NBSIR 79-1912

Temperature Measurement on Operating Surface Mounted 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

September 1979

Sponsored by:
Consumer Product Safety Commission
5401 Westbard Avenue
Bethesda, Maryland 20016

NBSIR 79-1912

TEMPERATURE MEASUREMENT ON OPERATING SURFACE MOUNTED 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

September 1979

Sponsored by:
Consumer Product Safety Commission
5401 Westbard Avenue
Bethesda, Maryland 20016

U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, *Secretary*
Luther H. Hodges, Jr., *Under Secretary*
Jordan J. Baruch, *Assistant Secretary for Science and Technology*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

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

TEMPERATURE MEASUREMENT ON OPERATING SURFACE MOUNTED LIGHTING FIXTURES

P. Michael Fulcomer

ABSTRACT

Potentially hazardous temperatures may result from adding thermal insulation in the attic above surface mounted incandescent lighting fixtures and/or operating these fixtures with lamps of higher wattage than specified. This study was concerned with the range of temperatures generated (1) within the fixture, (2) within the electric junction box associated with the fixture and (3) on the adjoining ceiling and attic surfaces.

Test results indicate that the addition of minimal insulation (equivalent to R-11) over a surface mounted lighting fixture which contains two or more rated lamps, is likely to cause normal household branch circuit supply wiring associated with the fixture to operate above its specified 60°C temperature rating. Overlamping (using lamps of higher wattage than specified for the fixture) and/or additional load current flowing through the branch circuit wire will cause even higher supply wire temperatures.

With all three conditions present (i.e., insulation over the fixture, overlamping, and an additional 15 ampere load current flowing through the supply wire), the tests indicate that the temperature of associated branch circuit wiring will exceed 80°C for a one lamp fixture and 100°C for fixtures with two or more lamps.

Key Words: Surface mounted incandescent lighting fixture; thermal insulation; overlamping; hazardous temperatures; branch circuit wiring; electrical junction box; load current; thermocouple

TEMPERATURE MEASUREMENT ON OPERATING SURFACE MOUNTED LIGHTING FIXTURES

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 potential household electrical system safety problem. This report is based upon work funded by CPSC to address one facet of the problem. Potentially hazardous temperatures can result from (1) adding thermal insulation in the attic above surface mounted incandescent lighting fixtures and/or (2) operating these fixtures with lamps of higher wattage than specified. This study was concerned with the range of temperatures generated (1) within the fixture, (2) within the electric junction box associated with the fixture and (3) on the adjoining ceiling and attic surfaces. A companion report, entitled Temperature Measurement on Operating Recessed Lighting Fixtures, NBSIR79-1913, concerns potentially hazardous temperatures which may result from adding thermal insulation in the attic above recessed incandescent lighting fixtures.

Test results presented herein indicate that the addition of minimal insulation (equivalent to R-11) over a surface mounted lighting fixture which contains two or more lamps, and which is operating with rated bulbs, is likely to cause normal household branch circuit supply wiring associated with the fixture to operate above its specified 60°C temperature rating. Overlamping (using lamps of higher wattage than specified for the fixture) and/or additional load on the branch circuit wire will cause even higher supply wire temperatures. Either overlamping or additional load current, when combined with minimal insulation over the fixture, may also cause the temperature of branch circuit wire associated with a one lamp fixture to exceed a 60°C rated value.

With all three conditions present (i.e., insulation over the fixture, overlamping, and an additional 15 ampere load current flowing through the supply wire), the tests indicate that the temperature of associated branch circuit wiring will exceed 80°C for a one lamp fixture and 100°C for fixtures with two or more lamps.

General Method

To determine representative temperatures generated by surface mounted lighting fixtures, four such fixtures were individually installed in a controlled environment mock-up of a ceiling, complete with an overlying attic section. The four fixtures ranged from a one-lamp flush mounted (no space between the ceiling and the fixture enclosure) model to a four-lamp semi-flush mounted model. In the semi-flush mode, there is some space between the top of the fixture enclosure and the ceiling.

Each fixture was tested: (1) with no insulation in the attic; (2) with glass fiber batts equivalent to R-11; and (3) with glass fiber batts equivalent to R-33 installed in the attic. Under each of these conditions, temperature measurements were made with and without an additional 15 ampere current flowing through the associated branch circuit supply wiring. The above tests were made with rated 60 watt lamps and also under two conditions of overlamping, using 100 watt and 150 watt lamps.

Temperatures were recorded at various points on the fixture, the fixture mounting hardware, the associated ceiling electric box, the nearby attic and ceiling surfaces, 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 size of and installation details for each fixture.

Test Assembly Description

The test assembly consists of a 4 foot by 4 foot section of 1/2 inch sheetrock ceiling nailed to 2 X 6 inch wood joists spaced 16 inches on center. The lighting fixture under test was mounted 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 12 inches above and 24 inches below the ceiling.

Electrical connections to the fixture were made in a 3 1/2 inch by 1 1/2 inch deep ceiling box attached beneath a 2 X 4 which was fastened between the center two 6 inch joists. The fixture was mounted to the ceiling by machine screws which fastened into the ceiling box.

Supply wiring to the fixture was non-metallic sheath cable with two #14 copper conductors and a separate ground (type NM, 14-2 with ground). Wiring was arranged so that the cable carrying the branch circuit current passed through the ceiling box into which the light fixture was connected. Additional load could be put on the branch circuit wiring by connecting a 1500 watt electric space heater to the circuit through a variable voltage transformer. Current drawn by the space heater was adjusted by changing the transformer output.

Lighting Fixtures Description and Installation

Dimensional diagrams of the four surface mounted lighting fixtures tested are shown in figures 1 through 4; all are rated for 60 watt lamps. Fixture A contains two lamps, fixture B three lamps, fixture C four lamps, and fixture D one lamp.

Both fixtures A and D were enclosed lamp types, designed for mounting flush to the ceiling. Fixture B was labeled as "flush mounted" on its packaging material, but both it and fixture C were actually designed to be mounted semi-flush, with the fixture frame separated from the ceiling. No instructions accompanied fixture B, however, and with minor changes in installation procedure, it could be mounted flush, thereby causing extremely high temperatures in the electrical box above the fixture. This will be discussed in greater detail later.

The canopies of fixtures A and D measured 8 1/2 inches and 6 3/4 inches in diameter, respectively. When installed, the upper edges of the canopies fit flush against the ceiling. In each case, the fixture attaches directly to the ceiling box above by two machine screws. For fixture D, a separate crossbar is connected between the outlet box ears, and the canopy is screwed to the crossbar. A glass cover, which completely encloses the lamps, is attached to each canopy by means of three small hand-tightened screws spaced equidistantly around the lower edge of the canopy. When installed, the overall depth from the ceiling was 4 3/4 inches for fixture A and 4 1/4 inches for fixture D.

Both fixtures A and D are designed so that there is a space approximately 3/4 inch deep between the ceiling surface and the canopy base. This space (not visible once the fixture is installed) was probably intended for a glass fiber insulation pad, equal to the diameter of the canopy and approximately 1 1/4 inches thick, which was supplied with each fixture. However, the installation instructions furnished with the fixtures made no mention of the insulation pad nor how it was to be installed. Therefore, testing of the fixtures was done both with and without the insulation pad installed in the canopy base.

