled.

References

How to Maintain Electric Equipment, GET-1125, General Electric Company Operators Lesson No. 12, Alternating Current Machinery--Transformers and Regulators
Power O&M Bulletin No. 14, Painting of Transformers and Oil Circuit Breakers
Power O&M Bulletin No. 3, Testing Electrical Equipment Insulation
Power O&M Bulletin No. 11, Maintenance of Mineral Insulating Oil
Power O&M Bulletin No. 6, Permissible Overloading of Oil Immersed Transformers and Regulators
Power O&M Bulletin No. 1, Testing and Maintenance of High Voltage Bushings
Power O&M Bulletin No. 23, Fire-fighting, Cause and Prevention

- 12.01 Foundation, rails, and trucks Annual inspection. Check foundation for cracking and settling. A slight shift of the transformers may break bushings or connecting oil or water lines. See that rail stops are firmly in place to hold transformer in position on the rails. Check transfer car and matching of its rails with transformer deck rails at each position. Paint metalwork as needed.
- 12.02 Tanks and radiators Daily, weekly, or monthly inspection. Check for unusual noise and oil and water leaks.
- 12.03 Oil and water piping Annual inspection. Clean dirt and oil from radiating surfaces. Repaint as necessary. Stop excessive vibration of radiator tubes. Tighten loose or vibrating parts. Check for unusual internal noises. Inspect oil and water piping, valves, and plugs. Manipulate radiator cutoff valves to see that they are in operating condition, and secure in the open position. See that all oil drain valves which can be operated without wrenches are plugged or locked to prevent unauthorized opening.
- 12.04 Valves and plugs Daily, weekly, or monthly inspection. Check oil level in main and auxiliary tanks, oil-filled bushings, etc. Changes in oil levels from time to time should be noted, taking into consideration the change in level caused by change in oil temperature. A rise in level in a water-cooled transformer (for a given temperature) indicates that water is leaking from the cooling coils into the oil.
- 12.05 Oil levels, gages, and relays Annual inspection. Clean dirty gage glasses and connections into tank. Check oil level indicators and relays for proper operation. Replenish oil if below normal. Drain out and replace bushing oil if dirty or discolored.
- 12.06 Breathers and vents Daily, weekly, or monthly inspection. See that relief diaphragm has not opened and breathers and vents appear to be normal.
- 12.07 Relief diaphragm Annual inspection. See that relief diaphragm is in operating condition and closes tightly. The nonshattering-type diaphragm should be actuated to see that it is not stuck shut from rust or paint. Make sure that the material used in the shattering-type diaphragm is not too thick or tough to be broken by reasonable internal pressure. See that screens and baffles

in vents or breathers are not obstructed or broken. If breathers are of the dehydrating type, check chemicals and replace if depleted.

<u>Annual inspection.</u> Check external supply and drain piping for leaks. Flush out cooling coils or heat exchanger water passages with air and water. Test coils for leaks by applying air pressure to coils and observing for bubbles rising in oil and drop in air pressure with supply valve closed, or use a hydrostatic pressure test. A pressure of about 75 pounds per square inch is recommended. If water scale is present, circulate a solution of 25 percent hydrochloric acid and water through the coils until clean. Then flush out thoroughly. Clean external surfaces of coils.	12.08 Water-cooling coils and piping
<u>Daily inspection.</u> See that proper supply of cooling water is flowing.	12.09 Flow indicators and relays
<u>Annual inspection.</u> Check waterflow indicators and relays for proper operation.	
<u>Annual inspection.</u> Clean and test water tubes similar to cooling coils. Check for oil and water leaks.	12.10 Heat exchangers
<u>Daily inspection.</u> See that oil-circulating pumps are in operation when required.	12.11 Oil pumps
<u>Annual inspection.</u> See Section 6.	
<u>Daily inspection.</u> See that fans are in operation when necessary.	12.12 Cooling fans
<u>Annual inspection.</u> Check motors and control as per Sections 8 and 14.	
<u>Daily, weekly, or monthly inspection.</u> Check and record transformer temperatures.	12.13 Temperature indicators and relays
<u>Annual inspection.</u> Check calibration of temperature indicators and relays. Check and clean relay contacts and operating mechanism.	
<u>Daily or weekly inspection.</u> Check gas pressure left in tanks and change out at about 25-pound pressure.	12.14 Inert gas tanks

- 12.15 Gas regulator gages and relays Daily or weekly inspection. See that proper gas pressure is being maintained in transformer.
- Annual inspection. Check setting and operation of regulator and relay. See that gages are indicating properly.
- 12.16 Gas piping and valves Annual inspection. Check for gas leaks by applying liquid soap on all joints, valves, connections, etc., with gas pressure raised to the maximum recommended by the transformer manufacturer.
- 12.17 Gas analysis Quarterly inspection. Check analyzer for proper operation. Analyze gas. Purge if oxygen content is over 5 percent.
- 12.18 Bushings Weekly or monthly inspection. Check for chipped or broken porcelain, excessive dirt film, oil level, and oil or compound leaks.
- Annual inspection. Clean porcelain with water, chlorothene, or other suitable cleaner. Repair chipped spots by painting with lacquer such as red glyptal. Inspect gaskets for leaks. Tighten bolts. Check power factor. Check oil sample from bottom of bushing for dielectric strength and presence of water which may be entering at top. Replace or replenish oil if necessary.
- 12.19 Bushing current transformers and potential devices Annual inspection. Check tap setting and adjustments at terminal board to see that they agree with diagrams. Check insulation resistance of wiring with devices connected. Check ratio and phase-angle adjustments of potential devices if changes have been made in secondary connections and burden. Tighten connections, including potential device tap, into bushing.
- 12.20 Main terminals and ground connections Daily, weekly, or monthly inspection. Check for presence of foreign material, birds' nests, etc., in or near connecting bus work, loose or heating connections, and loose or broken tank ground connections.
- Annual inspection. Tighten all bus and ground connections. Refinish joint contact surfaces if they have been overheating. Inspect ground cable to see that it is not loose or broken.
- 12.21 Core and coils Not scheduled. If the transformer has been properly maintained and not overheated and barring internal failure, it should not require untanking within its normal life. If sludge has been allowed to form due to overheating and oxidation of the oil, the transformer should be untanked and the

core, coils, oil passages, tank, and water-cooling coils washed down with clean oil under pressure to remove sludge and other accumulations which prevent proper circulation of the oil. Inflammable liquids should not be used in cleaning the core, coils, or inside of tank. Provide sufficient fresh air for workman while working inside of tank. While untanked, check for loose laminations, core bolts, insulating blocks, etc., and other pertinent features on the check list.

