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13

# Temperature Classes of Electrical Insulators

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## 1. Introduction

In early times, the temperature classes of electric insulators were simply divided into natural organics, inorganics, and combinations thereof. In the late 1930s, the types of synthetic resins became diverse and their production volumes increased, with their application range being gradually expanded to insulation. In the late 1940s, when silicone resin became a popular insulator material, the H-class insulator was added to the temperature classes, and it became increasingly necessary to find applications for heat resistant materials in electric instruments.

Under such circumstances, IEC[1] issued a recommendation on the temperature classes of electric insulators, followed by IEC Publication 85[2] (1957), which established the classification system currently in use. In Japan, JEC 147[3] (1957), which was prepared by the Japanese Electrotechnical Committee, and JIS C 4003 (established in 1962, revised in 1977, and confirmed in 1982), which was prepared by the Japanese Industrial Standards Committee, contain material-classifying tables as a reference.

In parallel, the evaluation method for insulator classification was established, and some testing techniques for the high temperature life of new material for temperature classification were investigated intensively in the United States. The results were issued in many IEC Publications.[4] Such investigation has been continued to find a short time testing method of high temperature life.

This paper reviews the temperature classes of electric insulators.

Contents

## 2. Insulation classes for electric equipment

In 1977, the Electric Instrument Rules Committee of the Japanese Industrial Standards Committee discussed the classes of electrical insulation and drew up JIS C 4003: Classes of electrical insulation, to clarify the classes of motor insulation and their maximum allowable temperatures (Table 1)

Table 1. Maximum allowable temperatures of various types of insulation

| Insulation classes | Maximum permissible temperature (°C) |
|---|---|
| Y | 90 |
| A | 105 |
| E | 120 |
| B | 130 |
| F | 155 |
| H | 180 |
| C | Over 180 |

The following are brief explanations of those insulation techniques.

i) Class-Y insulation: Withstands a temperature of up to 90°C; typically made of cotton, silk, or paper

ii) Class-A insulation: Withstands a temperature of up to 105°C; reinforced Class-Y materials with impregnated varnish or insulation oil

iii) Class-E insulation: Withstands a temperature of up to 120°C

iv) Class-B insulation: Withstands a temperature of up to 130°C. This has a form that inorganic material is hardened with adhesives. This is the first insulator using this structure.

v) Class-F insulation: Withstands a temperature of up to 155°C; for example, made of Class-B materials that are upgraded with adhesives, silicone, and alkyd-resin varnish of higher thermal endurance

vi) Class H insulation: Withstands a temperature of up to 180°C; for example, made of inorganic material glued with silicone resin or adhesives of equivalent performance

vii) Class-C insulation: Withstands a temperature of up to 180°C or higher; made of 100% inorganic material

As explained above, electrical insulation is classified with its maximum allowable temperature. By adopting an insulation technique of higher thermal endurance, electric instruments can be downsized.

## 3. Temperature classes of materials used for various insulators

Once the temperature classes of insulation have been established, those of the individual materials of each insulator become important. JIS C 4003 provides a table of material temperature classes as a reference, in addition to the text. This reference table adopted the Standards of the Japanese Electrotechnical Committee of the Institute of Electrical Engineers of Japan, JEC 147 (1960), prepared by the Thermal-Endurance Classifying Committee of the Institute of Electrical Engineers of Japan in accordance with IEC Publication 85 (1957) and in consideration of then domestic situations and completed. Table 2 is that insulator classification table.

It should be noted that in this table every material is not always classified into a specific temperature class; rather, the table provides information for reference purposes only. The performance (durability) of a material can be easily changed through the combination of materials, treatment of varnish, and method of use. Thus, the Standards clearly suggest that when a manufacturer uses a material for insulation, the manufacturer must decide on its own whether the selected material is suitable for the relevant insulation, and that the manufacturer must conduct a well designed long life test for each purposes.

