operation
and
maintenance
handbook

Fluorescent and Mercury Vapor Lighting

Cleaning and Relamping

Maintenance Series Handbook MS-39

PREFACE

To economically prolong the light level required for good working conditions, a systematic method of cleaning, washing, and group lamp replacement must be followed. However, the factors which affect lighting efficiency vary from one building to another and also vary within parts of a building. It is not feasible to state an overall specific frequency for cleaning, washing, and lamp replacement.

The procedures prescribed in this handbook shall be put into effect in all buildings having fluorescent and/or mercury vapor lighting systems. The group replacement procedure is applicable to workrooms only and then only if each workroom area is over 10,000 square feet.

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FLUORESCENT LIGHTS

110 PRINCIPAL FACTORS IN LIGHT DETERIORATION

111 Age of Lamps

111.1 The calculated life of a fluorescent lamp, based on three burning hours per start, is 18,000 hours. When operated for six to 12 burning hours per start, the lamps may be expected to last from 22,000 to 26,000 lighting hours. In some of the newer buildings more powerful types of lamps have been installed in workrooms which have a calculated life of only 12,000 hours on three burning hours per start.

111.2 When fluorescent lights are turned on the wattage required to energize the transformers approximates the amount of power that would operate the lamp from 30 to 60 minutes. The frequency of starts also has an effect on the life of the lamp. Lamps should not be turned off unless it is expected that they will remain off for more than one hour.

111.3 Lamp efficiency or light output will decrease until the lamp has burned two-thirds of its expected life and will then stabilize until it burns out.

112 Lamp Failures

Based on three burning hours per start, lamp failures will begin at about 8,400 hours and by 18,000 hours approximately one-half of the lamps will have burned out, reducing the light output by 50% if the burned-out lamps are not replaced.

113 Dust and Dirt Accumulation

Dust and dirt on the lamps, reflecting surfaces, diffusion surfaces, and side panels of the fixtures, based on the amount of dirt being generated in an average building, may reduce light output after 4,000 hours about 25%, and at the end of 7,500 hours about 35%.

114 Combined Effect of Age, Failures, and Dust

If cleaning or replacement action is not accomplished on a regular and systematic basis the combination of age, failures, and dust could substantially reduce the light level in a short period of time.

120 KEEPING RECORDS

121 Maintaining Control by Areas

For purposes of control, buildings shall be divided into areas containing from 150-300 lamps. These areas should be ones in which similar functions are being performed and hours of occupancy are the same. Each area should be identified by a number or in some other manner.

122 Use of Form 4834

Set up a record card for each area to record cleaning, washing, and lamp replacements. This record will aid in determining the frequency in scheduling these various operations in each of the zoned areas. Use Form 4834, Fluorescent Fixture Maintenance Record, which can be requisitioned from supply centers. Exhibit 1 shows this adapted form with typical entries.

130 CLEANING AND WASHING

131 Introduction

131.1 WORK FORCE

Cleaning and washing shall be done by cleaning employees.

131.2 TYPES OF FIXTURES

The lighting in the workrooms can consist of a 4-foot or 8-foot, 2-tube fixture with or without louvers and also strip lighting may be present.

131.3 CHECKING LIGHT LEVELS

In large buildings it may be necessary to consult the regional maintenance staff to determine the light level to be maintained. At their discretion, light meter readings by qualified personnel may be authorized to check the light levels before and after cleaning and washing. In buildings over 50,000 square feet of interior area it would be beneficial to obtain a simple foot-candle meter for use in finding and eliminating lighting problems. The meter should not be used to determine minimum or maximum lighting levels, but only as a maintenance tool for lighting maintenance.

UNIT - FLUORESCENT FIXTURES	NUMBER	LOCATION & OFFICE	AREA NUMBER
2-Tube, P.G., 48", Louvered	150	2nd Floor - Rear	

PROCEDURE, STEPS, OR JOB	FRE-QUENCY	SCHEDULE WEEK OF YEAR	EST. MAN. HOURS HRS.	x	FREQ.	= TOTAL
CLEANING	12	4-8-13-17-22-26-31-35-39-44-48-52	.62	x	12	7.4
WASHING	4	5-18-31-44	22.2	x	4	88.8
RELAMPING		Incl. in washing		x		
OTHER				x		
			TOTAL			96.2

RECORD OF WORK DONE

DATE	1/27	2/4	2/23	4/1	5/5	5/11								
LABOR HOURS	.75	22	.5	.75	.75	.5								
JOB														
YEAR TO DATE	.75	22.75	23.25	24.0	24.75	25.25								

PROCEDURE (CONTINUE AS NECESSARY ON REVERSE)

[redacted]9131 882 - RRNT-22427

PS Form 4834 - Oct. 1972

FLUORESCENT FIXTURE MAINTENANCE RECORD

KARDEX U S PATENT NO. 2,527,901

Exhibit 1

132 Cleaning

132.1 DEFINITION

Dusting, damp wiping, or vacuuming of fixtures and lamps is defined as cleaning. The amount of dust is the basis for determining which method to use. However, a combination of these methods might be required.

132.2 FREQUENCY

Normally, fixtures and lamps should be scheduled for cleaning at intervals sufficient to maintain the required light level. Cleaning frequencies must be established in accordance with MS-47, Housekeeping-Postal Facilities.

132.3 DUSTING

.31 For light dust accumulation on side panels and tops of fixtures, the high dusting tool shall be used. This tool is a feather duster, Item C-1118, with a lightweight bamboo handle. Heights up to 20 feet can be reached from the floor without ladders, scaffolds, or platforms. The feathers on this tool pick up dust by electrostatic action when passed with a gentle, steady and continuous contact over the surface being dusted. When used in this manner, no dust will be dropped or scattered from the tool. When the duster becomes loaded with dust, it should be shaken out crisply in a trash container to unload the dust.

