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Temperature Measurement on Operating Recessed Lighting Fixtures

P. Michael Fulcomer

Product Safety Technology Division
Center for Consumer Product Technology
National Engineering Laboratory
National Bureau of Standards
Washington, D.C. 20234

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U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, *Secretary*
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SI CONVERSION UNITS

In view of the present accepted practice in this country for building technology, common U.S. units of measurement have been used throughout this document. In recognition of the position of the United States as a signatory to the General Conference on Weights and Measures, which gave official status to the metric SI system of units in 1960, assistance is given to the reader interested in making use of the coherent system of SI units by giving conversion factors applicable to U.S. units used in this document.

Mass	1 pound - mass (lb_m) = 0.4535924 kg
Length	1 inch = 0.0254 meter (m)
Temperature	t (Celsius) = 5/9 [t(Fahr) - 32]
Torque	1 lbf · in = 0.113 newton meter (Nm)
Time	1 hour = 60 minutes = 3,600 seconds

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ABSTRACT

Potentially hazardous temperatures may result from adding thermal insulation in the attic above recessed incandescent lighting fixtures. The National Electric Code for 1978 specifies that ". . .thermal insulation shall not be installed within three inches of a recessed fixture enclosure, wiring compartment or ballast and shall not be so installed above the fixture as to entrap heat and prevent the free circulation of air. . ." The purpose of this investigation was to determine the effectiveness of various protective barriers in maintaining the requisite three-inch spacing and in preventing over-temperature conditions when loose-fill insulation is installed around recessed lighting fixtures.

For the devices tested, the results indicate that properly installed open-top barriers are sufficient to allow the fixture and associated branch circuit wiring to operate within specified ratings. However, a barrier closed at the top by any method, can cause branch circuit wiring, the external surface of the barrier and/or parts of the fixture to operate at temperatures above those designated as "safe".

Key Words: Recessed incandescent lighting fixture; thermal insulation; hazardous temperatures; protective barrier; branch circuit wiring; electrical junction box; load current; thermocouple.

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Introduction

Rising utility rates and the decreasing supply of available energy have resulted in efforts to make both new and existing homes more energy efficient. For many older homes, one of the most cost effective ways to reduce energy consumption is to increase the depth of thermal insulation in the attic. When energy was cheap and plentiful, the extra cost of increased insulation was greater than the cost of energy saved over a considerable period of time, but this is no longer true. Accordingly, insulation is now an attractive means of saving energy economically. Unfortunately, the addition of thermal insulation over the electrical wiring and lighting fixtures of older homes may cause problems related to the safety of the household electrical system.

The Consumer Product Safety Commission (CPSC) is currently investigating various aspects of this household electrical system safety problem. This report is based upon work funded by CPSC to address one facet of the problem. Potentially hazardous temperatures may result from adding thermal insulation in the attic above recessed incandescent lighting fixtures. The National Electrical Code (NEC) for 1978 specifies that ". . .thermal insulation shall not be installed within three inches of a recessed fixture enclosure, wiring compartment or ballast and shall not be so installed above the fixture as to entrap heat and prevent the free circulation of air. . ." This study was concerned with the effectiveness of various protective barriers in maintaining the requisite three-inch spacing and in preventing over-temperature conditions when cellulose loose-fill insulation is installed around recessed incandescent lighting fixtures. A companion report, entitled Temperature Measurement on Operating Surface Mounted Lighting Fixtures, NBSIR79-1912, concerns potentially hazardous temperatures which may result from adding thermal insulation in the attic above surface mounted incandescent lighting fixtures.

Test results presented herein indicate that properly installed open-top barriers are sufficient to allow recessed fixtures and associated branch circuit wiring to operate within specified ratings. However, a barrier closed at the top by any method, can cause branch circuit wiring, the external surface of the barrier and/or parts of the fixture to operate above their rated "safe" temperatures.

General Method

To determine representative temperatures that occur in barrier-protected recessed lighting fixtures, three such fixtures were individually installed in a controlled environment mock-up of a ceiling complete with an overlying attic section. Cellulose loose-fill insulation was placed in the attic portion, but kept at least three inches away from hot surfaces of the

lighting fixture by one of three different barrier devices. Each lighting fixture was tested with each of the three barrier devices. Temperatures were recorded at various points on the barrier device, the fixture, the fixture mounting hardware and on the fixture and supply wires.

The pertinent steady state temperatures obtained for each fixture are included in chart form with this report, along with dimensional diagrams showing the relationship of each fixture to the barriers that were used around it.

Test Assembly Description

The test assembly consists of a 4 foot by 4 foot section of 1/2 inch sheet rock ceiling nailed to 2 X 6 inch wood joists spaced 16 inches on center. The lighting fixture was placed equidistant between joists in the center of the test assembly using standard hardware. To reduce convective heat loss due to higher than normal air flow in the laboratory, the test assembly includes sides which extend 16 inches above the ceiling and 24 inches below the ceiling.

Supply wiring to the fixture is non-metallic sheath cable with two #14 copper conductors and a separate ground (type NM, 14-2 copper with ground). Wiring is such that the cable carrying branch circuit current passes through the junction box into which the light fixture is connected. The method by which each fixture was connected into the branch circuit is discussed in the following section.

Lighting Fixtures Description

Dimensional diagrams of the three lighting fixtures tested are shown in figure 1. Fixture A is rated for a 150 watt lamp, fixture B for a 75 watt lamp and fixture C for a 100 watt lamp.

Fixtures A and C are prewired units which means that branch circuit supply wire rated for 60°C can be (and was) connected directly into the electrical box supplied as part of the fixture. Higher temperature fixture wire connects this box to the lamp socket. Fixture B requires a separate junction box (not supplied with the fixture) for connection to the branch circuit supply wire.