Table 2. Temperature classes of insulator materials

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Insulation type | Main or sub | Insulation material | Adhesive, impregnant, or coating material used together with the insulator specified in Column 3 | Target insulator |
| Y | Main | Cotton, silk, or other natural plant or animal fibers O<br>Regenerated cellulose O<br>Cellulose acetate O<br>Polyamide fiber O<br>Paper and paper goods O<br>Press board O | None | None |

| | | | | |
|---|---|---|---|---|
| | | Hard fiber O<br>Wood O<br>Aniline resin<br>Urea resin | | |
| | Sub | Acrylic resin<br>Polyethylene<br>Polystyrene<br>Vinyl chloride (soft or hard)<br>Vulcanized natural rubber | None | None |
| A | Main | Impregnated or liquid-dielectric immersed cotton, silk, or other natural plant or animal fibers O<br>Regenerated cellulose O<br>Cellulose acetate O<br>Polyamide fiber O<br>Paper and paper goods O | None | Oil-modified natural resin O<br>Ceramics, copal<br>Other natural resin O<br>Cellulose derivatives<br>Paint O<br>Higher-temperature-resistant materials O<br>Insulation oil and synthetic insulation oil O |
| | | Press board O<br>Hard fiber O<br>Wood O | None | |
| | | Varnish cloth (cotton, silk, or other natural plant or animal fibers; regenerated cellulose, cellulose acetate, or polyamide fiber base) O<br>Varnish paper O | Oil-modified natural or synthetic resin varnish O | |
| | | Laminated wood plates | Phenol resin | |
| | | Cellulose acetate film O<br>Cellulose acetate butyrate film O<br>Bridged polyester resin<br>Enamel wire oil varnish O<br>Enamel wire polyamide resin<br>Enamel wire polyvinyl formal[1] | None | |
| | Sub | Polychloropylene, nitrile rubber | None | As above |
| E | Sub | Enamel wire polyurethane resin<br>Enamel wire epoxy resin | None | Oil-modified asphalt and oil-modified synthetic resin varnish<br>Bridged polyester resin<br>Material with thermal endurance higher than that of epoxy resin |
| | | Cellulose-filled mold products O<br>Cotton lamination O<br>Paper lamination O | Melamine resin<br>Phenol resin O<br>Phenol furfural resin | |
| | | Bridged polyester resin<br>Cellulose triacetate film<br>Polyethylene terephthalate film O<br>Polyethylene terephthalate fiber O | None | |
| | | Varnish-treated polyethylene terephthalate cloth | Oil-modified alkyd varnish | |
| B | Main | Glass fiber ※ O<br>Asbestos ※O | None | Oil-modified asphalt and oil-modified synthetic resin varnish O<br>Bridged polyester resin O<br>Epoxy resin O<br>Polyurethane resin O<br>(If they will be exposed to strong mechanical stress, these are not good choices. In such a case, use unmodified phenol resin.)<br>Material of higher thermal endurance O |
| | | Varnish glass cloth O<br>Varnish asbestos O | Oil-modified synthetic resin varnish | |
| | | Mica products (with or without support material) O | Shellac, asphalt or bituminous compound O<br>Oil-modified synthetic resin O<br>Alkyd resin O<br>Bridged polyester resin O<br>Epoxy resin | |
| | | Glass lamination O<br>Asbestos lamination O<br>Mineral-packed mold products O | Melamine resin O<br>Phenol resin O | |
| | Sub | Enamel wire silicone resin [2]<br>Enamel wire polyethylene terephthalate [2] | None | As above |
| | | Mineral-packed mold products | Bridged polyester resin | |
| | | Polyfluorinated ethylene resin [3] | None | |

| | | | | |
|---|---|---|---|---|
| F | Sub | Glass fiber ※ O<br>Asbestos ※ O | None | Resin listed below featuring excellent thermal endurance<br>Alkyd resin<br>Epoxy resin<br>Bridged polyester resin<br>Polyurethane resin<br>Silicone alkyd resin O<br>Silicone phenol resin O<br>Material of higher thermal endurance O |
| | | Varnish glass cloth O<br>Varnish asbestos O<br>Mica products (with or without support material) O | Resin listed below featuring excellent thermal endurance<br>Alkyd resin<br>Epoxy resin<br>Bridged polyester resin<br>Polyurethane resin<br>Silicone alkyd resin O | |
| H | Main | Glass fiber ※ O<br>Asbestos ※ O | None | Silicone resin O |
| | | Varnish glass cloth O<br>Varnish asbestos O | Silicone resin | |
| | | Rubber glass cloth O | Silicone rubber O | |
| | | Mica products (with or without support materials)<br>Glass lamination O<br>Asbestos lamination O | Silicone resin O | |
| | | Silicone rubber | None | |
| C | Main | Mica O<br>Ceramic O<br>Glass O<br>Quartz O<br>Inorganic materials with properties similar to the above O<br>(Note: The maximum permissible temperature is limited by the material's physical, chemical, and electric properties at each operating temperature) | None | Inorganic adhesives such as glass or cement O |
| | Sub | Varnish glass cloth O<br>Varnish asbestos mica products O | Silicone resin of excellent thermal endurance (Maximum permissible temperature 225°C) O | Silicone resin of excellent thermal endurance (Maximum permissible temperature 225°C) |
| | | Polytetrafluoroethylene resin (Maximum permissible temperature 250°C) | None | |