.32 For heavy dust accumulation, use treated dust cloths. The dusting is performed "in place" without the removal of the lamps or louvers. To get at the lamps, release one side of the louver and allow to swing free. Then dust all parts of the fixture and the lamps using straight strokes at all times. The louvers do not gather dust as fast as other surfaces of the fixture and therefore do not require frequent dusting.

.33 The use of vacuum dusting equipment greatly reduces the amount of dust dropped or scattered as may occur with a feather duster or treated cloths. The dust bag should be emptied as often as is necessary to maintain efficient operation of the machine. Dusting with vacuum cleaners requires more time than is allowed for feather dusting and is used only when other methods cannot be used and approval is given by the regional maintenance staff.

132.4 DAMP WIPING

Where the dust accumulation is likely to contain grease, a sponge dampened with a detergent solution is more effective than a treated cloth. A trial with both the treated cloth and sponge with detergent will indicate which is best under the particular conditions.

133 Washing

133.1 FREQUENCY

Wash the entire fixture when dusting or damp wiping methods do not restore the required light level. When group replacement of lamps is needed, try to schedule the replacement with washing of the fixtures. Wash only when there are a minimum number of personnel working in the area. No washing shall be done when personnel are working beneath the fixture.

133.2 BASIC WASHING PROCEDURE

a. Remove the louvers and tubes.
b. Wash the remainder of the fixture in place.
c. Wash tubes or replace with new tubes.
d. Wash and reinstall the louvers.

133.3 ALTERNATE WASHING PROCEDURES

.31 Procedure No. 1

Using a two-man team, one man on the lift platform or scaffold washes the fixture and the second man on the floor washes the louver in a portable tank having washing and rinsing compartments. This can also be done by one man alternately washing the fixture and when descending to move the platform, washing the louver before again ascending the platform. Extra louvers should be available to allow louvers to dry before being reinstalled.

.32 Procedure No. 2

In this procedure the louvers are taken to a central point to be washed and then returned to the location where the fixtures are being washed. It is necessary to have an extra supply of clean louvers at the start to replace the dirty ones being removed. The dirty ones are taken to the central point to be washed and made available as needed. In larger buildings with greater workload and more manpower, one man can wash the louvers at a central point and bring them to the man who is washing the fixtures. In smaller buildings where the workload is small and manpower is limited, one man can use this procedure by alternating the washing of the louvers and then the fixtures.

133.4 METHOD FOR WASHING FIXTURES AND TUBES

.41 Material and Equipment Needed

a. Powdered synthetic detergent.
b. Four natural sponges (two for washing, two for rinsing).
c. Two buckets (one for cleaning solution, one for rinse water).
d. Scaffold, lift platform, or safety platform ladder.
e. Roll of 1-inch masking tape.

.42 Sequence

a. Place the scaffold or other equipment so that the maximum number of fixtures can be safely reached from one location.
b. After mounting the platform, remove the louver and place it on the floor of the platform.
c. Remove the tubes and place them on the floor of the platform so that they will not be kicked while washing the fixture.
d. Cover the sockets with 1-1/2 by 1-inch strips of masking tape.
e. Pick up the wash sponges, one in each hand, and squeeze them out so that about a cupful of water remains in each. This will leave the sponges wet enough to wash with a sliding action instead of a pulling action. After some experience, the feel of the sponges will indicate when the proper quantity of water remains in them. With a sponge in each hand place one sponge on the outside surface of the side panel and the other sponge in the inside surface of the same panel. Move both sponges simultaneously toward the other end of the fixture. Grasp the other side panel of the fixture in the same mannner and move both sponges back to the end of the fixture from which started. If there is a top surface on the fixture make one stroke down the entire length. Turn the sponges over and repeat the entire process, two sides and top (if any). Place the wash sponges back in the bucket containing the cleaning solution.
f. Pick up the rinse sponges and squeeze them as dry as possible. Repeat the washing procedure with the rinse sponges but perform it only one time. Remove masking tape from sockets and save strips for reuse.
g. If the tubes removed are to be used again, they must be washed. Using a rag, pick up the tube, holding it about a third of the way from the end. Pick up a wash sponge with free hand and wrap it around the far end of the tube. Push the tube through the sponge till the hands meet. Move the rag hand to grasp tube on washed part above the sponge. Pull tube the rest of the way through sponge. This makes one continuous washing stroke the entire length of the tube.
h. Replace the tube in the sockets. Use the rag while handling the tube to prevent smearing. Repeat the tube washing process for each tube to be reinstalled in the fixture just washed.
i. Replace the louver. (The louver will have been washed as described in 133.5 by a second man on the floor or will be from a supply of clean louvers.)

.43 Time

See Chapter 4 of Handbook MS-47, Housekeeping - Postal Facilities, for unit of performance to wash a fluorescent light fixture.

133.5 METHOD FOR WASHING LOUVERS

.51 Material and Equipment Needed

a. Powdered synthetic detergent.
b. Two-compartment portable louver washing truck with drying racks.

NOTE: In small buildings where the expense of the tanks would not be warranted, two 55-gallon drums can be used, one for the wash solution and one for the rinse water. Large facilities may be eligible for automatic louver washers. See Publication 24, *Supply Catalog,* for ordering requirements.

.52 Sequence

a. Fill the first compartment about 3/4 full with warm water adding detergent at the rate of about two ounces per gallon of water.
b. Fill the other tank about 3/4 full with clear cold water for rinsing.
c. Dip the louver in the cleaning solution four or five times to provide agitation and a cleaning action.
d. Dip the louver in the rinse water two or three times.
e. Hang the louver on the rack to drip dry.