For fixture A, the frame, electrical box, B (see figure 1), and lamp socket assembly, S, form a permanently connected unit. The box is mounted on the fixture frame with the floating socket assembly connected to the box by a flexible metal cable through which the fixture wire runs. The frame assembly contains a hole into which a separate reflector, R, is to be inserted. This frame assembly is mounted above the ceiling over a hole which matches the one in the frame. The socket assembly is then pushed down through the hole and mounted on the reflector in either the high or low position, and the reflector then pushed up into position above the ceiling. A trim assembly (the glass bezel, louver or other enclosure visible from below the ceiling) is then added below the reflector. The

reflector can be removed from the frame and interchanged with other reflectors and trim assemblies designed to achieve a distinctive lighting effect.

The maximum wattage lamp to be used in this fixture is specified according to socket assembly position for certain reflector-trim combinations. Access to the electric box is gained from below with the reflector removed.

Preliminary tests were run on this fixture to determine the combination of parts which produced the highest temperatures. This is discussed further in the Results Section of this report. At this point it suffices to say that the highest temperatures under rated conditions were obtained with the socket mounted in its high position and a "pin-hole" trim assembly attached into the reflector from the ceiling side. This trim assembly has a blackened interior shield (not visible from below) surrounding a two-inch diameter central hole through which the light is emitted.

The spacing between electric box and reflector in this fixture (see figure 1) is insufficient to allow a barrier which is three-inches from the reflector to pass between the box and the reflector. Thus, the electric box must be located inside the barrier.

Fixture B is of a type generally known as a "high hat." The box, B, on top of this fixture is not intended for connection of 60°C rated household supply wiring and such connection was not made for our tests. However, if 60°C rated wire were connected into the box, B, contrary to the installation instructions which accompany the fixture, this could result in badly overheated supply wiring. (See the Results Section.)

Supply connections for fixture B were made in a separate junction box located 18 inches from the fixture. Wire rated for 150°C was connected from this box through a flexible metal conduit to a connection with lamp socket fixture wire in the box, B, located above the reflector. Six feet of the 150°C rated wire was supplied with the fixture, but the flexible metal conduit was not. A piece of BX cable from which the original wires had been removed was used. In order to replace the fixture, access to box B is gained by releasing three retaining clips and pulling the fixture down through the ceiling.

Fixture C is a prewired unit with connection between box B and lamp socket S achieved with high temperature wire protected by a 3/8 inch diameter rigid metal tube. The reflector R is removable for access to the electrical box B from below. The lamp in this unit is mounted horizontally.

The spacing from box to reflector for this fixture permits a barrier three inches from the reflector to pass between the box and reflector.

Barrier Description

The three barriers tested, X, Y and Z, are commercially produced items sold expressly for the purpose of keeping insulation at least three inches away from recessed lighting fixtures.

Barrier X consists of four asbestos panels, 12 X 16 X 1/8 inches thick, assembled with eight metal clips to form an open ended box. Either the 12 inch or the 16 inch dimension can be placed vertically depending on how the box is put together, but the clips are so designed that 12 inch vertical panels cannot be mixed with 16 inch vertical panels in the same box. The clips will, however, permit shorter box dimensions than the panel width (12 or 16 inches) by extending sides beyond the corners. (See diagram B-X of figure 1.) This barrier is heavy enough to remain in place without staples or tape.

Barrier Y is cut to size from a 14 inch wide by 24 foot long roll of 30 gauge aluminum which is a yellow color on the exterior side. Bending locations are provided every two inches along the roll. Since two inches of the overall height are designed as fold-out tabs for stapling or taping the barrier in place, the finished height of the barrier is only 12 inches. Six metal clips are supplied in a separate plastic bag, two of which are used to clip the cut ends together to form the barrier. Cutting can be done with tin snips or a large pair of shears. The resulting edges are sharp. This barrier has very little weight and must be taped or stapled in place.

Barrier Z is a 26 gauge galvanized sheet metal box which comes in two sizes. The smaller is 11 inches high and 14 1/2 inches square, while the other is a rectangle 11 inches high, 14 1/2 inches wide and 20 inches long. Barrier Z is made to fit over and completely enclose the recessed light fixture. The box is heavy enough so that it need not be held in place by staples or tape.

Barrier Installation

Although barrier Y was the easiest to customize to a particular fixture, installation problems were encountered with each of the barriers. Instructions which accompanied each barrier are reproduced in Appendix A.

Because of flexibility limitations with barrier X, the required three inch spacing between the barrier and the light fixture enclosure could not be achieved for either fixture A or C (see diagrams A-X and C-X of figure 1). This barrier will not fit between joists with its 16 inch dimension horizontal and the barrier cannot be assembled with its sides of different heights. The 1/8 inch thick asbestos panels are difficult, if not dangerous, to cut, so that the barrier could be installed only with the 12 inch dimension horizontal. This dimension was not sufficient to provide the required spacing except for fixture B.

Since barrier Y is relatively lightweight, it had to be stapled or taped in placed to insure that barrier to fixture spacing would remain constant. This was sometimes awkward, and always time consuming.

Barrier Z was sometimes difficult to install in between the joists--particularly where a supply wire happened to pass through a hole in the joist in an area to be occupied by the barrier. In such instances, the sides had to be bent inward to provide space for the supply wire.