Fixtures B and C are similar in the way that they are attached to the ceiling (see figures 2 and 3). The 4 1/2 inch diameter canopy of each is screwed to the electrical ceiling box via a crossbar which is connected between the box ears. The socket structure of each (for fixture B, three horizontally oriented sockets spaced 120 degrees apart, and for fixture C, four horizontally oriented sockets spaced 90 degrees apart) is attached to the canopy by a nut tightened down on the socket structure center post which protrudes up through a hole in the canopy center. The side frame of each fixture is supported by a glass bezel which is attached to the socket structure by means of a single decorative cap nut threaded onto the nipple protruding from the lower end of the socket structure. The bezel for fixture B is a convex opal glass 16 inches in diameter which supports a round, simulated walnut side frame. The bezel for fixture C is a 16 inch

square, flat glass diffuser which supports a square, simulated wood side frame.

No fixture insulation pad and no installation instructions were supplied with fixture B. The fixture also had no indication of being UL rated although it was purchased in Maryland, where UL rating is required. The fixture was packed in a box which described it as being a "flush mounted" fixture. When mounted with the painted side of the 4 1/2 inch diameter canopy facing down, however, the top of the 16 inch diameter frame was actually 3/4 inch below the ceiling surface (see figure 2). Inverting the canopy allowed the socket structure to be raised sufficiently so that the fixture frame could contact the ceiling and thereby constitute a true "flush mount." Testing of the fixture was done in both its semi-flush and flush mounting positions.

When installed, 60 watt lamps extended 2 1/4 inches beyond the outer edge of the canopy of fixture B; 150 watt lamps extended 3 1/4 inches beyond. Distance between the ceiling and the lamp surface for flush mounting was 1 1/4 and 1 1/8 inches, respectively, for 60 and 150 watt lamps. With the fixture mounted semi-flush, these distances were 2 1/8 and 2 inches, respectively.

Installation instructions were supplied with fixture C and a 4 1/2 inch diameter by 1 inch thick glass fiber insulation pad was attached inside the fixture pan. When mounted according to instructions, the top of the 16 inch square frame was approximately 2 3/4 inches below the ceiling and the distance between the ceiling and the lamp surface was 2 1/4 inches for 60 watt lamps, and 2 1/8 inches for 150 watt lamps. Overall fixture depth from the ceiling was 5 1/2 inches.

Testing Procedures

Each fixture was tested with: (1) rated 60 watt lamps installed in all sockets; (2) 100 watt lamps in all sockets; and (3) 150 watt lamps in all sockets. Under each of these conditions, the fixtures were tested with and without an additional 15 ampere load current flowing through the branch circuit supply wiring. Total lamp current, lamp voltage and branch circuit load current (if any) were monitored by means of transducers connected into the test set-up. Prior to each test, supply voltage was adjusted so that the particular lamps installed would dissipate the total power for which they were labeled. During the test this adjusted voltage was held constant by an ac voltage regulator.

All fixtures were tested under the above conditions with no insulation in the attic and with attic insulation equivalent to R-33. In addition, fixtures B, C and D were tested with attic insulation equivalent to R-11. The latter was achieved with foil-backed glass fiber batts, approximately 3 1/2 inches thick, installed so that the foil side rested against the ceiling. The R-33 insulation was achieved by adding two more layers of the R-11 batts without a vapor barrier. The 1/2 inch unpainted sheetrock

ceiling, the 3 1/2 inch ceiling box, and the 2 X 4 crosspiece to which the box was attached were all replaced when the next lighting fixture was installed for testing.

Temperatures were recorded at various points (1) in the ceiling box, (2) on the fixture, (3) on the fixture and supply wires (4) on the surrounding upper (attic) and lower (ceiling) sheetrock surfaces by means of #30 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 was in contact with the subject surface and no more than partially covered by the tape.

The fixtures were tested in the order of their alphabetic designation. Two series of tests were performed on fixture B: the first set with the fixture mounted flush to the ceiling and the second set with the fixture mounted semi-flush. Prior to the second test series, the position of some thermocouples mounted on the upper and lower surfaces of the sheetrock ceiling were changed to better relate to the location of the lamps below the ceiling. Both attic and ceiling surface thermocouples were repositioned at various distances out from the center of the fixture, but either on a line which was directly over the axis of a lamp and lamp socket combination or on a line which bisected the angle between the axes of two adjacent lamp and lamp socket combinations.

The data logging device contained 40 input channels, of which only 25 were eventually used. Of the 25 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 22 to monitor thermocouple outputs. Three ac-to-dc transducers were used to change ac voltage and current readings into the low voltage dc accepted by the data logger.

Fewer than 22 thermocouples were used in the tests of fixtures A and B in their flush mounted positions. Following these two tests, thermocouples were added to measure temperature at additional locations in the ceiling box and on the ceiling and attic surfaces. At that same time, more specific locations for measuring ceiling and attic surface temperature were introduced. Of the 22 points eventually monitored for temperature, five were in the electrical ceiling box or on associated fixture mounting hardware, three on the fixture and supply wires, five on the upper sheetrock surface (attic), three on the lower sheetrock surface (ceiling), one on the fixture canopy and one on the 2 X 4 wood support crosspiece. Three thermocouples were used to monitor air temperature at locations around the light fixture and one to monitor ambient room temperature.

More precise information on thermocouple location is included in the first column of the data sheet for each figure as shown in tables 1 through 4. Where a letter symbol appears in the second column, this corresponds to the thermocouple location indicated by an identical symbol on the dimensional diagram for that fixture (figures 1-4). Not all locations are indicated on the diagrams.

The data logging device was programmed to monitor voltage, currents and temperature 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. Tests that were started with all points at room temperature required 2 to 3 hours before temperatures reached equilibrium with no thermal insulation above the fixture, and 5 to 9 hours with insulation above the fixture. However, only 45 and 90 minutes (first without and then with thermal insulation above the fixture) were required for temperatures to reach 80 to 90 percent of their equilibrium value on the supply wire, in the ceiling electrical box and on the upper sheetrock surface (attic side). Temperatures on the fixture wire and on the lower sheetrock surface reached 85 to 95 percent of equilibrium after only 30 and 45 minutes, respectively.

A return to room ambient temperature was not always required between tests. Tests proceeded without a cool-down period if temperatures in the following test were expected to be equal to or higher than those in the preceeding test. Examples of this occurred when an external 15 ampere load was added without changing the amount of insulation in the attic or when insulation in the attic was increased without reducing the load. A short cool down period was allowed when a reduction of some temperatures might be expected under the new conditions. An example of this occurred when a no-load test with insulation equivalent to R-33 in the attic followed a test with R-11 insulation in the attic and a 15 ampere external load on the supply wire. In this case, the decrease in supply wire temperature resulting from the reduced load usually more than offset the slight temperature increase resulting from greater attic insulation depth.

