TM 5-681

WAR DEPARTMENT TECHNICAL MANUAL

INSPECTIONS AND PREVENTIVE MAINTENANCE FOR

ELECTRICAL FACILITIES

WAR DEPARTMENT • AUGUST 1945

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SECTION I

GENERAL

1. Purpose and Scope

This Technical Manual provides the basis for a properly coordinated maintenance program for electrical systems used on Army posts. It outlines the necessary tests, inspections, and servicing procedures and explains the preventive maintenance forms and records that are used. Frequencies recommended for inspections and services are *minimums*. If maintenance problems are complicated by severe service or unusual atmospheric conditions, more frequent inspections may be scheduled on approval of the service command or Air Force command. For further details on safety procedures and on operation, maintenance, and testing of electrical equipment found on Army posts, see TM 5–680 (when published).

2. Maintenance Responsibility

a. UNIT COMMANDER. Commanding officers of using organizations are responsible for insuring that electrical facilities are kept in good physical condition and are protected from damage and vandalism. They must also make certain that the post engineer is notified promptly of all operating deficiencies.

b. MAINTENANCE PERSONNEL. Inspections and preventive maintenance services are performed in the lowest echelon which has the necessary tools, parts, qualified electricians, and available manpower. Each echelon must be so thoroughly trained in its responsibilities that it applies them automatically. This manual may not include detailed maintenance instructions for all electrical equipment on every post. The lack of information on a particular piece of equipment does not relieve maintenance personnel of the responsibility for all necessary inspections and services. General responsibilities include:

(1) Inspecting, repairing, and protecting electrical facilities and preventing unnecessary deterioration.

(2) Keeping electrical equipment clean, lubricated, and in proper operating condition.

(3) Checking the condition and security of supporting members and connections of all equipment inspected.

(4) Correcting defects on discovery or properly reporting them to a higher echelon.

c. ELECTRICAL SUPERVISOR. The electrical supervisor is responsible for—

(1) Scheduling regular inspections and preventive maintenance services and assigning qualified personnel to the job.

(2) Issuing repair orders and seeing that they are carried out.

(3) Keeping adequate, up-to-date records of inspection and maintenance.

(4) Continuously checking the work of maintenance personnel.

d. POST ENGINEER. The post engineer is responsible for—

(1) Coordinating maintenance operations with needs of using organizations to insure minimum interruption of electrical service.

(2) Conformance to rules on safety and clearances stated in the National Electrical Safety Code, fifth edition, published by the National Bureau of Standards.

(3) Setting up a file of manufacturers' bulletins for all electrical equipment on the post.

(4) Using the services and experience of serving utilities.

(5) Insuring satisfactory performances of the over-all maintenance program.

3. Inspection and Maintenance Records

The forms discussed below are specially designed to help post engineer personnel do their work.

a. WORK SHEETS. Work sheets are provided for the various sections of the electrical system. (See figs. 2, 4, 9, 10, 12, and 15.) Their use insures uniform maintenance practices by post engineer personnel.

(1) *Description.* Each work sheet lists the

necessary inspections and services for a particular section of the electrical system, identifying each operation by an item number. The location of a rectangular check space in the time-schedule columns alongside the list determines the minimum frequency for performing each operation.

(2) *Use.* (*a*) Inspectors are responsible for servicing equipment and for making appropriate entries on the work sheet. Before starting his inspection, he enters his name, the date, and location of equipment to be serviced. As he completes each step in the maintenance procedure, he marks the check space with one of the following.

1. √ if equipment is found satisfactory.
2. X if adjustment is required.
3. XX if repair or replacement is necessary.

(*b*) If adjustment or repair is needed and the inspector makes the correction, he circles the X or XX thus: Ⓧ or ⓍⓍ. If he does not correct the defect immediately or if correction is to be made by higher echelon, he enters a full explanation in the space for remarks, including the item numbers to identify defects involved. The electrical supervisor has the necessary work orders issued to complete higher echelon repairs. Item numbers are included to identify any defects so noted.

(3) *Relation to manual.* This manual includes a paragraph for each section of the electrical system covered by a work sheet, and explains operations listed on the work sheet. To simplify cross reference the manual explanation and corresponding work-sheet operation have the same identifying item number. As an additional guide, the manual also contains time-schedule columns, and indicates frequency for each maintenance step by location of the item number in these columns.

b. PREVENTIVE MAINTENANCE SCHEDULE. WD AGO Form 5–91 (Preventive maintenance schedule for electrical facilities) (fig. 1), is a yearly consolidated record of the post maintenance program. The electrical supervisor makes necessary entries on the form, taking his information from the work sheets. If the work sheet shows that a necessary repair or adjustment had not been completed, the electrical supervisor draws a diagonal line through the check space on the preventive maintenance schedule, thus: ☒. When repairs are completed, he marks the space thus: ☒. He uses the same marking if the inspection showed that no repairs were necessary. The electrical supervisor keeps the form posted conspicuously in his office where it can be referred to or inspected at any time. On the first of each year, he prepares and posts a new form, entering in the fourth column (fig. 1) the date each item was last inspected. This helps in preparing work schedules, since reference to the third and fourth columns shows immediately when the next inspection of each item is due.

c. RECORD CARDS. The electrical supervisor keeps a file of the following permanent record cards for each transformer, motor, and building wiring system maintained by post engineer personnel: WD AGO Form 5–82 (Transformer record card) (fig. 3); WD AGO Form 5–84 (Building electrical inspectors' record) (fig. 11); and WD AGO Form 5–83 (Motor or generator record card) (fig. 14). Instructions on using these forms are given in appropriate paragraphs of sections II and III.

d. DAILY LOG. The electrical supervisor also keeps a daily record of major incidents affecting the post electrical facilities. For example, he would list primary distribution outages affecting one or more transformers or the main source of supply. The entry would include the cause of the outage, when it occurred, and its duration. Any convenient form or notebook can be used for this log.

W.D.,A.G.O.
FORM NO.5-91
Nov. 1944

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SECTION II

PREVENTIVE MAINTENANCE SERVICES AND TECHNICAL INSPECTIONS OF ELECTRICAL SYSTEMS

4. Transformer Substations

a. GENERAL. Responsibility for maintaining post transformer substations depends on whether they are the property of the government or the serving utility.

(1) *Government-owned.* Government-owned substations are maintained by the post engineer's electrical staff; only competent skilled personnel are used for this work. If no skilled personnel are available on the post, the post engineer sets up a list of off-post personnel on whom he can call for routine and emergency maintenance. The post engineer keeps records of all work done by such personnel.

(2) *Utility-owned.* The serving utility maintains post substations which it owns. Information received by the post engineer concerning operation or maintenance of a utility-owned substation is referred to the utility through established channels.

b. INSPECTION AND MAINTENANCE INSTRUCTIONS. Maintenance required for transformer substations is outlined on WD AGO Form 5–87 (Work sheet for substation inspection and preventive maintenance services) (fig. 2), and in the supplementary instructions below. For instructions on using the work sheet. see paragraph 3*a*.

Caution: Inspector must always be accompanied by a qualified electrician when inspecting substations.

Monthly and semiannual inspections do not require handling high-voltage equipment. For all other inspections, the station must be deenergized and effectively grounded (see discussion of safety requirements, TM 5–680). Switch stick or hot-line tools stored at the substation must be checked at each monthly inspection.

W.D., A.G.O.
FORM NO.5-87
NOV: 1944

WORK SHEET FOR SUB-STATION INSPECTION AND PREVENTIVE MAINTENANCE SERVICES

SPECIAL INSTRUCTIONS: See TM 5-681 For Detailed Instructions & Procedures. See Mfr. Manual for Technical Information.

LOCATION	DATE	INSPECTOR

LEGEND FOR MARKING				SYMBOLS
✓ — SATISFACTORY	X — ADJUSTMENT REQUIRED	REPAIRS OR XX— REPLACEMENT	DEFECT 0 — CORRECTED	☐ — INSPECT AND CORRECT

2 YEARS	YEAR	6 MONTHS	MONTH		
					GENERAL APPEARANCE
			☐	1	FENCE
			☐	2	WARNING SIGN
			☐	3	GATES *(Fastened and locked)*
			☐	4	DOORS - WINDOW AND BUILDING
			☐	5	WEEDS AND TRASH
			☐	6	EQUIPMENT PAINTED
					ARRESTERS
	☐			7	LOOSE CONNECTIONS
	☐			8	CHIPPED, SHATTERED, CRACKED
	☐			9	CONNECTIONS TO GROUND
	☐			10	CLEARANCES
	☐			11	CHECK FOR CLEAN SURFACE
					BUSHINGS AND INSULATORS
			☐	12	CRACKED OR BROKEN
☐				13	CLEAN
					CONNECTIONS
☐				14	LOOSE
☐				15	DEFECTIVE
					GROUNDS TO
☐				16	TRANSFORMER TANK
☐				17	SWITCHGEAR HOUSING
☐				18	OPERATING LEVER
☐				19	LIGHTNING ARRESTERS
☐				20	METAL FENCE
		☐		21	ACCIDENTAL GROUNDS ON UNGROUNDED SYSTEMS
					OIL CIRCUIT BREAKERS
☐				22	TIGHTEN ALL NUTS AND BOLTS
☐				23	CONTACT SURFACES
☐				24	CONTACT ADJUSTMENT
☐				25	OPERATING MECHANISM *(Clean and lubricate)*
☐				26	LENGTH OF BREAKER STROKES
☐				27	OPENING AND CLOSING SPEED
☐				28	OPERATING VOLTAGE
☐				29	CLOSING RELAY
☐				30	CONDITION OF OIL
☐				31	LEAKS

REMARKS AND RECOMMENDATIONS

2 YEARS	YEAR	6 MONTHS	MONTH		
					OIL CHECKS AND TESTS
	☐			32	MOISTURE
	☐			33	CARBONIZATION
	☐			34	DIRT AND SLUDGE
	☐			35	INTERIOR OF EQUIPMENT
	☐			36	TEST
					POLE TOP SWITCHES
☐				37	CLEAN AND ADJUST
☐				38	GREASE
☐				39	OPERATION
☐				40	ARCING HORNS
☐				41	LOCKED
☐				42	GROUND AND GROUND RESISTANCE
					REGULATORS
			☐	43	OIL LEVEL
			☐	44	CRACKED OR BROKEN BUSHINGS
	☐			45	OPERATING MECHANISM
	☐			46	MOTOR
	☐			47	LUBRICATION
	☐			48	CONTACT MAKING VOLTMETER
☐				49	ARCING OF CONTACTS
☐				50	LIMIT SWITCHES
☐				51	MOTOR CONTROL RELAY
EVERY 5 YEARS				52	LOOSE NUTS AND BOLTS
					TRANSFORMERS
			☐	53	TEMPERATURE
			☐	54	COOLING EQUIPMENT
			☐	55	OIL LEVEL AND LEAKAGE
			☐	56	LOAD READINGS *(for loads at or above rated capac*
☐				57	FUSED DISCONNECTS
					UNIT TYPE SUB-STATION
			☐	58	CLEAN COMPARTMENTS
			☐	59	STORAGE BATTERIES AND CHARGER
			☐	60	OIL LEVEL AND TEMPERATURE
			☐	61	INERT GAS PRESSURE
EVERY 5 YEARS				62	MANUFACTURER'S INSPECTION
					LOAD TESTS
	☐			63	LOAD TEST MAIN BUS
	☐			64	LOAD TEST EACH FEEDER
	☐			65	VOLTAGE TEST

DISPOSITION OF WORK SHEET

THIS WORK SHEET SHOULD BE HELD IN THE POST ELECTRIC MAINTENANCE FILE UNTIL REPAIRS ARE COMPLETED AND INFORMATION RECORDED ON MAINTENANCE SCHEDULE W.D., A.G.O. FORM NO. 5-91 AND ALL TEST DATA PROPERLY RECORDED. IT MAY THEN BE DESTROYED.

Figure 2.

GENERAL APPEARANCE

2 Years	Year	6 Months	Month	
				Keep the substation neat and clean. Maintain substation bus and bus supports in a good workmanlike manner. Increase frequency of maintenance for equipment near coastal waters or corrosive or dusty atmosphere.
			1	*Fence.* Check condition of fences; repair and paint them when necessary.
			2	*Warning signs.* Make sure warning signs are in proper position, one on entrance gate, one on each side of inclosure, and one attached to substation structure near parts carrying high voltage. Signs should read DANGER and should state the voltage.
			3	*Gates.* See that gates are fastened, padlocked, and in good operating condition.
			4	*Doors, windows, and buildings.* Check condition of switchhouse building, roof, doors, and windows, and repair if necessary.
			5	*Weeds and trash.* Remove all trash and all grass and weeds growing within the inclosure.
			6	*Equipment painted.* Inspect transformers, oil switches, and other equipment for cleanliness and adequacy of paint protection.

ARRESTERS

			7	*Loose connections.* Check for loose line and ground connections. Tighten all electrical connections.
				Caution: Equipment must be deenergized and grounding harness installed where applicable.
			8	*Chipped, shattered, cracked.* Examine housing for chipping, shattering, cracks, or other damage.
			9	*Connections to ground.* Make sure ground connections are continuous and securely fastened to grounding rods. See that grounding conductors on wood structures are protected with wood moulding to at least 8 feet above earth level.
			10	*Clearances.* To prevent external flashovers, maintain same clearance between line terminal and grounded structures as between line conductors on the same structure.
			11	*Check for clean surface.* Keep external surfaces of arresters clean to prevent flashovers.