Installation of any of the barriers requires the cutting of notches for the supply wiring to pass through. Barrier Y is the easiest to cut, but modification (notching) of all three models requires tools that insulation installers may not normally carry. Barrier Y can be cut with shears, but heavy duty tin snips are required to cut barrier Z. Small sections of barrier X can be broken out with pliers or similar tools. If it is not notched, barrier Z is the most likely to damage non-armored supply wire because of the barrier weight and relatively sharp lower edge.

The location of the electrical junction box relative to the barrier is not addressed in any of the installation instruction furnished with the barriers. This is perhaps due to the fact that the National Electric Code is rather ambiguous on this point. Section 370-19 of the 78 code states that "junction, pull and outlet boxes shall be so installed that the wiring contained in them can be rendered accessible without removing any part of the building. . ." This probably does not preclude having to gain access to the attic and then dig through whatever insulation is installed in order to gain access to the fixture supply wire connectors. Some local jurisdictions may have other requirements, of course. In any event, placing the electrical junction box outside the barrier, as was necessary when barrier X was used with fixture C, can present significant problems should changing of the fixture subsequently become necessary or desirable. Electrical connections are not available from below unless the barrier is removed; once removed, the barrier would be extremely difficult (if not impossible) to replace in its original location and yet have all the loose fill insulation outside the barrier.

Once a barrier is installed, there is the practical problem of introducing loose fill attic insulation without allowing the insulation to fall inside the barrier or to completely bury it. In Northern latitudes where insulation depths of up to 16 inches are recommended, the problem could be particularly acute: the heights of barriers Y and Z are only 12 and 11 inches, respectively.

Insulation can be kept outside the barrier during insulation installation by blocking the barrier top, but this blockage must be removed when the job is finished. Access to the barriers will be difficult if the joists, walking planks, etc. are buried under 8 to 10 inches or more of loose fill insulation. One solution is to remove the lighting fixture reflector and push the blocking cover off from below, but this requires that non-electricians dismantle parts of the electrical lighting fixture. This procedure will not succeed in removing insulation which gathers on top of barrier Z.

Testing Procedures

Rated lamps were installed in each fixture. Lamp current and voltage and branch circuit load current (if any) were monitored by means of transducers connected into the test set-up. Supply voltage was initially adjusted so that the particular lamp installed would dissipate the power for which it was labeled. This adjusted voltage was then held constant by an ac voltage regulator.

Each lighting fixture was tested with each of the three barrier devices. In addition, the two pre-wired fixtures, A and C were tested both with and without an external 15 ampere load on the branch circuit wiring. This was done to determine what effect the added current might have on the temperature of branch circuit wiring which enters the fixture junction box. Fixture B was not tested with an external load because the branch circuit wiring was connected into a junction box located over 18 inches away from the fixture and separated from it by thermal insulation.

Cellulose insulation meeting Federal Specification #HH-I-515C, Type 1, Class 25, was installed in the attic to a depth of between 11 and 16 inches depending on the height of the barrier device being used. Testing was done with the barrier uncovered at the top and for one or two covered conditions. Barriers X and Y were tested with cardboard over the top and again with fiberglass batts equivalent to R22* over the top. The cardboard used was 3/32 inch thick. Barrier Z was tested in two conditions: with no insulation covering its top metal surface and with 4 inches of cellulose loose fill covering this surface. Both size configurations of barrier Z were checked with fixture C to determine what effect box size has on the various temperatures measured.

When light fixtures and/or barrier devices had to be changed, sufficient insulation was removed with a large shop vacuum to allow the exchange to take place. After the exchange was completed, the removed insulation was replaced into the attic around the barrier.

Temperatures were recorded at various points on (1) the barrier device, (2) the fixture, (3) the fixture mounting hardware, (4) the supply wire and (5) the fixture wire by means of 30-gauge chromel-alumel thermocouples connected to a programmable data logging device. The thermocouples were held in place by teflon tape, .003 inches thick, installed so that the thermocouple bead was in contact with the subject surface and no more than partially covered by the tape.

The data logging device contained 40 input channels, 20 for each of two simultaneous tests. Of the 20 channels, two were assigned to monitor lamp voltage and current, one to record branch circuit load current in excess of the lamp current, and the remaining 17 to monitor temperatures. Three ac to dc transducers were used to change ac voltage and current readings into the low voltage dc accepted by the data logger.

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*Because of the limited time available for testing, two layers of available R-11 insulation batts were used rather than waiting to obtain the specified R-19.

Of the 17 temperature monitored points, six were located on the barrier, four on the enclosed fixture, one in the electrical box, one at the junction of fixture mounting hardware and the wood joists, one on the lamp socket and three on the fixture and supply wires. One channel was assigned to monitor ambient room temperature. Initially ambient temperature both above and below the test ceiling were monitored, but since variation from room ambient was insignificant, one of the channels was assigned elsewhere.

More precise information on thermocouple locations for each fixture/barrier combination tested is included in the left hand column of the data sheet for that fixture. The plan view locations of thermocouples on each barrier are shown by small circles in the diagrams of figure 1. Two or more thermocouples were often attached at the same horizontal coordinates, on the barrier, but at different heights above the ceiling. For this reason, most of the plan diagrams have only one or two places marked on the barrier for thermocouple measurements. Where more than one horizontal location was used, a letter next to the circle in the plan diagram corresponds to the same letter notation on the respective data sheet to indicate horizontal position of the thermocouple on the barrier.

The data logging device was programmed to monitor voltage, currents, and temperatures every 15 minutes. Each test was continued until none of the recorded temperatures changed by more than 1°C in 3 hours or until a reliable prediction could be made of the final steady state temperatures. With open top barriers, tests that were started with all points at room ambient required 2 to 3 hours before temperatures reached steady state values. With barriers closed at the top by R22 insulation, this time ranged from 6 to 9 hours.

