1.0 PURPOSE

The purpose of this document is to establish a criterion for the evaluation of a window or lens used as part of an explosion-proof (X/P) enclosure.

2.0 SCOPE

This policy supplements Title 30 Code of Federal Regulations Part 18 (30 CFR 18) requirements and applies to all new X/P enclosure certifications or new designs of enclosures requested as part of an approval action utilizing a window or lens (including luminaires). It also applies to modifications to existing window and lens assemblies submitted to MSHA for approval under the Revised Approval Modification Program (RAMP).

3.0 REFERENCES

3.1. Standard Operating Procedure for Processing Part 18 Certification Applications, ASAP2015

3.2. Impact Testing of Lenses, 30 CFR, 18.66(a), ASTP2132

3.3. Requirements for Explosion Testing Per 30CFR 18.62, ASTP2137

3.4. Test of Flammability of Plastic Materials for Parts in Devices and Appliances, UL94 -Vertical Burning Test (V-2)

3.5. A&CC Report Tr81100, Thermal Shock Test Procedures for Windows and Lenses.

4.0 DEFINITIONS

4.1. American Standard Association (ASA) - Nationally recognized American standards for mechanical sizes and dimensions.

4.2. Crack - A separation of material throughout its thickness.

4.3. Craze - Defects that appear as surface cracks and have a silvery appearance when light is passed through the material.

4.4. Luminaire - A complete lighting assembly including lamp/bulb and enclosure.

4.5. Polycarbonate resin manufacturer - The manufacturer of the raw material (resin).

4.6. Sheet/molded part vendor - The company that forms the polycarbonate resin into a sheet or a finished molded part.

5.0 CRITERIA

5.1. An application for MSHA investigation and/or testing of an enclosure containing a window(s) (lenses) shall comply with applicable requirements in 30 CFR 18. Among those requirements is that the enclosure with its window or lens be constructed of suitable materials, of good quality workmanship, based on sound engineering principles; and safe for its intended use.

5.2. Requirements for an Adhesive-Bonded Windows or Lenses

5.2.1. A metal fastening which acts as a retainer in the event of a bond failure.

5.2.2. The use of an adhesive, having a hardness below that of the window, during and after adhesive cure, at temperatures in the range of at least 0-150° C. The use of an adhesive that bonds the perimeter of the window to its holder.

5.2.3. A statement from the adhesive formulator that the adhesive is chemically compatible with the window and all enclosure materials that form the enclosure to window or lens bond.

5.2.4. Adhesive formulator's procedures for use of the adhesive and documentation from the applicant that the adhesive will be applied according to those procedures.

5.3. Requirements for Glass Windows or Lenses

5.3.1. The applicant shall submit the assembly and fabrication procedures to assure the use of glass that is free of chips, cracks, pits and other defects 1/32-inch or larger in one or more dimensions on any surface that contacts metal, gasket, or bonding material.

5.4. Documentation and Technical Requirements for Polycarbonate Windows or Lenses

5.4.1. Name and address of the polycarbonate resin manufacturer.

5.4.2. Grade/type of raw material base.

5.4.3. Identification of the vendor who forms the sheet or molded part and their part/catalog number for the sheet/part.

5.4.4. No design or use of a polycarbonate window or lens will be accepted that is not in accordance with the polycarbonate resin manufacturer's guidelines.

5.4.5. A window or lens that exhibits crazing or cracking either before or after machining (if required), shall not be used in MSHA approved equipment. A caution statement to this affect shall appear on the applicable drawing or specification.

5.4.6. Applicants shall permanently label each window or lens in a manner acceptable to MSHA that will not adversely affect permissibility and will permit tracing the source of the window or lens. The applicant shall maintain in-house traceability for each lens as to lot and source.

5.4.7. Confirmation that the methods and materials used in forming and/or constructing the explosion-proof enclosure are chemically compatible with the polycarbonate material. The confirmation should address the use of solvents, machine lubricating fluids, thread locking chemicals and other incompatible chemicals and materials that could contaminate the lens during the construction of the enclosure.

5.4.8. Confirmation that any secondary machining operations conducted on the window or lens are consistent and in agreement with the polycarbonate resin manufacturer's guidelines. These operations include but are not limited to, the drilling of screw holes, proper radii and fillets to reduce sharp corners, thread design, and part bonding.