BUSHINGS AND INSULATORS

Caution: On visual inspection, do not touch energized equipment. For inspection 13, equipment should be deenergized.

			12	*Cracked or broken.* Check visually for cracked or broken bushings and insulators.
			13	*Clean.* Clean bushings and insulators as required by local conditions. If continuous service is necessary, get special instructions for washing insulators and bushings while circuit is energized.

CONNECTIONS

2 Years	Year	6 Months	Month	
				Caution: For inspections 14 through 20, equipment must be deenergized and grounding harness applied where applicable.
14				*Loose.* Check connections to grounds and all equipment and make sure they are tight and well secured.
15				*Defective.* Check for corroded or damaged connectors. Replace if necessary to maintain good contact.

GROUNDS

16				*Grounds to equipment.* Test ground resistance to all equipment. See
17				that transformer tank, switchgear housing, operating levers, lighting
18				arresters, and metal fencing are properly connected to station ground.
19				Ground resistance should not exceed 3 ohms for water-pipe connec-
20				tions or 15 ohms for driven grounds. Use at least four ground rods.
		21		*Accidental grounds.* Test for accidental grounds on ungrounded equipment.

OIL CIRCUIT BREAKERS

Before making the inspections below, take the breaker off the circuit and apply grounding harness. Inspect every 2 years, preferably in the spring. Inspections may be required at shorter intervals if breaker operates frequently to clear heavy fault currents.

22				*Tighten.* Tighten all nuts and bolts in the mechanism.
23				*Contact surfaces.* Inspect contacts and replace those badly burned or pitted. If contact surfaces are only roughened, smooth them with No. 00 sandpaper; do not use emery cloth.
24				*Contact adjustment.* Check contacts for proper alignment; see that contact surfaces bear with firm uniform pressure and are properly adjusted.
25				*Operating mechanism.* Make sure breaker and operating mechanism work smoothly and freely without binding and are free of dirt. Lubricate bearing points with a good grade of machine oil.
26				*Length of breaker stroke.* Measure length of breaker stroke and adjust if necessary.
27				*Opening and closing speed.* Check breaker opening and closing speed and adjust if necessary.
28				*Operating voltage.* With full operating current flowing, check operating voltage at mechanism terminals to be sure it is adequate for correct operation. Make sure operating current is correct.
29				*Closing relay.* Check closing relay for proper operation.
30				*Condition of oil.* Check oil in breaker. See items 32 through 36.
31				*Leaks.* Note and report any oil leaks.

OIL CHECKS AND TESTS

	32			*Moisture, carbonization, dirt and sludge.* Take sample of oil from
	33			equipment, spread it in a thin coat on a bright tin surface, and inspect

2 Years	Year	6 Months	Month	
	34			for moisture, carbonization, dirt, and sludge. If oil shows signs of any of these conditions, filter and retest. When adding oil to electrical equipment, use same type and grade as presently in service. See discussion of insulating oils, TM 5–680.
	35			*Interior of equipment.* Check interior of equipment. Clean if necessary, using new oil applied under pressure. Discard oil used for washing.
	36			*Test.* Test dielectric strength of oil, using 1-inch disks spaced 0.1-inch apart. If oil tests lower than 18 kilovolts, filter to raise dielectric strength to 25 kilovolts. Oil removed from circuit breakers is often heavily carbonized. Therefore, unless there are large quantities of oil, filtering may not be economically feasible.

POLE TOP SWITCHES

Caution: Equipment must be deenergized and grounding harness applied where applicable.
If switch cannot be bypassed, jumpered out, perform inspections and services below when line is taken out of service for other reason. However, interval between inspections must not exceed 2 years.

			37	*Clean and adjust.* Clean contacts. To prevent damage, adjust so full contact can be obtained on all phases without slamming switch.
			38	*Grease.* Grease all contacts with nonoxide grease.
			39	*Operation.* Adjust and tighten nuts. See that all movable parts operate freely.
			40	*Arcing horns.* Set arcing horns so they barely touch when switch is opened and closed.
			41	*Locked.* Lock pole top switches to prevent unauthorized tampering.
			42	*Ground and ground resistance.* Inspect for loose, broken, and corroded ground connections to operating handle. Check ground resistance, preferably in the fall.

REGULATORS

			43	*Oil level.* Check that oil level is at required height. Add oil if necessary. When adding oil to electrical equipment, use same type and grade as presently in service. See discussion of insulating oils, TM 5–680.
			44	*Cracked or broken bushings.* Note and report cracked or broken bushings.
		45		*Operating mechanism.* Check to see that operating mechanism functions according to manufacturer's instructions.
		46		*Motor.* Check motor for faulty starting, noisy operation, excessive sparking, loose connections, etc.
		47		*Lubrication.* Clean and lubricate motor, using oil of proper viscosity for the climate. Clean and lubricate other moving parts as required by manufacturer's instructions. For further information on motors, see section III.

2 Years	Year	6 Months	Month	
		48		*Contact-making voltmeter.* Check voltage level of contact-making voltmeter by reading voltage on load-center testing terminals. On regulators, with line-drop compensators, turn contact arms back to zero when taking voltage measurements.
		49		*Arcing of contacts.* Observe arcing of voltmeter contacts; if arc sputters, contacts are faulty and may need replacement.
		50		*Limit switches.* Observe operation of limit switches to make sure movable contacts open with a snap action and close completely.
		51		*Motor-control relay.* See that motor-control relay operates without chatter or sluggishness.
52 (every 5 years)				*Loose nuts and bolts.* Raise interior from tank and check for loose nuts and bolts and defective contacts and bushings. Check condition of insulation on cable leads from rotor; replace if found brittle or defective. See that bearings, gears, and other operating mechanisms operate properly and are adequately oiled. Wash with new oil applied under pressure if sludge deposits are found.

TRANSFORMERS

53 *Temperature.* Test functioning of temperature gauge by installing temperature gauge in well provided for this purpose. If test well is not provided, take tank temperature by carefully attaching temperature gauge at top of tank, below oil level. Add 5° Centigrade (C.) to tank temperature to get approximate oil temperature in tank.

Test temperature of transformers operating at full load. Never allow oil temperature of oil-immersed, self-cooled transformers to exceed 95° C.; do not operate such transformers long at temperatures above 90° C.

54 *Cooling equipment.* Check cooling equipment on transformers for proper operation of fans and control relays or correct circulation of cooling water. Modify lubrication schedule for fan motors in accordance with severity of service performed.

Caution: Observe usual safety procedures in vicinity of high-voltage wires. See TM 5–680 for safe clearance distances.

55 *Oil level and leakage.* Check oil level. If low, inspect all valves and tanks for leaks and make necessary repairs immediately. Keep oil at level required by manufacturer.

When adding oil to electrical equipment, use same type and grade as presently in service. See discussion of insulating oils, TM 5–680.

56 *Load readings.* When transformers are known to be operating at rated load, or above, take ammeter readings of load at peak-load period to detect and prevent excessive overloading.

Caution: Equipment must be deenergized and grounding harness applied where applicable.

57 *Fused disconnects.* Examine contacts, insulators, mountings and operating mechanism. Grease noncontact surfaces with nonoxide grease.

SWITCH CUBICLES, PRESSURE-TYPE TRANSFORMERS, AND UNIT-TYPE SUBSTATIONS

2 Years	Year	6 Months	Month

Caution: Observe usual safety procedures in vicinity of high voltage wires. See TM 5–680 for safe clearance distances.

58 *Clean compartments.* Clean all compartments. Check space in rear of switching compartment to make sure it is not used for storing miscellaneous items.

59 *Storage batteries and charger.* Check water level in batteries and add distilled water if necessary. Check battery charger to see that it functions properly.

60 *Oil level and temperature.* Check oil gauge for oil level in transformer. Check temperature indicator for signs of overload.

61 *Inert-gas pressure.* Where transformers operate with inert-gas pressure in transformer, observe and record pressure-gauge readings to detect leaks and to note whether pressure meets manufacturer's specifications. If a leak is indicated, follow manufacturer's instructions for finding it.

62 (every 5 years) *Manufacturer's inspection.* Because the operating mechanism of a unit substation is extremely complicated, it is maintained by the manufacturers' representatives, who make a complete and detailed check of the entire unit at least every 5 years. The post engineer arranges with the manufacturer for other necessary maintenance work.

LOAD TESTS

Caution: Use of rubber gloves or hot-line tools is mandatory. All energized wires, buses, etc., in reach of personnel must be protected or effectively roped off.

63 *Load test main bus.* Test load on main bus. A hook-on ammeter with proper hot-stick handle may be used. Rearrange load of feeders to balance phases as closely as possible at main bus. Record test results on work sheet.

64 *Load test each feeder.* Test load on feeders and balance phases as closely as possible. Transfer loads above-carrying capacity of a circuit to other feeders to reduce line losses and give better regulation. Record test results on work sheet.

65 *Voltage test.* Test supply voltage of post distribution system at the substation, using potential transformers if available, or at a nearby distribution transformer of known ratio when it is under load. Record test results on work sheet.

5. Auxiliary Power Sources

a. GENERAL. Post engineer personnel maintain both permanently installed and portable auxiliary electrical-power sources and insure that they are always in condition for immediate use. Electrical personnel are not responsible for fuel supply, maintaining air pressure for starting or inspecting the prime mover and related equipment unless the responsibility is specifically assigned them by the post engineer.

b. INSPECTION AND MAINTENANCE INSTRUCTIONS. For specific inspection and maintenance procedures, see section III. The work sheets and procedures for motor maintenance discussed in that section also apply to generators. To adapt these work sheets and instructions for use with generators, substitute the word *generator* for *motor* throughout the forms and text.

c. STARTING AND OPERATING INSTRUCTIONS. Post instructions for starting and operating an auxiliary power plant near the equipment. Make certain that all operators memorize these instructions.

6. Underground Distribution Systems

Underground distribution systems are extremely dependable and give long, trouble-free service if properly maintained. The schedule of inspections below provides good maintenance procedure and helps prevent long outages which sometimes occur in underground cable systems.

a. TRANSFORMER RECORD CARD. WD AGO Form 5–82 (fig. 3), is a permanent record of transformer test data. A record card is kept for each government-owned transformer in the underground distribution system, including subway-type transformers in manholes and distribution-type transformers in above-ground vaults. Data are obtained from the inspectors, who give the electrical supervisor a daily list of all transformers inspected, including exact test results. The electrical supervisor enters the data on the proper record card.

b. INSPECTION AND MAINTENANCE INSTRUCTIONS. (1) Maintenance operations for underground distribution systems are shown on WD AGO Form 5–90 (Work sheet for underground distribution and preventive maintenance services) (fig. 4), and discussed further in the instructions below. For instructions on using the work sheet, see paragraph 3*a*.

(2) To help control work on extensive underground systems, prepare a system map similar to the overhead distribution map discussed in paragraph 7*a*. As inspection of an item is completed, check it off on the map.

W. D., A. G. O. FORM NO. 5-82

TRANSFORMER RECORD CARD

NUMBER

MAKE	STYLE OR SPECIFICATION	KVA	PHASE	TYPE / FORM	MFRS. SERIAL NUMBER

CYCLES
$ IMP.
PRI. V
DATE RECEIVED
SEC. V

ACCESSORIES
☐ SEMAPHORE ☐ THERMOMETER
☐ OIL GAUGE ☐ DRAIN VALVE

KIND OF SERVICE
☐ OUTDOOR
☐ INDOOR
☐ SUBWAY

NO.	LOCATION	POLE OR LOC. NO.	DATE INST.	PHASE WIRES	PRI. VOLTS	SEC. VOLTS	DATE REMOVED	REMARKS
1								
2								
3								
4								
5								

CONNECTED LOAD

LOC. NO.	BUILDINGS SERVED	KW	DATE	KW	DATE	KW	DATE	KW	DATE

(SEE REVERSE SIDE FOR ADDITIONAL SPACE FOR CONNECTED LOAD AND FOR LOAD TESTS)

CONNECTED LOAD (Cont'd.)

LOC. NO.	BUILDINGS SERVED	KW	DATE	KW	DATE	KW	DATE	KW	DATE

LOAD TESTS

DATE	AMPERES			AMPS. X VOLTS			TOTAL KVA	DATE	AMPERES			AMPS. X VOLTS			TOTAL KVA
	LEG 1	LEG 2		LEG 1	LEG 2				LEG 1	LEG 2		LEG 1	LEG 2		

Figure 8.