A return to room ambient conditions was not always required between tests. Tests proceeded without a cool-down cycle if temperatures in the following test would be equal to or higher than those in the preceding test. Examples of this are when an external 15 ampere load is added without changing the barrier configuration, or when the barrier top is covered following an open top test. A short cool down cycle was used when a reduction of some temperatures might be expected under the new conditions. An example of this is when a no load, cardboard covered barrier test follows an uncovered test on the same barrier, but with a 15 ampere external load on the supply wiring. In this case, the decrease in supply wire temperature when the load is removed may more than offset the increase due to the cardboard over the barrier.

Results

The steady state temperatures recorded for each light fixture under the various testing conditions are listed in tables 1, 2 and 3. Table 4 is an extraction and compilation of this data to show temperatures at four critical locations (one location is shown under two different conditions) for each light fixture/barrier combination tested and for each of the

different barrier top conditions under the specified combination. All listed temperatures have been corrected for an ambient of 20°C*. Temperatures exceeding the limits specified for each location are circled in table 4.

The four critical temperature locations noted in table 4 and the limiting temperatures at each location are:

1. Outer surface of barrier device--90°C maximum. Section 410-65(a) of the 78 NEC states that "fixtures shall be so constructed or installed that adjacent combustible material will not be subjected to temperatures in excess of 90°C."

2. Supply wire insulation--60°C maximum. Household branch circuit wiring is normally of the type rated for 60°C. Since the temperature of the wire increases if there is an external load on the branch circuit, both no load and load conditions were tested and are recorded in table 4.

3. Fixture wire insulation--150 to 200°C maximum. Fixture wire is normally rated for 150°C maximum and was so rated for fixtures B and C. Fixture A uses wire rated for 200°C maximum.

4. Fixture enclosure--150°C maximum. According to the Underwriters' Laboratory Standard for Safety for Electric Lighting Fixtures, UL57, August 15, 1977, no point on the outside of a recessed lighting fixture enclosure should exceed 150°C in temperature.

The data contained in table 4 provides the basis for statements in the Summary section.

Temperatures measured in the electric box mounted above the reflector of fixture B did not exceed the rating of the fixture wire intended to be used in this box. However, loss of, or failure to follow the light fixture installation instructions could result in connection of 60°C rated branch circuit wiring into this box. Since the 99° to 150°C temperatures recorded in this box under various conditions of operation far exceed a 60°C wire rating, such connection could result in very unsafe operating conditions.

Fixtures A and B, in addition to being tested under different barrier conditions, were also tested under different fixture conditions for the same barrier arrangement. This was part of an effort to determine a worst case condition for each fixture. This information is included in tables 1 and 2, respectively.

Three variations were tried with fixture A. In one, the socket assembly was placed in the "low" position on the reflector while still using a 150 watt lamp and pin hole trim assembly. The manufacturer's

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*Room ambient temperature sometimes varied plus or minus a few degrees from the desired 20°C. In such cases, this difference was either added (if the ambient was less than 20°C), or subtracted (if the ambient was greater than 20°C) from the actual reading to arrive at the temperature listed in the table.

catalog indicates that a lamp of 75 watts or less should be used under these conditions. Temperatures on the mounting hardware and lower portions of the open-topped barrier were about 6°C higher with the socket assembly mounted in the "low" position. Even though this configuration produced slightly higher temperatures, it was not used in obtaining data for this fixture because it represents an over-rated condition.

A second variation involved the use of a fresnel lens trim assembly and associated reflector. This arrangement provided a closed assembly on the bottom, but the reflector contained two 1/4 inch wide by 1-1/2 inches long slots designed to accept the fresnel lens mounting hardware. With an open top barrier, all temperatures were 1 to 2°C lower with the fresnel lens assembly installed in place of the pin hole trim assembly. With a covering of R22 over the barrier, temperatures with the fresnel lens assembly installed were 5 to 10°C lower than with the pin hole trim assembly under similar conditions.

The third variation was conducted with a 150 watt reflective flood lamp in place of the normal 150 watt lamp. This lowered temperatures at all locations from 5 to 20°C with an open top barrier.

For fixture B, substitution of a 75 watt reflective flood in place of the regular 75 watt lamp lowered temperatures on the open topped or cardboard covered barrier about 3°C. Temperature decreases on the fixture surface were much more dramatic, ranging from 15 to 20°C.

Summary

These test results indicate the following:

1. Properly installed open-topped barriers are effective in maintaining the three inch spacing between thermal insulation and the light fixture enclosure.

2. The three inch clearance requirements of the NEC, as provided by the open-topped barriers, are sufficient to allow these fixtures and associated branch circuit wiring to operate within their specified temperature rating.

3. Barriers in which the air flow is restricted by covering the top can cause branch circuit wiring, and in some cases, fixture wiring to operate above their rated "safe" temperatures.

4. The branch circuit wiring was always the first item to exceed its rating.

5. When a barrier is closed on top by a layer of insulation, temperatures on the exterior surface of the barrier can exceed the 90°C limit specified by the National Electric Code, and temperatures on various parts of the fixture itself can exceed the

150°C limit required by Underwriters' Laboratory Standard for Safety for Electric Lighting Fixtures (UL-57).

6. Fixtures rated for and operated with lower wattage lamps provide a wider margin of safety than do fixtures rated for and operated with high wattage lamps.

7. Significantly lower maximum temperatures are observed as the volume enclosed by a barrier increases.

Comment

If limited to lower wattage fixtures (or to higher wattage fixtures using less than rated lamps), closed top barriers not covered with insulation could possibly provide safe operating conditions if: (1) connecting branch circuit wiring were of a higher temperature rating, and (2) the total volume enclosed by the barrier were larger. Increasing barrier height is one method of achieving the latter; this would in turn alleviate another potentially serious problem--the burying of the barrier under insulation.