5.4.9. Annealing and Surface Treatments

5.4.9.1. Detailed procedures for annealing/stress relieving the window or lens shall be provided. Annealing shall be conducted after any machining operation such as hole drilling, etc., to relieve the stress caused by the machining. The polycarbonate resin manufacturer should be consulted as to the proper annealing procedure.

5.4.9.2. Annealing may be waived when stress testing indicates that the residual stress levels in the part after machining, molding, extruding, etc. do not exceed the resin manufacturer's recommended levels of 900 to 1200 psi. The stress test method shall be that method recommended by the manufacturer of the specific resin being used. If the applicant, or anyone other than the resin manufacturer conducts the stress test, the applicant shall provide to MSHA a written test procedure. MSHA reserves the right to witness the tests, and any follow-up tests as part of a quality assurance investigation.

5.4.9.3. Information concerning additives (i.e. glass fibers) used during molding, extruding or processing and surface treatments or coatings applied to the window or lens.

5.4.10. None of the surfaces contacting the polycarbonate shall cause point stress to the window or lens. Therefore, surfaces such as the edges of the cutout opening on an enclosure cover and metal retaining frames, shall be smooth and rounded to a minimum radii of 0.015".

5.4.11. Windows or lenses may be fastened in their holders by means of mechanical (threading, bolting, etc.) retention.

5.4.12. In addition to lock washers, all securing bolts shall use "extra heavy" American Standard Association (ASA) type flat washers or equivalent (see Appendix No.1). This requirement may be waived if the retainer is of an adequate thickness, based on the bolt diameter. (See table below)

5.4.13. Bolts shall be tightened to the recommenced torque for the specified thread size (See table below). This torque will be listed on a metal plate located near the securing bolts. The torque should be specified on the enclosure assembly drawing.

BOLT DIAMETER	TORQUE (ft. lbs.)	MINIMUM RETAINER THICKNESS
1/4"	10 – 12	.190" (3/16" NOMINAL)
5/16"	17 – 19	.190" (3/16" NOMINAL)
3/8"	30 – 35	.190" (3/16" NOMINAL)

BOLT DIAMETER	TORQUE (ft. lbs.)	MINIMUM RETAINER THICKNESS
7/16"	50 – 55	.190" (3/16" NOMINAL)
1/2"	60 – 65	.220"
M6	10 –12	.190" (3/16" NOMINAL)
M7	12 –14	.190" (3/16" NOMINAL)
M8	17 – 19	.190" (3/16" NOMINAL)
M10	35 – 39	.190" (3/16" NOMINAL)
M12	60 – 65	.220"

5.4.14. A flammability rating in accordance with UL 94 -Vertical Burning Test (V-2) or better is required for the specified minimum thickness of the window or lens. Information from the resin manufacturer must be submitted that documents the UL 94 (V-2) rating of the window or lens at the thickness specified

5.5. Technical Requirements for Luminaire Lenses

5.5.1. Provision shall be made for securing the lamp/bulb within the enclosure in order to maintain a fixed distance from the lamp/bulb to the interior surface of the lens. This distance shall be specified on the luminaire assembly drawing.

5.5.2. Fluorescent lamps shall be electrically or mechanically designed so that in the event that a lamp breaks, the cathodes would not remain energized for a length of time that would heat the inside surface of the lens to a temperature greater than 240° F (115°C).

5.5.3. Electrical conductors contained within luminaries with polycarbonate lenses shall use insulation that is chemically compatible with polycarbonate, such as Teflon. Insulating materials such as PVC shall not be used.

5.5.4. Mercury vapor, and other lamps that emit high levels of ultraviolet radiation that would adversely affect the optical and mechanical properties, i.e., color, shall not be used.

6.0 TESTING AND PERFORMANCE REQUIREMENTS

(Must be conducted in the following order.)

6.1. Internal surface temperature tests - Luminaire lens only.

6.1.1. Internal surface temperature tests will be conducted according to "Internal Surface Temperature Measurement of Plastic Mine Luminaire Lens" located in Appendix No. 2. The tests will be conducted at a 15% over-voltage input. The internal surface temperature shall not exceed 240 degrees F (115°C)

6.2. Thermal Shock Tests

6.2.1. Thermal shock tests will be conducted on four windows or lenses in accordance with "Thermal Shock Test Procedures for Glass Windows and Lenses," A&CC Report Tr81100 with the following changes in procedure:

6.2.2. A polycarbonate window or lens in its holder shall be heated to 240 degrees F in lieu of 302 degrees F.

6.2.3. All four windows or lenses shall pass the test

6.3. Impact Tests

6.3.1. Impact tests will be conducted on windows or lenses in their holder according to Impact Testing of Lenses 30 CFR, 18.66(a), ASTP2132. These samples shall be the same window or lens used in thermal shock tests.