W. D., A. G. O.
FORM NO. 5-90

WORK SHEET FOR UNDERGROUND DISTRIBUTION AND PREVENTIVE MAINTENANCE SERVICES

SPECIAL INSTRUCTIONS: See T.M5-681 for detailed Instruction and Procedure

MANHOLE OR VAULT (Location or No.)	DATE	INSPECTOR

LEGEND FOR MARKING				SYMBOLS
✓ – SATISFACTORY	X – ADJUSTMENT NEEDED	XX – REPAIRS OR REPLACEMENT	0 – DEFECT CORRECTED	☐ – INSPECT AND CORRECT

5 YEARS / YEAR / MONTH

UNDERGROUND SYSTEM MANHOLES

1	VENTILATING WHEN FUMES ARE PRESENT
2	CLEAN
3	ROOFS, WALLS, FLOOR
4	DUCT
5	SEWER AND SUMPS
6	CABLE RACKS
7	COVER

CABLES

8	ELECTROLYSIS
9	GROUND WIRE CONNECTIONS
10	CABLE SHEATH BOND
11	CRACKS, BREAKS AND PUNCTURES
12	CABLE RACKS AND INSULATORS
13	CABLE TEMPERATURE

JUNCTION BOXES – CABLE

14	GASKET BREAKS AND LEAKS
15	COVER BOLTS
16	LINK CONNECTIONS
17	AIR PRESSURE

5 YEARS / YEAR / MONTH

POTHEADS

18	CLEAN
19	CRACKED PORCELAIN
20	LEAKAGE
21	TERMINALS

TRANSFORMER VAULTS

22	CLEAN
23	ROOF, WALLS, FLOOR
24	INSULATORS, CUTOUTS & BUS BARS
25	GROUND CONNECTIONS
26	VENTILATION
27	LOCK AND DOOR
28	IDENTIFICATION
29	FUSE EQUIPMENT

TRANSFORMERS

30	LOAD TEST *(No change in loading)*
31	LOAD TEST *(Load changes)*
32	LEAKAGE OF OIL
33	OIL TEST

REMARKS AND RECOMMENDATIONS

DISPOSITION OF WORK SHEET

THIS WORK SHEET SHOULD BE HELD IN THE POST ELECTRICAL MAINTENANCE FILE UNTIL REPAIRS ARE COMPLETED AND INFORMATION RECORDED ON MAINTENANCE SCHEDULE W.D., A.G.O. FORM NO.5-91 AND ALL TEST DATA PROPERLY RECORDED. IT MAY THEN BE DESTROYED.

Figure 4.

UNDERGROUND-SYSTEM MANHOLES

5 Years | Year | Month

Prepare maintenance schedules so manhole inspections are made at the same time as cable inspections.

Caution: Inspector must always be accompanied by a qualified electrician when inspecting manholes.

1 — *Ventilating when fumes are present.* Before entering manhole, make sure it is free from dangerous gases. If presence of inflammable or obnoxious gas is *detected or suspected,* ventilate manhole thoroughly with a power or hand blower placed on windward side of manhole opening. Blowers should be equipped with a canvas tube long enough to reach within 18 inches of bottom of manhole. Determine source of gas and take necessary steps to eliminate it. Provide some means of ventilating manholes located near gasoline storage tanks or fueling stations. To assist natural ventilation when men are working in a manhole, hang a canvas curtain from top of manhole guard to about 18 inches above manhole floor, and turn curtain broadside to wind. Never take lighted cigarettes or other open flames into a manhole until certain manhole does not contain explosive gases. Sparks from tools striking against metal or stone may also set off an explosion if explosive gas mixture is present.

2 — *Clean.* Remove dirt and all superfluous material found in manhole.

3 — *Roof, walls, floor.* Examine manhole roof, walls, floor, and duct entrances for cracks or other defects, and make all necessary repairs. Apply asphalt paint to rusted iron beams, cable racks, manhole frames, and equipment in manhole. If a ladder is permanently installed, inspect it carefully for weakness due to rusting or corrosion. If base of ladder is under water, remove water so entire ladder can be inspected. Coat rusted portions with asphalt paint.

4 — *Duct.* Inspect duct shields. Note whether cable is free to expand or contract and if it is being damaged by abrasion at duct entrances. Replace defective or rusted shields.

5 — *Sewer and sumps.* Keep drainage system open; clean out sumps that are filled with dirt and clear plugged sewer connections.

6 — *Cable racks.* Check for loose anchor bolts, missing cable racks, broken or missing rack insulators, and defective or missing cable saddles. Examine supports for severe rusting or corrosion. Make sure supports are adequate and that cable is not riding too near the edge and is not sagging between supports. Replace defective or missing items.

7 — *Cover.* See that manhole cover is not cracked or broken and that it seats properly in the frame. Clean out plugged vent holes. Where double covers or gasketed inner covers are used, inspect gaskets and replace them if necessary.

CABLES

Prepare maintenance schedule so cables in a draw-in-type system are inspected in late summer months, when load plus summer heat is most likely to show up flaws such as leaks, hot spots, movement of cables, etc. However, if load is considerably heavier at some other time of the year, schedule inspection at that time.

5 Years	Year	Month	
	8		*Electrolysis.* If direct current is used in the vicinity, test lead-covered cables for signs of electrolysis. Measure voltage difference between cable sheath and earth, water pipes, gas pipes, and all other submerged metal structures, taking readings at manholes, vaults, or other locations where cable is readily accessible. (See fig. 5.) For best results, make these measurements with a high-resistance voltmeter having zero at center of scale. Cable sheath should be negative to earth and other underground structures to prevent damage from electrolysis. If voltage reading is greater than plus or minus ¼ volt, consult the serving utility for proper action to minimize effect of electrolysis or cathodic action.
	9		*Ground-wire connections.* Inspect ground wire for corroded and loose connections. Replace if not tight and in good condition.
	10		*Cable-sheath bond.* Make sure bonding wire extends at right angles to lead cable sheath and does not touch cable sheath at any point other than point of attachment, where it should be completely covered with solder. Check bond contact for looseness or corrosion. Good bonding contact is essential. Observe temperature.
	11		*Cracks, breaks, and punctures.* Inspect entire length of cable in manhole for punctures, cracks, breaks, or leaks in lead sheath. Look for hairline cracks at bends in cable. Be particularly careful in checking at duct mouths, where most cable defects occur. Make sure there are at least 3 inches of straight cable coming out of duct. Cable which is bent at duct edge may become excessively worn by rubbing against duct during expansion and contraction caused by load changes. Check for duct shields which have fallen out or are out of line, rusted, or corroded. Refasten shields to cable in proper position or replace if necessary. Inspect joints carefully for cracks, bulges, checks near ends, leaking compound, or any signs of deterioration. If cable is partially or completely submerged, examine sheath for signs of corrosion or electrolysis, which is most likely to take place at the waterline. Corroded bond wires or cable supports are signs of electrolysis. If water drains into manhole through cinders or decayed vegetable matter, it may have a fairly high acid or alkaline content and may damage cables. Check solder seals and wipes for corrosion, since they may be affected even when cable sheath is not.
	12		*Cable racks and insulators.* Check cable racks and insulators to insure that cables and joints are properly supported at all times. Make sure cables or joints are not pressing against manhole wall or so far from wall that they are liable to fall off supports. Note any unusual cable movement. Cables may be pulled off supports by contraction and expansion due to temperature and load changes. Cables may tend to creep in one direction as result of difference in elevation of supports. Cables may move more at one end of manhole than at the other, causing excessive bending in cables or straining at joints.
	13		*Cable temperature.* For rough check on cable temperature, feel entire length of cable sheath in manhole. If bare hand cannot be held comfortably on sheath, outside temperature of cable is over 55° C. (131° F.) and conductor temperature is over 80° C., or *over* maximum rated temperature for copper in most cables. Any marked difference in temperature in same cable length indicates that local hot spot is developing. Report overheated cables and hot spots immediately.

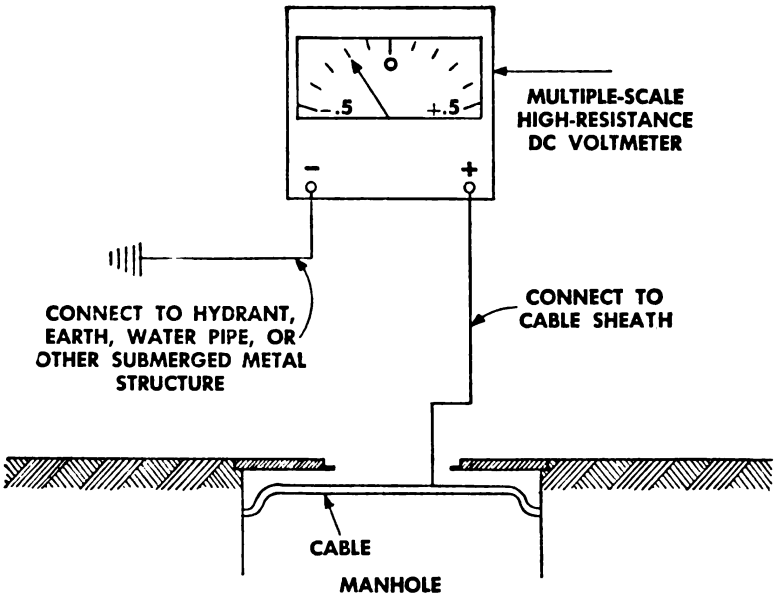


Figure 5. Using high-resistance voltmeter to test for electrolysis.

JUNCTION BOXES—CABLE

5 Years	Year	Month	
			Junction boxes are the sealed, waterproof-type boxes used for lead-covered cable branch circuits, with link connections for isolating various sections of the circuit.
	14		*Gasket breaks and leaks.* Inspect cover gasket visually for breaks or leakage.
	15		*Cover bolts.* Check cover for loose, broken, or missing clamp bolts.
	16		*Link connections.* Whenever junction box is open, check the links and clips for loose connections.
		17	*Air pressure.* If junction box operates with internal air pressure, make sure a minimum internal pressure of 15 pounds is maintained.

POTHEADS

Caution: Deenergize circuit if possible. If necessary to work hot, use of rubber equipment is mandatory on voltages of 5,000 or less. On voltages above 5,000 use hot-line tools.

	18		*Clean.* Clean potheads thoroughly. Increase frequency of cleaning in corrosive or dusty atmosphere.
	19		*Cracked porcelain.* Inspect for cracked or broken porcelain and report defects noted.
	20		*Leakage.* Examine for signs of leaking compound, especially on potheads mechanically connected to cable sheath. Repair if leakage is found.
	21		*Terminals.* Open and clean terminals on disconnecting-type potheads. Check for overheating, a sign of poor contact. Increase frequency of inspection if equipment is exposed to corrosive gases.

TRANSFORMER VAULTS

5 Years	Year	Month	

Caution: Use of rubber gloves or hot-line tools is mandatory. All energized wires, buses, etc., in reach of personnel must be protected or effectively roped off.

Schedule vault inspections for same time as cable inspection is performed. Before inspecting any vault, check for presence of dangerous gases, paying particular attention to vaults near gasoline storage tanks. If gas is found, take necessary steps to eliminate it. Never take lighted cigarettes or open flames into a vault until certain that it is free from explosive gases.

22 *Clean.* Clean vaults, ventilating grates, and air ducts. Increase frequency of cleaning air ducts if atmospheric conditions make it necessary. *Do not store unnecessary materials in vaults.*

23 *Roof, walls, floor.* Check vault for structural defects in roof, walls, or floor. If there are signs of moisture seeping into vault, make necessary repairs to correct this condition. Generally, excessive amounts of water in vault indicate need for sewer repairs. If vault is equipped with a sump pump, operate it by hand to test its performance. Check pump motor in accordance with instructions in section III.

24 *Insulators, cutouts, and bus bars.* Inspect for cracked or defective insulators and bushings. Remove dust from insulators, cutouts, bus bars, transformers, fuses, and other equipment in vault by wiping with a cloth or feather duster. Do not clean equipment operating at over 5,000 volts while it is energized. When cleaning energized equipment operating at less than 5,000 volts, always wear rubber gloves; nearby equipment must be separated or protected with rubber covering to prevent accidental contact with an energized conductor.

25 *Ground connections.* Check resistance of ground connections on cable, transformer cases, and other grounded equipment. Resistance should not exceed 25 ohms.

26 *Ventilation.* Report high air temperature within vault and provide additional ventilation. Insure good air circulation around transformers carrying rated load or higher.

27 *Lock and door.* Make sure door lock is in good operating condition and keys are available to proper personnel. If vault door does not swing freely, repair it immediately. Paint rusted spots on doors and other metal fixtures in vault.

28 *Identification.* See that identification and warning signs are properly placed outside vault door.

29 *Fuse equipment.* Inspect cutouts for cracked or damaged housings and hangers. Check condition of fuse holders and line and load contacts. Clean, adjust, and lubricate contacts to prevent corrosion and overheating, which cause outages and damage to equipment.

TRANSFORMERS

Caution: Use of rubber gloves or hot-line tools is mandatory. All energized wires, buses, etc., in reach of personnel must be protected or effectively roped off.

Maximum load on subway transformers depends on their ability to dissipate heat losses. Ordinarily, they may be loaded to 125 percent of name-plate

5 Years	Year	Month	
			rating if load is continuous for no more than 2 hours, with at least a 1-hour cooling period before transformer is loaded again. If load is to be continuous for 4 hours, do not exceed name-plate rating. For further information see TM 5–680.
			Check temperature of transformers and cutouts periodically by touch, first making certain transformer and cutout cases are grounded. If they feel too warm, notify the post engineer so load tests can be made. High temperature may also be due to inadequate ventilation. Cutouts may overheat because of poor contact of the fuse link, so the fuse link should be removed and contacts inspected. Oil level should also be checked.
			Note. Before connecting additional load to a transformer, refer to record cards and tests to make sure capacity is available.
		30	*Load test.* Make load test on transformers which supply a steady connected load. Install Max-I-Meters or equivalent for at least 24 hours at season of greatest load. Tests may also be made during loading period by spot-checking with split-coil ammeter, GE type AK-1 voltammeter or equivalent. If there are not enough meters available, borrow from serving utility. Enter test results on work sheet under "Remarks," and report data to electrical supervisor for entry on transformer record cards.
		31	*Load test.* Make load test on transformers which supply a building or vicinity where the load is known to be increasing. Transformers supplying technical facilities should be load tested more frequently than once a year. For procedure, see item 30.
		32	*Leakage of oil.* Check tank for leaking seams, drain plugs, and valves, and for leads siphoning oil. If leaks are found, remove transformers from service and make necessary repairs.
		33	*Oil tests.* When a transformer which has been in service 6 years or more is disconnected from line and returned to shop for any reason, give it an oil test. Do *not* give oil test to transformer connected to the line.