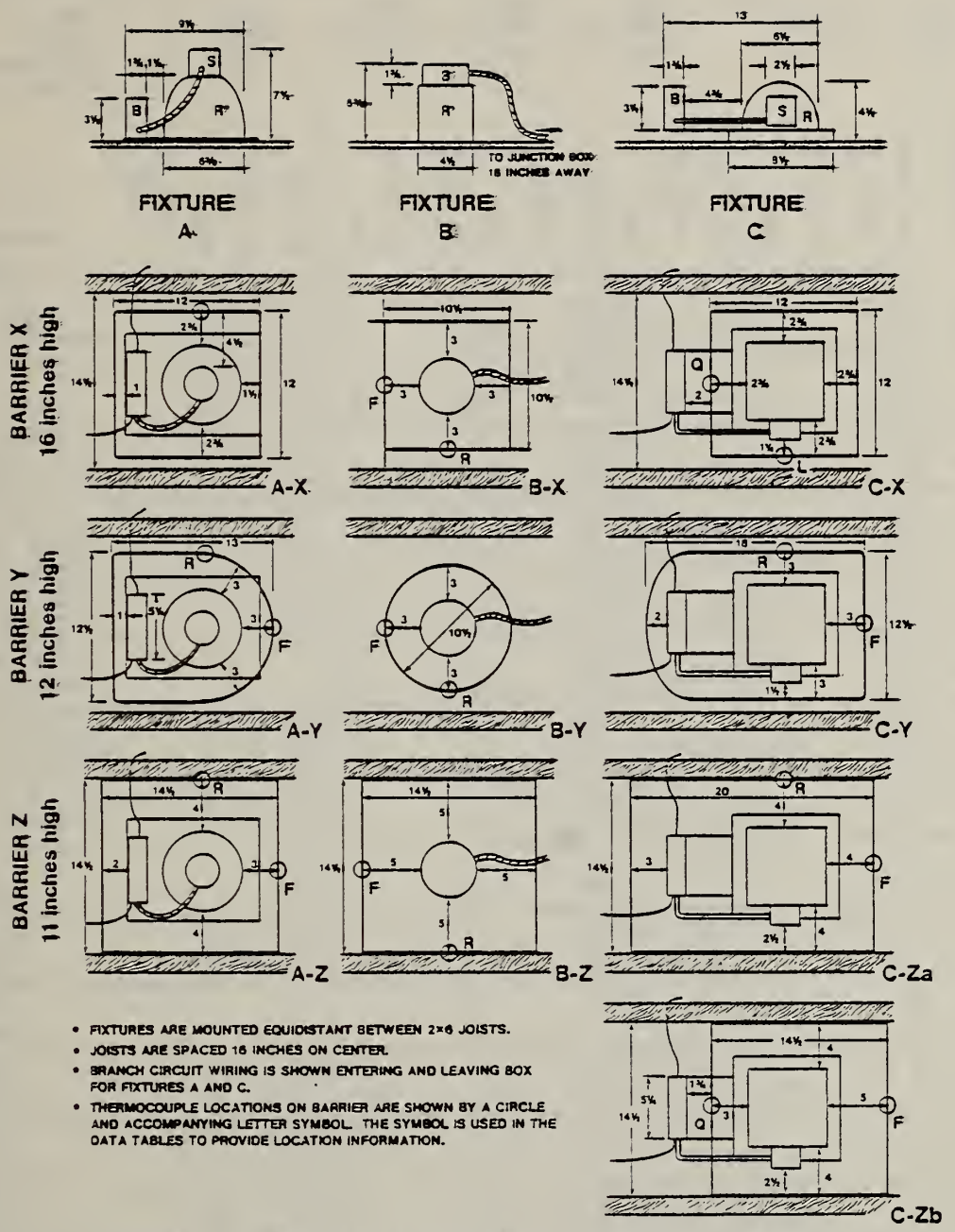


Figure 1. Dimensional Diagrams of Each Lighting Fixture and of the Various Light Fixture/Barrier Configurations Tested.

TABLE 1. TEMPERATURE DATA FOR FIXTURE A

Fixture rated for one 150 watt lamp with adjustable socket in "high" position.

Temperatures in °C are listed on the data sheet. Readings have been corrected for an ambient of 20°C. Top reading made with 15 amp additional load on supply wiring. Bottom reading made with no additional load.