.53 Time

The elapsed time for this procedure (items c through e) is about one minute.

140 LAMP REPLACEMENT

141 Areas Other Than Workrooms Over 10,000 Square Feet

Spot replacement of lamps shall be made on an *as-needed* basis.

142 Workroom Areas Over 10,000 Square Feet

142.1 SPOT REPLACEMENT

Spot replacement of lamps shall be made until 20% of the lamps are spot replacements.

142.2 GROUP REPLACEMENT

When spot replacement of the lamps in an area reaches 20%, all the lamps in the area should be replaced. The best 20% of the lamps removed should be kept for future spot replacements in the same area. The lamps which are replaced should be destroyed. The cleanest and brightest lamps, checked while they are lighted, should be picked as *spares.* These *spares* should be marked with an identifying sticker when stored. If possible, the lamps kept to be used as spares should be stored in a separate bin for each area. When the bin becomes empty, it will automatically indicate that it is time for group replacement.

NOTE: At the postmaster's request, group replacement of any area may be stopped, and spot replacement used. The areas so changed must have sufficient light to prevent any problem or complaint on lighting level and no additional lighting fixtures will be installed in these areas to increase the lighting level without written permission from the regional maintenance staff.

142.3 SPARE LAMP USAGE

When making succeeding group replacements, none of the lamps with the identifying stickers from earlier replacement groups should be kept as spares.

CAUTION: Tubes should be kept in protective cartons until put into fixtures or until destroyed after removal.

143 Estimated Intervals Between Group Replacements

An indication of the probable interval between group replacement is shown in exhibit 2. Column 1 shows the number of hours the lamps will burn continuously without being turned off. Column 2 shows the number of hours per month the lamps would burn based on 30 workdays per month. Experience shows that 20% of lamps will be burned out when the lamps have reached about 80% of their rated life. Column 4 shows this 80% rated life. Column 5 shows the average number of months between relampings which is obtained by dividing column 4 by column 2. In leased or rented space, the ballast replacement is the responsibility of the lessor except in a few buildings where the Postal Service has assumed all maintenance obligations under the lease.

150 SAFETY PRECAUTIONS

151 Instructions to Employees

Employees performing replacement, cleaning or washing of fluorescent fixtures must be instructed in the basic construction features of the fixtures to avoid any accidents with electric current.

152 Use of Ladders

Safety platform stepladders, both folding and nonfolding, with guardrails must be used.

153 Use of Scaffolds or Platforms

Scaffolding or movable platforms must have a guardrailing around the sides.

154 Ballast Replacement

Ballast replacement in Government-owned buildings shall be accomplished by qualified electricians only. Electric current must be turned off when work is being performed.

155 Destruction of Lamps

See section 160.

160 DISPOSAL OF DEACTIVATED LAMPS

Care should be taken in the disposal of lamps. For disposal, deactivated lamps should be placed in

ESTIMATED INTERVALS BETWEEN GROUP REPLACEMENTS BASED ON NUMBER HOURS LAMPS BURN DAILY

(1)	(2)	(3)	(4)	(5)
Hours Per Day	Hours Per Month	Rated Lamp Hours	Times 80%	Estimated Interval Between Replacements (Months)
24	720	29,000	23,200	32.2
18	540	26,000	20,800	38.5
12	360	23,500	18,800	52.2
10	300	22,000	17,600	58.7
6	180	18,000	14,400	80
3	90	15,000	12,000	133.3

Notes: a. Column (2) = Column (1) times 30.
b. Column (4) = Column (3) times 80%.
c. Column (5) = Column (4) divided by Column (2).

Exhibit 2

cartons from which new lamps have been taken, and then placed in the trash. Hand and machine destruction of lamps is no longer required because poisonous powders are no longer present.

170 PROCUREMENT OF SUPPLIES AND EQUIPMENT

Obtain necessary supplies and equipment using established requisition procedures. Source documents for supplies are Publication 24, Supply Catalog and the GSA Supply Catalog.

CHAPTER 2

MERCURY VAPOR LAMPS

210 PRINCIPAL FACTORS IN LIGHT DETERIORATION

211 Age of Lamps

211.1 The calculated life of a mercury vapor lamp, based on five burning hours per start is 24,000 hours. As the burning hours per start increase to continuous burning, the life expectancy increases.

211.2 The frequency of starts also has an effect on the life of the lamp. Lamps should not be turned *off* unless it is expected that they will remain *off* for more than one hour.

211.3 Lamp efficiency or light output will decrease until the lamp has burned two-thirds of its expected life and will then stabilize until it burns out.

212 Lamp Failures

At about 35% of the rated hours of lamp life, 5% to 10% of the lamps fail, and at 95% of the rated life, 65% of the lamps will have failed. The light output of the system will be greatly decreased during this time if the burned out lamps are not replaced.

213 Dust and Dirt Accumulation

See section 113.

220 KEEPING RECORDS

221 Maintaining Control by Areas

For purposes of control, buildings shall be divided into areas containing from 80 to 120 lamps. These areas should be ones in which the same type of work is being performed and hours of occupancy are the same. Each area should be identified by a number or in some other manner.

222 Use of Form 4834

See section 122.

230 CLEANING AND WASHING

231 Introduction

231.1 WORK FORCE

Cleaning and washing shall be done by cleaning employees.

231.2 TYPES OF FIXTURES

The lighting in the workroom consists of single lamp fixtures.

231.3 CHECKING LIGHT LEVELS

See section 131.3.

232 Cleaning

Clean mercury vapor lamps by a method similar to that described in section 132.