Results

The steady state temperatures recorded for each light fixture under the various testing conditions are listed in tables 1 through 4. Table 5 is an extraction and compilation of this data to show temperatures at five critical locations (one location is shown under two different conditions) for each light fixture tested. Table 5 includes results obtained both with rated lamps and with higher than rated lamps installed, but except for fixture B, it does not include the results obtained in testing a fixture without the fixture insulation pad in place. Reference must be made to the individual tables for this latter data. (Table 5 includes the results of testing fixture B without the fixture insulation pad in place because these are the only results available for this fixture. No insulation pad was supplied with fixture B.) All listed temperatures have been corrected for an ambient of 20°C*. Temperatures exceeding the limits specified for each location are circled in table 5.

The critical temperature locations noted in table 5 and the limiting temperatures at each location are:

1. Fixture wire insulation - 150°C maximum. None of the fixtures tested indicate the rating of the fixture wire used. However,

*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.

three of the four fixtures are UL rated and as such must have fixture wire rated for at least 150°C. The wire of the non-UL rated fixture B was similar in composition to the other three.

2. Supply wire insulation - 60°C maximum. Household branch circuit wiring is normally of the type rated for 60°C. Neither the wire insulation nor any of the surfaces which it may touch should exceed this temperature. Since the wire temperature increases if there is an external load on the branch circuit, both no-load and load conditions were tested and are included in table 5.

3. Attic and ceiling sheetrock surfaces - 90°C maximum. Section 410-5 of the 1978 National Electric Code states that "Fixtures shall be so constructed, or installed, or equipped with shades or guards that combustible material will not be subjected to temperatures in excess of 90°C". Either the thermal insulation that touches the attic side of the sheetrock or the surface finish applied over the ceiling side of the sheetrock might be combustible.

The data contained in table 5 provides the basis for statements in the Summary section.

Table 1 for fixture A does not include all the same data that the other tables do because the decisions to include tests involving thermal insulation equivalent to R-11, to reposition attic and ceiling thermocouples, and to eliminate joist temperature measurements were made during the testing of fixture B. Table 1 does show, however, that the temperature on the branch circuit supply wire inside the ceiling box reached 70°C when operated with rated lamps installed in the fixture and with thermal insulation equivalent to R-33 above. Results from testing the other three fixtures showed that most of the temperature increase due to the addition of thermal insulation above a fixture is evident with an insulation thickness equivalent to R-11. The difference in temperatures with a thickness equivalent to R-11 and one equivalent to R-33 is usually less than 5°C, hence the temperature of branch circuit wire associated with fixture A would exceed its specified rating even with minimal thermal insulation equivalent to R11 over the fixture.

The insulation pad reduces lamp heat transferred to the parts above it, but increases the heat to parts below the pad. Therefore, temperatures in the ceiling box are somewhat lower with the fixture insulation pad installed, while temperatures on the fixture wire are actually somewhat higher.

The temperature of the fixture wire in fixture A exceeded 150°C when 100 watt lamps were installed and fixture insulation was in place. This was true with or without thermal insulation overhead. With the fixture insulation pad in place, the addition of attic thermal insulation caused only minor increases in fixture wire temperature.

For fixture B, temperatures in the ceiling electrical box exceeded 60°C even under the least stringent conditions, with the fixture mounted in the less hazardous semi-flush position, operating with rated lamps, and with no thermal insulation overhead. Addition of minimal thermal insulation caused temperatures in the box to exceed 90°C. Use of 100 watt lamps (a real temptation with this fixture because of the poor light transmission through the opal glass bezel) resulted in temperatures over 120°C in the ceiling box and up to 140°C on the ceiling surface above the lamps.

Flush mounting of fixture B caused temperatures 15 to 30°C higher than those under comparable conditions with semi-flush mounting. Data for the fixture when flush mounted and overlamped with 150 watt lamps is not complete due to the occurrence of a short circuit failure in the ceiling electrical box. The high temperatures in the box (over 200°C) caused supply wire insulation to become brittle and subsequently crack, then fall away from the conductor at various locations. A resulting short circuit to ground caused the ground fault interrupter, which was installed in series with the electrical supply, to open and thus terminate the test. Less than 65 hours of fixture testing time had elapsed before the wire failure.

Fixture C, with rated lamps installed and R-11 thermal insulation overhead, caused temperatures to exceed 70°C on the supply wire and in the ceiling electrical box. Overlamping with 100 watt lamps combined with R-11 insulation overhead caused temperatures to exceed 90°C at these same locations. Although these temperatures are 30 to 35°C lower than those which resulted in fixture B under similar conditions, the temperatures are still considerably above the specified safe values.

While the lamps of fixtures B and C are located the same distance from the ceiling (see figures 3 and 4), the frame of fixture C is farther from the ceiling. The lower frame position presumably allows greater inflow of the cooler surrounding air to fixture C. Also, the lack of fixture insulation for fixture B causes temperatures on the supply wire and in the ceiling box for that fixture to be 3 to 7°C higher than they otherwise would have been.

A fixture wire rating of 150°C was not exceeded under any conditions for fixture C. Attic and ceiling surface temperatures were exceeded under overlamped conditions with thermal insulation above.

Fixture D, a one lamp fixture, caused no serious over-ratings when operated with its rated 60 watt lamps. The unloaded supply wire temperatures did not exceed 60°C, even with R-33 thermal insulation overhead. When loaded with an additional 15 amperes, however, the supply wire reached 69°C with R-33 thermal insulation. Overlamping in combination with thermal insulation and additional load, caused temperatures on the supply wire and on the ceiling box to exceed 80°C. Specified "safe" fixture wire and ceiling or attic temperatures were not exceeded under any conditions.

Summary

These test results on surface mounted lighting fixtures indicate the following:

1. Addition of minimal insulation (equivalent to R-11) over a surface mounted lighting fixture containing two or more lamps and operating with rated bulbs, is likely to cause normal household branch circuit wiring associated with the fixture to operate above its specified 60°C temperature rating.

2. Addition of minimal insulation (equivalent to R-11) over a surface mounted lighting fixture operating with two or more 100 watt lamps instead of the rated 60 watt lamps is likely to cause temperatures in excess of 90°C on the associated branch circuit wiring. Temperatures will likely exceed 60°C for a one lamp fixture under the same conditions.

3. Most of the temperature increase due to addition of thermal insulation above a surface mounted lighting fixture is evident with an insulation thickness equivalent to R-11. Increase in insulation thickness from an equivalence of R-11 to one of R-33, causes only a minor increase (usually less than 5°C) in temperatures measured in and around the lighting fixture.

4. Addition of a 15 ampere load current on the branch circuit supply wiring increases the wire temperature by 15 to 20°C, with the larger increase occurring for wire covered by thermal insulation.

5. The associated branch circuit wiring is likely to be the first component of a surface mounted lighting fixture to exceed its rating. (For the three multi-lamp fixtures tested, the 60°C rating for this wire was exceeded even when these fixtures were operating with rated lamps and no thermal insulation above them.)