Lamp Trim Socket Position Barrier Top Condition Thermocouple Location	150W Pinhole High X Open	Cardboard	R22 batt	150W Pinhole Low X Open	Cardboard	R22 batt	150W Fresnel lens High X Open	Cardboard	R22 batt	150W Pinhole High Y Open	Cardboard	R22 batt	150W Flood Pinhole High Y Open	Cardboard	R22 batt	150W Pinhole High Z Bare metal	4" loose fill over metal
Fixture Wire. 1/4 inch from socket	135 135	155 155	191 188	 134	 	 	 135	 183	187 183	136 137	 158	 193	 111	 	 	199 198	 220
Socket. On metal clip	139 139	157 157	193 190	 138	 	 	 140	 186	189 186	141 141	 160	 195	 133	 	 	217 216	 235
Supply wire. Inside junct. box	49 33	87 71	118 97	 36	 	 	 31	 86	107 86	51 34	 71	 103	 29	 	 	111 95	 124
Junction box, B. Inside top center	41 33	80 73	112 101	 36	 	 	 31	 89	100 89	45 35	 73	 106	 30	 	 	106 97	 128
Supply cable casing. 1/2 inch from box	43 31	81 70	115 97	 31	 	 	 30	 87	102 87	48 31	 70	 103	 29	 	 	106 93	 123
Socket housing, S. Outside top center	 	 	 	 96	 	 	 95	 149	153 149	99 97	 130	 167	 79	 	 	161 160	 184
Socket housing, S. Outside side center	92 92	125 124	161 159	 91	 	 	 90	 146	150 146	 91	 123	 158	 74	 	 	161 160	 184
Reflector, R, exterior. Side, 2 inches up	86 86	102 101	136 134	 94	 	 	 77	 123	127 123	88 38	 104	 138	 59	 	 	148 147	 170
Barrier: top center	 	 	118 114	 	 	 	 	 	111 108	 	 73	 128	 	 	 	72 71	 146
outside 10 inches up	34 33	73 72	107 105	 37	 	 	 33	 97	99 97	32 33	(R)* 76	 114	 27	(R)*	 	78 77	(R)* 129
outside 6 inches up	 	 	 	 	 	 	 	 	 	36 34	(F) 77	 111	 30	(F)	 	84 83	(F) 123
outside 3 inches up	39 38	74 74	105 101	 44	 	 	 36	 92	95 92	38 36	(R) 76	 107	 29	(R)	 	87 85	(R) 116
inside 3 inches up	40 39	77 77	109 104	 44	 	 	 37	 93	98 93	38 37	(R) 77	 109	 30	(R)	 	92 90	(R) 124
outside 1 inch up	40 38	71 72	101 98	 44	 	 	 36	 88	92 88	36 34	(F) 75	 99	 29	(F)	 	83 82	(F) 113
Mounting hardware. Junc. of joist & strap	35 34	49 51	69 67	 40	 	 	 34	 60	63 60	 32	 49	 66	 28	 	 	82 81	 104
Exposed trim. At ceiling	 	 	 	 114	 	 	 73	 94	97 94	77 77	 77	 98	 55	 	 	117 117	 129
Ambient room	21 20	21 23	22 21	 21	 	 	 20	 21	20 21	20 19	 19	 20	 19	 	 	21 20	 20

*Letters in parenthesis indicate barrier thermocouple locations on corresponding diagrams (A-Y and A-Z) of figure 1.

TABLE 2. TEMPERATURE DATA FOR FIXTURE B

Fixture rated for one 75 watt lamp

Temperatures in °C are listed on the data sheet. Readings have been corrected for an ambient of 20°C. Readings made with no additional load on supply wiring.

Thermocouple Location / Lamp, Trim, Barrier, Top Condition	75W Louver X			75W Ref. Flood Louver X			75W Louver Y			75W Louver Z	
	Open	Cardboard	R22 batt	Open	Cardboard	R22 batt	Open	Cardboard	R22 batt	Bare metal	4" loose fill over metal
Fixture wire. 1/4 inch from socket	95	113	126	77	91		96	115	149	131	145
Socket. On metal clip	102	116	130	79	92		102	119	153	138	151
Fixture box, B. Inside on reflector top	99	113	127	74	86		99	116	152	137	150
Fixture wire casing. 1/2" outside barrier	27	42	51	26	41		28	42	66	46	58
Fixture box, B. Outside, top center	60	86	101	50	71		60	88	125	99	116
Fixture box, B. Outside, side center	67	89	103	53	73		67	92	128	105	120
Reflector, R, exterior. Side, 4 inches up	93	107	122	68	81		94	111	147	131	146
Reflector, R, exterior. Side, 2 inches up	85	99	113	65	77		89	104	140	127	139
Barrier: top center		54	83		50			58	113	54	96
outside 10 inches up	(R)* 31	56	74	(R)* 30	52		(R)* 30	60	101	(R)* 53	87
outside 6 inches up	(F) 32	58	74	(F) 29	55		(F) 32	59	98	(F) 57	83
outside 3 inches up	(R) 37	59	74	(R) 34	55		(R) 35	58	93	(R) 56	77
inside 3 inches up	(R) 38	60	75	(R) 34	56		(R) 35	59	95	(R) 59	81
outside 1 inch up	(F) 33	55	69	(F) 29	57		(F) 32	53	84	(F) 55	75
Mounting hardware Junc. of joist & strap	29	37	44	28	38		30	41	59	53	67
Exposed trim. at ceiling	70	76	87	61	67		70	79	110	105	117
Ambient room	19	19	20	19	20		20	20	20	20	21

*Letters in parenthesis indicate barrier thermocouple locations on the corresponding diagrams (B-X, B-Y and B-Z) of figure 1.

TABLE 3. TEMPERATURE DATA FOR FIXTURE C

Fixture rated for one 100 watt lamp

Temperatures in °C are listed on the data sheet. Readings have been corrected for an ambient of 20°C. Top reading made with additional 15 amp load on supply wiring, bottom reading made with no additional load.