233 Washing

233.1 FREQUENCY

See section 133.1.

233.2 WASHING PROCEDURE

a. Allow sufficient time after lights are turned off for bulbs to cool.
b. Disconnect light diffuser.
c. Wash bulb or replace with new bulb.
d. Wash fixture.

233.3 METHOD FOR WASHING FIXTURES AND BULBS

.31 Material and Equipment Needed

a. Powdered synthetic detergent.
b. Two natural sponges (one for washing, one for rinsing).

c. Two buckets (one for cleaning solution, one for rinse water).
d. Scaffold, lift platform, or safety platform ladder.
e. Roll of 1-inch masking tape.

.32 Sequence

a. Place scaffold or other equipment so that the maximum number of fixtures can be safely reached from one location.
b. After mounting the platform, disconnect the diffuser and allow it to hang.
c. Remove the bulb and place it on the floor of the platform in a place where it will not be kicked while washing the fixture.
d. Cover the socket with 1-1/2 by 1-inch strips of masking tape.
e. Pick up the wash sponge and squeeze it out until about a cupful of water remains. This will leave the sponge wet enough to wash with a sliding action instead of a pulling action. After some experience, the feel of the sponge will indicate when the proper quantity of water remains in it. Starting at the top, wash the inside of the fixture with continuous strokes. Turn the sponge and wash the outside of the fixture again starting at the top. Place the wash sponges back in the bucket containing the cleaning solution.
f. Pick up the rinse sponge and squeeze it as dry as possible. Repeat the washing procedure with the rinse sponges. Remove masking tape from sockets and place on rail.
g. If the bulb is to be used again, it must be washed. Using a rag, pick up the bulb by its base. Pick up wash sponge with free hand and wash bulb starting at the base and working out.
h. Replace the bulb in the socket, using the rag to prevent smearing while handling the bulb. Be sure bulb is completely dry to prevent electrical short circuits.
i. Replace the diffuser after washing it with the sponge.

.33 Time

The elapsed time for this procedure, including platform positioning, is approximately five minutes.

240 LAMP REPLACEMENT

241 Areas Other Than Workrooms Over 10,000 Sq. Ft.

Make spot replacement of lamps on an *as needed* basis.

242 Workroom Areas Over 10,000 Sq. Ft.

242.1 SPOT REPLACEMENT

Make spot replacement of lamps until 20% of the lamps have been replaced.

242.2 GROUP REPLACEMENT

See section 142.2.

243 Estimated Intervals Between Group Replacements

It is estimated that with 10 or more burning hours per start, a 100 to 1000 watt Mercury Vapor lamp will last about 24,000 hours. Assuming 30 working days per month, group relamping should occur after approximately 64 months, based on 80% of rated lamp life.

250 SAFETY PRECAUTIONS

See section 150.

260 DISPOSAL OF DEACTIVATED LAMPS

Take care in the disposal of lamps so that the public and others will not be exposed to any dangers.