Remark: Materials marked with ※ are regarded as belonging to the current insulator class if treated with a material listed in Column 5. Materials marked with O are proven by the Thermal-Endurance Classifying Committee of the Institute of Electrical Engineers of Japan to be sufficiently useful as a material of the class.

Notes: (1) Enamel wire polyvinyl formal... This is classified into Class E (sub) in the I.E.C. Table. However, we found that it should be classified into Class A unless it shows excellent heat resistance.

(2) Enamel wire silicone resin, enamel wire polyethylene terephthalate... In the test using yarned test pieces or the Marlette test or motor test using these materials as a magnet wire, they are known to have heat resistance approximately 30-40°C higher than that of enamel wire polyvinyl formal. Thus, they are classified into Class B.

(3) Polytrifluorinated ethylene resin... Its mechanical properties change depending on the fabrication conditions. Good fabrication techniques provide heat resistance as high as 130°C for an extended period. (Source: JIS C 4003)

In Table 2, "Main" means that the material is widely recognized as being useful in the class, and "Sub" means that the material's performance has not been confirmed, although it is often used on a trial basis.

## 4. Testing method of high temperature life for various materials

The heat resistance classification of insulators relies on either of the following:

(a) Field records recognized over the long term

(b) Experimental life test for new materials (not always verified theoretically)

When using method (b), we conduct an accelerated aging test under the same conditions as employed for known reference material whose performance has already been proven, and decide the temperature class of the new material according to the test results compared with those of the known material. This is the technique that is employed by IEC[5] and used widely by many institutes.

To analyze the thermal aging of organic materials (both natural and synthetic), T.W. Dakin et al. have proposed a theory[6] considering the chemical reactions of oxidizing decomposition, polymerization, bridging, and evaporation of plasticizer.

According to their theory, the rate of chemical reactions can be expressed by the following equation:

$$\frac{dc}{dt} = -kc^n \text{.....(1)}$$

where c: concentration of the reacting material; t: time; n: rank of reaction; and k: reaction rate constant

Assuming that concentration C in (1) can be replaced by physical property P, we generally obtain the following equation:

$$f(P) = -kt + f(Po) \text{.....(2)}$$

where f (P) is a function of P and Po is P at t=0

Assuming n=1,

$$\log P = -kt + \log Po \text{.....(3)}$$

Substituting Arrhenius' reaction rate constant k in eq. (3),

$$k = A.e^{-E/RT}$$

where A: frequency constant; E: activation energy; R: gas constant; and T: absolute temperature

Solving (3) to obtain t in log form:

$$\log t = \log \left(\frac{1}{A} \cdot \log \frac{Po}{P}\right) + \frac{E}{RT} \text{.....(4)}$$

Assuming that te is the aging time (life time) required for physical property P to reach Pe (for example, 50% of the initial value) ,

$$\log te = \log \left(\frac{1}{A} \log \frac{Po}{P}\right) + \frac{E}{RT} \text{.....(5)}$$

In eq. (5) , $\log \left(\frac{1}{A} \cdot \log \frac{Po}{P}\right)$ is a constant and, if expressed by A', eq. (5) reduces to (6) .

$$\log te = A' + \frac{E}{RT} \text{.....(6)}$$

According to the theory of T. W. Dakin et al., because A', E, and R are constant, log te (logarithm of life time, te) is proportional to $\frac{1}{T}$ (absolute temperature of aging temperature).

Specifically, the maximum temperature is estimated from the temperature increase of the instrument based on its design. Next, we choose three to four temperatures that are higher than the maximum temperature as aging temperatures, calculate the aging time at each temperature at which the physical property changes into Pe, plot the relations of (log te - $\frac{1}{T}$), connect these points, check the linearity, and extrapolate this life line to lower temperatures by 20 thousand hours in order to determine the corresponding aging temperature and decide on the temperature class.