Lamp	100W Flat White Glass			100W Flat White Glass			100W Flat White Glass		100W Flat White Glass	
Trim	Outside Barrier			Inside Barrier			Inside Barrier		Outside Barrier	
Box Location	X			Y			Z		Z	
Barrier										
Top Condition / Thermocouple Location	Open	Cardboard	R22 batt	Open	Cardboard	R22 batt	Bare metal	4" loose fill over metal	Bare metal	4" loose fill over metal
Fixture Wire.	76	93	115	72	92	113	103	118	107	125
1/4 inch from socket	76	92	114	72	92	111	103	115	108	123
Socket.	83	101	121	80	99	119	109	124	114	130
On metal clip	83	100	120	80	99	117	109	121	114	129
Supply wire.	63	75	90	41	70	95	79	99	86	100
Inside junct. box	32	45	59	26	52	74	62	78	55	67
Junction box, B.	52	65	81	31	60	87	69	89	74	89
Inside top center	33	47	61	26	53	76	63	80	58	70
Supply cable casing.	-	-	-	38	65	90	74	94	81	94
1/2 inch from box	-	-	-	25	51	73	61	77	53	63
Socket housing, S.	53	76	101	47	72	97	84	102	90	110
Outside top center	53	75	100	48	72	94	83	97	90	108
Reflector, R, exterior.	88	114	136	89	113	135	124	139	129	145
Top center	90	113	135	90	113	133	125	136	129	145
Reflector, R, exterior.	66	85	107	65	84	106	97	112	101	119
Side, 2 inches up	66	84	106	65	85	103	97	109	102	118
Barrier:	-	56	101	-	59	94	52	97	56	104
top center	-	55	100	-	58	80	52	92	56	102
outside	(Q)* 32	62	92	(R)* 27	55	84	(R)* 56	75	(Q)* 58	96
10 inches up	31	60	89	27	54	79	55	70	59	94
outside	38	64	89	31	56	81	55	77	61	88
3 inches up	(L) 37	63	87	(F) 31	56	78	(F) 55	73	(F) 62	85
outside	40	68	93	30	55	80	58	79	70	94
3 inches up	(Q) 38	65	90	(R) 29	55	77	(R) 56	74	(Q) 69	91
inside	39	63	94	31	57	32	61	82	73	97
3 inches up	(Q) 38	65	91	(R) 31	56	79	(R) 60	77	(Q) 72	94
outside	42	66	89	31	53	75	51	84	72	94
1 inch up	(Q) 38	62	85	(F) 31	53	72	(R) 50	80	(Q) 70	90
Mounting hardware.	32	46	62	31	48	66	56	71	64	80
Junc. of joist & strap	32	46	61	31	48	64	56	67	64	81
Exposed trim.	39	41	51	41	42	54	55	62	58	66
At ceiling	40	40	51	41	43	53	55	60	59	65
Ambient room.	21	20	21	20	20	20	20	20	20	20
	20	20	21	19	19	19	18	20	19	19

*Letters in parenthesis indicate barrier thermocouple locations on the corresponding diagrams (C-X, C-Y, C-Za and C-Zb) of figure 1.

TABLE 4. EXTRACTION AND COMPILATION OF CRITICAL TEMPERATURE DATA FROM TABLES 1, 2 AND 3

Pass/Fail judgements in the table are made on the ability of a barrier to prevent excessive temperatures when used with a specific light fixture.

Temperatures in °C listed in table.

Circled readings are above the maximum specified for that point (see text).

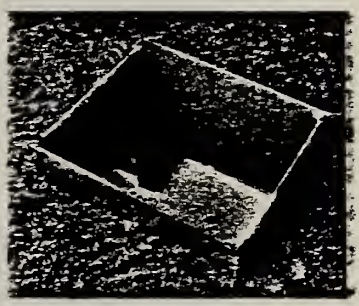
Barrier	Top Covering	Measurement Locations	Fixture A 150W rating vertical lamp 150W					Fixture B 75W rating vertical lamp 75W					Fixture C 100W rating horizontal lamp 100W				
			On Barrier (max)	Supply Wire - No Load	Supply Wire - 15A Load	Fixture Wire	On Housing (max)	On Barrier (max)	Supply Wire - No Load	Supply Wire - 15A Load	Fixture Wire	On Housing (max)	On Barrier (max)	Supply Wire - No Load	Supply Wire - 15A Load	Fixture Wire	On Housing (max)
X	Open		38	33	49	135	92	37	99*	-	95	93	38	32	63	76	90
			Pass					Pass					Pass				
	3/8 inch cardboard		74	(71)	(87)	155	124	59	(113*)	-	113	107	65	45	(75)	92	113
			Fail					Pass					Fail				
	R22 fiberglass batt		(105)	(97)	(118)	188	(159)	74	(127*)	-	126	122	(90)	59	(90)	114	135
			Fail					Pass					Fail				
Y	Open		36	34	51	137	97	35	99*	-	96	94	31	26	41	72	90
			Pass					Pass					Pass				
	3/8 inch cardboard		77	(71)	(90)	158	130	60	(116*)	-	115	111	56	52	(70)	92	113
			Fail					Pass					Fail				
	R22 fiberglass batt		(114)	(103)	(123)	193	(167)	(101)	(152*)	-	149	147	79	(74)	(95)	111	133
			Fail					Fail					Fail				
Z (Electric Box Inside)	Bare metal		85	(95)	(111)	198	(160)	57	(137*)	-	131	131	56	(62)	(79)	103	125
			Fail					Pass					Fail				
	4 inches loose fill over metal		(146)	(124)	-	(220)	(184)	(96)	(150*)	-	145	146	(92)	(78)	(99)	115	136
			Fail					Fail					Fail				
Z (Electric Box Outside)	Bare metal												70	55	(86)	108	129
													Fail				
	4 inches loose fill over metal												(102)	(67)	(100)	123	145
													Fail				

*These temperatures were measured in the box on top of this fixture. If supply wire rated for 60°C is brought into this box, an "above specification" condition will result.

SIMPLE, FAST INSTALLATION

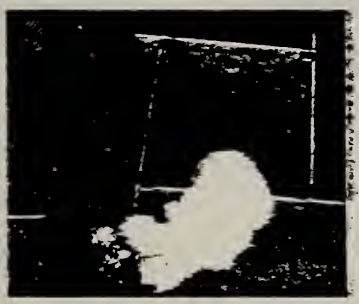
Start assembly by attaching adjustable metal clip of panel #1. Connect #2 panel with second clip. Clip top and bottom of panels.