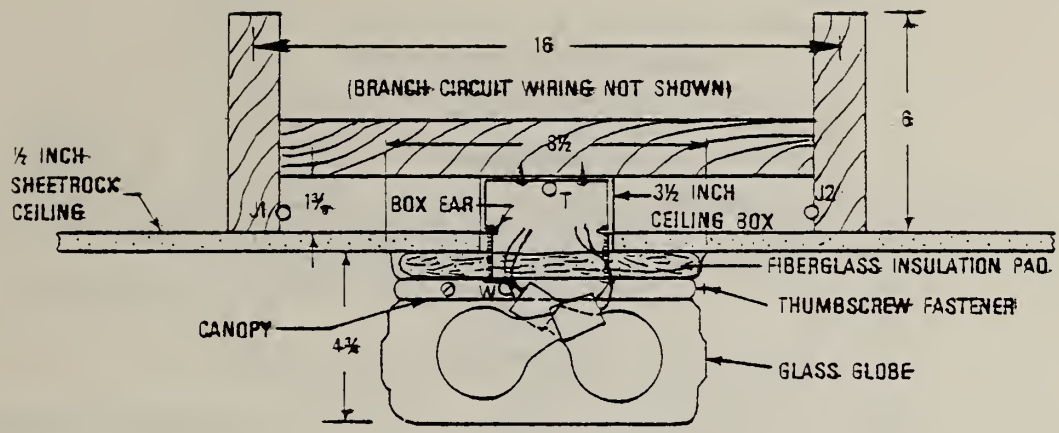
6. For surface mounted fixtures containing more than one lamp, overlamping (using lamps of higher wattage than specified for the fixture) combined with minimal insulation over the fixture is likely to cause fixture wire temperature and attic and ceiling surface temperatures to exceed their rated "safe" values.

Comment

The test results summarized above are based on the testing of four different surface mounted lighting fixtures. These four appeared to be representative of fixtures available at the time this investigation was initiated in 1978. Sufficient information was obtained from the tests to

indicate that household branch circuit wiring is likely to operate above its present 60°C temperature rating when associated with surface mounted fixtures over which minimal thermal insulation has been placed or in which higher wattage lamps than specified are used. Further testing is necessary, however, to (1) establish the upper limit that the wire temperature may reach when used with various fixtures and conditions of operation, and (2) to determine whether wire currently rated for 60°C might actually be operated safely at somewhat higher temperatures. This information would provide a basis for future decisions involving either (1) raising the 60°C rating for currently used wire, (2) requiring the use of wire presently rated for 75, 90 or 120°C, or (3) some combination of the first two.

Testing should also be done on surface mounted fixtures which meet a recently imposed "insulated ceiling" (or IC) specification by Underwriters' Laboratories. This type of fixture was not available during the period when tests were in progress for this report.



FIXTURE A

FLUSH MOUNT

TWO LAMPS RATED FOR 60 WATTS MAX.

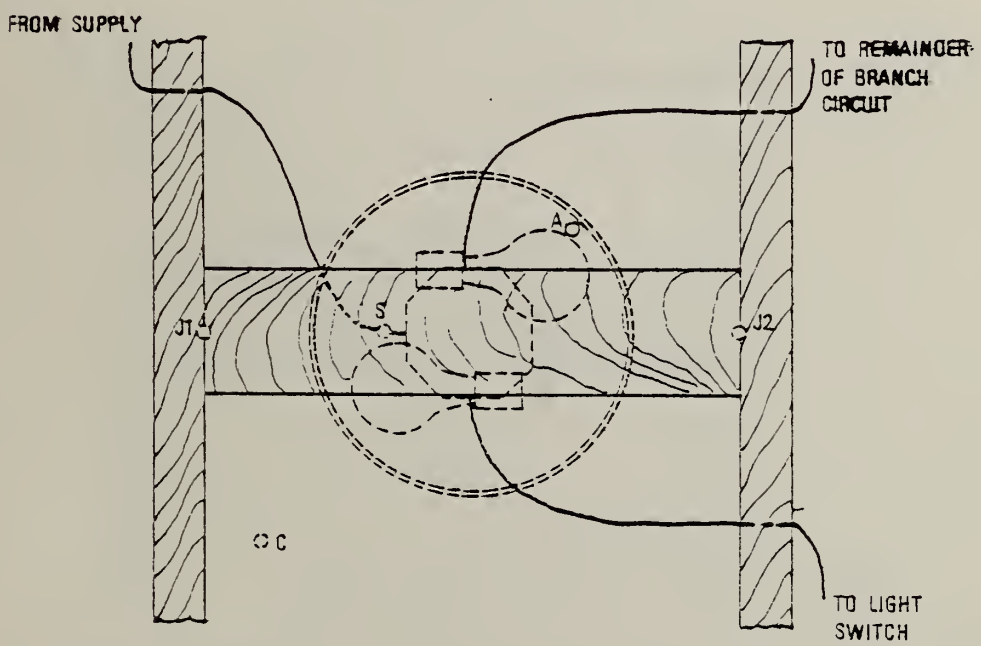
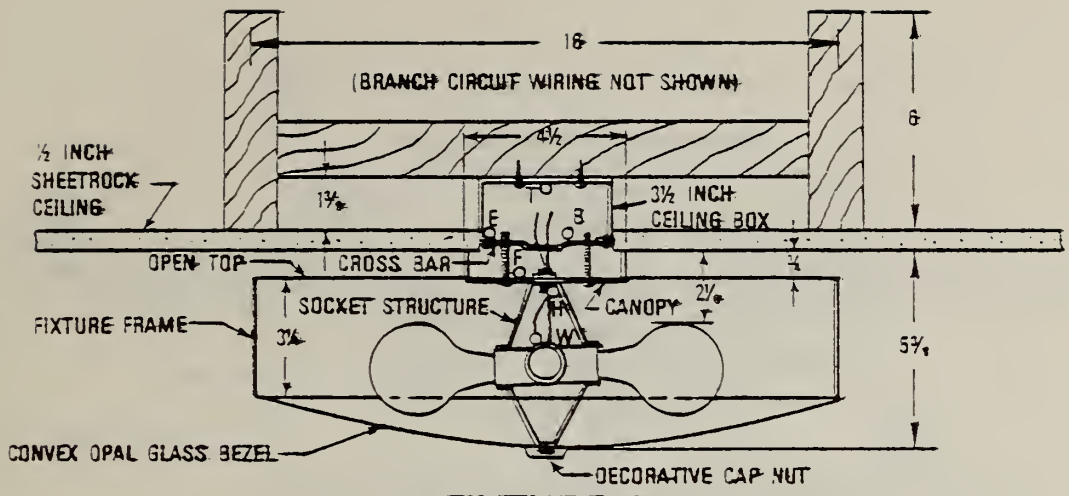


Figure 1. Dimensional Diagram of Fixture A Installation.

A small circle accompanied by a letter indicates a thermocouple location. Not all locations are shown. The letter identifies temperature data from Table 1 which corresponds to the location shown.



FIXTURE B

SEMI-FLUSH MOUNT

THREE LAMPS RATED FOR 60 WATTS MAX.