For example, in Fig. 1, suppose that a high-temperature life test has been conducted at temperatures $T_1$-$T_4$, and that the aging times for 50% degradation of the physical property are found from the degradation curve to be $t_1$-$t_4$.

By plotting (log t - $\frac{1}{T}$) with the reciprocal of the absolute temperature of the aging temperature on the lateral axis and with the reciprocal of the aging time (time of degradation) on the vertical axis, a nearly linear line can be obtained by connecting those plots (Fig. 2).

Fig.1 Degradation curve

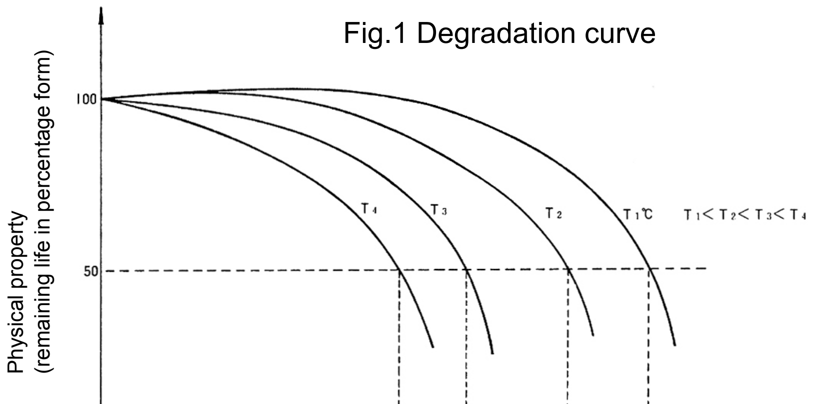
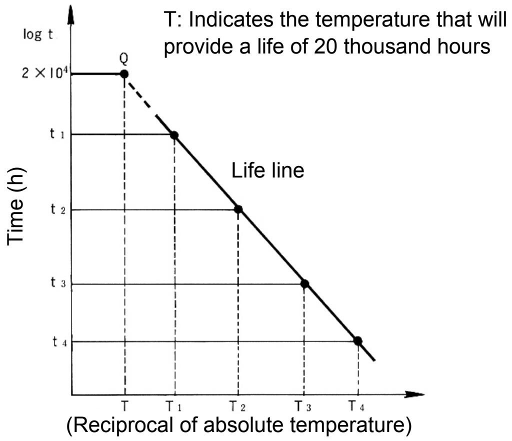


Figure 2. Heat-resistant life line




By extending this life line to lower temperatures and reading the cross-point, Q, with t=20,000 hours and temperature T (max. operating temperature) on the lateral axis, all information on the temperature class of the material can be obtained. The following is the specific testing method.

i) Test sample

Many insulators are composites using adhesives and varnish.

They are used as test samples following a simple varnish treatment. For example, the helical-coil method is a life testing method for impregnated varnish. By winding a bare Cu wire densely to form a cylinder, impregnating and coating the varnish and drying/sintering it to make a test sample, its bending breakage stress after heating can be determined and the thermal degradation rate can be checked simply. Another example is the method in which varnish is impregnated in a glass cloth and dried to make a varnish glass cloth for use as a test sample, and the breakdown voltage is then determined following thermal degradation. Another is the twisted-pair method, in which a test sample made of two twisted enamel wires is used. Meanwhile, the heat resistance of laminated material can be examined easily by using a test sample of an appropriate size to conduct a bending test or tensile strength test.

ii) Cycle conditions in the aging test

Some tests require rather complex degradation cycles, such as continuous heating, heating → cooling, heating → cooling → moisture absorption, and heating → cooling → moisture absorption → vibration, to attain the goal of testing. As for the aging temperatures, the minimum aging temperature, which is approximately 20°C higher than the projected operating (max.) temperature, and three to four points, each of which is 20°C, 40°C, 60°C, and 80°C higher than the minimum aging temperature, respectively, must be selected. In addition, they must be selected so that the minimum degradation temperature provides a life as long as at least 100 hours.

iii) Selecting a physical property

As the index of the aging test, a physical property should be selected that is suited to the expected use, such as strength (tensile, bending), elongation, breakdown voltage, and weight loss, which makes the test easy and empirically reduces measurement error.

iv) Deciding the life end point

It is necessary to decide in advance, for each use of the material, the percentage of the life end point of the physical property in relation to the initial value. Because it depends on the physical property selected as the life index, there is no set rule. However, it is often decided to be 50% of the initial value. The percentage should be decided in consideration of the operating conditions, life, and safety of the electric instrument.

v) Life of an electric instrument

Although the life of an electric instrument depends on the adopted material and operating conditions, 20 thousand hours can be used as a guide for estimating the maximum temperature.