6.3.2. All four windows or lenses shall pass the tests.

6.4. Explosion Tests

6.4.1. Explosion tests will be conducted according to Requirements for Explosion Testing PER 30 CFR, 18.62, ASTP2137 on four windows or lenses mounted in the enclosure in which certification is sought. These shall be the same windows or lenses used in the impact tests.

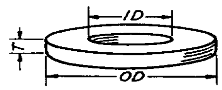
6.4.2. All four windows or lenses shall pass the tests. A window or lens will be considered as failed if it cracks, breaks, or crazes.

6.5. Solvent Stress Tests

6.5.1. When deemed necessary by MSHA, to determine stress levels in the window or lens assembly, solvent stress cracking tests will be conducted in accordance with the polycarbonate resin manufacturer's guidelines.

A76
APPENDIX D

American Standard Plain Washers*



Size	Light ID	Light OD	Light Thickness	Medium ID	Medium OD	Medium Thickness	Heavy ID	Heavy OD	Heavy Thickness	Extra heavy ID	Extra heavy OD	Extra heavy Thickness
0	5/64	3/16	0.020									
1	3/32	7/32	0.020									
2	3/32	1/4	0.020									
3	1/8	1/4	0.022									
4	1/8	1/4	0.022	1/8	5/16	0.032						
5	5/32	5/16	0.035	5/32	3/8	0.049						
6	5/32	5/16	0.035	5/32	3/8	0.049						
7	11/64	13/32	0.049	3/16	3/8	0.049						
8	3/16	3/8	0.049	3/16	7/16	0.049						
9	13/64	15/32	0.049	7/32	1/2	0.049						
3/16	7/32	7/16	0.049	7/32	1/2	0.049	1/4	9/16	0.049			
10	7/32	7/16	0.049	1/4	9/16	0.049	1/4	9/16	0.065			
11	15/64	17/32	0.049	1/4	9/16	0.049	1/4	9/16	0.065			
12	1/4	1/2	0.049	1/4	9/16	0.049	1/4	9/16	0.065			
14	17/64	5/8	0.049	5/16	3/4	0.065	5/16	7/8	0.065			
1/4	9/32	5/8	0.065	5/16	3/4	0.065	5/16	3/4	0.065	5/16	7/8	0.065
16	9/32	5/8	0.065	5/16	3/4	0.065	5/16	7/8	0.065	5/16	7/8	0.065
18	5/16	3/4	0.065	3/8	3/4	0.065	3/8	7/8	0.083	3/8	1 1/8	0.065
5/16	11/32	11/16	0.065	3/8	3/4	0.065	3/8	7/8	0.083	3/8	1 1/8	0.065
20	11/32	11/16	0.065	3/8	3/4	0.065	3/8	7/8	0.083	3/8	1 1/8	0.065
24	13/32	13/16	0.065	7/16	7/8	0.083	7/16	1	0.083	7/16	1 3/8	0.083
3/8	13/32	13/16	0.065	7/16	7/8	0.083	7/16	1	0.083	7/16	1 3/8	0.083
7/16	15/32	59/64	0.065	1/2	1 1/8	0.083	1/2	1 1/4	0.083	1/2	1 5/8	0.083
1/2	17/32	1 1/16	0.095	9/16	1 1/4	0.109	9/16	1 3/8	0.109	9/16	1 7/8	0.109
9/16	19/32	1 3/16	0.095	5/8	1 3/8	0.109	5/8	1 1/2	0.109	5/8	2 1/8	0.134
5/8	21/32	1 5/16	0.095	11/16	1 1/2	0.134	11/16	1 3/4	0.134	11/16	2 3/8	0.165
3/4	13/16	1 1/2	0.134	13/16	1 3/4	0.148	13/16	2	0.148	13/16	2 7/8	0.165
7/8	15/16	1 3/4	0.134	15/16	2	0.165	15/16	2 1/4	0.165	15/16	3 3/8	0.180
1	1 1/16	2	0.134	1 1/16	2 1/4	0.165	1 1/16	2 1/2	0.165	1 1/16	3 7/8	0.238
1 1/8	.....	.....	.....	1 3/16	2 1/2	0.165	1 1/4	2 3/4	0.165			
1 1/4	.....	.....	.....	1 5/16	2 3/4	0.165	1 3/8	3	0.165			
1 3/8	.....	.....	.....	1 7/16	3	0.180	1 1/2	3 1/4	0.180			
1 1/2	.....	.....	.....	1 9/16	3 1/4	0.180	1 5/8	3 1/2	0.180			
1 5/8	.....	.....	.....	1 11/16	3 1/2	0.180	1 3/4	3 3/4	0.180			
1 3/4	.....	.....	.....	1 13/16	3 3/4	0.180	1 7/8	4	0.180			
1 7/8	.....	.....	.....	1 15/16	4	0.180	2	4 1/4	0.180			
2	.....	.....	.....	2 1/16	4 1/4	0.180	2 1/8	4 1/2	0.180			
2 1/4	.....	.....	.....	.....	....	.....	2 3/8	4 3/4	0.220			
2 1/2	.....	.....	.....	.....	....	.....	2 5/8	5	0.238			
2 3/4	.....	.....	.....	.....	....	.....	2 7/8	5 1/4	0.259			
3	.....	.....	.....	.....	....	.....	3 1/8	5 1/2	0.284			