- Annual inspection. Lower the oil level to at least the top of the core. Inspect for sludge on core and windings. Inspect underside of cover for moisture and rust and clean up. Check connections at terminal board. Tighten all bolted connections, core bolts, etc., within reach. 12.22
Internal inspection
- 12.23
Terminal board and connections
- Weekly or monthly inspection. Note position of ratio adjuster and that it is adequately locked to prevent unauthorized operation. 12.24
Ratio adjuster
- Annual inspection. Inspect contacts and clean if reachable on internal inspection. If not reachable for visual inspection, check each position with wheatstone bridge across winding to detect poor contact. Work adjuster back and forth over complete range several times.
- Daily or weekly inspection. Note position of tap changer. See that positions on all three transformers are the same and that manual operating device is locked. 12.25
Tap changer
- Annual inspection. Drain oil from contact compartment. Clean and refinish contact surfaces. Check contact spring pressure. Check contact operating mechanism. Tighten connections and other bolts.
- Annual inspection. Check motor as in Section 8. Check and adjust brake. Check gears, shafts, and lubrication. 12.26
Motor and drive
- Annual inspection. Check condition of contacts and refinish if burned or corroded. Check contact springs, operating rods, and levers. Check closing and opening position with respect to position of main contacts. 12.27
Auxiliary and limit switches

- 12.28 Annual inspection. See that positions indicated correspond to position of main contacts. Check remote electrical position indicators for correct operation, obstruction to movement of pointer, etc.
- 12.29 Weekly inspection. Check and record reading of operation counter.
- Annual inspection. Check operation counter for correct registration.
- 12.30 Annual inspection. Run tap changer or regulator through several complete cycles by both control relay and manual control, and observe contacts and mechanism for proper operation.
- 12.31 Daily or weekly inspection. See that all power, control, and alarm supply circuit switches are closed and fuses in place so that circuits are completed.
- Annual inspection. Inspect fuses or circuit breakers on all power, control, and alarm supplies to auxiliary equipment and devices. Check and tighten wiring connections at all terminal points. Inspect wiring for open circuits, short circuits, and damaged insulation. Check insulation resistance of wiring with devices connected.
- 12.32 Annual test. Check the insulation resistance between each winding and between each winding and ground. Disconnect all external leads at the bushing terminals, except where the connecting leads can be suitably isolated at adjacent disconnecting switches, for this test. A similar test using a capacitance bridge is recommended where such an instrument is available.
- 12.33 Annual test. Check the dielectric strength of the insulating oil in the main and auxiliary tanks and oil-filled bushings. (See Power O&M Bulletin No. 11.)
- 12.34 The acidity of the insulating oil in the main tank should be checked at intervals of not more than 5 years. Transformers operating at high temperatures or showing signs of sludging

or dark color of the oil should be checked more frequently. Oil may be checked in the field with a Gerin test kit or samples sent to the Denver laboratory.

Not scheduled. The necessity for filtering and/or reclaiming the insulating oil will depend on the results obtained from the oil dielectric and oil acidity tests. It may be more economical to replace the oil in small transformers rather than filter or reclaim it. 12.35
Filter and
reclaim oil

Monthly. Where a water spray system is used, see that control valves and automatic devices are in operating condition and water supply is available. 12.36
Fire
protection

Annually. With transformer deenergized, try out water spray system. Observe fog nozzles for proper coverage and spray. See Section 3.19. (See Power O&M Bulletin No. 23.)

13. Lightning Arresters

INSPECTION CHECK LIST

Item of inspection	Inspection interval		Procedure reference
Base and supports	M	A	13.01
Procelain shells and insulators		A	13.02
Grading rings		A	13.03
Arrester units (internal)		NS	13.04
Gaps		A	13.05
Weather sheds and hoods		A	13.06
Line and ground connections		A	13.07
Operation indicators	W	A	13.08
Operation tests		A	13.09

W--Routine Weekly inspection.

M--Routine monthly inspection.

NS--Not scheduled.

A--Annual inspection.

References

Power O&M Bulletin No. 5A, Proper Installation of Lightning Arresters
Operators Lesson No. 19, Lightning Surge Protection

<u>Monthly inspection.</u> Visual inspection to detect cracking, settling, or shifting of base or supports which might place strain on arrester units.	13.01 Base and supports
<u>Annual inspection.</u> Check for cracking, settling, or shifting of base or supports. Check tension on spring tiedowns on suspended arresters in hottest and coldest weather and adjust as necessary. Clean and revarnish wooden supports for oxide-film arresters as necessary. Tighten bolts and screws.	
<u>Annual inspection.</u> Clean porcelain insulators and arrester unit shells. Repair chipped spots on porcelain with lacquer such as red glyptal.	13.02 Porcelain shells and insulators
<u>Annual inspection.</u> Check and tighten grading rings on high-voltage arresters.	13.03 Grading rings
<u>Not scheduled.</u> It would generally not be practical or necessary to dismantle an arrester unit such as a General Electric thyrite unit for inspection of the thyrite disks, gaps, resistors, etc. However, if tests made under Section 13.09, or outside inspection, indicate possible damage from a heavy discharge, all internal parts should be inspected and replaced as necessary. Check for condensation inside of unit.	13.04 Arrester units (internal)
<u>Annual inspection.</u> Check external gaps, smooth off arc-burned spots, and readjust spacing.	13.05 Gaps
<u>Annual inspection.</u> See that weather sheds and hoods of oxide-film arresters are securely fastened in place. Repaint as necessary.	13.06 Weather sheds and hoods
<u>Annual inspection.</u> Check and tighten line and ground connections. Check ground lead for corrosion or damage below ground line. Check ground resistance. See that all leads are as short and direct as possible, in accordance with Power O&M Bulletin No. 5A.	13.07 Line and ground connections
<u>Weekly inspection.</u> Note and record operation indicator reading.	13.08 Operation indicators
<u>Annual inspection.</u> Check indicator for proper operation.	