The high-temperature life test therefore continues for at least 5,000 hours at the minimum test temperature. This means that the test requires almost seven months of continuous heating to obtain the first point on the life line. Thus, nearly a year is required to determine the life line.

Since JEC147 (1960), Institute of Electrical Engineers of Japan has continued its research and surveys on material and test methods, and has issued the results in a technical report[7].

## 5. Temperature classification used in other standards

### 5-1. Japanese National Railways Standard (JRS)

As shown in the table below, temperature increase is used as a standard to decide the temperature classification of vehicle motors used in JR trains and locomotives.

Table 3. Vehicle motor standards[8)]

Unit: deg.

| Component \ Insulation class | | Cass B | Class F | Class H |
|---|---|---|---|---|
| Stator coil | Resistance method | 130 | 155 | 180 |
| Armature coil | Resistance method | 120 | 140 | 160 |
| Commu-tatator | Electric-type-thermometer method | 105 | | |
| Standard ambient temperature | | Standard 25°C; Maximum 40°C | | |

JRS decides the insulation class based on the temperature rise of the coil, unlike JEC and JIS. In the case of the maximum temperature of the Class-H stator coil, the standard ambient temperature reaches 205°C and the maximum ambient temperature reaches as high as 220°C. Thus, the insulator may be seriously damaged.

### 5-2. Relative temperature index used in UL standards

UL-764B[9)] (1975) specifies a method for determining the long-term heat resistance of polymeric materials, and expresses the recommended temperature index of material using the relative temperature index (RTI). This index indicates the ability of material to maintain a specific property when exposed to high temperatures, thereby serving as a measure of a material's high-temperature durability. RTI can be obtained through the following:

i) Field experience

ii) A long term degradation program

The procedure specified in ii is the same as those of the aforementioned IEC and JIS, in which linearity is checked with plotting (log t - $\frac{1}{T}$). However, the time is set to 60 thousand hours when a reference material is available; otherwise, 100 thousand hours for extrapolation is required to determine the corresponding RTI.

Table 4 is an excerpt from RTI described in UL-764B. For details, refer to the review paper[10)].

Table 4. Example of the relative temperature index[a)]

| Material name | | Relative temperature index (°C) |
|---|---|---|
| Polyamide (6, 11, 12, 66, 610, 612 nylon) [b)] | | 65 |
| Polycarbonate [b)] | | 75 |
| Polyethylene terephthalate | Mold products | 65 |
| | Film≦0.25 mm | 105 |
| Polypropylene | | 65 |
| Teflon TFE | | 180 |
| Teflon FEP | | 150 |
| Silicone | Mold products [c) d)] | 150 |
| | Rubber (RTV) | 105 |
| Epoxy | Mold products [c) d)] | 130 |
| Casting or potting | | 90 |
| Diallylphthalate | Mold products [c) d)] | 130 |
| Unsaturated polyester | Mold products [c) d)] | 130 |
| Mica composite | | |
| Epoxy or polyester bonding | | 130 |
| Phenol resin bonding | | 150 |
| Silicone bonding | | 200 |

a) Part of UL-746B (1975); for reference
b) Using an inorganic filler such as glass fiber
c) Molded at high temperature and high pressure
d) Including inorganic fiber and excluding fiber reinforced systems using liquid resin

### 5-3. Electric apparatus regulations and using temperature of insulators

Ministerial ordinance No. 85, issued by the former MITI in 1962, showed how to handle electrical apparatuses from a technological viewpoint and specified detailed new enforcement regulations[11)] An attached table of the enforcement regulations shows the upper temperature limits of insulators.

To officially decide the limits, the Japan Electrical Safety & Environment Technology Laboratories now conducts the test based on the practical rules of the insulator certification test[12)]. The upper temperature limit is decided by extrapolating the life line to 40 thousand hours.

Table 5 shows some upper limits sampled from the attached table. Refer to the enforcement regulations and check/test rules for details.