Clip panel #3 to panel #2 as illustrated.



Clip panel #4 as illustrated.

Score and notch a panel to accept wiring.



Side panels are adjustable to maintain 3" code clearance. Insulation can be blown around panels to required. R-Value (up to 16" of material).

Protect other heat sources such as furnace flues.

BARRIER Y INSTRUCTIONS

Installation Instructions

Measure top light fixture housing, then check table at right for length of material needed. Unroll, and using measuring rule, cut to length.

With yellow side facing you; bend tabs out to form base. Form shield to fit fixture, keeping unit 3" from light fixture on all sides.**

Overlap ends and fasten with enclosed clip. Bend overlap at clip to secure.

Place shield over light. Cut opening in base for electric cable with sufficient clearance.

Secure base with 3/8" staples, tape, or adhesive. Cover top of shield and insulate surrounding protected fixture. Remove covering.

Make sure "WARNING" sticker is Clearly Visible.

**NOTE. If the light is under a roof truss, or against the floor joist you may have to cut sections of the shield and bend to allow the board to pass through the shield.

How to determine length

for Square or Rectangular Fixtures

FIXTURE MEASUREMENTS	LENGTH NEEDED	FIXTURE MEASUREMENTS	LENGTH NEEDED
6" x 6"	50"	8" x 7"	56"
6" x 7"	52"	8" x 8"	58"
6" x 8"	54"	8" x 9"	60"
6" x 9"	56"	8" x 10"	62"
6" x 10"	58"	8" x 11"	64"
7" x 7"	54"	9" x 9"	62"

Formula to determine the length for guard needed:

(1) Add the measurement of 2 adjoining sides
(2) Multiply this sum by 2 and add 26 inches.

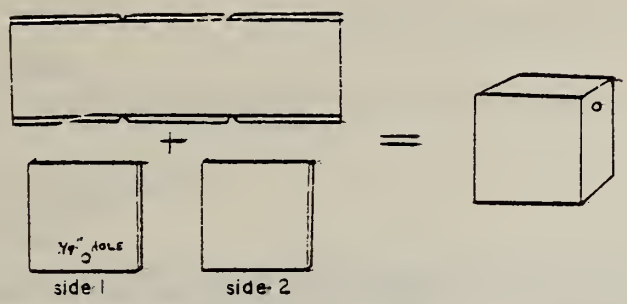
EXAMPLE — A box 6" x 8" requires a 54 inch guard:

(1) 6" + 8" = 14"
(2) 14" x 2 = 28" + 26" = 54"

RECOMMENDED GUARD LENGTH FOR ROUND FIXTURES

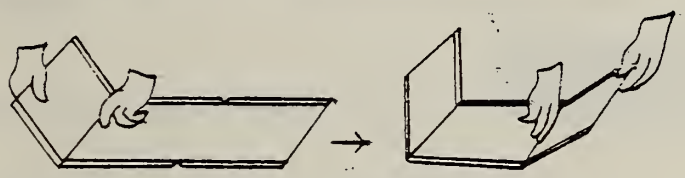
DIAMETER OF FIXTURE	GUARD SIZE
4"	32"
5"	36"
6"	38"
7"	42"
8"	44"
9"	48"

BARRIER Z INSTRUCTIONS



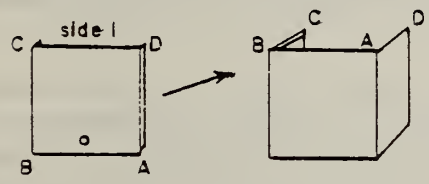
STEP 1

Bend long sheets at notches.



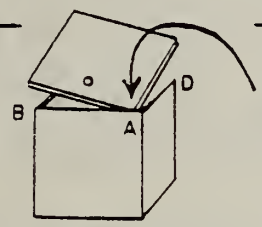
STEP 2

Turn box Upright.



STEP 3

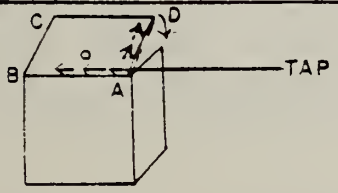
ATTACH side 1 by Pushing down corner at point A until LOCKED.



PUSH DOWN AT POINT A.

STEP 4

TAP edge of side 1 into channel from point A to point B. Continue tapping to points C and D.



STEP 5

Turn box over and continue with side 2 as in step 3 and 4

side 2

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15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Potentially hazardous temperatures may result from adding thermal insulation in the attic above recessed incandescent lighting fixtures. The National Electric Code for 1978 specifies that ". . .thermal insulation shall not be installed within three inches of a recessed fixture enclosure, wiring compartment or ballast and shall not be so installed above the fixture as to entrap heat and prevent the free circulation of air. . ." The purpose of this investigation was to determine the effectiveness of various protective barriers in maintaining the requisite three-inch spacing and in preventing over-temperature conditions when loose-fill insulation is installed around recessed lighting fixtures.

For the devices tested, the results indicate that properly installed open-top barriers are sufficient to allow the fixture and associated branch circuit wiring to operate within specified ratings. However, a barrier closed at the top by any method, can cause branch circuit wiring, the external surface of the barrier and/or parts of the fixture to operate at temperatures above those designated as "safe".

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Recessed incandescent lighting fixture; thermal insulation; hazardous temperatures; protective barrier; branch circuit wiring; electrical junction box; load current; thermocouple.

18. AVAILABILITY

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