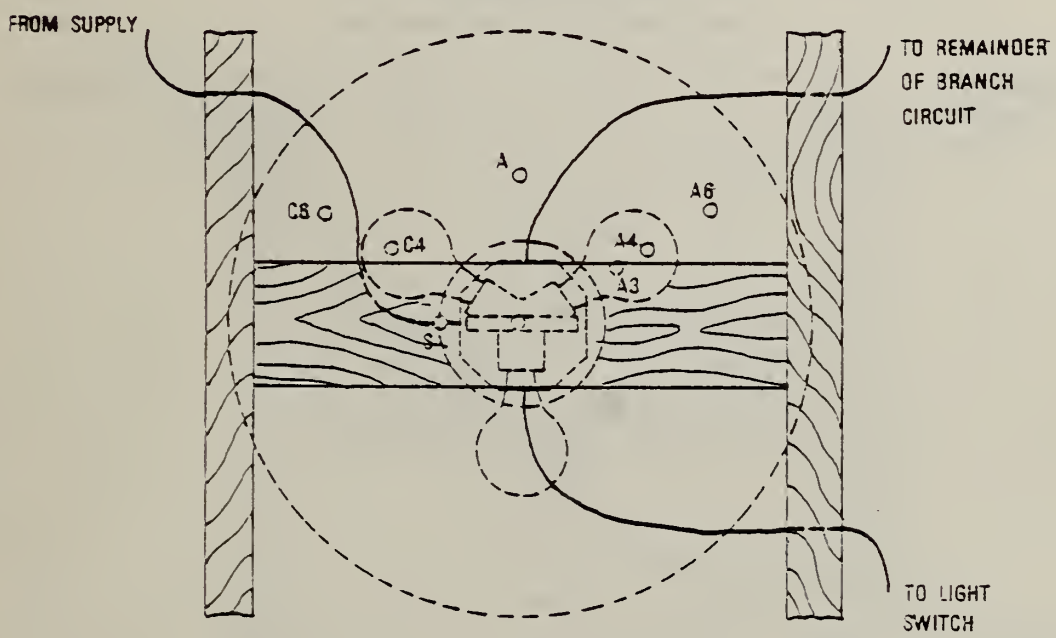
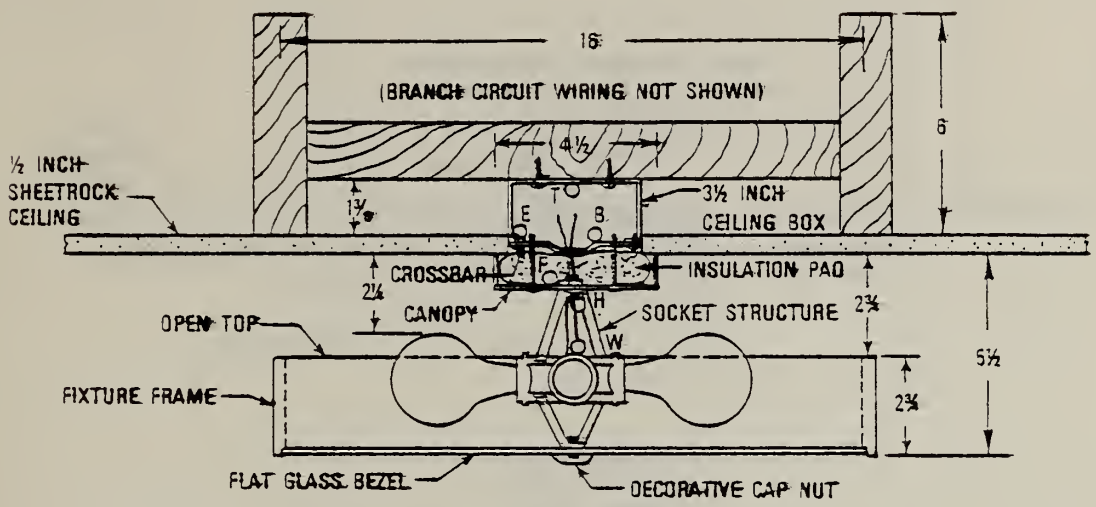


Figure 2. Dimensional Diagram of Fixture B Installation.

A small circle accompanied by a letter indicates a thermocouple location. Not all locations are shown. The letter identifies temperature data from Table 2 which corresponds to the location shown.



FIXURE C

SEMI-FLUSH MOUNT

FOUR LAMPS RATED FOR 60 WATTS MAX.

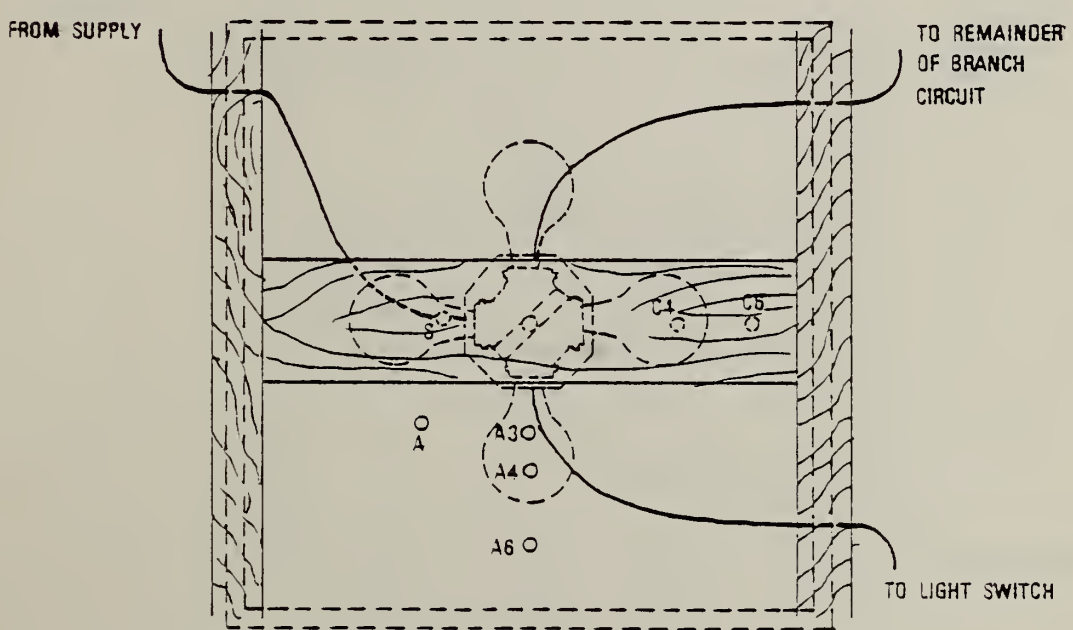
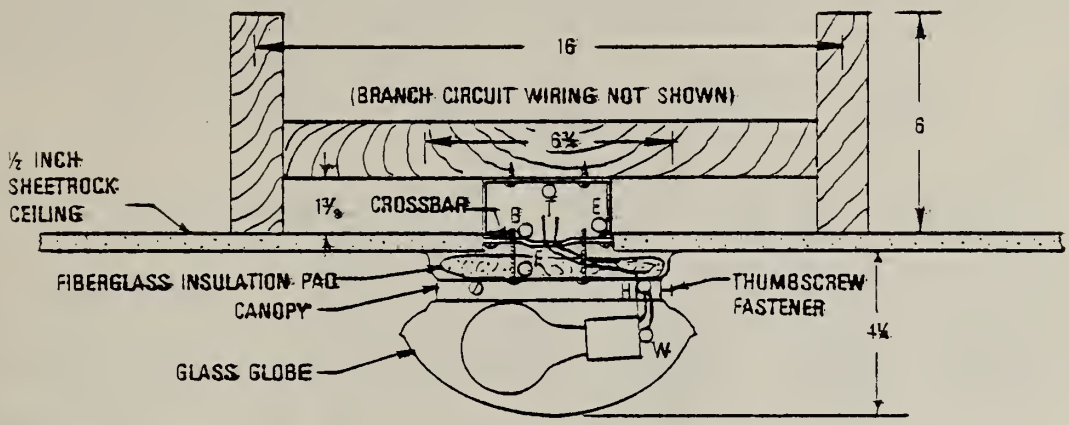