APPENDIX A

TROUBLESHOOTING FLUORESCENT LIGHTING

Fluorescent lighting installations have common problems. This appendix shows some of the most common problems, their characteristics and possible causes, and the corrective action that should be taken.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
I LAMPS FAIL TO LIGHT	All	Blown fuse or open circuit breaker	Replace or reset as necessary. Search for possible short circuit in equipment or wiring.
	Preheat	Reset type starter not reset	Reset manual type. If automatic type, disconnect circuit or remove starter from socket for about one minute, then reconnect circuit. If starter cuts out again, see other POSSIBLE CAUSES in this section.
	All	Wrong lamps	Check ballast label, replace with correct lamp.
	All	Poor contact between lamp and sockets	Check to see if lamp is seated correctly. Gently twist lamp with recessed double contact bases to assure proper seating. Clean sockets thoroughly. Adjust or replace loose sockets. Replace sockets which are corroded, broken, or show evidence of arcing. Improper spacing and alignment of sockets may cause poor contact. Adjust or replace fixture.
	Trigger start Rapid start	Lack of correct cathode heat	In either of these systems, a lamp which has one or two blackened ends may not be receiving adequate cathode heating. This may be caused by poor contact, by problems within the ballast, by use of improper ballasts, wiring or low line voltage. These are discussed on the following pages. Different devices may be used to test cathode heater voltage. It is best to use a voltmeter with a lamp base attachment containing a resistor for a *dummy load* to draw the proper cathode current. Values of dummy loads and limits of cathode heater voltage can be obtained from USA Standards or lamp manufacturers. When a tester is inserted into a dirty or corroded socket, the contacts are often scraped clean enough to get a proper reading. Be certain that the contacts are in good condition and that the lamp was seated as well as the tester.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
I LAMPS FAIL TO LIGHT (Continued)	All	Normal end of life of lamps	Cathode coating is exhausted. This is characterized by dense end blackening extending from the end of the lamp along the lamp wall for two to three inches. Lamps may flash for a short period of time or appear to shimmer. Instant start lamps may swirl. The ends of a preheat lamp may flash on and off. If an arc occurs, it may be identified by a shimmering effect during the brief time it exists. In some two-lamp circuits, the good lamp may burn at reduced brightness, possibly damaging the cathodes. Also, both lamps may be out when only one has failed. Check each individually. Replace failed lamps promptly to avoid ballast damage. If a good lamp has burned at low brightness for some time or shows indications of being near the end of life, it should also be replaced.
	Preheat	Welded starter controls or shorted starter condenser	Generally indicated by a lamp glowing at the ends but not attempting to start. Test starter and replace if necessary. If lamp ends have been glowing and it starts immediately upon starter removal, replace the starter.
	Preheat	Starter at end of life	Check the starter in a properly operating adjacent fixture or check the circuit with one of the following: A new starter, a starter from a fixture operating normally, a dummy starter or a manual starter. A dummy starter can be made from an old starter by shorting the pins or leads. Insert it into the starter socket and remove when the lamp ends begin to glow. This should be repeated three or four times if necessary. If the lamp has not been starting, but does start on any one of these attempts, the trouble is in the previous starter and it should be replaced. A manual starter can be made by connecting a hand switch with approximately 12 inches of wire lead-in series with the two posts in a starter base. It is used in the same manner as the dummy starter except that the switch is opened rather than the base being removed from the socket.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
I LAMPS FAIL TO LIGHT (Continued)	All	Ballast not delivering minimum lamp requirements	All ballasts must properly limit the current flow in the lamp to a value within reasonable limits of the lamp rating. In addition, ballasts must provide sufficient current and starting voltage. These values can be found in USA Standards or obtained from lamp suppliers. To check, use appropriate ammeters and voltmeters. Replace ballast.
	Instant start Trigger start Rapid start	High humidity or accumulation of dirt on lamps	Remove, clean and replace lamps. If humid and dusty conditions prevail, it might be possible to enclose the lamps.
	All	Extreme ambient temperature (hot or cold)	Correct ambient if practical. Otherwise, change to a ballast rated for existing conditions.
	All	Voltage at fixture too low	Measure with proper voltmeter. Correct or use ballast rated for existing supply.
	Trigger start Rapid start	Inadequate starting aid	These systems require metal starting aids, at ground potential, in close proximity and running the length of the lamp. The fixture reflector generally serves as the starting aid. Provide proper starting aid. Requirements can be found in USA Standards or obtained from lamp manufacturers.
	All	Improper wiring	Determine if the wiring is in accordance with the diagrams on the ballast label. Check all connections to see that they are secure. Check the sockets for proper wire arrangement. Make sure that no short circuits exist such as caused by leads being in contact with the fixture.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
I LAMPS FAIL TO LIGHT (Continued)	All	Improper wiring (Continued)	There should be almost full line voltage between the black lead and metal fixture. Measure voltage across the lamp from the lampholder on one end to the lampholder on the other using a voltmeter with a 100 ohm per volt minimum input impedance. Be sure to measure across the two hot connections where only one connection at each end is hot. If there is low or no voltage, take readings at succeeding points back to the power line to determine the problem location. In some installations which require high open circuit voltages, in particular instant start lamps, an interlocking socket is used. This system requires that a lamp be inserted in the socket to complete the primary ballast circuit. Therefore, it is necessary to complete this circuit to obtain ballast output readings. In a preheat system both ends of one lamp should glow with a dummy starter installed. If not, or if in three or four attempts there is no effort to start when the dummy is removed, there could be an open circuit. If one end of each lamp glows, the wiring is crossed. In either case, check the wiring against the ballast label and make necessary corrections.
	All	Leak in lamp	Indicated by absence of fluorescent glow when lamp is exposed to a spark coil. Replace lamp.
	All	Blown protector within ballast	Check continuity of primary leads. (Note: Power must be turned off when using continuity tester.) If no continuity, replace the ballast. If ballast is replaced, refer to wiring diagram on new ballast. Often it is advisable to replace 40 watt preheat with 40 watt rapid start and instant start lead-lag with instant start series sequence ballasts.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
I LAMPS FAIL TO LIGHT (Continued)	Preheat Trigger start Rapid start	Open circuit in lamp electrodes	This may be caused by improper wiring, grounding, insufficient ballasting or broken lampholders. Any of these can cause a higher than normal voltage to be applied across the cathode. Other possible causes are transportation damage, poor welds, broken coils, and lamps with air leaks. Test with continuity tester or by connecting adjacent lamp contacts in series with a test resistance such as a 25 watt incandescent lamp on a 120 volt line.
	All	Short circuit within ballast	If one lamp is operating at full brightness and the other is out in a rapid start series sequence circuit, there is probably a shorted starting condenser. This can be determined by investigating continuity between the leads to the lamp that is out. If any two leads at opposite ends show continuity, there is a short circuit. Replace the ballast. See also *Ballast not delivering minimum lamp requirements,* page A-4.
	All	Ballast end of life	When ballast windings fail, the ballast will no longer supply lamp requirements. Insulation life is affected by time and temperature. Leaking compound, except for a small amount at the lead holes, which is normal, cracking or brittle insulation, and discoloration on the can are all indications of ballast approaching or having reached end of life. Many times, successive lamps seem to have short life in a particular fixture before it is realized that a ballast is not working properly. Check with continuity testers, voltmeters, and ammeters as shown in USA specifications and ballast manufacturers' publications. Replace the ballast.
II SLOW OR ERRATIC STARTING	All	Wrong lamps	See section I, page A-2.
	All	Poor contact between lamp and sockets	See section I, page A-2.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
II SLOW OR ERRATIC STARTING (Continued)	Trigger start Rapid start	Lack of correct cathode	See section I, page A-2.