7. Overhead Distribution Systems

The electrical-facility maintenance program includes periodic inspections of government-owned transmission and distribution lines, with additional inspections after each outage. Inspections cover all wires, poles, transformers, and auxiliary equipment. Periodic system load tests and load-balance tests are necessary to show whether distribution circuits are properly balanced. Unbalanced loads cause excessive line losses and low voltage throughout the system. Complete records are kept of power failures and their causes to help reveal weak points in the system and show where maintenance is most needed. Thus, fuses blowing frequently during storms may indicate inadequate lightning-arrester protection, poor grounds, improper connection of arresters, or faulty transformer bushings. Repeated circuit outages during storms may indicate inadequate wire spacings, cracked insulators, excessive sag, or tree interference.

Caution: Perform live-line maintenance on high-voltage lines only if the lines cannot be taken out of service for necessary maintenance.

a. DISTRIBUTION AND BLOCK MAPS. (1) *Preparation.* To assist inspectors in their work, each post prepares block maps and distribution system maps or field-checks existing maps to bring them up-to-date. A procedure is also set up to help keep maps current by providing for monthly postings of all extensions, alterations, deletions, and other changes. For standard symbols used in the maps, see figure 6. For typical electrical distribution and block maps, see figures 7 and 8. Existing maps need not be revised merely to conform to these symbols and illustrations; however, for purposes of standardization, new maps should conform to the examples shown.

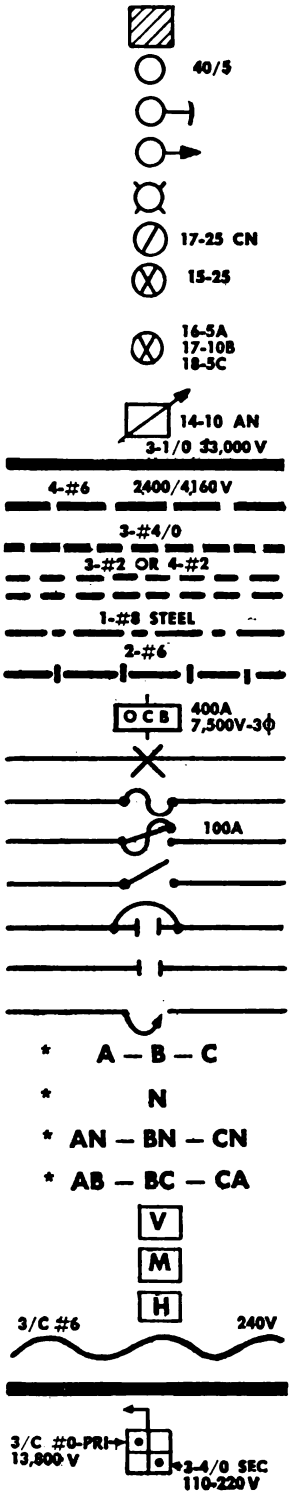
(2) *Use.* The maps provide a basis for checking work progress and insuring complete coverage of the overhead distribution system. Inspectors check off the map, pole by pole, as

they proceed with their work. When their inspection is complete, they turn in the maps to the electrical supervisor.

b. TRANSFORMER RECORD CARD. Record cards are kept on all transformers in the overhead distribution system, just as for those in the underground system. (See par. 6*a*.)

c. INSPECTION AND MAINTENANCE INSTRUCTION. The inspection schedule for an overhead distribution system provides for two types of inspections, one from the ground and one from the pole top. The former is a walking tour of the system to inspect equipment visually from the ground; use of field glasses increases the effectiveness of this check. Pole-top inspection involves climbing the poles for closer examination of equipment. Steps in these inspections are outlined on WD Form 5–85 (Work Sheet for overhead distribution and preventive maintenance services (fig. 9),) and discussed further in the instructions below. For instructions on using the work sheet, see paragraph 3*a*.

Caution: On climbing inspections the usual safety procedure when in the vicinity of high voltage wires must be followed. See safety section, TM 5–680.



SUBSTATION OR SWITCHING & METERING POINT

POLE — SIZE & CLASS

POLE WITH DOWN GUY (ANCHOR)

POLE WITH HEAD GUY

POLE WITH STREET LIGHT

SINGLE-PHASE TRANS—NO 17, 25 KVA, ON PHASE CN

3-PHASE TRANS—NO 15, 25 KVA

3-PHASE TRANS BANK NO 16, 5KVA
NO 17, 10KVA
NO 18, 5KVA

CONSTANT-CURRENT TRANS—NO 14, 10 KW, ON PHASE AN

TRANSMISSION — NUMBER, SIZE, & VOLTAGE

PRIMARY—NUMBER, SIZE, & VOLTAGE

SINGLE-PHASE SECONDARY

3-PHASE SECONDARY

SERIES STREET LIGHTING — NUMBER & SIZE

MULTIPLE STREET LIGHTING — NUMBER & SIZE

OIL CIRCUIT BREAKER—SIZE & RATING

POLE-TOP SWITCH

PRIMARY FUSE-CUTOUTS (NOTE IF RECLOSING TYPE)

FUSED DISCONNECTS—SIZE

SOLID DISCONNECTS

JUMPER POINT CLOSED

CONDUCTOR OPEN

HOT-LINE TAPS

CONDUCTOR-PHASE DESIGNATION

NEUTRAL OR GROUNDED CONDUCTOR

LOAD-PHASE DESIGNATION FOR 3 ϕ — 4-WIRE SYSTEMS

LOAD-PHASE DESIGNATION FOR 3 ϕ — DELTA SYSTEMS

TRANSFORMER VAULT

MANHOLE

HANDHOLE

BURIED CABLE

UNDERGROUND CONDUIT SHOWING DUCT SECTION AND OCCUPIED DUCTS

*Use serving utility's designation when possible.

LEGEND FOR ELECTRICAL DISTRIBUTION SYSTEM MAPS AND BLOCK MAPS

Figure 6.

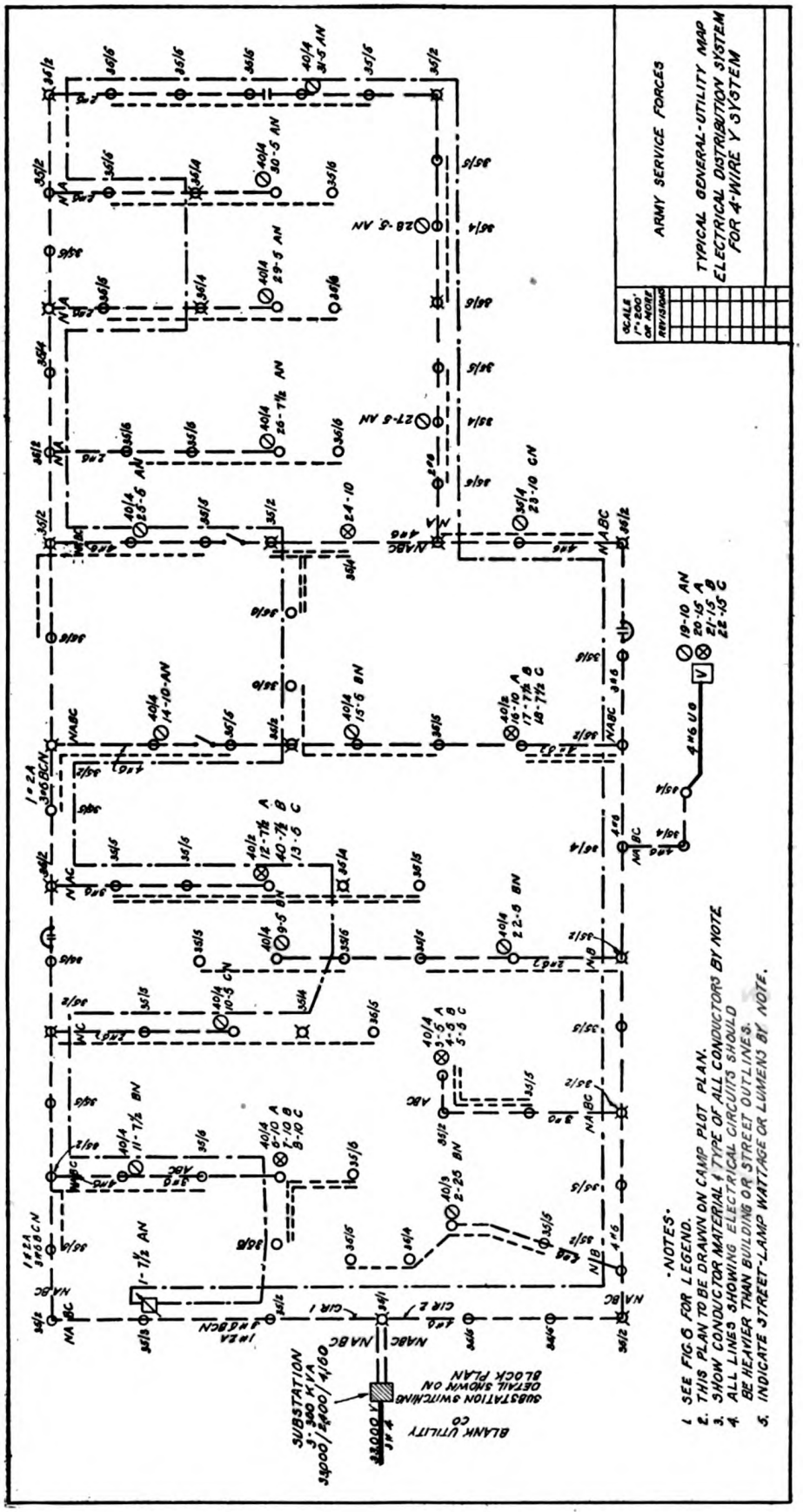


Figure 7.

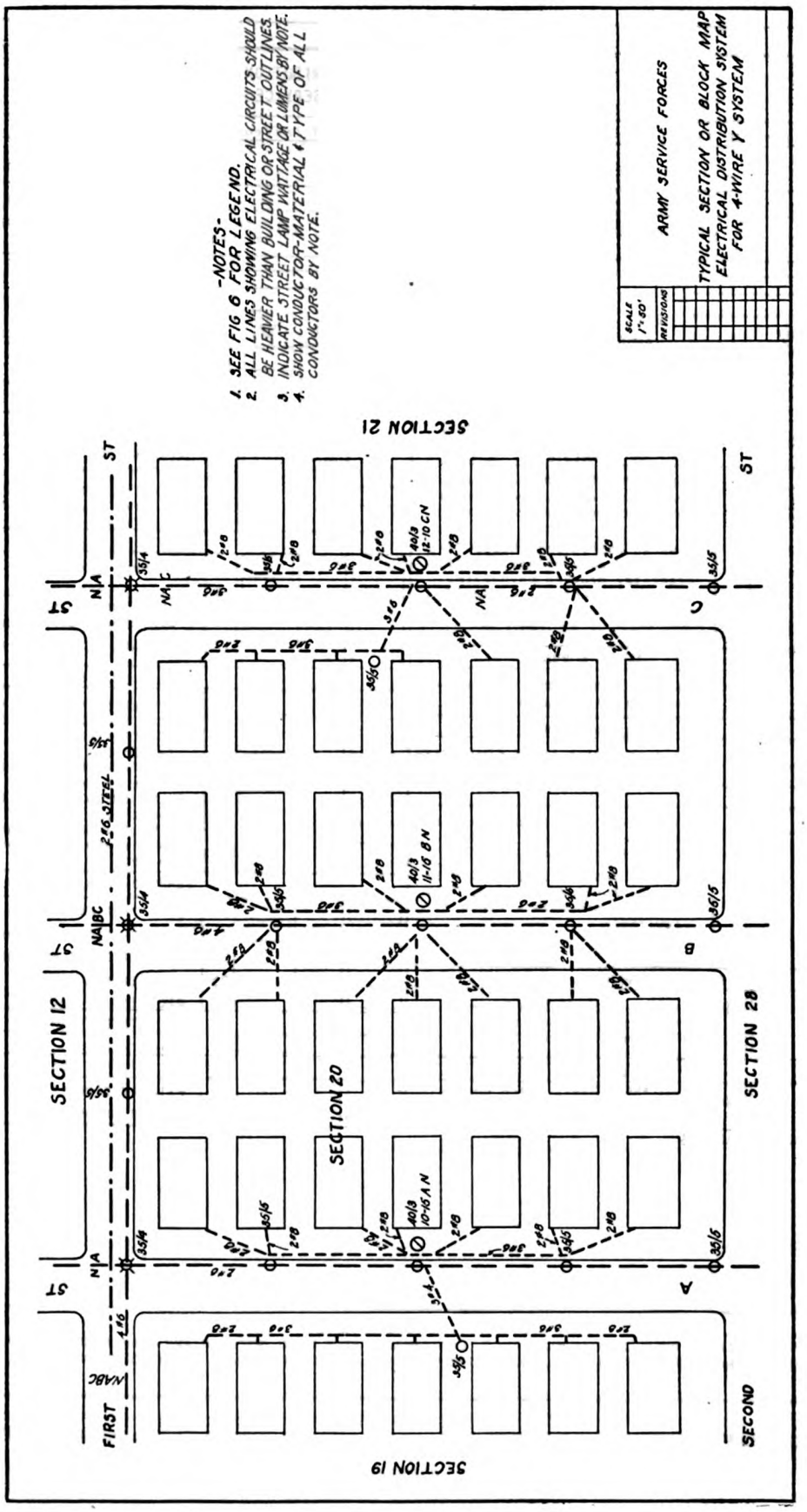


Figure 8.