Figure 3. Dimensional Diagram of Fixture C Installation.

A small circle accompanied by a letter indicates a thermocouple location. Not all locations are shown. The letter identifies temperature data from Table 3 which corresponds to the location shown.



FIXTURE D

FLUSH MOUNT

ONE LAMP RATED FOR 60 WATTS MAX.

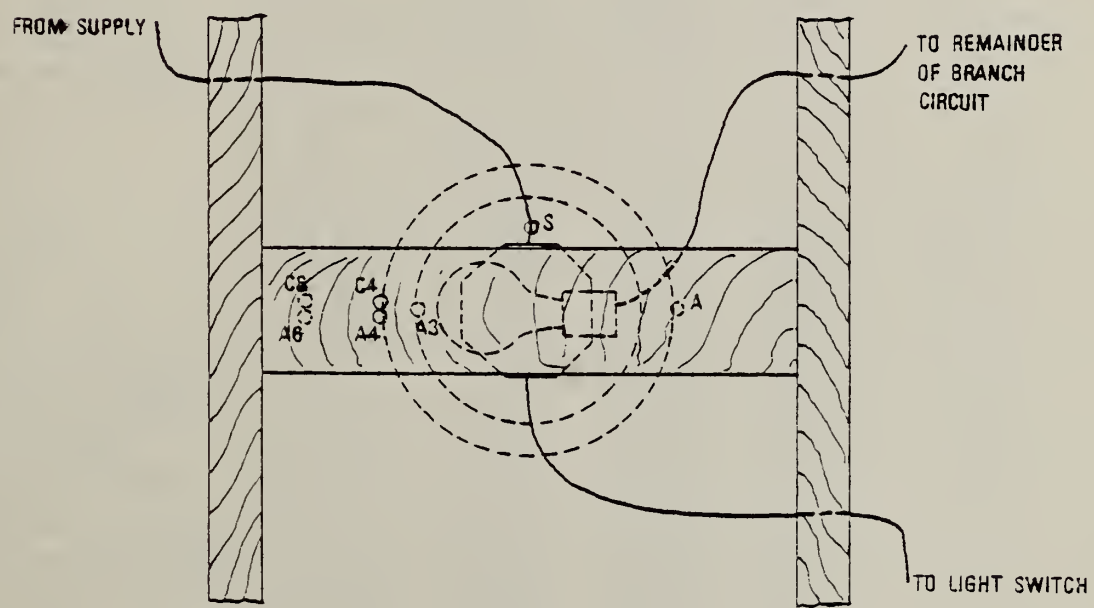


Figure 4. Dimensional Diagram of Fixture D Installation.

A small circle accompanied by a letter indicates a thermocouple location. Not all locations are shown. The letter identifies temperature data from Table 4 which corresponds to the location shown.

TABLE 1. TEMPERATURE DATA FOR FIXTURE A

Fixture rated for two 60 watt lamps

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

Lamp		60W			60W			100W			150W			150W		
Fixture Insulation		In Place			None			In Place			In Place			None		
Attic Insulation		None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts
Thermocouple Location*																
Fixture Wire. 1/4 inch from socket	W	124 122		129 126	117 115		123 120	162 161		171 168	202 194		201 199	183 181		191 187
Fixture Canopy. At wire pass-through hole																
Fixture Canopy. Surface facing ceiling box																
Supply Wire. Inside ceiling box		66 50		89 70	74 62		97 81	75 62		119 99	86 69		135 114	110 96		147 129
Supply Wire Casing. 1/2 inch from box	S	49 38		74 60	54 43		79 66	54 44		101 85	62 45		114 97	76 60		118 102
Ceiling Box: inside, top of crossbar																
inside, top of ear																
inside, top center	T	57 50		81 70	68 64		92 84	66 61		110 99	75 67		126 114	102 97		140 131
inside, on cable clamp		59 52		82 72	69 64		92 85	69 63		113 102	78 69		128 116	103 96		141 132
Attic Surface: over lamp, 4 inches from center	A	44 41		66 59	43 41		67 62	50 49		89 82	57 56		103 97	58 56		96 87
Ceiling Surface: 8 inches from center	C	31 29		44 38	26 25		41 38	35 35		53 49	43 42		65 60	40 39		65 59
Wood Joist: 1/2 inch up from ceiling	J1	31 29		52 42	28 26		51 44	32 31		67 59	36 34		78 70	38 36		81 70
Wood Joist: 1/2 inch up from ceiling	J2	30 28		52 44	28 26		51 46	33 32		67 62	37 35		79 73	38 35		79 74
Ambient: in test assembly																
Ambient: in test assembly																
Ambient Room.																

*Symbols in second column (if any) indicate thermocouple locations on the corresponding diagram of figure 1.