	Preheat	Sluggish starter causing prolonged flashing at each start	Test starter in fixture known to be correctly operating. Replace starter.
	All	Ballast not delivering minimum lamp requirements	See section I, page A-4.
	Instant start Trigger start Rapid start	High humidity or accumulation of dirt on lamps	See section I, page A-4.
	All	Extreme ambient temperatures (either hot or cold)	See section I, page A-4.
	All	Voltage at fixture low or fluctuating	Measure with appropriate voltmeter. A recording voltmeter will be helpful if fluctuating voltage is suspected.
	Trigger start Rapid start	Inadequate starting aid	See section I, page A-4.
	All	Improper wiring	See section I, pages A-4 and A-5.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
III NEW LAMPS FAIL WITHIN THE FIRST FEW DAYS OF OPERATION	All	Wrong lamps	See section I, page A-2.
	All	Wrong ballast	Inspect to see if proper ballast is in use for the fixture and for existing environmental and electrical conditions. Check frequency rating and line voltage. Replace with appropriate ballast.
	Preheat	Reset type starter not reset	See section I, page A-2.
	All	Improper wiring	See section I, page A-4.
	All	Leak in lamp may develop so slowly that lamp operates satisfactorily for a short period of time	See section I, page A-5.
	Preheat Trigger start Rapid start	Open circuit in lamp electrodes	See section I, page A-6.
	All	Short circuit within ballast	See section I, page A-6. Replace ballast.
IV SHORT LAMP LIFE	All	Wrong lamps	Replace lamp with lamp type indicated on ballast.
	All	Normal failures	In a group of lamps, it is normal for some failures to occur early.
	All	Short burning cycle	The adverse effect on lamp life caused by turning lamps off and on frequently is actually more costly than allowing lamps to burn. A general rule is that if lamps are expected to remain off less than one hour, they should not be turned off.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
IV SHORT LAMP LIFE (Continued)	All	Poor contact between lamp and sockets	See section I, page A-2.
	Trigger start Rapid start	Lack of correct cathode heat	See section I, page A-2.
	All	Ballast not delivering minimum lamp require-ments	See section I, page A-4.
	All	Voltage at fixture too high or too low	If voltage is too high or too low, the cathodes will be damaged resulting in shorter lamp life. Check line voltage at fixture and correct supply as necessary, or use a ballast designed for the voltage being supplied.
	All	Wrong ballast	See section III, page A-8.
	Preheat	Wrong starter	Consult starter manufacturers' publications or package. Replace with correct starter.
	Preheat	Sluggish starter	Test starter in fixture known to be correctly operating. Replace starter.
	Preheat	Premature starting	The lead lamp in a two-lamp circuit is often prone to start before its cathodes are properly heated. Replace with starter designed to reduce this effect.
	Instant start Rapid start	Lamp operating in the glow state	When one lamp in a two-lamp series sequence circuit has failed, the other may burn at re-duced brightness, in a glow state. Replace failed lamps promptly.
	All	Improper wiring	See section I, pages A-4 and A-5.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
IV SHORT LAMP LIFE (Continued)	All	Open circuit in lamp electrodes	See section I, page A-6.
	All	Short circuit within ballast	See section I, page A-6.
V SNAKING, BLINKING, OR FLICKERING	All	Impurities within lamp	Occasionally the arc in a fluorescent lamp may swirl and twist within the lamp. This usually occurs in a new lamp and will disappear when the lamp has been operated a few days. Turning the lamp on and off may remedy this. If not, replace the lamp.
	All	Normal stroboscopic effect due to alternating current	Can be reduced by using warm colors, by operating on lead-lag circuits or by operating on three-phase power supplies.
	All	Poor contact between lamp and sockets	See section I, page A-2.
	All	Normal end of life of lamps	See section I, page A-3.
	All	Low bulb wall temperature	Low lamp wall temperature caused by adjacent air can cause flickering or blinking. Protect or enclose the lamp. Preheat lamp may be corrected adjusting adjacent air temperature or using proper thermal starter.
	All	Wrong ballast	If the ballast frequency rating is not the same as the line frequency, flickering may occur. Replace with correct ballast.
	Preheat	Wrong starter	Remove the starter while the lamp is lighted. If the flashing stops, the starter is the wrong size, or is defective. Replace it.
	Preheat	Sluggish starter	See Section II, page A-7.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
V SNAKING, BLINKING, OR FLICKERING (Continued)	Preheat	Starter not cycling correctly to properly preheat electrodes	Rapid blinking of lamp occurs. Test starter in adjacent circuit and replace.
	All	Ballast not delivering minimum lamp requirements	See section I, page A-4.
	All	Voltage at fixture too high or too low	Measure with suitable voltmeter and correct. See section IV, page A-9.
	All	Improper wiring	See section I, pages A-4 and A-5.
	All	Open circuit in lamp electrodes	See section I, page A-6.
VI REDUCED LIGHT OUTPUT	All	Normal maintenance	After the first 100 hours of burning, the output of fluorescent lamps will slightly diminish and generally be unnoticeable. Group relamping decreases the change in level of illumination which occurs when lamps are burned beyond rated life.
	All	Dirty lamps, fixtures or room surfaces	The lamps, fixture reflectors and louvers can accumulate a heavy coating of dirt over a period of time. Clean all, including floors, ceilings, and walls, if necessary.
	All	Change in room surfaces	Remodeling or refinishing can cause levels of illumination and change.
	All	Extreme ambient temperature (hot or cold)	See section I, page A-4.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
VI REDUCED LIGHT OUTPUT (Continued)	All	Ballast not delivering minimum lamp requirements	If the current in a lamp is lower than normal, light output will be reduced. See section I, page A-4.
	Preheat	Defective starter	If a lamp appears to remain in a low brightness state, there may be a defective starter. Replace starter.
	All	Voltage at fixture too low	See section I, page A-4.
	All	Improper wiring	See section I, pages A-4 and A-5.
VII CENTER OF LAMP DARK, ENDS LIGHTED	Preheat	Shorted starter condenser	See section I, page A-3.
	Preheat Trigger start Rapid start	Improper wiring	See section I, pages A-4 and A-5.
	Rapid start	Low bulb wall temperature	Under conditions of extreme cold, 1500 ma lamps may reach the point where the ends only are lighted and the center is dark. Correct ambient or enclose lamp.
VIII DARK AREAS OR SPOTS ON LAMP	All	Mercury condensation	Air currents can cause cool spots on the lamp wall which then will cause the mercury inside to condense at these locations. Cool spots can also be caused by close louvers or other heat conducting objects. Streaks may occur along the lower cooler part of the lamp. These can be eliminated temporarily by turning the lamp 180°. Dark spots may occur on new lamps. These will usually evaporate after the lamp has been burned for a while.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
VIII DARK AREAS OR SPOTS ON LAMP (Continued)			In dc operation, the current should be frequently reversed to prevent mercury from accumulating at the cathode end.
IX DARK ENDS (One or Both) (Continued)	All	Normal end of life of lamps	See section I, page A-3.
	Rapid start	Normal lamp design	Some lamp types have pressure control chambers at the ends and as a result, the ends appear darker than the center.
	All	Normal attrition of cathode coating	Gray or brownish bands may occur near the cathode. These have no effect on life or performance of the lamp.
	All	Wrong lamp	See section I, page A-2.
	All	Poor contact between lamp and sockets	See section I, page A-2.
	Rapid start Trigger start	Lack of correct cathode heat	See section I, page A-2.
	Preheat	Wrong starter	See section IV, page A-9.
	Preheat	Sluggish starter	See section II, page A-7.
	All	Wrong ballast	See section III, page A-8.
	All	Ballast not delivering minimum lamp requirements	See section I, page A-4.
	All	Low ambient temperature	In extreme cold, centers of lamp may be lighted and ends dark. The 1500 ma lamps may do just the opposite. Correct ambient or enclose lamp.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
IX DARK ENDS (One or Both) (Continued)	All	Voltage at fixture too high or too low	See section IV, page A-9.
	All	Improper wiring	See section I, pages A-4 and A-5.
	All	Open circuit in lamp electrodes	See section I, page A-6.
X DIFFERENCE IN LAMP COLORS	All	Normal maintenance	See section VI, page A-11.
	All	Wrong lamp color	Check labels on lamps which appear different to see that they are actually the same color. Replace with correct color.
	All	Range of manufacturing tolerances	If colors appear to vary to extreme, consult manufacturer.
	All	Variation in fixtures	Paints and plastics change color and often yellow with age. Dirty fixtures can also create differences.
	All	Variations in environment	Differences in ceilings, walls, floors, furnishings and additional sources of illumination can affect the appearance of the lamp color.
	All	Variations in temperature or air currents	See section I, page A-4, *Extreme ambient temperatures (hot or cold).*
	All	Voltage at fixture too low	See section I, page A-4.
	All	Improper wiring	See section I, pages A-4 and A-5.