* ASA B27.2—1958. All dimensions in inches.

Appendix II

Internal Surface Temperature Measurement of Plastic Mine Luminaire Lens

PREPARATION FOR TESTING

Before the actual internal surface temperature of the plastic luminaire lense can be measured, the luminaire must be "setup" properly. The "setup" of the luminaire consists of placing or supporting the luminaire on a thermal insulating material such as 1/2" thick wood. The luminaire should not be in contact with heat sinking surfaces such as a metal bench top. The room in which the testing is to take place should be free from all drafts. Therefore, doors and windows should be closed to minimize air movement over the luminaire. The ambient room temperature should be maintained from 68 ^{o}F to 74 ^{o}F. A small safety factor is incorporated since actual underground conditions are normally cooler and the air flow is much greater.

Once the luminaire is set up and operational, it is energized and allowed to operate until it stabilizes at its normal operating temperature. While operating at its stabilized temperature, the hottest point on the exterior of the plastic lense is located by using a surface pyrometer and moving it across the surface of the lense until the highest reading is obtained. In most cases, the hottest point will be above the filament/ cathode of the lamp being used. When the hottest external spot is identified, the point radially below the external hot spot is selected as the point to be monitored.

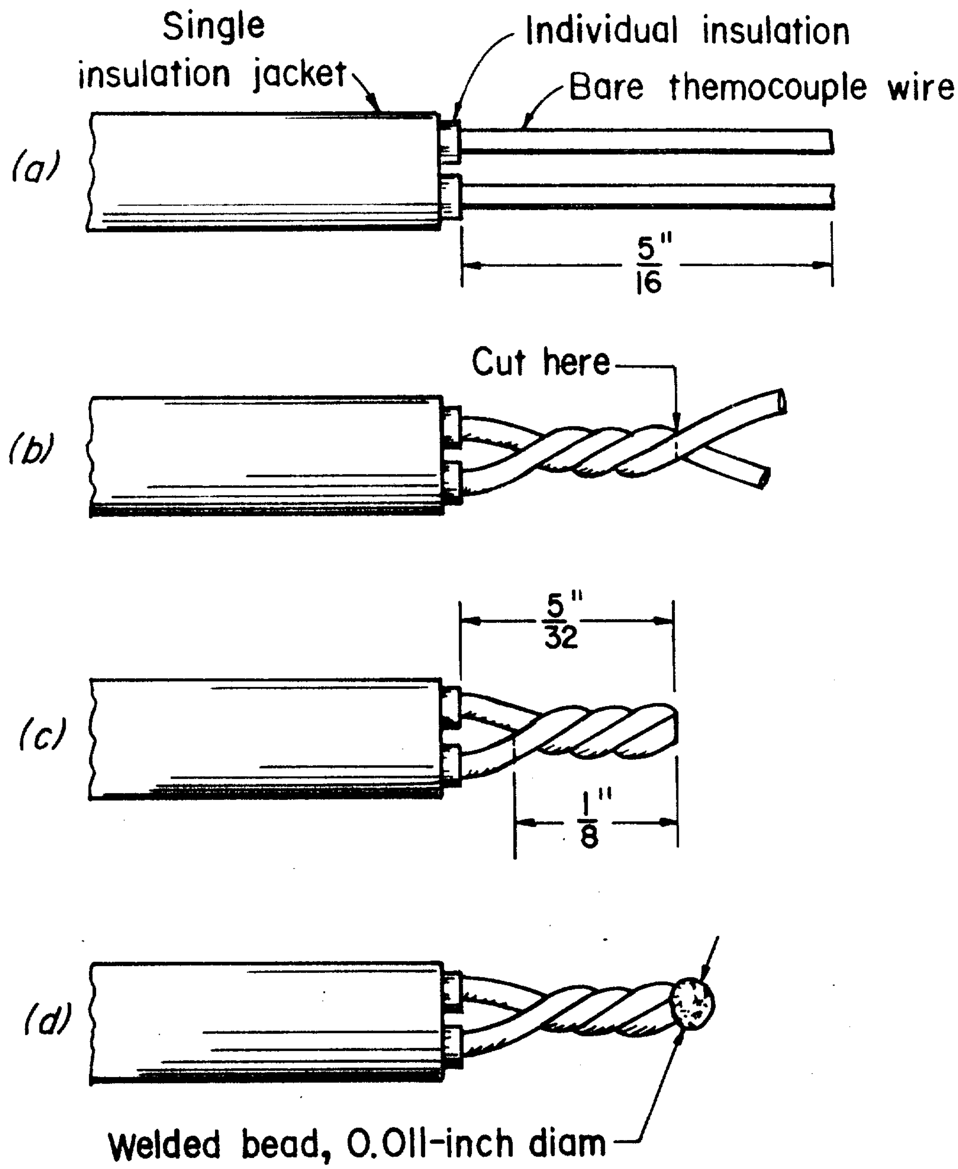


PLATE I

PGH-80
670

TRANSDUCERS USED - THERMOCOUPLES

Thermocouples are used for the measurement of temperatures. Therefore, the selection of the type, insulation and size of the thermocouple is important.

ANSI Type T (copper/constantan) thermocouples were chosen since they could perform in the temperature range expected with relatively low limits of error 0 to 350 °C, ± 1 °C or 0.75%).[2]