13.09
Operation
tests

Annual inspection. There is no positive means of telling by external inspection whether the modern, completely enclosed arrester units are in proper operating condition. Heavy discharges may have fused the gaps together or burned the circuits open without causing visible external damage. Arresters made up of units up to about 20 kilovolts each can be given a spark-over test by applying potential to each unit separately from an oil test set or high potential test set. The tests should be completed promptly to prevent overheating the arrester. Having made such a test on an arrester unit of a particular type and manufacture which is known to be good, a comparison can be made with other arrester units to determine whether there is any probable internal damage.

14. Switchboards and Control Equipment

INSPECTION CHECK LIST

Item of inspection	Inspection interval	Procedure	reference
<u>Switchboards and Control Panels</u>			
Panels and supports	W A		14.01
Metal boxes and cabinets	W A		14.02
Panel wiring	A		14.03
Terminal blocks	A		14.04
Auxiliary and control relays	W A		14.05
Control switches and pushbuttons	W A		14.06
Indicating lamps	D W A		14.07
Meters and instruments	D W A		14.08
Position indicators	D W A		14.09
Protective relays	D W A		14.10
Test switches or blocks	A		14.11
Rheostats and resistors	A		14.12
<u>Motor Starters and Controllers</u>			
Metal boxes and cabinets	A		14.02
Knife switches	A		14.13
Fuses and circuit breakers	A		14.14
Contacts	A		14.15
Contact springs and shunts	A		14.16
Blowout coils and arc chutes	A		14.17
Operating or holding solenoid and magnet frame	A		14.18
Operating shaft or rod	A		14.19
Mechanical and electrical interlocks	A		14.20
Latches and trip devices	A		14.21
Auxiliary switches	A		14.22
Overload trip	A		14.23
Step starter timers	A		14.24
Compensator or autotransformer	See Section 12		
Miscellaneous control devices	A		14.26
Power Supplies and Wiring	W A		14.27

D--Routine daily inspection (at attended stations only).

W--Routine weekly inspection.

A--Annual inspection.

References

- Operators Lesson No. 15, Meters and Instruments
 Power O&M Bulletin No. 16, Field Test Procedure for Protective Relays
 Operators Lesson No. 13, Protective Relays
 Operators Lesson No. 2, Switchboard Terminal Block Marking Strips and Tags for Control Wire Terminations
 Power O&M Bulletin No. 22, Watt-hour Meter Maintenance and Testing

- 14.01
Panels and supports
14.02
Metal boxes and cabinets
- Weekly inspection. Check for general cleanliness and condition of finish. Clean off dust, dirt, and grease. Use a solution of mild soap and water to remove dirt and grease from panels. Many cleaning compounds are harmful to the finish and should not be used. Since switchboard panels having considerable equipment on them are difficult to refinish, care must be taken in cleaning them. Wax may be used where the gloss is not objectionable. Oil-base polish has a tendency to collect dust and retain fingerprints. Linseed oil may be used on slate panels if used sparingly and wiped dry.
- Annual inspection. Repair finish and panel and door hardware and clean up as necessary. Tighten bolts and screws. Check boxes and cabinets in damp locations for corrosion and rust. Clean and refinish as necessary.
- 14.03
Panel wiring
14.04
Terminal blocks
- Annual inspection. Check for general housekeeping. Blow out wiring and equipment on back of panels with clean, dry, compressed air or use an industrial-type vacuum cleaner with nonmetallic hose fittings if available. Inspect wiring for open circuits, short circuits, and damaged insulation. Check insulation resistance of wiring or equipment on which the insulation appears to be questionable. Remark conductor tags or designations before they become obscure. Replace lost conductor tags. Tighten connections at terminal points.
- 14.05
Auxiliary and control relays
- Weekly inspection. Check condition of contacts. Note whether coil temperature is excessive. Check noise and vibration of alternating-current contactor magnet frame and armature.
- Annual inspection. Finish contacts with fine file. Pits in the contact surfaces are not objectionable, but projections should be removed. Replace contacts if repairing is impractical. Check arc chutes, blowout coils, and barriers. Tighten connections. Check contact shunts. Check contact spring pressure and contact wiping action. Check insulation between circuits or phases. Note whether operating coil temperature

is excessive. Check alinement and vibration of alternating-current magnet frame and armature and examine shading ring.

Weekly inspection. Try out operation of control switches or pushbuttons wherever possible to see if operation is correct.

14.06
Control
switches and
pushbuttons

Annual inspection. Examine contacts and refinish with fine file if burned or corroded. Check contact operating cams, levers, or drums. Check contact spring pressure. Tighten connections. Examine insulation.

Daily inspection. Check lamps to see that they are not burned out, and replace as necessary.

14.07
Indicating
lamps

Annual inspection. Inspect indicating lamps, series resistors, and color caps. Check to see that each lamp gives correct intended indication. Tighten connections.

Daily or weekly inspection. Note sticking of moving element of indicating and recording instruments and watt-hour meters, unsatisfactory inking of record on recorders, and incorrect timing of recorder charts. Have these faults corrected at first opportunity.

14.08
Meters and
instruments

Annual inspection. Check calibration of important instruments and recorders or others suspected of being incorrect. Check watt-hour meters against rotating standard and adjust as necessary. Check to see that movement is free and unobstructed. Check pivots and bearings and repair or replace as necessary. See that cover gaskets are tight so as to exclude dust, dirt, moisture, and insects. Clean cover glasses using a damp cloth so as to avoid placing a static charge on the glass which affects the indication of some instruments. Check external resistors, reactors, and potential fuses. Tighten connections. Check wiring connections if any changes have been made in associated circuits or equipment.

Daily or weekly inspection. Note sticking pointers.

14.09
Position
indicators

Annual inspection. Check for correct positioning between transmitter and receiver. Check for friction and vibration of moving element and excessive heating.