W.D., A.G.O.
FORM NO. 5-85
Nov. 1944

WORK SHEET FOR OVERHEAD DISTRIBUTION AND PREVENTIVE MAINTENANCE SERVICES

SPECIAL INSTRUCTIONS: See T M 5-681 for detailed Instructions and Procedure

POLE LOCATION OR NO.	DATE	INSPECTOR

LEGEND FOR MARKING				SYMBOLS
✓-SATISFACTORY	X- ADJUSTMENT NEEDED	XX- REPAIRS OR REPLACEMENT	O - DEFECT CORRECTED	☐-INSPECT AND CORRECT

5 YEARS	2 YEARS	YEAR			
			ARMS, PINS & STRUCTURES		
☐			1	VISUAL FROM GROUND *(Splits, twisted, decay, defective pins)*	
			2	CLIMBING INSPECTION *(Splits, twists, decay, defective pins)*	
			ARRESTERS		
			3	VISUAL FROM GROUND *(Shattered, cracked, missing, ground continuity and mounting brackets)*	
☐			4	CLIMBING INSPECTION *(Loose line or ground connections, bolts, brackets, cracked porcelain, corrosive mounting, clean if necessary)*	
			BOLTS & BRACES		
☐			5	CLIMBING INSPECTION *(Rusted bolts and nuts. Missing braces)*	
			BUILDING SERVICES		
		☐	6	INSULATORS, DRIP LOOPS *(Defective insulators, drip loop, conduit)*	
			CUTOUTS		
		☐	7	VISUAL FROM GROUND *(General condition, connections, housing, - clean if required)*	
☐			8	CLIMBING INSPECTION *(Cracked or damaged housing, hangers, fuse holders & contacts - clean if required)*	
			FUSED AND UNFUSED DISCONNECTS		
	☐		9	CLIMBING INSPECTION *(Contacts, insulators, mechanism, - clean & grease if necessary)*	
			GROUNDS		
	☐		10	RESISTANCE *(Test, check connections to all equipment, moulding protection)*	

5 YEARS	2 YEARS	YEAR			
			GUYS & ANCHORS		
		☐	11	CORROSION *(Broken strands, creep, loose connections, broken, missing & clearances)*	
			INSULATORS		
		☐	12	VISUAL FROM GROUND *(Cracked, broken, missing)*	
☐			13	CLIMBING INSPECTION *(Cracked, broken, missing - clean if required)*	
			LINE WIRES		
		☐	14	TWISTED, SLACK, TAUT OR CROSSED	
		☐	15	CLEARANCES BETWEEN CONDUCTORS, ABOVE WALKS, STREETS, RAILROADS, AND COMMUNICATION LINES	
		☐	16	ADEQUATE CLIMBING SPACE	
			POLES, WOOD		
		☐	17	UNTREATED *(Decay, shell & heart rot, buckling, leaning & split)*	
		☐	18	BUTT TREATED *(Split buckling, leaning)*	
☐			18	BUTT TREATED *(Sound for heart-rot probe at ground for decay)*	
		☐	19	FULLY CREOSOTED *(Split, buckling, leaning)*	
☐			19	FULLY CREOSOTED *(Sound for heart-rot, probe at ground line for decay)*	
			TRANSFORMERS, DISTRIBUTION		
☐		☐	20	LOAD TEST *(No change in loading)*	
		☐	21	LOAD TEST *(Load change)*	
☐			22	CONNECTIONS & BUSHINGS	
☐			23	OIL LEAKAGE	
☐			24	OIL TEST	
			TREE TRIMMING		
		☐	25	TRIM TREES	
			VOLTAGE TESTS		
☐			26	PRIMARY CIRCUITS	
☐			27	END OF SECONDARY	

REMARKS AND RECOMMENDATIONS

DISPOSITION OF WORK SHEET

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Figure 9.

5 Years	2 Years	Year	
			ARMS, PINS, AND STRUCTURES
		1	*Visual from ground.* Check general condition of arms, pins, and wood structures; note defects such as splits, twisting, decay, and defective pins.
		2	*Climbing inspection.* Check for decayed and split cross-arms or timbers, particularly around pins. Determine extent of decay by prodding around pins with screw driver. Replace arm when decay or splits cause loose pins or seriously reduce strength. Replace twisted arms, usually a result of unbalanced strains on dead end points, with a properly guyed new arm. Check for damaged pins causing loose insulators, usually a result of insulator leakage. Replace if damaged. Examine wood structures for all weakening defects, decay, and the like and report necessary repairs.
			ARRESTERS
		3	*Visual from ground.* Check for shattered, cracked, or missing mounting bracket. Check continuity of ground connection.
		4	*Climbing inspection.* Inspect for loose line and ground connections; make sure all connections are tight and make good electrical contact. Check mounting bracket for corrosion, loose bolts, and breaks. Inspect porcelain housing for cracks and broken porcelain. To prevent external flashovers, maintain required clearances to grounded hardware and line conductors. In contaminated atmospheres, clean exposed insulation surfaces periodically. Inspect more frequently if located in a heavy storm area. Before handling arresters connected to circuits above 5,000 volts, disconnect them from line. ***Caution:*** Line must be deenergized before high-voltage arresters (above 5,000 volts) are connected to line conductor.
			BOLTS AND BRACES
		5	*Climbing inspection.* Replace immediately braces and bolts which are missing, broken, or so rusted they will not safely support attached equipment.
			BUILDING SERVICES
		6	*Insulators, drip loops.* Replace defective insulators immediately. Install drip loops in wires at service entrance to buildings to prevent water from following wire into building and causing outage or fire hazard. Provide service wire with proper clearance from roads, walks, and other buildings. Check entrance condulet for missing cover or other defects.
			CUTOUTS
		7	*Visual from ground.* Note general condition of connections, housing, and supports. Remove straw and other debris carried by birds.
		8	*Climbing inspection.* Check for cracked or damaged housings and hangers and for condition of fuse holders. Inspect for loose and corroded line and load contacts, which may cause outages and damage to equipment. To facilitate operating cutouts which are attached to arm with adjustable hanger, turn cutouts toward pole to make a 60° angle with arm. Clean and adjust contacts and lubricate to prevent corrosion. To prevent flashover, clean porcelain insulation on cutouts as often as needed to remove conductive coating which tends to form. Cleaning is not often necessary on circuits under 5,000 volts.

5 Years	2 Years	Year

FUSED AND UNFUSED DISCONNECTS

9 *Climbing inspection.* Check contacts, insulators, mountings, and adjustment of mechanism which operates rod and interphase shafts. See that contact surfaces are clean and bright. Whenever a switch is open for any reason, inspect contacts, clean if necessary, and protect them with coating of non-oxide grease.

GROUNDS

10 *Resistance.* Test enough grounds to make certain satisfactory grounding condition exists in all vicinities. Resistance of a ground should not exceed 3 ohms for water-pipe connections or 25 ohms for artificial grounds. Ordinarily, resistance of grounds connected to water pipes need not be measured. Examine connection to pipe to be sure it is making good electrical contact. If resistance of artificial ground is 25 ohms or more, drive at least one additional ground rod; space ground rods not less than 6 feet apart. If additional ground rods do not reduce resistance below 25 ohms, the post engineer should ask assistance of the serving utility and/or the service command.

Check ground connections to transformer cases, secondary neutral wires, lightning arresters, and ground rods. See that ground wire is rigidly supported, not cut, and that cross section is not accidentally reduced to any great extent. Make sure ground wire is covered with ground molding to at least 10 feet above pole base. Where ground wire passes other wires on pole, cover ground wire for at least 6 feet below and 4 feet above the wires.

GUYS AND ANCHORS

11 *Corrosion.* Check guys for corrosion, broken strands, creeping of anchors, loose connections, and clearance to live conductors. Report defective, broken, or missing guys for replacement.

INSULATORS

12 *Visual from ground.* Check for broken, cracked, or missing insulators and replace if necessary. Use field glasses if available.

Caution: Use of protective equipment or hot-line tools is mandatory. If insulators must be cleaned, and circuit cannot be deenergized, a carefully coordinated safety procedure must be followed.

13 *Climing inspection.* Check for cracked or broken insulators; if any are found, replace immediately to prevent outages, loss of current, and damage to equipment. Clean insulators periodically with a solvent such as ammonia, carbon tetrachloride, or soapy water to remove dirt deposits which under moist conditions may cause flashover. After cleaning with solvents, wash with neutralizing solution of sodium bicarbonate. Insulators on circuits under 5,000 volts need not be cleaned often. More frequent cleaning is necessary if voltage is higher or if installation is near coastal waters or localities with dirty atmosphere. Use the system recommended by the serving utility when washing insulators on high voltage lines.

LINE WIRES

14 *Twisted, slack, taut, or crossed.* Note tension in line wires and report off-standard conditions. Adjust immediately wires which are too slack or too tight. Clear any crossed wires and make necessary changes to prevent recurrence.

5 Years	2 Years	Year	
		15	*Clearances.* Check to see that all clearances are correct. For approved clearances between conductors and above guys, walks, streets, highways, railroads, and communication lines, see TM 5–680 or National Electrical Safety Code.
		16	*Climbing space.* Check for adequate climbing space on all poles and clear any dangerous conditions noted. For standards see TM 5–680 or National Electrical Safety Code.

POLES, WOOD

To reduce fire hazard, remove tall grass, weeds, and inflammable material within 4 feet of base of pole. To provide drainage, earth should be rounded about base of pole to a height of approximately 6 inches. If pole is to be tested for rot, determine amount of decay at ground line by digging out around pole to a depth of 1 foot. Support rotted poles with pike poles or guys until they can be permanently braced or removed.

		17	*Untreated.* Inspect untreated poles for decay at ground line, shell or heart rot, splitting, damage by lightning, leaning or buckling due to overload or strain. Report any defects for immediate repair.
		18	*Butt-treated.* Inspect butt-treated cedar poles for splitting, damage by lightning, and leaning or buckling due to overload or strain.
18			Test butt-treated cedar poles for heart rot by sounding above ground line; test further by drilling into pole below ground line after pole has been set for 15 years. Repeat drilling test every 5 years thereafter.
		19	*Fully creosoted.* Inspect full-length-creosoted southern-pine poles for splitting, damage due to lightning, and leaning or buckling due to overload or strain.
19			Test for heart rot by sounding only; do not bore test holes in these poles. After pole has been set for 15 years, test for shell rot by probing at or below ground line; repeat test every 5 years thereafter. Use a probing rod, taking care not to damage pole.

TRANSFORMERS DISTRIBUTION

Caution: Use of rubber gloves or hot-line tools is mandatory. All energized wires in reach of personnel must be protected.

Ordinarily, overhead distribution transformers may be loaded to 150 percent of name-plate rating if load is continuous for no more than 2 hours, with at least a 1-hour cooling period before transformer is loaded again. If load is to be continuous for 4 hours, do not exceed 125 percent of name-plate rating. For further information see TM 5–680.

Note. **Before connecting additional load to a transformer, refer to record cards or tests to make sure capacity is available.**

20			*Load test.* See item 30, paragraph 6.
		21	*Load test.* See item 31, paragraph 6.
22			*Connections and bushings.* Correct loose and corroded transformer and bus connections immediately to prevent heating, faulty service to attached equipment, or outage. Inspect bushings and leads and clean periodically to avoid flashover due to dirt.

5 Years	2 Years	Year	
23			*Leakage of oil.* See item 32, paragraph 6.
24			*Oil test.* When a transformer which has been in service for 6 years or more is disconnected from line to replace arm or pole or to change transformer size, give it an oil test. Do *not* give oil test to transformers connected to the line.

TREE TRIMMING

		25	*Trim trees.* Trees near overhead lines are a potential source of trouble because they may break and blow across wires during a storm. The limbs may break wires or cause a short circuit. To avoid this type power interruption, establish a regular program of tree trimming. For limbs under 3 inches in diameter, allow at least 8 feet of overhang clearance, at least 4 feet of side clearance, and at least 3 feet of underneath clearance. Maintain a climbing space 40 inches square through trees on climbing side of pole. Do heavy pruning and heading back of old trees in late fall or during winter when trees are dormant. Trim new growth soon after spring growing period.

VOLTAGE TESTS

		26	*Primary circuits.* Test primary-line voltage on each circuit at distribution transformer nearest substation, at middle of circuit, and at end of circuit. Repeat test whenever considerable load has been added to circuit. If voltage is higher than standard or more than 5 percent below standard, determine the cause and take necessary corrective steps.
		27	*End of secondary.* Determine voltage at end of secondary lines by testing for 24-hour period, using a recording voltmeter, if available. If possible, make test at location having greatest line drop. Make additional check whenever considerable load is added to a building. Do not move transformers, increase size of secondaries, or install additional transformers to correct a voltage drop of less than 5 percent, unless voltage is critical for proper operation, as with link trainers, teletype machines, X-ray machines, etc.