TABLE 2. TEMPERATURE DATA FOR FIXTURE B
Fixture rated for three 60 watt lamps

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

Lamp		60W			60W			100W			150W			150W		
Mounting		Semi-flush			Flush			Semi-flush			Semi-flush			Flush		
Attic Insulation		None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R14 batts	R33 batts
Thermocouple Location*																
Fixture Wire.		109	117	118	123	140	143	142	153	154	179	196	197	202		
1/4 inch from socket		109		118	123		140	141	151	154	177	195		202	224	
Fixture Canopy.	H	99	111	112				131	146	143	168	195	196			
At wire pass-through hole		97		111				129	143	147	165	192				
Fixture Canopy.	F	95	110	112				125	146	149	159	195	196			
Surface facing ceiling box		93		110				123	142	147	156	191				
Supply Wire.		71	106	111	86	131	139	91	140	146	113	188	192	137		
Inside ceiling box		59		96	74		122	77	122	130	97	170		122	200	
Supply Wire Casing.	S	56	96	104	64	116	126	66	130	137	69	173	179	94		
1/2 inch from box		47		92	56		111	59	115	124	60	158		85	183	
Ceiling Box: inside,	B	73	102	106				94	136	142	119	184	188			
top of crossbar		68		100				88	127	135	114	176				
inside,	E	68	99	104				89	133	139	114	181	185			
top of ear		64		99				85	125	134	109	175				
inside,	T	62	96	103	80	125	132	81	130	137	103	177	182	129		
top center		59		97	77		124	77	121	130	97	170		125	202	
inside,		61	96	102	83	128	135	79	128	136	100	177	181	140		
on cable clamp		58		97	79		127	75	122	131	95	171		135	205	
Attic Surface: over lamp,	A3	52	88	99				58	121	130	62	163	173			
3 inches from center		51		94				54	114	125	61	161				
over lamp,	A4	58	90	100	59	111	120	66	122	130	80	164	174	93		
4 inches from center		55		96	58		116	65	115	126	79	163		93	189	
over lamp,	A6	49	79	89				54	109	118	69	150	160			
6 inches from center		49		84				54	103	114	69	148				
between lamps,	A	50	84	94				55	120	126	66	157	165			
4 inches from center		48		90				53	114	123	64	154				
Ceiling Surface: over lamp,	C4	91	112	114				117	142	145	166	204	205			
4 inches from center		90		113				116	139	143	164	201				
over lamp,	C6	87	90	95				94	121	129	134	130	135			
6 inches from center		87		95				94	119	128	132	131				
Ambient: in test assembly,		24	26	26				26	30	29	29	31	32			
3 inches below ceiling		24		27				26	28	30	28	32				
Ambient: in test assembly,		21	22	22				22	24	23	24	24	24			
13 inches below ceiling		22		22				23	23	24	23	25				
Ambient Room		20	20	20	20	19	20	20	20	21	20	19	19	20		
		19		18	20		20	19	20	19	20	17		20	20	

*Symbols in second column (if any) indicate thermocouple locations on the corresponding diagram of figure 2.

TABLE 3. TEMPERATURE DATA FOR FIXTURE C

Fixture rated for four 60 watt lamps

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

Lamp / Fixture Insulation		60W In Place			60W None			100W In Place			100W None			150W In Place		
Attic Insulation / Thermocouple Location*		None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts
Fixture Wire.		88	95	94	86	91	91	115	121	122	111	120	119	122	132	135
1/4 inch from socket		87	93	94	85	90	90	113	120	123	109	118	117	120	130	131
Fixture Canopy.	H	81	88	88	80	87	87	108	116	117	103	112	114	121	133	134
At wire pass-through hole		80	87	87	80	86	86	106	115	117	102	111	112	120	131	131
Fixture Canopy.	F				73	83	82				96	107	109			
Surface facing ceiling box					72	80	81				93	105	106			
Supply Wire.		61	89	91	64	86	86	74	114	118	78	107	112	81	132	137
Inside ceiling box		46	71	73	53	70	72	57	93	97	66	90	94	66	113	117
Supply Wire Casing.	S	51	84	86	46	82	82	60	107	112	55	102	109	58	126	132
1/2 inch from box		39	70	72	41	69	71	46	90	95	49	88	93	50	111	115
Ceiling Box: inside top of crossbar	B															
inside, top of ear	E	52	79	80	56	75	74	66	101	105	71	95	98	73	120	124
		49	73	75	54	71	73	61	95	99	68	91	94	70	114	117
inside, top center	T	50	80	82	55	77	77	61	102	107	68	96	101	67	122	127
		45	71	73	52	70	72	56	93	97	63	90	94	63	113	117
inside, on cable clamp		49	78	80	54	75	74	61	100	105	67	94	97	67	120	124
		45	72	73	51	70	72	56	93	98	64	89	93	64	113	116
Attic Surface: over lamp, 3 inches from center	A3	47	75	75	44	74	74		95	102	52	94	99	58	119	124
		47	72	73	44	72	75		93	100	51	92	98	58	116	121
over lamp, 4 inches from center	A4	47	75	75	45	73	76	48	94	101	52	93	98	57	117	123
		47	74	74	43	72	76	47	93	99	50	92	98	54	115	119
over lamp, 6 inches from center	A6	42	70	69	38	63	67	48	83	92	43	83	88	50	109	115
		42	68	69	38	63	67	46	83	90	41	82	88	50	107	112
between lamps, 4 inches from center	A	42	73	73	39	76	76	49	93	99	45	96	102	52	120	126
		41	70	71	39	72	73	47	89	95	43	92	98	51	116	121
Ceiling Surface: over lamp 4 inches from center	C4	68	85	87	73	89	89	87	112	114	89	110	113	111	143	146
		68	82	85	73	87	88	85	110	112	86	107	110	110	140	142
overlamp, 6 inches from center	C6	62	71	72	66	75	75	69	95	100	72	95	98	101	130	135
		62	69	70	66	73	72	67	92	99	71	93	96	100	128	131
Ambient: in test assemoly 3 inches below ceiling		27	29	29	26	28	27	30	33	32	29	31	31	33	35	35
		27	29	29	26	28	28	30	33	32	28	30	31	32	34	34
Ambient: in test assembly 18 inches below ceiling		22	22	22	22	23	23	22	24	23	23	24	24	24	25	25
		22	22	22	22	22	23	22	24	23	23	23	24	25	25	25
Ambient Room		20	18	20	21	20	21	20	21	20	21	21	21	21	21	21
		19	18	18	20	19	19	19	19	19	21	20	20	20	20	21

*Symbols in second column (if any) indicate thermocouple locations on the corresponding diagram of figure 3.