- 14.10 Protective relays Daily or weekly inspection. Visual inspection for anything unusual about contacts, coils, or moving elements. Check targets and reset them.
- 14.11 Test switches or blocks Annual inspection. Check taps, resistor settings, or other adjustments against relay data sheets. Check setting for correct operation and adjust as necessary. Examine moving parts and see that they are free and unobstructed. Examine relay and test switch contacts and refinish with fine file if burned or corroded. See that cover gaskets are tight so as to exclude dust, dirt, moisture, and insects. Note excessive heating of coils and resistors. Tighten connections. Check wiring connections if any changes have been made in associated circuits or equipment. Try out trip circuit, if possible, to see that relay trips all devices as intended. (See Power O&M Bulletin No. 16.)
- 14.12 Rheostats and resistors Annual inspection. Clean contact buttons and brush if corroded, burned, or cutting. Check brush and hub contact spring pressure. Check resistor elements for burned-out or corroded sections. Test insulation from line to grounded parts.
- 14.13 Knife switches Annual inspection. Check hinges and clips for good contact. Tighten connections. Check door interlocks of safety switches if provided. Clean insulating base if dirty.
- 14.14 Fuses and circuit breakers Annual inspection. Note fuses that are running too hot and replace with proper size or correct the load. See that fuses are tight in the clips and contact surfaces are clean. See that renewable links are tight in holders. See that spare fuses are on hand. Where the small enclosed circuit breakers are used for circuit protection instead of fuses, check mechanical operation of breaker and tighten connections.
- 14.15 Contacts Annual inspection. Dress contacts, if rough, with a fine file. It is necessary to remove only the projecting beads. Pits in a flat, smooth surface are not objectionable.
- 14.16 Contact springs and shunts Check for alinement and adjustment. Check rolling or wiping action and spring pressure. Check flexible shunts and replace if frayed. Tighten connections.

<u>Annual inspection.</u> See that turns of blowout coils are not short circuited and that coil is properly assembled to blow arc outward, not inward. See that arc chutes are in good condition.	14.17 Blowout coils and arc chutes
<u>Annual inspection.</u> Note if coil is operating too hot, and if so, check resistance for possible short-circuited turns. Check alinement of matching faces of magnet frame. Check shading ring for open circuit. A noisy alternating-current solenoid generally indicates poor alinement or a broken shading ring, either of which will cause heating of the solenoid.	14.18 Operating or holding solenoid and magnet frame
<u>Annual inspection.</u> See that shaft is free to move in its bearings or rods are free in the guides.	14.19 Operating shaft or rod
<u>Annual inspection.</u> See that interlocks are properly adjusted to prevent closing of both contactors, such as on a reversing starter, at the same time. Tighten operating arm supports.	14.20 Mechanical and electrical interlocks
<u>Annual inspection.</u> Check latches on latched-in contactors or manually-operated starters for wear and insecure holding. (Check trip solenoid as in Section 14.18.)	14.21 Latches and trip devices
<u>Annual inspection.</u> Clean and refinish contacts if corroded or pitted. Check spring pressure. Tighten connections. Check operating levers or linkage. Check closing and opening adjustment with respect to main contacts.	14.22 Auxiliary switches
<u>Annual inspection.</u> Check operating current and time delay of thermal or magnetic overload trip and see that it is correct for the motor or other equipment controlled. See that trip device functions reliably. Check time delay dashpots for binding; leaking valves; and low, dirty, or incorrect oil.	14.23 Overload trip
<u>Annual inspection.</u> Check time-delay device used for controlling steps on multistep starters to see that proper time delay is obtained and operation is reliable.	14.24 Step starter timers
<u>Annual inspection.</u> Check and clean contacts of control devices such as pushbuttons, time switches, pressure, vacuum or float switches, etc., and see that these devices are in proper operating condition.	14.26 Miscellaneous control devices

14.27
Power
supplies and
wiring

Weekly inspection. See that all power and control supply circuit switches are closed and fuses in place.

Annual inspection. Check and tighten wiring connections at terminal points. Inspect wiring for open circuits, short circuits, and damaged insulation. Check insulation resistance of wiring with devices connected.

15. Communication Equipment

INSPECTION CHECK LIST

Items of inspection	Inspection interval	Procedure	reference
<u>Voice Frequency Telephone Equipment</u>			
Line patrol	Q	A	15.01
Line leakage resistance		SA	15.02
Line loop resistance		SA	15.03
Manual switchboard		SA	15.04
Automatic exchange	M	A	15.05
Transmitters, receivers, dials, ringers, magnetos, and switch hooks		A	15.06
Ringing generator	M	A	15.07
Batteries	M		15.08
Fuses, heat coils, and arresters		SA	15.09
<u>Powerline Carrier Equipment</u>			
Tubes		SA	15.20
Circuit voltages and currents	M		15.21
Aline tuned circuits in transmitter, receiver, and check line trap		A	15.22
Protective airgap in tuning unit and coupling capacitor		A	15.23
Transmitter-receiver and control chassis		M	15.24
Lead-in insulator		A	15.25
Handsets, ringers, and magnetos		A	15.06
Equipment cabinets		A	15.27
Emergency battery	M		15.08
Emergency motor generator	M	A	15.29
<u>Radio Telephone Equipment--Fixed and Mobile</u>			
All transmitter test (required by radio rules and regulations:			
Frequency	M	SA	15.40
Modulation percent, if AM	M	SA	15.41
Modulation frequency deviation, if FM	M	SA	15.42
Power output	M	SA	15.43
Transmitters and receivers:			
Test voltages and currents	M		15.44
Tubes		SA	15.45
Alinement and receiver sensitivity	M	SA	15.46

INSPECTION CHECK LIST--Continued

Items of inspection	Inspection interval	Procedure reference
<u>Radio Telephone Equipment--Fixed and</u>		
<u>Mobile--Continued</u>		
Transmitters and receivers--Continued:		
Antenna and transmission line	M	SA 15.47
Ventilation and dust	M	A 15.48
Antenna tower		SA 15.49
Standby power supply	M	SA 15.50
Main power supply	M	15.51
Mobile stations only:		
Battery, battery cable, and connections	M	15.52
Dynamotor	A	15.53
Generator and voltage regulator	M	15.54
Antenna	A	15.55
Noise level	M	15.56
<u>Supervisory Control and Telemetering</u>		
<u>Equipment</u>		
Electronic amplifiers, signal generators, etc.:		
Test voltages and currents	M	15.44
Tubes	SA	15.45
Telemetering transmitters and receivers and switchboard recorders	D	AM 15.57
Relays	M	A 15.58

D--Routine daily inspection.
W--Routine weekly inspection.
M--Routine monthly inspection.
Q--Quarterly inspection.
SA--Semiannual inspection.
A--Annual inspection.