8. Street-lighting Systems

Street-lighting and auxiliary equipment is normally inspected during regular inspections of the post electrical-distribution system. However, the preventive maintenance procedure below is set up to insure that this part of the system is not overlooked and to provide for regular lamp-bulb replacement. It may be practical for the inspector covering the overhead-distribution system to carry along the work sheet for street lighting and include both inspections on the same trip; however, lamp-outage patrol and group-lamp replacement (items 7, 8, and 9 below) must be performed on separate trips.

a. TRANSFORMER RECORD CARD. Performance records of each constant-current transformer is kept on a transformer record card. (See par. 6*a*.)

b. MAPS. Electrical distribution maps (par. 7*a*) are used by inspectors to check off their progress, lamp by lamp, as they make their inspection. Maps are turned in to the electrical supervisor as soon as the inspection is completed.

c. INSPECTION AND MAINTENANCE INSTRUCTIONS. Steps in maintenance of street-lighting systems are outlined on WD AGO Form 5–86 (Work sheet for street lighting and preventive maintenance services (fig. 10)). Instructions below supplement the work sheet, giving detailed procedures for each step. For instructions on using the work sheet, see paragraph 3*a*.

W. D., A. G. O.
FORM NO. 5-86
OCTOBER 1944

WORK SHEET FOR STREET LIGHTING AND PREVENTIVE MAINTENANCE SERVICES

SPECIAL INSTRUCTIONS: See T M5-681 for Detailed Instruction and Procedure

POLE OR LAMPPOST LOCATION	DATE	INSPECTOR

LEGEND FOR MARKING				SYMBOLS
√ – SATISFACTORY	X – ADJUSTMENT REQUIRED	XX – REPAIR OR REPLACEMENT	O – DEFECT CORRECTED	☐ INSPECT AND CORRECT

5 YEARS
2 YEARS
1 YEAR
MONTH
WEEK
2000 HOURS

CONSTANT CURRENT TRANSFORMERS

1																1	AMPERE TEST

CONTROL EQUIPMENT

2																2	OIL SWITCH (Tight connections, oil leaks, broken bushings, corroded tank)
2																2	OIL SWITCH (Renew oil, clean tank, check operating parts & contacts. Clean bushings, check interior wiring, renew gasket if necessary)
3																3	TIME CLOCK (Check and reset)
3																3	TIME CLOCK (Check contacts and grease with non-oxide grease)
3																3	TIME CLOCK (Clean and overhaul)
4																4	PHOTO CELL CONTROL

FIXTURES AND MOUNTING BRACKETS

5																5	LAMPS ON POLE BRACKETS (Loose bolts & wiring. Level installation, broken reflectors or glassware)
6																6	LAMP STANDARDS (Check connections, insulating transformer, corrosion, defective insulation. Clean out dust and dirt and check painting)

LAMPS

7																7	PATROL (Check for broken or burned out lamps)
8																8	GROUP REPLACEMENT OF SERIES LAMPS
9																9	REPLACEMENT MULTIPLE LAMPS

REMARKS AND RECOMMENDATIONS

DISPOSITION OF WORK SHEET

THIS CHECK SHEET SHOULD BE HELD IN THE POST MAINTENANCE ELECTRICAL FILE UNTIL REPAIRS ARE COMPLETED & INFORMATION RECORDED ON MAINTENANCE SCHEDULE W.D., A.G.O. FORM NO. 5-91 & ALL TEST DATA PROPERLY RECORDED. IT MAY THEN BE DESTROYED.

Figure 10.

5 Years	2 Years	Year	Month	Week	2,000 Hours

CONSTANT-CURRENT TRANSFORMERS

Lightning arresters, cutouts, and transformers are to be checked with other line equipment as described in paragraph 7.

1 — *Ampere test.* Check current in secondary circuit of constant-current transformer supplying a series lighting circuit. Adjust if necessary to obtain a current of not more than 6.60 amperes and not less than 6.56 amperes for 6.6-ampere lamps. Reduce number of lamps by at least 25 percent and note whether transformer adjusts itself to the proper current.

CONTROL EQUIPMENT

Usually, a manually operated oil switch, a time clock, or a photoelectric device turns series street lights on and off.

2 — *Oil switch.* Inspect oil switch for loose connections, oil leaks, broken bushings, corroded tank, etc.

2 — Renew oil and clean tank, checking all operating parts at same time. Examine contact surfaces and smooth them if necessary. Clean bushings. Check interior wiring for any defects. Renew cover gasket if necessary to provide a watertight closure.

3 — *Time clock.* If time clocks operate the contactor, check and reset clock; these clocks may lose or gain as much as 15 minutes a month.

3 — The average service life of a time clock is 5 years. Clean and overhaul all time clocks at 5-year intervals.

3 — Inspect contacts on low-voltage time switches, and grease with a nonoxide grease.

4 — *Photo-cell control.* Where street-lighting circuit is controlled by a photoelectric device, mount the electric eye to point north and up at a 22½° angle above the horizontal. Clean window in electric eye. On a cloudless day and after windows have been cleaned, check output of electric eye with a milliammeter. Normal output is between 1½ and 6 milliamperes, but it may be as low as ½ milliampere and still operate the relay. When output current is below ½ milliampere, replace electric eye and send it to manufacturer for repair.

Caution: Relay used with photo-cell is a delicate instrument and should be installed where it will be as free as possible from severe jar or vibration. Sticking contacts should be cleaned carefully, but other repairs should be made only by authorized, experienced personnel.

FIXTURES AND MOUNTING BRACKETS

5 — *Lamps on pole brackets.* Inspect lighting fixtures and mounting brackets for loose mounting bolts and wire connections, level installation, and broken reflectors and glassware. Schedule this inspection at same time as annual visual inspection of other overhead-line equipment.

5 Years	2 Years	Year	Month	Week	2,000 Hours
		6			

Lamp standards. Open and inspect ornamental lamp standards. Check connections and insulating transformer. Note conditions of insulation on wiring. Remove debris and check for corrosion or bad insulation. Note and report condition of painting.

LAMPS

7 *Patrol.* Patrol weekly to check for broken or burned-out lamps. This patrol may be eliminated if other post personnel cooperate by reporting burned-out lamps to post engineer.

8 *Group replacement of series lamps.* Divide the post's series street-lighting system into groups of 40 to 50 lamps for group replacement. This is approximately 1 day's work. Keep a record of casual burnouts in each group, and when 10 percent of group has been replaced because of burnouts replace and discard remaining lamps in group; clean glassware and reflectors at this time. Average burning life of standard 6.6-ampere series lamp is 2,000 hours.

Use discarded lamps for replacement in fixtures close to electrical shop where correcting frequent outages will not require considerable transportation and time.

On series lights having removable series socket, replace film-disk cutout and replace lamp in series socket before inserting socket in fixture.

Check drip loops and seals around wires as they enter the fixture or bracket. Note whether ventilation is satisfactory.

9 *Replacement, multiple lamps.* Replace multiple streetlight lamps when burned out or blackened from long service. Do not use group-replacement system for multiple lamps.

9. Building Systems and Equipment

Building wiring is subject to all sorts of tampering and must be checked frequently to reduce fire hazard, correct defective wiring, and eliminate oversized lamps and improper fusing. The schedule of inspections below is intended to assure good maintenance procedure and to prevent outages and fire losses.

a. BUILDING ELECTRICAL INSPECTOR'S RECORD CARD. WD AGO Form 5–84 (fig. 11), is used for a permanent record of building-wiring inspections. Identification data at the top is filled in during the first inspection; spaces on the back are filled in when periodic inspections are made. Space is provided for a rough sketch of the building, showing authorized lamp sizes. These cards are kept in the electrical supervisor's files when not in use by inspectors.

b. INSPECTION AND MAINTENANCE PROCEDURES. (1) WD AGO Form 5–88 (Work sheet for building, wiring and preventive maintenance services) (fig. 12), helps the building inspector find defects in building-wiring systems and insures complete maintenance. For instructions on using the work sheet, see paragraph 3*a*.

(2) Quarterly inspections shown on the work sheet are first echelon maintenance and are performed by the using service when ordered by the post commander. This plan results in more economical and satisfactory service. However, final responsibility rests on the electrical staff who inspect annually and report on the performance of first echelon inspections and maintenance services. The using service replaces defective incandescent lamps, getting new ones by exchange from the post engineer. The electrical staff replaces fluorescent lamps.

(3) The using service uses the work sheet when making its inspection. After checking items for which it is responsible and performing necessary services, it sends the work sheet to the post engineer, who transfers information to the preventive maintenance schedule (par. 3*b*) and prepares any necessary work orders.

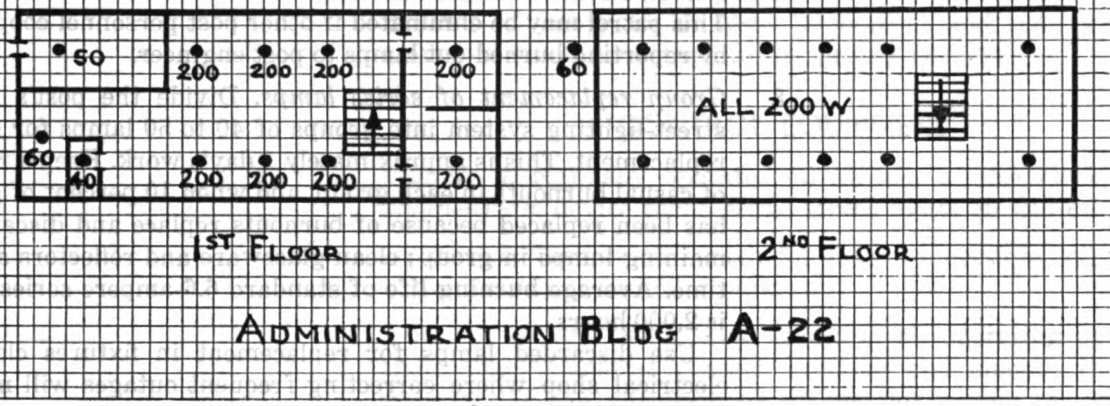
(4) Instructions below supplement the work sheet, giving detailed procedures for each inspection.

W.D., A G.O. FORM NO. 5-84

BUILDING ELECTRICAL INSPECTOR'S RECORD

LOCATION		BUILDING TYPE	VOLTAGE	PHASE	METER
CONNECTED LOAD	**CRITICAL LOAD**	**TRANSFORMER**		**TYPE CONSTRUCTION**	

SKETCH OF BUILDING SHOWING STANDARD LAMP SIZES



AUTHORIZED LOAD

LAMPS	MOTORS	COOKING AND OTHER

ROUTINE INSPECTION RECORD

QUARTERLY		QUARTERLY		QUARTERLY		YEARLY	
DATE	INSPECTOR	DATE	INSPECTOR	DATE	INSPECTOR	DATE	INSPECTOR
						5 YEARS	
						DATE	INSPECTOR

Figure 11.

W.D., A.G.O.
FORM NO. 5-88
NOVEMBER 1944

WORK SHEET FOR BUILDING WIRING AND PREVENTIVE MAINTENANCE SERVICES

SPECIAL INSTRUCTIONS: See T M 5-681 for detailed Instruction & Procedure

BUILDING NUMBER AND LOCATION	DATE	INSPECTOR

LEGEND FOR MARKING				SYMBOLS
√ - SATISFACTORY	* ADJUSTMENT REQUIRED	XX - REPAIR OR REPLACEMENT	0 - DEFECT CORRECTED	☐ - INSPECT AND CORRECT

5 YEARS
1 YEAR
3 MONTHS

			1	GENERAL CONDITION *(Circuits, overload, National Code)*
			2	LOOSE WIRES AND CONNECTIONS *(Loose or bare, poor connections, non-standard attachments, defective attachment cords, cords too long, fire hazards)*
			3	LAMP SIZES *(Correct size)*
				DISTRIBUTION PANEL
			4	GENERAL *(Clean, look, circuit identification)*
			5	FUSES *(Sizes, shorted out)*
			6	CONNECTIONS *(Wires, lugs, switch contacts, fuses)*
			7	GROUNDS *(Test for accidental grounds)*
			8	LOAD BALANCE ON CIRCUITS
			9	GROUNDED NEUTRAL *(Continuity, resistance of rod)*
				LIGHTING FIXTURES
			10	REFLECTORS AND LAMPS *(Clean)*
			11	LAMPS INCANDESCENT *(Burned out or blackened)*
			12	LAMPS FLUORESCENT *(Burned out, faulty, low voltage, blackened)*

REMARKS AND RECOMMENDATIONS

DISPOSITION OF WORK SHEET

THIS WORK SHEET SHOULD BE HELD IN THE POST ELECTRICAL MAINTENANCE FILE UNTIL REPAIRS ARE COMPLETED AND INFORMATION RECORDED ON MAINTENANCE SCHEDULE W.D., A.G.O. FORM NO. 5-91 AND ALL TEST DATA PROPERLY RECORDED. IT MAY THEN BE DESTROYED.

Figure 12.

WIRING SYSTEM

5 Years	Year	3 Months	
			Make repairs to wiring and equipment in a permanent manner, using approved materials. Temporary work saves little time, must be replaced later, and is a fire hazard.
	1		*General conditions.* Make sure wiring is done in a workmanlike manner, circuit arrangement is correct, circuits are not overloaded, and work conforms with National Electrical Code in all essentials.
	2		*Loose wires and connections.* Inspect each building for loose wires, poor connections, bare conductors, unauthorized or nonstandard attachments, defective convenience outlets and switches, defective attachment cords, improper use or length of attachment cords, use of wiring or fixtures as support for extraneous items, and any condition likely to cause fire.
	3		*Lamp sizes.* Report all lamps larger than standard prescribed for outlet and replace them with proper size lamps.