Table 5. Upper limits of useful temperatures of insulators[a)]

| Material name | Reinforced by | Upper limit (°C) No.1[c)] | Upper limit (°C) No.2[c)] |
|---|---|---|---|
| Polyethylene | - | 50 | 80 |
| Bridged polyethylene | - | 90 | 120 |
| Polypropylene | - | 105 | 110 |
| | G[b)] | 110 | 120 |
| Modified polyphenylene oxide (PPO) | - | 75 | 120 |
| | G | 100 | 140 |
| Polyacetal | - | 100 | 120 |
| | G | 120 | 130 |
| Polycarbonate | - | 100 | 125 |
| | G | 120 | 130 |
| Polyethylene terephthalate | - | 120 | 125 |
| | G | 130 | 150 |
| Polytetrafluoroethylene (Teflon) | - | 250 | |
| Silicone resin Lamination | Minerals | 180 | 220 |
| Silicone resin Mold | Minerals | 180 | 220 |
| Polyimide Film | - | 210 | 250 |
| Polyimide Lamination | - | 190 | - |

a) This table is cited from the Details of Regulations of Electrical-Apparatus Technology Basis issued in 1979 by the Japan Electric Association, p. 319, for reference purposes. Refer to the Details.
b) "G" indicates glass fiber reinforcement.
c) No. 1 means that the material is generally known to maintain this temperature.
No. 2 means that the material can be used at this temperature on a trial basis according to predetermined procedures.

## 6. Conclusion

It have passed 28 years since IEC Pub. 85 on temperature classification was published in 1957, and a number of experts have reviewed it. This paper has pointed out that JEC147 and JIS C 4003 were established with reference to the IEC publication, and that the IEC concepts have been reflected in the UL standards and electrical apparatus regulations. ISO2578 is the corresponding international standard.

New materials with performance proven through long-term life evaluation tests have not been added to the IEC list. However, considering that the related JIS has been left unchanged for over 20 years, the descriptions should be updated.

Some quick evaluation methods have been investigated by the Institute of Electrical Engineers of Japan and IEC working groups. We hope that the investigation results will be reported soon.

<References>


1) IEC: International Electrical Commission. Organized in 1908; in charge of preparing/issuing international standards as an activity of the ISO's electrical/electronic department.
2) IEC Publication 85 (1957): Recommendations for classification of materials for the insulation of electrical machinery and apparatus in relation to their thermal stability in service.
3) JEC 147 (1960), "Types of electrical insulation" or IEEJ technical report No. 48 (Sept. 1961)
4) For example, IEC Pub. 172, 216, 290, 370, etc.
5) IEC Pub. 216-1; Part 1. General procedures for the determination of heat resistance properties, temperature indices, and thermal endurance profiles. (1974)
6) T. W. Dakin; AIEE Trans. 67, Pt. III 113 (1948)
7) IEEJ technical report No. 51 (June 1962)
IEEJ technical report II, No. 28 (August 1974)
IEEJ technical report II, No. 134 (August 1950)
8) JRS 15255 2197 15AR3 "General main motors" (revised on Nov. 30, 1963)
9) UL-746B (1975) Revised on 3/20/78, 5/25/78, and 12/14/78
10) For example, Isono's review paper, Industrial Materials Vol. 27, No. 11, pp. 21-27 (1979)
11) Revised version (Sept. 25, 1979) of Details of Regulations of Electrical-Apparatus Technology Basis, issued byJapan Electric Association
12) Practical Rules of the Organic Insulator Certification Test, issued by Japan Electrical Safety & Environment Technology Laboratories (June 1, 1981)



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# Three Bond fine chemical products help the progress of optical communications

Optical fibers as thin as a human hair have brought technical innovations to the world of communications. Telephones, TV, fax machines, telex, and other emerging new media--the root of such forms of mass media is optical-communications systems using fiber optics.

As optical communications technology advances significantly due to fiber optics contained in its core, fine chemical products are also expected to keep pace with such progress to support communications technology. Introduced here are the high performance light-curing resin and epoxy resin for optical communications that Three Bond has developed based on its more than 30 years of expertise in research on fine chemicals. These products have played a key role as raw materials, coating materials, and adhesives in the field of optical communications.

Their excellent moisture resistance, workability, and refractivity meet the demanding needs of optical communications.