<u>Quarterly inspection.</u> Line should be patrolled. Observe and correct faulty insulators, sagging conductors, broken crossarms, leaning poles, and tree limbs touching or near conductors. Unauthorized taps should be removed.	15.01 Line patrol
<u>Annual inspection.</u> Line patrolled as above, but patrol should be equipped to completely recondition the line. Schedule this inspection to come after winter or most stormy season.	
<u>Semiannual inspection.</u> Check leakage resistance of line with high resistance voltmeter in series with battery and connected between line and ground.	15.02 Line leakage resistance
<u>Semiannual inspection.</u> Check line loop resistance with wheatstone bridge and compare with normal reading.	15.03 Line loop resistance
<u>Semiannual inspection.</u> Check cords, lights, relays, annunciators, and all contact points.	15.04 Manual switchboard
<u>Monthly inspection.</u> Check relays and selectors for proper operation. Check relay armatures and contacts. Correct only the discrepancies actually observed.	15.05 Automatic exchange
<u>Annual inspection.</u> Check cabinets for dust leaks. Clean all contact points and clean between all armatures and cores. Make complete continuity test.	
<u>Annual inspection.</u> Check transmitters, receivers, dials, ringers, magnetos, and switch hooks. Transmitters and receivers suspected of poor operation should be tested by comparison with a standard set. Lubricate magnetos. Clean and adjust dial governor, and dial and switch hook contacts.	15.06 Transmitters, receivers, dials, ringers, magnetos, and switch hooks
<u>Monthly inspection.</u> Check bearing lubrication, sliprings, and brushes.	15.07 Ringing generator
<u>Annual inspection.</u> Clean thoroughly, dress rings if necessary, and wash out and lubricate bearings.	
<u>Monthly inspection.</u> Check specific gravity. Apply equalizing charge as required. Check dry batteries and replace as necessary. (See Power O&M Bulletin No. 12.)	15.08 Batteries

- 15.09 Fuses, heat coils, and arresters Semiannual inspection. Check fuses, heat coils, and arresters for proper operating condition.
- 15.20 Tubes Semiannual inspection. Check all tubes with mutual conductance tube tester. Pay particular attention to tubes that have operated over 4,000 hours, and also to tubes that tend to fail prematurely. Discard tubes when mutual conductance falls to 50 percent.
- 15.21 Circuit voltages and currents Monthly inspection. Check voltages and currents in each stage and compare with manufacturer's recommended values and previous month's readings. If voltages and currents do not have reasonably correct values or indicate a dropping off or incipient failure, check and, if faulty, replace components that caused the incorrect readings.
- 15.22 Aline tuned circuits Annual inspection. Aline all tuned circuits in transmitter and receiver, and check tuning of indoor and outdoor of line tuning units, hybrids, and filters in the base of the coupling capacitor. Check line trap for peak performance. One method of checking line trap consists of opening line and checking signal level at equipment cabinet, and then closing the ground switch behind the wave trap and comparing the readings. Retune trap if necessary.
- 15.23 Protective airgap in tuning unit and coupling capacitor Annual inspection. Check protective airgap in tuning units and coupling capacitor for proper spacing.
- 15.24 Transmitter-receiver chassis Monthly inspection. Check for excess heat by feeling of transformer and other components. Check for unusual odors which might indicate overheating. If set is equipped with fan and/or air filter, check operation of fan, check to see that filter is clean, and provide extra ventilation or heat deflecting baffles as necessary to insure low temperature operation of tubes and other components. Excessive heat is the main cause of reduced component and tube life.
- Check received signal strength either by built-in metering or with carrier-frequency voltmeter. Compare with previous month's readings and if low, locate trouble and correct.

Check setting of controls on automatic simplex transfer equipment and adjust to prevent voice clipping or operation by noise bursts.

On FM receivers, adjust squelch for best compromise setting between optimum sensitivity and false opening on noise.

<u>Annual inspection.</u> Clean lead-in insulators to reduce leakage current. Use carbon tetrachloride.	15.25 Lead-in insulators
<u>Annual inspection.</u> Check cabinets for weather tightness if outdoor type. Check mounting. Clean out and dust.	15.27 Equipment cabinets
<u>Annual inspection.</u> Check bearing, commutator, and brushes. Lubricate as necessary. Break regular power supply circuit to see that emergency motor generator starts. Check for correct voltage and frequency of generator output with emergency load.	15.29 Emergency motor generator
<u>Monthly inspection.</u> Check to see that frequencies of various transmitters are together by noting, on a receiver, beat frequencies between two AM transmitters and receiver discriminator readings for FM transmitters.	15.40 Frequency transmitter
<u>Semiannual inspection.</u> Check frequency of all transmitters to see that frequency tolerance as given in Section 254 of the <u>Reclamation Instructions</u> is not exceeded. The results of this test should be entered in the station log. This test must also be made whenever any change is made which may change the carrier frequency or its stability.	
<u>Monthly inspection.</u> Check all transmitters by listening for distortion.	15.41 Modulation percentage-- AM
<u>Semiannual inspection.</u> Check modulation of all transmitters, using oscilloscope method, to insure that modulation is within the limits specified in Section 254 of the <u>Reclamation Instructions</u> .	
<u>Monthly inspection.</u> Check modulation of all transmitters by listening to relative loudness of received signal.	15.42 Modulation frequency deviation-- FM
<u>Semiannual inspection.</u> Check modulation of all transmitters using the carrier null method or frequency deviation monitor to insure that modulation does not exceed that specified in Section 254 of the <u>Reclamation Instructions</u> .	