TROUBLESHOOTING GUIDE FOR FLUORESCENT LIGHTING (Continued)

PROBLEM	SYSTEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
XI RADIO AND TELEVISION INTERFERENCE	All	Radiation from lamp to receiver antenna circuit	Tune the receiver to where maximum interference occurs, then turn off lamps. If interference ceases, the lamps are responsible. In not, look elsewhere. For 40 watt lamps, the receiver should be 10 feet away. If the receiver must remain within radiation range, proper grounding will eliminate the trouble.
	All	Radiation from electrical supply line to receiver antenna circuit	See next item, *Line feedback from lamp through electrical supply line to the receiver.*
	All	Line feedback from lamp through electrical supply line to the receiver	Feedback from the electrical supply line, as well as line radiation itself can usually be stopped by suitable filters installed at the fixtures or at centralized locations.
XII BALLAST NOISE	All	Normal ballast hum	Manufacturers rate their ballast from a noise standpoint beginning with "A" as the quietest. If necessary, replace with a ballast of quieter sound rating.
	All	Loose vibrating fixture components such as louvers, lenses, panels and ballast	Tighten or replace as necessary.
	All	Defective ballast	An indication of a defective ballast is an increasing hum. The defective ballast can be located by turning off sections of the installation and then individual fixtures. Replace ballast.

APPENDIX B

TROUBLESHOOTING GUIDE FOR HIGH INTENSITY DISCHARGE LAMPS

High intensity discharge lamps consist primarily of mercury and metal halide lamps. In general, installations having these types of lighting systems, will have similar problems.

This appendix shows some of the most common problems, their characteristics and possible causes, and the corrective action that should be taken.

TROUBLESHOOTING GUIDE HIGH INTENSITY DISCHARGE LAMPS

PROBLEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
I LAMPS FAIL TO START	Normal end of lamp life	Test the lamp in an adjacent fixture which is known to be operating properly. Series ballasts will occasionally extinguish the adjacent lamp if one is removed. Replace as required.
	Lamp loose in socket – improper insertion and seating	Inspect lamp base to see if there is any indication of arcing at the center contact button. Tighten lamp for proper seating. Check for distorted base. Replace lamp.
	Electric eye inoperative	To test, cover electric eye to block out light while power is applied to fixture. Replace electric eye.
	Defective or improper wiring	Inspect wiring to determine if it agrees with wiring diagram on the ballast label. Check connections for any looseness. Determine if correct wiring is being used. Repair circuit.
	Voltage at fixture too low	Input line voltage to ballast should be within 10% of nameplate rating. Check should be made when circuit is under full load. Correct voltage input.
	Improper or defective ballast	Make sure that ballast nameplate data agrees with the line voltage and lamp used. Improper ballasting will frequently cause lamp failure. A shorted ballast will generally cause seals at end of arc tube to rupture with a blackening in seal area. Replace ballast.
	Improper lamp operating position (Metal Halide only)	The operating position should agree with the lamp design. Correct position.
	Lamp has been operating; cool down time too short	H.I.D. lamps require from 4 to 20 minutes to cool sufficiently to relight.
	High restrike voltage (metal halide only)	This condition is peculiar to the metal halide lamp and does not occur with the mercury lamp. If the supply voltage to a metal halide lamp is interrupted during the warm-up period, the subsequent voltage required to restart the lamp may be higher than that required for a lamp that is at normal temperature. Allow time for lamp to cool.
	Improper ballast for lamp operating conditions	Under low temperature conditions, the ballast may not supply sufficient voltage to start the lamp. This can also occur at high temperature condition. Replace ballast.