A fluoroplastic - TFE insulation was chosen due to its chemical inertness, electrical properties and thermal stability. It was determined that some types of insulation not having the same properties as a fluoroplastic TFE could "breakdown" chemically under thermal stress and "attack" and weaken certain types of plastics causing false failures of the lens. Therefore, the physical properties of the fluoroplastic TFE were necessary.

The thermocouple wire used was doubly insulated. First, each wire was individualy coated with fluoroplastic TFE, then both wires were formed into a single jacket by a second coating of the same material. (See PLATE 1, (a)). Since both thermocouple wires are contained in a single jacket, penetration and placement of the thermocouples into the luminaire, as well as the handling and routing of the wires, is simplified.

The physical size of the thermocouple wire is probably the most important consideration of the three selection factors. It was determined through preliminary testing, that greater repeatability of measurements was achieved when small diameter thermocouple wires were used (AWG 40).

2 ANSI MC 96.1

The AWG 40 wire permits a minute junction to be formed. Therefore, the effect the thermocouple junction has on the plastic surface being measured is kept to a minimum. Any heat sinking or hot spot effects, along with the plastic surface perturbance in emplacement of the thermocouple junction, is minimized with the small wire. Since the junction is small, only a drop of solvent is required to position it, causing little distortion to the lense surface. This wire is also easier to manipulate when used in the single jacket construction. The only disadvantage of small wire is that it is quite fragile and must be handled with some care. The AWG 40 wire has a diameter of 0.00315". The overall diameter of the total thermocouple wire, considering the insulations and the two wires, is 0.028" X 0.034". The junction diameter is typically 0.011" after being formed by twisting the leads and welding. As shown on PLATE 1, (c), the approximate exposed length of wire is 5/32" and the approximate length of the coils is 1/8".

See PLATE 1 items (a) thru (d) for sequence of forming the thermocouple junction.