- 15.43
Power
output
- Monthly inspection. Check radiofrequency power output by noting received signal strength or cathode current in final amplifier. Replace tubes or retune as necessary. If tubes are replaced or retuning necessary, the procedure under Section 15.44 should be followed. Transmitter will have longer life and less maintenance if tubes are operated at lower than rated output. Criterion for radiofrequency tube replacement should be incipient channel failure rather than low radiofrequency output. Lowering radiofrequency power by one quarter will give longer life, yet the loss in signal strength at the receiver will be only 1 decible which is barely noticeable. Reduced heat also increases life of other components. (An exception is the UHF transmitter, which should be operated at rated load for best life.)
- Semiannual inspection. Measure antenna power with radio-frequency wattmeter or by reading cathode and screen grid currents as directed in manufacturer's instructions. Adjust power to the minimum, which will provide satisfactory communication. This measurement is required by Section 254.0.13 of Reclamation Instructions.
- 15.44
Test voltages
and currents
- Monthly inspection. Make readings of all voltages and currents for which jacks or switches have been provided. Compare with new equipment and previous month's readings to detect pending failure. Enter readings in book which is left at the station. Record all component and tube replacements and adjustments. Use these readings as a guide for tube replacement rather than testing tubes each month.
- 15.45
Tubes
- Semiannual inspection. Test tubes with a mutual conductance-type tube tester. Discard all tubes whose G_m has dropped to 50 percent of rated value and which have operated over 4,000 hours, particularly if jack current and voltage readings indicate low performance of stage involved. In deciding whether or not to replace tubes, give more importance to a sudden decrease in G_m than to a low reading which has existed for some time. Replace with industrial tubes (where available) those tubes which have a tendency for short life and particularly where the cost of travel involved to replace tubes can offset the higher cost of industrial tubes.
- 15.46
Alinement
- Monthly inspection. Check receiver sensitivity by reading limiter or detector current when receiving a calibrated signal. Noise, in some cases, can be a useful signal for this test. Check discriminator for FM receivers on noise and also from remote transmitter when possible.

Semiannual inspection. Aline tuned circuits in transmitter and receiver according to manufacturer's instructions. Check receiver sensitivity by reading limiter grid current or detector output with a known calibrated signal. Check signal level required to break squelch. Record readings in book.

Monthly inspection. Make visual check of antenna and transmission line and measure standing wave ratio. Check pressure on gas-filled lines. 15.47
Antenna and
transmission
line

Semiannual inspection. For nonresonant lines, measure standing wave ratio of antenna and transmission line with micromatch or similar device. If different from previous readings, as listed in record book, investigate and remedy cause.

Monthly inspection. Clean air filters, if any, and make sure that equipment is operating as cool as possible. Remove dust, if present, with vacuum cleaner, not by blowing or wiping. 15.48
Ventilation
and dust

Annual inspection. Remove dust accumulation with vacuum cleaner.

Semiannual inspection. Check guys for looseness. Check base of wood towers for rotting and treat as indicated in Section 17.01, if necessary. Check steel towers for rust, particularly near the ground line or footing. Paint as indicated in Section 17.05, if necessary. Check grounding and grounding system. 15.49
Antenna
tower

Monthly inspection. Start standby generator and check operation of transfer controls by opening primary alternating-current powerline. Check supply of fuel and lubricating oil. Check specific gravity of starting battery. See Power O&M Bulletin No. 12, and adjust charging rate if necessary. Check generator voltage and adjust if necessary. 15.50
Standby
power supply

Semiannual inspection. Make thorough inspection of motor and generator and transfer device. Make operating test with all stations in system operating on standby power, simultaneously, to see that additional noise created by standby generator or low voltage is not interfering with system operation, particularly where repeaters are involved. In stations using gasoline fuel with underground storage, drain and refill fuel tank with fresh gasoline. Stored gasoline tends to form gums which will foul carburetor,

valves, and piston rings. If gasoline storage is above ground, replacement of gasoline supply should be at 3-month intervals.

- 15.51 Main power supply
Monthly inspection. Check main power supply voltage and take steps to maintain as close to rated value as possible. To illustrate the importance of supply voltage control, tests have shown that operating electronic equipment continuously at 10 percent overvoltage increases the rate of failure by 237 percent.
- 15.52 Battery, cable, and connections
Monthly inspection. Check condition of battery and measure voltage at radio set while transmitting. Drop in battery cable should not exceed 10 percent of battery voltage. If voltage at radio set is low, check connections, relays, and fuses for excess drop.
- 15.53 Dynamotor
Annual inspection. Inspect brushes and bearings and replace or grease in accordance with manufacturer's instruction book.
- 15.54 Generator and voltage regulator
Monthly inspection. Check for correct operation of generator and voltage regulator and maintenance of battery charge without undue loss of battery water. Tube life is extended by operating voltage regulator at lowest voltage, which will keep battery charged. Recommended setting is 7.1 and 14.2 volts for 6- and 12-volt systems, respectively.
- 15.55 Antenna
Annual inspection. Make careful check of complete antenna and transmission line, giving particular attention to connection of coaxial cable braid on flexible spring-type antenna installations.
- 15.56 Noise level
Monthly inspections. Make and record readings of limiter grid current on noise alone, to use as general sensitivity check and also to detect any increase in generator, ignition, or static noise.
- 15.57 Telemetering transmitters and receivers
Daily inspection. Observe telemeter indicators and recorder charts for any abnormal performance. Check battery indicators on switchboard recorders.
Monthly inspection. Check battery condition on recording instruments. Make zero and full-scale checks, if provided. Clean and lubricate instruments as directed in the instruction books. Remove dust from optical systems.

Annual inspection. Clean and lubricate or replace bearings and pivots. Clean relay contacts and readjust if necessary. Make calibration test from primary measuring point to recorder or indicating instrument. Test all electronic tubes and measure circuit voltages and currents.

Monthly inspection. Observe operation of relays, listening for irregular spacing of operations or other unusual sounds, and looking for contact arcing. Check for dust and moisture in relay enclosure. Check supply battery voltage. Check relay coils for excessive temperatures. Remove supply voltage in order to check operation of all relays. 15.58
Relays

Annual inspection. Clean all relays and check for proper operation. Adjust, if necessary, in accordance with manufacturer's instructions. Replace contacts on badly burned relays. Clean relay enclosures and seal against entrance of dust, moisture, and insects.