DISTRIBUTION PANEL

	4		*General.* Keep distribution-panel inclosure closed and locked if possible. Clean and remove dust or extraneous material. Check circuit identification and bring it up-to-date. See that fuse or switch cabinet is accessible for servicing.
	4		Electrical staff checks and reports on performance of these operations.
	5		*Fuses.* Check distribution panels for proper fusing. Make sure fuses are not larger than rated current-carrying capacity of conductor on any circuit. Detect and replace defective fuses which have been bypassed by any means.
	5		Electrical staff checks and reports on performance of above operations.
	6		*Connections.* Check security of all connections to panel. Note if wires, lugs, switch contacts, or fuses are hot, indicating poor contacts or overload.
	6		Electrical staff checks and reports on performance of above operations.
	7		*Grounds.* Use test lamp or other simple means to detect accidental grounds on system.
	8		*Load balance on circuits.* Balance legs of a single-phase three-wire or three-phase four-wire system. Readings taken with a hook-on ammeter during normal-load period or a quick survey of the connected load on each circuit is usually sufficient.
	9		*Grounded neutral.* Wherever possible, ground neutral to water system. Check continuity of ground wire. If system has a ground rod, test to make sure ground resistance does not exceed 25 ohms.

LIGHTING FIXTURES

	10		*Reflectors and lamps.* Clean lighting fixtures and lamps. Wash reflectors with soapy water and rinse with clean water. Dry-wiping is unsatisfactory as it invariably leaves dirt on reflector.
	10		Electrical staff checks and reports on performance of above operations.
	11		*Lamps, incandescent.* Replace burned-out or blackened lamp bulbs promptly to insure efficient illumination.
	11		Electrical staff checks and reports on performance of above operations.

5 Years	1 Year	3 Months
		12

Lamps, fluorescent. Give fluorescent lighting special maintenance attention since auxiliary equipment is damaged when faulty or burned out lamps are not removed from circuit. Keep fluorescent tubes clean and note darkened tubes for replacement. Report faulty operation immediately to post engineer and request replacement of tubes which are darkened or not operating. A fluorescent lamp approaching the end of its life flashes on and off unless protected by starters to prevent blinking. Request immediate replacement of flashing lamps to prevent harmful continuous working of starter and failure due to overloading lamp ballast.

Low voltage generally causes trouble with fluorescent-lamp installations. Check voltage if lamps are operating badly.

12 Electrical staff checks and reports on performance of above operations.

10. Disposition of Work Sheets

Completed inspection and maintenance work sheets are filed by the electrical supervisor until the information is entered on a permanent record. Special information on transformers is recorded on WD AGO Form 5–82 (pars. 6*a*, 7*b*, and 8*a*), and that relative to buildings on WD AGO Form 5–84 (par. 9*a*). A complete summary of maintenance performed is entered on WD AGO Form 5–91 (par. 3*b*). After all information is transferred to appropriate forms, work sheets may be discarded.

SECTION III

PREVENTIVE MAINTENANCE SERVICES AND TECHNICAL INSPECTIONS OF ELECTRIC MOTORS

11. General

Modern motors are sturdily built and with reasonable care give long continuous service. Post engineer electrical personnel are responsible for inspecting and maintaining all electric motors and for adhering to a strict, regular schedule in performing these duties. Frequency and thoroughness of inspection depends on such variable factors as continuity of operation, surrounding conditions, the equipment driven, and motor design. Additional detailed post engineer maintenance responsibilities are listed in paragraph 2.

12. First Echelon Preventive Maintenance

The scope of first echelon maintenance of motors varies according to the user's skill and tools. For example, mess-hall personnel are not expected to repair or adjust the refrigerator motor. However, attendants at water-pumping stations, central-heating plants, sewage-disposal plants, and cold-storage plants, and the refrigerator, heating, and engineer shop mechanics all have the necessary tools and ability to perform first echelon motor maintenance. The responsibilities of each of the above are set forth in paragraphs 13 and 14. The post engineer should designate installations where operators in charge are responsible for motor maintenance, and notify operators of their specific responsibilities. Final responsibility, however, rests with the electrical staff, who inspect motors semiannually and report on the performance of first echelon inspections and maintenance services.

13. First Echelon Preventive Maintenance by Unskilled Users

The success of preventive maintenance of motors depends greatly on the cooperation of the equipment's user, who constitutes the first echelon of preventive maintenance. First echelon maintenance for the *unskilled user* does not require electrical or mechanical skill. It consists of keeping the motor clean and free from obstructions to ventilation, and notifying the post engineer of unusual noises, sluggish starting, unusual sparking, or overheating. The user follows the first echelon preventive maintenance instructions on WD AGO Form 5–81 ("Motors" first echelon preventive maintenance) (fig. 13). This form is posted conspicuously on or near the motor-driven equipment.

14. First Echelon Preventive Maintenance by Plant Operators, Inspector-mechanics, or Other Skilled Users

a. DUTIES. Skilled users such as plant operators and inspector-mechanics perform first echelon preventive maintenance on motors when so designated by the post engineer. (See par. 12.) Their duties include:

(1) Keeping motors *lubricated.*

(2) Keeping motors free from dirt or moisture.

(3) Freeing the operating space of articles obstructing air circulation.

(4) Checking oil level in sleeve bearing and replenishing as needed with SAE 10 grade of good mineral oil. Under heavy belt pull or high temperature a somewhat heavier oil should be used. See Supply Bulletin SB 10–139 for comparable government specifications.

(5) Checking grease in ball or roller bearings as required by manufacturer's specifications or as shown in paragraph 16.

(6) Reporting the following conditions to the post engineer for correction by electrical staff:

(*a*) Bearings leaking oil or missing oil-well cover.

(*b*) Oil rings not operating freely or carrying insufficient oil.

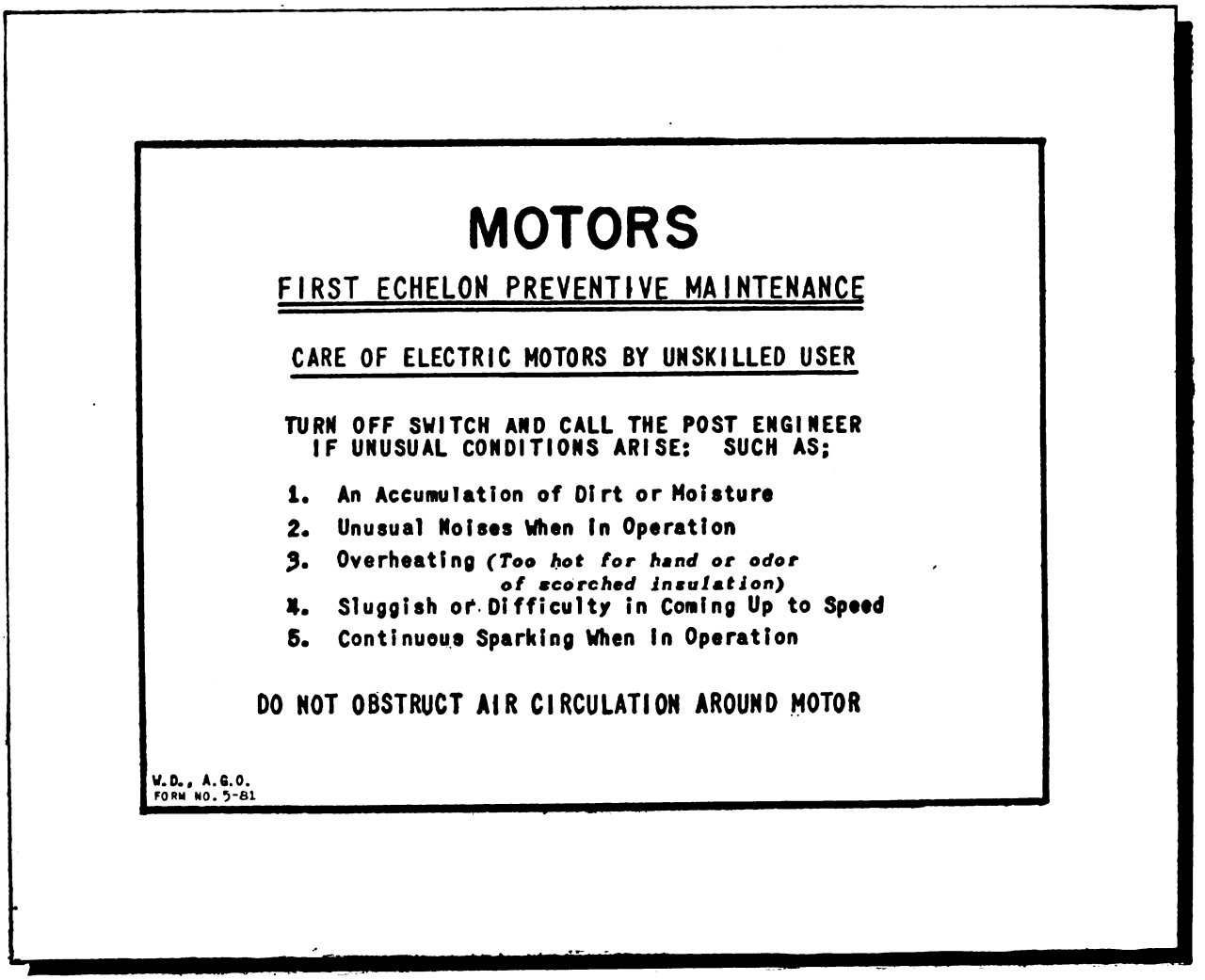


Figure 13.

(*c*) Hot bearings.

(*d*) Dirty brushes and commutator.

(*e*) Motor not starting or failing to come up to speed normally.

(*f*) Motor too hot by hand test.

(*g*) Continuous or excessive sparking at brushes.

b. FREQUENCY. For minimum frequency of inspections, see WD AGO Form 5–89 (Work sheet for motors or generators and preventive maintenance services). (See fig. 15 and par. 16.) Inspections above are covered on the work sheet under item numbers 1, 2, 3, 7, 8, 9, 10, 11, 12, 13, 16, 25, 26, and 27. First echelon maintenance personnel fill in the work sheet during each inspection and send the filled-in form to the electrical supervisor for entry in the motor record card.

c. TRAINING. Post engineer electrical personnel are responsible for training plant operators, inspector-mechanics, or other skilled users who perform first echelon preventive maintenance on motors.

15. Motor or Generator Record Cards

The post engineer and electrical personnel prepare and use WD AGO Form 5–83 (fig. 14) as a permanent record of maintenance. A card is made up for *all* motors for which the post engineer has maintenance responsibility. Data at the top of the card is filled in during the first inspection and kept up-to-date during subsequent inspections. The back of the card provides spaces to record inspections made. For convenience in scheduling and controlling inspections, motor record cards should be divided

into two groups: one for motors on which first echelon preventive maintenance is performed by unskilled users (par. 13), and the second for motors on which first echelon preventive maintenance is performed by skilled users or mechanics (par. 14). Group 1 motors are inspected by the electrical staff at 1-month, 6-month, and 1-year intervals; group 2 motors are inspected at 6-month and 1-year intervals.

16. Work Sheet For Motors and Preventive Maintenance Instructions

Use of WD AGO Form 5–89 (fig. 15), by all inspecting personnel insures uniform inspection and maintenance procedures, assists inspectors, and provides a means of reporting defects. More frequent checks than specified on this schedule should be made when advisable. For instructions on using the work sheet, see paragraph 3*a*. The instructions below supplement the work sheet, giving detailed procedures for each step.

W.D.,A.G.O FORM NO 5-83

MOTOR OR GENERATOR RECORD CARD

LOCATION		BUILDING NUMBER	DATE INSTALLED	DATE REPLACED
APPLICATION		MANUFACTURER		
PARTS BULLETIN		H.P.-K.W.	TYPE	FRAME
SERIAL NUMBER		VOLTS: ☐ AC ☐ DC		PHASE
BEARINGS	AMPS	FREQ.	DRIVE	BRUSHES
OVERLOAD PROTECTION		RPM	1st ECHELON MAINTENANCE BY USER ☐	

REPAIRS AND OVERHAUL

DATE INSPECTED	WORK ORDER	REPAIRS MADE BY	NATURE OF WORK	MATERIALS USED

(SEE REVERSE SIDE FOR ROUTINE INSPECTION RECORD)

ROUTINE INSPECTION RECORD

MONTHLY		MONTHLY		MONTHLY		SIX MONTHS	
DATE	INSPECTOR	DATE	INSPECTOR	DATE	INSPECTOR	DATE	INSPECTOR
						YEARLY	
						DATE	INSPECTOR

Figure 14.