INSTRUMENT USED - DATA LOGGER

A data logging indicating instrument was used to read and record the measured temperatures. The accuracy of the data logger system used for these tests is specified by the manufacturer as $\pm$ 0.8 ^{o}F when used with the "T" Type thermocouples. The data logger had a ten channel capacity, therefore, occasionally more than one luminaire was tested at a time, allowing some comparisons to be made. The luminaires were positioned so that they would not interact thermally. The overall temperature profile of a single luminaire could also be monitored using multiple thermocouples, although for the purpose of these tests, only the highest temperature was of interest.

The data logger was programed to record at thirty(30) minute intervals. The length of interval is not crucial, but thirty minutes was chosen because a substantial amount of readings (15 or 16) could be made in an 8 hour day, to allow the thermal profile of the luminaire to be graphed. No extensive changes will normally occur in the thirty (30) minutes between readings after the luminaire has "warmed-up".

It should be pointed out, that before any testing is conducted that all the testing equipment should be at thermal equilibrium. The thermocouple wires, data logger and any other associated equipment should be left at least overnight in the same room where the testing is to take place.

BONDING AGENT USED - SOLVENT

Methylene chloride was used to attach the thermocouple junction to the internal surface of the luminaires' plastic lense. Methylene chloride was recommended as a dissolving agent by the manufacturer of the plastic lense material.

The methylene chloride was dispensed by the drop using a hypodermic syringe. The syringe made it very easy to place a small amount of the fluid on the lense surface accurately.

THERMOCOUPLE WIRE ROUTING

After the hottest spot on the lense has been determined by the process described in section "Preparation for Testing", the point radially below the external hot spot is where the thermocouple junction will be internally located. Therefore, the lense is removed from the luminaire enclosure for emplacement of the thermocouple junction. Before the junction can actually be placed, the method of entry into the luminaire enclosure has to be determined.

It is important when considering the routing of the thermocouple lead wires into the luminaire, that the wire is not crushed or compressed, or adjacent to a heat sink or an electrical source.

Occasionally, when the design of the luminaire permits, the lead wires can be placed thru an extra cable gland entrance. If not, special modifications may be made to the enclosure to allow the thermocouple wires to enter. See PLATES 2 and 3 for suggested methods.