16. Switchyards and Substations

INSPECTION CHECK LIST

Items of inspection	<u>Inspection intervals</u>				Procedure reference
	Attended station	Unattended station	Attended station	Unattended station	
Yard and fences	D	A	M	A	16.01
Buildings			See Section 3		
Wood structures	M	A	M	A	17.01
Steel structures	M	A	M	A	17.05
Footings and guy anchors	M	A	M	A	17.06
Guys	M	A	M	A	17.07
Warning signs		A			17.08
Ground connections	M	A	M	A	16.08
Conductors and buses	M	A	M	A	16.09
Hardware	M	A	M	A	17.14
Insulators	M	A	M	A	17.15
Transformers and regulators			See Section 12		
Oil and air circuit breakers			See Section 10		
Disconnecting switches and fuses			See Section 11		
Lightning arresters			See Section 13		
Control equipment			See Section 14		
Lightning	D	A	M	A	16.17
Oil storage facilities	M	A	M	A	16.18
Conduit, ducts, trenches, and tunnels	M	A	M	A	16.19
Static capacitors	D	A	W	A	16.21
Storage batteries and chargers			See Section 6		
Power supplies and wiring	M	A	M	A	16.20

D--Routine daily inspection.
W--Weekly inspection.
M--Routine monthly inspection.
A--Annual inspection

References

Power O&M Bulletin No. 10, Retaining Glase-burned Insulators in Service
Power O&M Bulletin No. 8, Dependable Electrical Contacts
Power O&M Bulletin No. 25, Corrosion Protection of Buried and Submerged Metals

- Daily or monthly inspection. Check for anything unusual on the premises. See that gates, buildings, switches, etc., are locked where necessary to prevent unauthorized persons from entering or tampering with equipment. 16.01
Yard and fences
- Annual inspection. Check fence and gates for damage or openings through which animals or unauthorized persons might enter. Check fence ground connections. Cut weeds and grass as necessary, and apply weed killers where found to be effective. Repair eroded soil banks, retaining walls, roads, and walks. Clean up and remove rubbish. Check danger signs on fence and gates.
- Monthly inspection. Visual inspection to see that structure and apparatus ground leads are not loose or broken. 16.08
Ground connections
- Annual inspection. Check and tighten connectors and clamps in ground leads. Check ground leads to a point at least a foot below ground line to see that they are not broken or corroding. Check resistance of ground rods or ground mat.
- Monthly inspection. Make from-the-ground check of conductors to detect broken or damaged strands or loose connections. 16.09
Conductors and buses
- Annual inspection. Adjust sag in tension buses where necessary. Check tubular buses and flexible expansion joints and adjust if necessary to relieve strain on post-type insulators and bushings. Check joints for looseness and heating. Tighten connectors and clamps.
- Daily inspection. Note burned-out lamp bulbs in yard and building fixtures and have them replaced. 16.17
Lighting
- Annual inspection. Try out all lights and note whether they are all in proper operating condition. Clean lamp bulbs, lenses, and reflectors. In locations subject to excessive bugs, an additional cleaning may be necessary after the bug season has passed. Tighten fixtures and other lighting devices. Check lighting circuit time switches or other automatic control devices.
- Monthly inspection. Check for oil leaks in storage tanks. Note amount of oil on hand and see that receiving tank is maintained empty when not in actual use for draining oil from transformers or breakers in an emergency. 16.18
Oil storage facilities

Annual inspection. Check and repair oil leaks. Check valves, plugs, and piping. See that valves on active storage tanks, which can be operated without a wrench, are plugged or locked closed. Drain condensate from storage tank sump. Repaint tanks and piping if necessary. Check operation of oil pumps. Check hoses and other accessories used in draining or refilling apparatus tanks. (See also Section 6 on oil pumps.) Check for corrosion of buried oil piping and apply cathodic protection if necessary. (See Power O&M Bulletin No. 25.)

16.19
Conduit,
ducts,
trenches, and
tunnels

Monthly inspection. Visual inspection to detect moisture or other unusual conditions in conduit and duct runs, cable trenches, and tunnels.

Annual inspection. Make close observation of above and provide suitable waterproofing and drains where necessary. Check runs of metal conduit in soil for signs of corrosion. Paint metalwork in tunnels and cable trenches as necessary.

16.20
Power supplies
and wiring

Monthly inspection. See that power is available on all essential power, lighting, and control circuits.

Annual inspection. Inspect fuses or circuit breakers on power, lighting, and control circuits. Check and tighten wiring connections at terminal points. Inspect wiring for open circuits, short circuits, and damaged insulation. Check insulation resistance of wiring with devices connected.

16.21
Static
capacitors

Daily or weekly inspection. Inspect individual capacitor units for blown fuses and leaking cases.

Annual inspection. Deenergize and make close visual inspection for bulged cases, defective bushings, and loose connections. Check relays. Clean bushings.

17. Transmission Lines

INSPECTION CHECK LIST

Items of inspection	Inspection interval		Procedure reference
Wood poles	M	A	17.01
Crossarms	M	A	17.02
Pins	M	A	17.03
Braces	M	A	17.04
Steel towers	M	A	17.05
Footings and guy anchors	M	A	17.06
Guys	M	A	17.07
Warning signs		A	17.08
Ground wires and counterpoise	M	A	17.09
Main conductors and overhead ground wires	M	A	17.10
Conductor splices		A	17.11
Vibration dampers		A	17.12
Grading shields and arcing horns		A	17.13
Hardware	M	A	17.14
Insulators	M	A	17.15
Right-of-way	M	A	17.16
Line maintenance trucks			See <u>Reclamation</u> <u>Instructions</u> Vol. VIII, Part 13
Line maintenance tools	NS	A	17.18

M--Routine monthly inspection.

A--Annual inspection.

NS--Not scheduled.

References

Power O&M Bulletin No. 10, Retaining Glaze-burned Insulators in Service

Power O&M Bulletin No. 15, Care and Testing of Linemen's Rubber Gloves, Blankets, and Safety Equipment

Power O&M Bulletin No. 25, Corrosion Protection of Buried and Submerged Metals

General. Make ground or airplane patrol of line at intervals of about 1 month to detect general deterioration that should be repaired by the line crew.