TROUBLESHOOTING GUIDE HIGH INTENSITY DISCHARGE LAMPS (Continued)

PROBLEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
I LAMPS FAIL TO START (Continued)	End of ballast life	If ballast appears to be charred or the capacitors are swollen, check with appropriate testers. Replace ballast.
	Lamp defects, arc tube leaker, probe or cathode moly electrolysis, quartz devitrification around rod, open diode, open welds, diode or switch shorted	Replace lamp. NOTE: Arc tube leakers can be determined by using ohmmeter. All other defects can be determined by visual inspection of lamp.
II SHORT LAMP LIFE	Lamp physically damaged, outer bulb leaking, ring off	Investigate outer bulb for cracks. Check to see if bulb is broken where glass meets the base. Look for broken arc tube or loose metal parts. Bulb leaks will cause oxidation of metal parts. Replace lamp.
	Wrong ballast	Check line voltage and lamp to make sure they agree with nameplate data on ballast. Replace ballast.
III LAMPS FLICKER, GO OUT	Wrong ballast	With mercury lamps, improper ballasts can cause flickering or erratic operation. With metal halide lamps, this occurs during the start-up time. Wiring errors can also cause flickering. Under certain conditions new lamps may "cycle". Usually after three tries to start at 30 to 60 second intervals, lamps will stabilize and operate satisfactorily.
	High lamp operating voltage, low open circuit ballast voltage	Check lamp operating voltage. Measure ballast open circuit voltage. Replace as required.
	Variable voltage	Heavy loads from other sources can cause flickering during operation. Provide separate circuits for lights. Provide voltage regulators. Check for loose connections. Change type of ballast used.
	Hi-spike lamp	A defective lamp will sometimes require more voltage than the ballast can furnish, thus the lamp will extinguish. Cool and repeat the cycle. Replace lamp.
IV LAMP STARTS SLOWLY	Hard starter	Lamp may glow for extended periods of time destroying the cathodes. Check voltage and ballast. Replace lamp.
V FUSES BLOW OR CIRCUIT BREAKERS OPERATE ON LAMP START-UP	Overloaded circuit	Rewire to meet requirements of starting current of lamp and/or ballast combination.
	High momentary transient current	Possibly caused by reactor or auto-transformer ballasts which draw high initial currents. Use time delay elements to protect circuits. If these fail, change ballast.

TROUBLESHOOTING GUIDE HIGH INTENSITY DISCHARGE LAMPS (Continued)

PROBLEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
VI REDUCED LIGHT OUTPUT	Normal light depreciation	Check to see if lamp is functioning within normal range of burning time. If not, proceed through balance of this section. Replace lamp.
	Incorrect ballast	Compare ballast and lamp rating to see if they are compatible.
	Incorrect voltage	Check line voltage, wiring connections and socket points.
	Incorrect ballast output	Determine if ballast output conforms to lamp requirements. If voltage and current do not stabilize in 5 to 10 minutes warmup time, ballast output is incorrect and adjustment should be made. Adjust or replace.
	Dirt accumulation	Check and clean lamp and luminaire. Establish maintenance program.
VII ARC TUBE BECOMES BLACKENED OR SWOLLEN EARLY IN LIFE OF LAMP	Overwattage operation, improper ballasting	Check to see if lamp is operated on ballast designed for higher wattage lamp. Check ballast nameplate against lamp etch. Replace ballast.
	Excessive current or voltage, shorted capacitor(s)	Check ballast voltage. Determine if there are current or voltage surges. Check for shorted capacitors and replace ballast if required.
	Reflector problem	Reflector may refocus energy on arc tube causing it to overheat. Test luminaire if suspected.
	"Glow State" operation	Under certain lamp and/or ballast conditions, the lamp will go into partial discharge (dim blue glow) which will darken arc tube and cause short life. Replace lamp and check ballast.
VIII LAMP BREAKAGE OCCURS	Scratched glass bulb	Improper luminaire handling. Make sure that socket does not contact neck of bulb causing scratches in glass.
	Improper insertion	Screw into socket until firm contact is made.
IX DIFFERENCE IN LAMP COLORS	Normal maintenance	A color change can occur as lamps age. Spot replacement may show noticeable differences in lamp colors. Group replacement minimizes this problem.
	Wrong lamp color	Check etch on lamps to determine if they are the same color. Replace with correct color of lamp.

TROUBLESHOOTING GUIDE HIGH INTENSITY DISCHARGE LAMPS (Continued)

PROBLEM	POSSIBLE CAUSE	CORRECTIVE MAINTENANCE
IX DIFFERENCE IN LAMP COLORS (Continued)	Range of manufacturing tolerances	H.I.D. lamps may have slight color differences caused by variations in the quantities of materials in the arc tube. Interchange of lamps may minimize this effect.
	Variations in luminaires	Variations in the surface or finish of the reflectors and/or lenses may cause color differences. Fixture cleanliness will also affect colors.
	Variations in environment	Color differences in floors, ceilings, walls and furnishings, as well as other illumination sources, can affect the appearance of the lamp color.