W.D., A.G.O.
FORM NO. 5-89
November 1949

WORK SHEET FOR MOTORS OR GENERATORS AND PREVENTIVE MAINTENANCE SERVICES

SPECIAL INSTRUCTIONS: See TM 5-681 for Detailed Instructions & Procedures. See Mfr. Manual for Technical Information

BUILDING NUMBER AND LOCATION	MOTOR SERIAL NUMBER	DATE
MOTOR LOCATION	DRIVEN EQUIPMENT	INSPECTOR

LEGEND FOR MARKING				SYMBOLS
√ — SATISFACTORY	X — ADJUSTMENT REQUIRED	XX — REPAIR OR REPLACEMENT	O — DEFECT CORRECTED	☐ — INSPECT AND CORRECT

ANNUALLY
6 MONTHS
MONTHLY

SLEEVE BEARINGS & LUBRICATION

		1 OIL SEALS AND COVER
		2 OIL RING
		3 TEMPERATURE
		4 BELT, CHAIN OR GEAR PRESSURE
		5 ALIGNMENT
		6 END PLAY
		7 LUBRICATION *(Oil level, fill)*
		7 LUBRICATION *(Flush, refill, renew wicking)*

BALL OR ROLLER BEARINGS & LUBRICATION

		8 VIBRATION & TEMPERATURE
		9 GREASE RETENTION
		10 BELTS, CHAIN OR GEAR PRESSURE
		11 ALIGNMENT
		12 LUBRICATION *(Grease)*
		12 LUBRICATION *(Oil)*

BRUSHES & BRUSH HOLDERS

		13 CLEAN & CHECK *(Clean, check for chipping, heat cracks, loose connections, uneven wear)*
		14 LENGTH
		15 MOVEMENT & SPRING TENSION

COMMUTATOR OR SLIP RINGS

		16 CLEAN
		17 MICA, HIGH BARS, UNEVEN WEAR *(Clean, rough, high wear)*

ROTORS

		18 SQUIRREL CAGE *(Clean, loose bars local heating, fan blades)*
		19 WOUND *(Clean, collector rings pitted or eccentric, connections, wedges)*

ANNUALLY
6 MONTHS
MONTHLY

PROTECTIVE DEVICES & CONTROLS

		20 FUSES *(Size, contacts, loose connections)*
		21 STARTER & CONTROLS *(Clean, freedom of moving parts, connections, contact pressure & wear, excess heating)* THERMAL OVERLOAD RELAY *(Setting, rating, excess heating, contacts)* STARTING CYCLE *(Sluggish, sparking, rated speed)*

TESTS

		22 LOAD CHECK
		23 CLEARANCE – ROTOR & STATOR
		24 INSULATION RESIS. & GROUNDS

MISCELLANEOUS CHECKS

		25 MOTOR TEMPERATURE
		26 VENTILATION
		27 UNUSUAL NOISES
		28 ELECTRIC CONNECTIONS *(Wiring, switches, fuses, lugs, loose connections)*
		29 PROTECTION AGAINST MOISTURE
		30 MOTOR MOUNTING
		31 CLEAN & BLOWOUT WINDINGS
		32 GENERATORS *(Operation check)*
		32 STORAGE BATTERIES *(Electrolyte, level & gravity, charging equipment)*

REMARKS AND RECOMMENDATIONS

DISPOSITION OF WORK SHEET

THIS WORK SHEET SHOULD BE HELD IN THE POST MAINTENANCE ELECTRICAL FILE UNTIL REPAIRS ARE COMPLETED AND INFORMATION RECORDED ON MAINTENANCE SCHEDULE W. D., A. G. O. FORM NO. 5-91 AND ALL TEST DATA PROPERLY RECORDED. IT MAY THEN BE DESTROYED.

Figure 15.

SLEEVE BEARINGS AND LUBRICATION

Annually	6 Months	Month	

Bearings and lubrication are of the greatest importance in motor care: analysis of motor failures shows that most of them are caused by lack of lubrication. Follow the manufacturer's lubricating schedule and meet the motor-manufacturer's specifications for oil or grease by using a comparable standard Army lubricant. (See WD SB 10–139.)

1 *Oil seals and cover.* See that oil filler caps are closed so dust and dirt cannot get into bearing. Make sure oil seals, well covers, and plugs are tight. Check for oil creeping along shaft toward windings. Oil escaping from a bearing means trouble.

2 *Oil ring.* Check oil ring to be sure it is free and turns with shaft.

3 *Temperature.* Check that bearing temperatures do not exceed 80° C. for open-type motors or 90° C. for totally-inclosed motors, or temperatures specified by the motor manufacturer.

4 *Belt, chain, or gear pressure.* See that belts are no tighter than necessary to prevent slipping. Note if belt-tightening adjustment is all taken up. See that driving gears are not meshed too tightly and are turning together easily. Check chains for evidence of wear or stretch. See that chains clear housing. Check lubrication, especially for excess grease and oil in bottom of housing.

5 *Alignment.* Maintain proper alignment between motor and the machine it drives to prevent excessive bearing pressure. Align flexible couplings properly so there is no noise or excessive use of flexible medium.

6 *End play.* Check motor to see that end thrust is not excessive and shaft has a reasonable axial float.

7 *Lubrication.* When an oil gauge is used, check oil level and fill to line on gauge. When journal size is less than 2 inches, stop motor to check oil level.

7 Flush and refill oil reservoir. (Increase frequency if motor is used for hard-driven service.) Use good grade mineral oil with proper viscosity to meet temperature conditions. Oils designated by Navy symbols 2110, 2135, or 3050, or special oil to manufacturer's specification if required by service to be rendered, are suggested.

Small motors with sleeve bearings usually do not have oil-level gauges. On such motors it is good practice to add 30 to 60 drops of oil every 6 months or every 1,000 hours of operation. Renew wick or waste packing when glazed.

BALL OR ROLLER BEARINGS AND LUBRICATION

Follow the manufacturer's lubricating schedule and meet the motor-manufacturer's specifications for oil or grease by using a comparable standard Army lubricant. (See WD SB 10–139.)

8 *Vibration and temperature.* Feel housing for vibration and listen for unusual noises. Check that temperature does not exceed 80° C. for open-type motors or 90° C. for totally-inclosed motors, or temperatures specified by motor manufacturer.

9 *Grease retention.* Inspect for grease or oil creeping along shaft on inside of motor. Grease or oil escaping from a bearing means trouble and damages windings.

10 *Belts, chain, or gear pressure.* See item 4 above.

Annually	6 Months	Month	
		11	*Alignment.* See item 5 above.
	12		*Lubrication.* Lubrication required depends on how the motor is used. Average lubricating period is every 2 months for motors with grease-lubricated ball or roller bearings which are hard driven and on 24-hour service, and every 9 to 12 months for motors on light duty. On hard-driven motors, purge out old grease through drain hole and refill. Do not mix greases of different type or specifications. If change is desired, clean housing completely. Use special ball- and roller-bearing grease, Army specifications now pending. (See OFSB 6–2.) For general-purpose use at all temperatures, Gargoyle BRB No. 4 grease is suggested.
		12	*Lubrication.* The amount of oil needed to lubricate small motors equipped with oil-lubricated bearings varies considerably, depending on severity of service and number of hours the motor operates. Adding 30 to 60 drops for every 1,000 hours is generally good practice. Oils designated by Navy symbols 2110, 2135, or 3050 are suggested. Motors on continuous 24-hour schedule require special lubrication in accordance with load conditions.

BRUSHES AND BRUSH HOLDERS

		13	*Clean and check.* If brushes stick in holder clean holder and brush so brush works freely. If dirt and oil accumulate on commutator, faces of brushes become glazed and packed with dirt, causing harmful sparking. True up brushes worn unevenly or replace with a new set. Check pigtail connections for looseness. Examine brush faces for chipped toes or heels and for heat cracks. Replace those found damaged.
		14	*Length.* If brushes are worn so they do not touch commutator or touch it only lightly, replace them. For best results, use brushes of grade and rating recommended by manufacturer. A set of brushes should last for at least 2,500 hours. Keep spare brushes for all type motors on post in the electrical shop and identify them clearly, preferably by a number. Enter number on WD AGO Form 5–83.
		15	*Movement and spring tension.* If brush pressure is incorrect, correct it by adjusting spring tension. If brush pressure is uneven or brush springs are weak, replace springs. Do not try to correct uneven feed by bending springs. To prevent grooving of the commutator, stagger pairs of brush-holder arms about $\frac{3}{8}$ inch in an axial direction.

COMMUTATOR OR SLIP RINGS

		16	*Clean.* Check commutator to make certain it is clean because oil and dirt make good commutation impossible. Commutator should be clean, smooth, and polished brown in color. A bluish color indicates overheating. Reversing polarity of slip ring brushes will tend to eliminate pitting of slip ring.
		17	*Mica, high bars, uneven wear.* Wear on slip rings and commutators of electric motors is inevitable because these rotating parts are exposed to constant friction, but cannot be lubricated. Minimize wear on commutators and slip rings by preventing grooving. Wipe abrasive dust from the surface of slip rings and commutators. Finish rough or uneven surface of rings or commutators at the first opportunity by sanding with No. 00 sandpaper, grinding, or turning down, depending on depth of surface roughness. Do *not* use emery cloth. If mica is high, cut it down slightly below level of commutator so brushes make contact with commutator bars.

Annually	6 Months	Month	

ROTORS

18 — *Squirrel cage.* Check for broken or loose bars and evidence of local heating. If fan blades are not cast in place, check for loose or missing blades.

19 — *Wound.* Clean thoroughly around collector rings, washers, and connections. Tighten connections. If rings are pitted, spotted, or eccentric, have them refinished. See that all wedges over coils are tight.

PROTECTIVE DEVICES AND CONTROLS

20 — *Fuses.* For motor running protection, see that fuse ratings do not exceed 125 percent of capacity. Check fuse clips, starting switch, and connections for looseness or heating.

21 — *Starter and controls.* Keep starter and controls tight, clean, dry, and operating at rated voltage. Check freedom of moving parts. Test all connections for looseness and note any excess heating of parts. Note contact pressure, evidence of serious arcing, and remaining wear allowance on contacts. Replace or repair contacts as needed. Check thermal-overload relays for proper rating and setting; watch for signs of defective contacts and overheating of parts. Check condition of heating element and replace if necessary. See that starter or control provides proper starting cycle for service intended and that thermal units and relays give proper overload and no-voltage protection. On single-phase motors, check for sluggish starting, excessive sparking, and failure to attain full rated speed.

TESTS

22 — *Load check.* Check load on motor whenever change is made in duty performed or motor shows tendency to overheat. A reading with hook-on ammeter usually is sufficient check.

23 — *Clearance between rotor and stator.* Use long feeler gauges to check air gap between rotor and stator on 1-horsepower and larger motors. Clearance of rotor shows an experienced motor man the amount of wear in bearings. Exact clearance varies with motor size, speed, and manufacture so permissible limits are not well defined. A variation of 10 percent from average is usually permissible. A record of such yearly checks gives a picture of bearing wear.

24 — *Insulation resistance and grounds.* Test insulation on *all* motors over 5 horsepower; this includes motors driving important loads such as water pumps, sewage pumps, boiler-feed pumps, stokers, etc. On motors of 5 horsepower or less, test insulation on a representative group of motors. Make insulation tests by using a megger-type instrument or an electronic ohmmeter of proper sensitivity. Make tests between coils and frame and between individual coils. Do not check wet motors with a megger because the high voltage may break down insulation. Test wet motors with a low-voltage ohmmeter. For further test information, interpretation of results, and criteria for insulation resistance, see TM 5–680.

Note. Individual posts should not purchase meggers for this work but should obtain them from service command headquarters or the local utility company.

MISCELLANEOUS CHECKS

25 — *Motor temperature.* Check temperature by hand. Motor is not too hot if hand can be held on it with reasonable comfort. Most open-type motors are designed to operate safely with a temperature rise of 40° C., above an ambient

Annually	6 Months	Month	

of 40° C., ambient being air temperature in immediate vicinity of motor. This gives a stator temperature of 80° C. Wartime practice permits operation up to 90° C., 194° F. Totally-inclosed motors are usually designed to operate at temperatures up to 90° C. This temperature should not be exceeded by more than 5° C. at any time.

26 *Ventilation.* Examine ventilating openings to see that they are not restricting flow of air through motor. Remove unusual accumulation of dirt on housing, such as occurs in carpenter shops, etc. Do not permit any obstruction to air circulation around a motor.

27 *Unusual noises.* Locate cause of any unusual noise and take steps necessary to correct it.

28 *Electrical connections.* Make all electrical connections in a workmanlike manner and in accordance with the code for the service intended. Check electrical connections for conformance with National Electric Code. Check all wiring, switches, fuses, lugs, and joints for loose connections.

29 *Protection against moisture.* Make sure motor is shielded against drippings from sweating pipes or other sources. Do not obstruct free circulation of air around motor when correcting this condition.

30 *Motor mounting.* Insure that entire setting is secure and mounting bolts tight.

31 *Clean and blow out windings.* Blow dust from motors before it unites with water or oil to form a gummy substance. Wipe all dust from motor housings, slip rings, and commutators and blow dust from windings with a portable motor-driven low-pressure blower or with compressed air; do not use more than 40 pounds pressure. If neither is available, use hand bellows. Compressed air must be free from grit, metal, or moisture.

If oil or grease has worked its way into rotor or stator windings, report the motor as requiring thorough cleaning with solvent. Ordinarily, the motor must be returned to the shop for this operation.

32 *Generators.* Test stand-by electric generators at least monthly to check functioning of starting apparatus and to keep operators familiar with starting procedures. Check automatic-starting equipment, power change-over switches, and similar equipment to see that proper starting cycle is produced. Operate generator under normal load for 1 or 2 hours if possible. Observe any distress of generator, prime mover, or related equipment. Check for excess heating, lubrication, etc., as provided in preceding paragraphs. Make momentary starting checks *weekly* to make sure equipment is ready to operate.

32 *Storage batteries.* If storage batteries are used, check electrolyte for proper level and specific gravity. Check operation of charging equipment.

17. Disposition of Work Sheets

Completed inspection and maintenance work sheets are filed by the electrical supervisor until the information is entered on a permanent record. Special information on motors and generators is recorded on WD AGO Form 5–83 (par. 15). A complete summary of maintenance performed is entered on WD AGO Form 5–91 (par. 3*b*). After all information has been properly recorded on a permanent record, the work sheet may be destroyed.

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