TABLE 4. TEMPERATURE DATA FOR FIXTURE D

Fixture rated for one 60 watt lamp

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

Lamp		60W			60W			100W			100W			150W		
Fixture Insulation		In Place			None			In Place			None			In Place		
Attic Insulation		None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts
Thermocouple Location*																
Fixture Wire.		79	82	32	76	78	77	103	104	105	100	101	101	122	124	125
1/4 inch from socket		79	78	81	75	78	77	102	105	105	98	101	100	122	124	125
Fixture Canopy.	H	79	82	83	73	76	76	103	105	106	96	100	101	121	125	126
At wire pass-through hole		79	78	81	72	76	75	102	105	105	95	100	100	121	124	125
Fixture Canopy.	F				87	92	92				119	123	125			
Surface facing ceiling box					85	91	91				115	123	123			
Supply Wire.		54	68	69	66	79	80	67	80	84	84	101	104	76	99	100
Inside ceiling box		39	47	51	53	64	65	48	62	65	71	87	89	58	82	82
Supply Wire Casing.	S	43	58	59	52	66	67	51	65	69	62	83	86	55	82	82
1/2 inch from box		33	42	46	38	55	56	38	54	56	53	71	74	46	69	69
Ceiling Box: inside,	B	57	70	71	71	81	81	74	86	91	94	107	109	87	109	111
top of crossbar		52	67	61	64	75	75	66	79	82	89	101	103	82	102	103
inside,	E	49	62	63	63	74	75	60	74	79	82	98	100	71	94	96
top of ear		45	52	56	59	70	70	55	69	72	79	93	96	66	88	89
inside,	T	45	58	61	62	74	74	56	71	76	80	97	99	66	91	93
top center		40	48	53	57	68	69	50	64	67	76	92	94	60	82	84
inside,		44	58	59	58	71	71	54	68	73	74	92	95	62	86	88
on cable clamp		40	48	52	53	66	67	47	63	66	71	87	89	56	80	81
Attic Surface: over lamp,	A3	36	52	53	40	55	55	42	58	63	47	71	74	59	85	86
3 inches from center		36	48	47	38	49	52	41	54	58	46	65	69	55	82	82
over lamp,	A4	30	44	45				34	48	53				46	72	
4 inches from center		30	41	40				33	46	47				44	70	
over lamp,	A6	25	37	38				28	40	44				33	57	
6 inches from center		25	34	34				27	38	40				32	54	
opposite side	A	29	41	42				34	46	50				36	57	
4 inches from center		30	40	40				33	46	49				35	56	
Ceiling Surface: over lamp	C4	40	46	48	38	46	46	49	55	58	46	58	60	74	86	87
4 inches from center		40	46	46	37	45	45	48	55	56	45	56	57	73	85	85
over lamp	C6	29	36	37				34	41	43				46	59	
6 inches from center		29	35	34				33	40	41				46	58	
Ambient: in test assembly		22	22	22	23	22	23	23	22	23	21	23	23	24	24	25
3 inches below ceiling		21	20	22	22	21	22	22	22	21	22	22	22	22	24	24
Ambient: in test assembly		21	21	21	22	21	22	21	22	21	20	21	21	22	22	23
18 inches below ceiling		21	19	21	21	20	21	21	22	20	20	21	21	20	22	22
Ambient Room		21	20	20	21	20	21	20	21	20	20	20	20	21	21	21
		20	18	20	21	19	20	21	20	19	20	19	20	19	21	20

*Symbols in second column (if any) indicate thermocouple locations on the corresponding diagram of figure 4.

TABLE 5. EXTRACTION AND COMPILATION OF CRITICAL TEMPERATURE DATA FROM TABLES 1, 2, 3 AND 4

All readings below were taken with the fixture insulation pad installed except those for fixture B. No pad was supplied with this fixture. Temperature readings without the pad installed are 3-7°C higher on the supply wire and in the ceiling box but 3-7°C lower on the fixture wire. Readings below for fixture B were taken in a semi-flush mounting position. Flush mounting produced higher temperatures (see table 2).

Temperatures in °C listed in table. Circled readings are above the maximum specified for that location (see text).		Lamps	60 watt			100 watt			150 watt		
		Attic Insulation	None	R11 batts	R33 batts	None	R11 batts	R33 batts	None	R11 batts	R33 batts
Fixture	Measurement Locations										
A two lamps 60W	Fixture Wire		122	-	126	(161)	-	(162)	(194)	-	(195)
	Supply Wire - No Load		50	-	(70)	(62)	-	(99)	(69)	-	(114)
	Supply Wire - 15A Load		(66)	-	(89)	(75)	-	(119)	(86)	-	(135)
	Ceiling Box (maximum)		52	-	(72)	(63)	-	(102)	(69)	-	(116)
	Attic Surface (maximum		41	-	59	49	-	82	56	-	(97)
	Ceiling Surface (maximum)		-	-	-	-	-	-	-	-	-
B three lamps 60W	Fixture Wire		109	117	118	141	(151)	(154)	(177)	(195)	-
	Supply Wire - No Load		59	(91)	(96)	(77)	(122)	(130)	(97)	(170)	-
	Supply Wire - 15A Load		(71)	(106)	(111)	(91)	(140)	(146)	(113)	(188)	-
	Ceiling Box (maximum)		(68)	(96)	(100)	(88)	(127)	(135)	(114)	(176)	-
	Attic Surface (maximum)		55	86	(96)	65	(115)	(126)	79	(163)	-
	Ceiling Surface (maximum)		(90)	(111)	(113)	(116)	(139)	(143)	(164)	(201)	-
C four lamps 60W	Fixture Wire		87	93	94	113	120	123	120	130	131
	Supply Wire - No Load		46	(71)	(73)	57	(93)	(97)	(66)	(113)	(117)
	Supply Wire - 15A Load		(61)	(89)	(91)	(74)	(114)	(118)	(81)	(132)	(137)
	Ceiling Box (maximum)		49	(73)	(75)	(61)	(95)	(99)	(70)	(114)	(117)
	Attic Surface (maximum)		47	74	74	47	(93)	(100)	58	(116)	(121)
	Ceiling Surface (maximum)		68	82	85	85	(110)	(112)	(110)	(140)	(142)
D one lamp 60W	Fixture Wire		79	78	81	102	105	105	122	124	125
	Supply Wire - No Load		39	47	51	48	(62)	(63)	58	(82)	(82)
	Supply Wire - 15A Load		54	(68)	(69)	(67)	(80)	(84)	(78)	(99)	(100)
	Ceiling Box (maximum)		52	57	(61)	(66)	(79)	(82)	(82)	(102)	(103)
	Attic Surface (maximum)		36	48	47	41	54	58	55	82	82
	Ceiling Surface (maximum)		40	46	46	48	65	66	73	85	85

NBS-114A (REV. 9-78)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR79-1912	2. Gov't. Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE

Temperature Measurement on Operating Surface Mounted Lighting Fixtures

5. Publication Date: September 1979

6. Performing Organization Code

7. AUTHOR(S)

P. Michael Fulcomer

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, DC 20234

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

Consumer Product Safety Commission
5401 Westbard AVenue
Bethesda, Maryland 20016

13. Type of Report & Period Covered

14. Sponsoring Agency Code

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 surface mounted incandescent lighting fixtures and/or operating these fixtures with lamps of higher wattage than specified. This study was concerned with the range of temperatures generated (1) within the fixture, (2) within the electric junction box associated with the fixture and (3) on the adjoining ceiling and attic surfaces.

Test results indicate that the addition of minimal insulation (equivalent to R11) over a surface mounted lighting fixture which contains two or more rated lamps, is likely to cause normal household branch circuit supply wiring associated with the fixture to operate above its specified 60°C temperature rating. Overlamping (using lamps of higher wattage than specified for the fixture) and/or additional load current flowing through the branch circuit wire will cause even higher supply wire temperatures.

With all three conditions present (i.e., insulation over the fixture, overlamping, and an additional 15 ampere load current flowing through the supply wire), the tests indicate that the temperature of associated branch circuit wiring will exceed 80°C for a one lamp fixture and 100°C for fixtures with two or more lamps.

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)*

Surface mounted incandescent lighting fixture; thermal insulation; overlamping; hazardous temperatures; branch circuit wiring; electrical junction box; load current; thermocouple

18. AVAILABILITY ☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☐ Order From Sup. of Doc., U.S. Government Printing Office, Washington, DC 20402, SD Stock No. SN003-003-

☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

19. SECURITY CLASS (THIS REPORT)	21. NO. OF PRINTED PAGES
UNCLASSIFIED	22
20. SECURITY CLASS (THIS PAGE)	22. Price
UNCLASSIFIED	$3.00

USCOMM-DC

NBSIR 79-1912