17.01
Wood poles

Monthly inspection. Make from-the-ground check of poles for signs of decay, misalignment, and damage from lightning or other causes. Check crossarms for splitting.

17.02
Crossarms

Annual inspection. Make close inspection of the above. Repair or replace split or weakened poles, crossarms, or braces. See that pins are tight in arms and insulators.

17.03
Pins

Deterioration of an untreated wood pole in service begins in the ground section due to infection by wood-destroying fungi which are usually present in one form or another in the soil and air. The destructive fungi, once established, will continue to attack the wood unless stopped by the application of some preventive. The section of pole most subject to deterioration is from a few inches above to about 15 inches below the ground line.

17.04
Braces

Two general classes of preservatives are (a) oily materials such as creosote and (b) water solutions of toxic salts such as zinc chloride and sodium fluoride. Sodium fluoride penetrates well but is not permanent, while creosote or a mixture of creosote and coal tar is more permanent but does not penetrate as well. For this reason, a combination of sodium fluoride, creosote, and coal tar has been used and found very satisfactory and has increased the life of poles by about 6 years. Apply this treatment at 5-year intervals.

The treatment of standing poles, using sodium fluoride, creosote, and coal tar, can be applied as follows:

Remove the dirt from around the pole to a depth of about 15 inches. Remove the fungus rot material. Distribute a pound of sodium fluoride in powdered form against the pole to a point above the ground line and in the bottom of the trench. Backfill the dirt loosely against the pole. Form a narrow trench around the pole and about 10 inches deep. Pour 1-1/2 gallons of the creosote-coal-tar mixture against the pole all around to a height of about 18 inches above the ground line so as to go into all cracks. A container with a flattened spout which will pour a fan-shaped stream is convenient for applying the creosote. After a short period, the creosote-saturated soil should be pressed back against the pole

to fill up the trench. If the pole is located where the presence of creosote would not be objectionable on the surface of the ground, an additional 1/2 gallon of creosote should be applied over the backfilled dirt.

Monthly inspection. Make from-the-ground check of structure for signs of rusting or loose or damaged members. 17.05
Steel towers

Annual inspection. Make close inspection of the above. Tighten all bolts at 5-year intervals. Brush rusty spots with wire brush and apply a good paint such as grey emulsified asphalt. Apply two coats of black emulsified asphalt paint on the tower legs 18 inches above and below the ground line and over the top of concrete footings where used.

Monthly inspection. Check condition of footings and anchors particularly in locations subject to soil erosion, movement, or settling. 17.06
Footings and
guy anchors

Annual inspection. Check concrete footings for cracking and spalling. See that footings and anchors are firmly set. Stub poles as necessary. Check anchors and other buried metalwork for corrosion, at intervals of about 3 years, especially in corrosive soil, and apply cathodic protection if necessary. (See Power O&M Bulletin No. 25.)

Monthly inspection. Check for tightness and general condition. 17.07
Guys

Annual inspection. Tighten guy wires and clamps. After the first year of operation of the line, this can be extended to 2- to 5-year intervals. Apply emulsified asphalt paint on rusty spots on cable and guy rods 18 inches above and below ground line.

Annual inspection. See that an adequate number of warning signs are used on structures, fences, etc., and that they are securely attached. 17.08
Warning signs

Monthly inspection. Make from-the-ground check to detect loose or broken pole down leads, or broken or corroded ground connections. 17.09
Ground wires
and connections

Annual inspection. Tighten clamps on ground connections. Inspect counterpoise conductors at intervals for corrosion and poor connections. This is particularly important in corrosive soil. Check resistance of ground connections

and counterpoise. See that ground wire on poles and at tower footings is adequately protected from being broken.

- 17.10
Main conductors
and overhead
ground wires
- Monthly inspection. Make from-the-ground inspection with field glasses to detect broken strands, incorrect sag and clearances, etc.
- Annual inspection. Adjust sag and clearances where necessary. Tighten connections between overhead ground wires and down leads. Inspect conductors and overhead ground wires at supporting clamps at 5-year intervals for signs of weakening and burns, and reinforce as necessary.
- 17.11
Conductor
splices
- Annual inspection. Inspect splices with field glasses to detect failure.
- 17.12
Vibration
dampers
- Annual inspection. Tighten damper supports and grading shields at same time that conductor clamps are tightened.
- 17.13
Grading shields
- 17.14
Hardware
- Monthly inspection. Make from-the-ground inspection of hardware to detect loose bolts, pins, etc.
- Annual inspection. Tighten all clamps, pole bands, and other hardware. After first year of operation of the line, this can be extended to 2- to 5-year intervals. Paint rusty spots with grey emulsified asphalt or similar paint.
- 17.15
Insulators
- Monthly inspection. Make from-the-ground inspection of condition of insulators to detect broken skirts and excessive dirt.
- Annual inspection. Replace broken insulators. Repair chipped or glaze-burned spots with lacquer such as red glyptal. Clean insulators with water, chlorothene, or other suitable cleaner, if subject to excessive dirt or railroad or factory smoke. Check insulators at 5-year intervals with an insulator tester if a reliable tester is available.
- 17.16
Right-of-way
- Monthly inspection. Check for anything unusual, such as accumulation of dry materials around base of poles which might result in fire damage.

Annual inspection. In late summer or fall, clean away dry weeds and grass for a diameter of 10 feet around the base of each structure and guy anchor to prevent possible damage by fire. Structures located in fence corners where tumbleweeds tend to accumulate may require frequent attention during the dry season. Clear away brush and trees at 5-year intervals. Weed-killing chemicals now becoming available may prove successful for use in stopping growth around structures.

Not scheduled. See that tools are kept clean, dry, and in safe condition for use at all times.

17.18
Line maintenance tools

Annual inspection. Check over all tools such as hammers, wrenches, pliers, screwdrivers, drills, saws, axes, crowbars, picks, shovels, snatch blocks, ropes, chains, cables, cable grips, sheaves, etc. Have damaged or unsafe tools repaired or replaced. Check hot-line tools according to the manufacturer's instructions. Check rubber gloves, blankets, etc., according to Power O&M Bulletin No. 15.