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- **AVR-100: Adhesive for quartz glass, lenses, and their bonding**
  When cured, this adhesive has a refractive index of $n_D^{25}$ 1.460, which is as high as that of quartz glass. It cures in seconds with UV exposure, forms a flexible but hard film, and strongly adheres to glass. Its moisture resistance is also excellent.
- **AVR-110: Optical fiber clad material, mold material for optical components**
  When cured, this material has a refractive index of $n_D^{25}$ 1.450, which is as high as that of quartz glass. It cures in seconds with UV exposure and features excellent moisture resistance. Useful as a plastic fiber material for optical communications in combination with AVR-200.
- **AVR-200: Optical-fiber core material, mold material for optical components**
  When cured, this material has a high refractive index of $n_D^{25}$ 1.558. It cures in seconds with UV exposure, features high transparency and high light transmissivity, as well as excellent moisture resistance. Useful as a plastic-fiber material for optical communications in combination with AVR-110
- **UVR-016: Primary coating material for optical fiber**
  Keeps elasticity down to -40°C, with little light power loss at low temperatures, maintaining performance almost as high as that of silicone resin. It cures in seconds with UV exposure and features excellent moisture resistance.
- **UVR-017: Secondary coating material for optical fiber**
  Ultra-fast setting at a UV exposure of 60-100 mJ/cm$^2$. Features elasticity as high as that of nylon resin, and excellent moisture resistance.

## High-performance epoxy resin for optical communications

- **CVR-009 (main glue) and CVR-010 (curative): Adhesive for optical-fiber connectors**
  Two-liquid-type epoxy resin that strongly adheres to glass, metals, and plastics. After curing, it features flexibility, excellent thermal-shock resistance, low viscosity, and high workability.

# Introducing High-performance chemical products for electronics

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### One-liquid type high performance epoxy resin

This is a one-liquid type high performance epoxy resin developed for electric/electronic industry users.
With electric/electronic devices being reduced in size and weight but featuring high output, the epoxy resins used in such devices are required to have higher electric performance, chemical performance, and thermal endurance.
Additionally, in recent years, high workability has been added to such requirements in order to enable speedy, automated device assembly.
The ThreeBond 2000 Series consists of one-liquid type high performance epoxy resin developed to meet such needs

## ThreeBond 3000 Series:
### Light-curing resin

This is a one-liquid type (no solvent) light-curing resin developed based on our proprietary technology. This high performance material is designed to be particularly useful for industrial applications such as sealing, bonding, coating, and potting, and has attracted attention as a material contributing to cost reductions in a wide range of application areas, including electrical use, electronics, automobiles, and optical instruments.
It cures in seconds with polymerization when exposed to sunlight or 300-400-nm UV light emitted from a UV illuminator. It then robustly cured and features excellent flexibility, contact, chemical resistance, heat/cold resistance, and electronic performance, and thereby helps improve system performance and extend service life. Because it is a one-liquid type, there is no need for solvent and it cures in seconds, and you can easily improve the cleanliness of the working environment, automate and speed up the manufacturing process, and eventually reduce costs drastically.

## ThreeBond 3300 Series: Conductive resin material

This is a conductive resin material made of synthetic resin and conductive filler of carbon or metals such as silver, copper, and nickel. Adhesive, paste, and paint types are available to accommodate individual needs. Unlike solder, it strongly adheres to plastic, rubber, and ceramic materials, and is widely used for bonding between leads and electrodes, bonding of semiconductor chips and EMI components, fabrication of printed circuits and their repair, and bonding of jumper wires and electronic parts that require electrical conductivity, including through holes. Three Bond is constantly working to develop innovative products that meet the needs of the electric/electronic industries, in which technologies evolve rapidly.

## ThreeBond 2500 Series:
### Contact-conductivity restoring agent

This is a contact-conductivity restoring agent of which an extremely chemically stable, neutral polymer derivative is a major element. It prevents the sulfidization, oxidization, abrasion, and deformation of contacts, which are regarded as the key to the performance of electric instruments, thereby greatly extending their service life and preventing problems. It also works to clean and restore contacts whose functions have been impaired by sulfidization and oxidization. A variety of types are available to meet your needs.

<Major applications> Protection, lubrication and cleaning of volume dials, switches, and connectors

<Advantage> Various grades of products are available to meet a wide range of contact-pressure requirements.

ThreeBond TECHNICAL NEWS

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