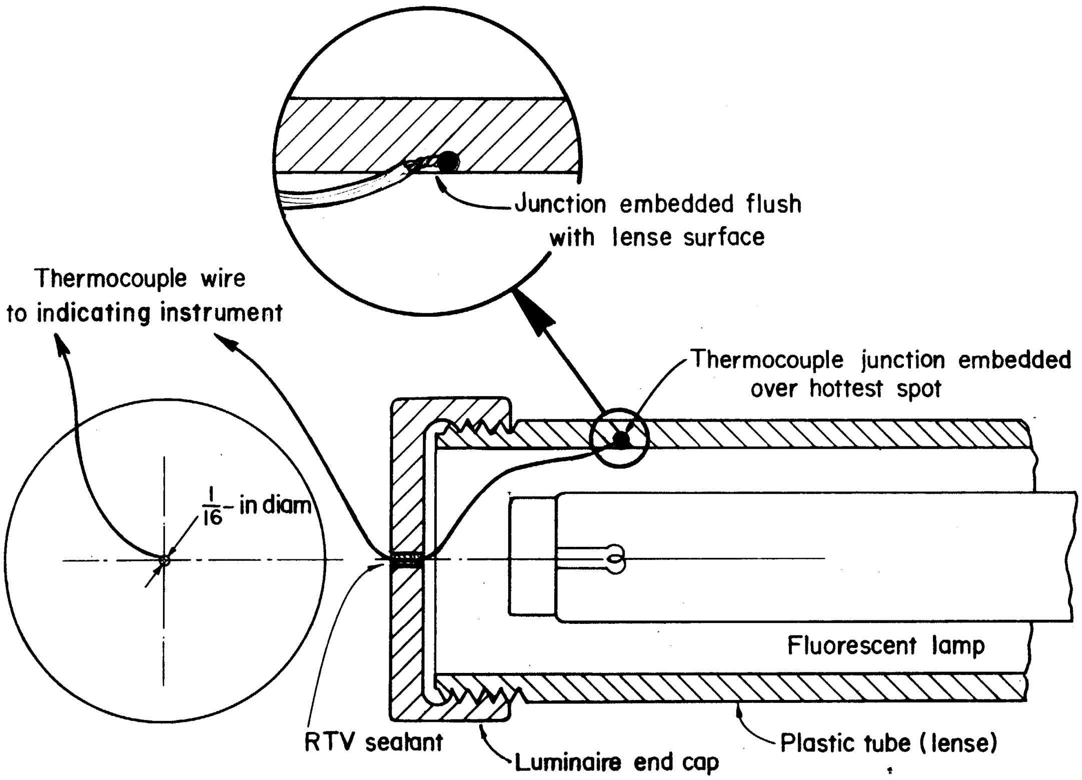


PLATE 2

PGH-80
671

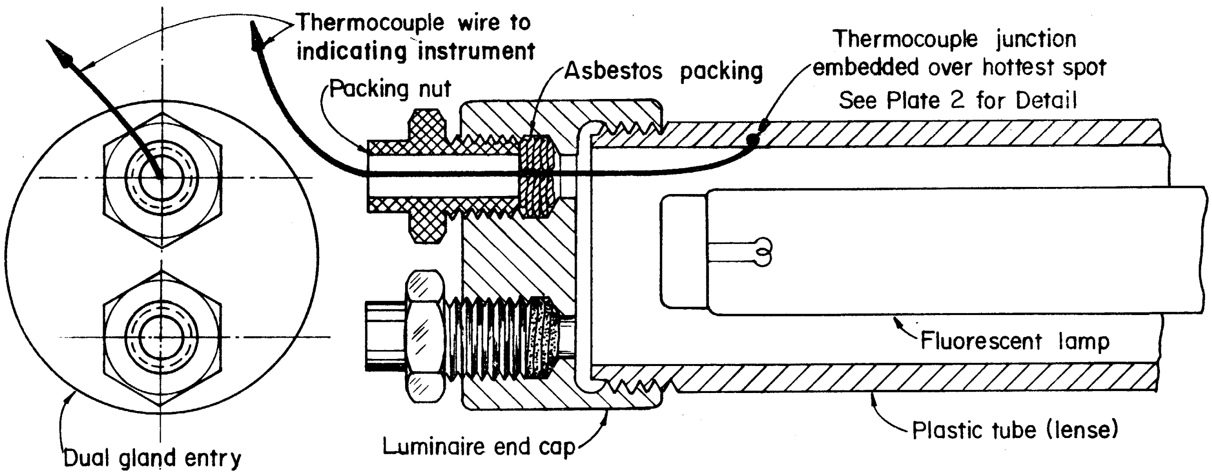


PLATE 3

PGH-80
672

THERMOCOUPLE JUNCTION EMPLACEMENT

Once the method of entry for thermocouple wire is determined, the thermocouple junction can be placed. First a small drop of methylene chloride is placed onto the spot where the junction is to be located. The drop should be approximately one-sixteenth of an inch (1/16") in diameter. The junction is then placed into the fluid and lightly pressed into position using the tip of the hypodermic syringe or any other small stainless steel object. It should be held in position with enough pressure, to force the junction and all exposed wire, into the plastic when softened by the solvent, so that the junction and wire are totally embedded in the plastic with the junction edge located evenly with the surface of the lense. Care must be taken to minimize smearing or distortion of the plastic area around the junction emplacement. Pressure should be maintained until the solvent evaporates. (See detail view on PLATE 2).

With the junction in place, the luminaire should be reassembled carefully and placed in its "setup" position as described in section "Preparation for Testing". The thermocouple wire is then connected to the data logger and the luminaire energized.

TEST PROCEDURES

Temperature measurements can be started once the luminaire is energized. Although the warmup temperatures are not of importance, thermal profile of the luminaire is sometimes desirable. Therefore, the data logger is set to record the temperature every thirty (30) minutes. The highest temperature recorded over an eight (8) hour period is the temperature of importance.

CONCLUSION

The methods described in this report required many hours of practice before they could be successfully performed. The techniques of forming the thermocouple measuring junction as well as embedding it into the lens were the most difficult, due to the small size of the thermocouple wire.

Other problems were encountered and solved in the development of these procedures. For instance, the thermocouple wires on occasion did break. Therefore, a plug and connector junction panel was used between the data logger and measuring junction. A broken thermocouple could be quickly and easily be replaced without disturbing the data logger, preventing undue delays in testing. Proper compensating connectors and extension wires were used.

It should be understood that each thermocouple installation is unique, since not all parameters of installation are identical from test to test. One of the purposes of this report is to identify those areas that are significant, so that temperature measurements can be made with uniformity and accuracy.