EPOXY TECHNOLOGY

Tech Tip #1

The Major Characteristics Of Adhesives

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THE MAJOR CHARACTERISTICS OF ADHESIVES

Adhesives for highly technical applications are generally designed for both performance and process ability. As a result, adhesives that are sold for high tech applications can dramatically differ in their characteristics even if their chemistries are relatively similar.

Adhesives can be one-component or two-components, filled or unfilled, and have a range of cure temperatures and methods. They can be heat cured, room temperature cured, UV cured or even a combination of UV and heat cure (known as dual cure).

In the following sections, the major adhesive characteristics are explained:

A. Single or Two Component Adhesives

Two-component adhesives have a much longer shelf life, can be stored at room temperature, and offer lower cure temperatures than single component systems.

The major advantage of single-component systems is that there is no weighing and mixing prior to use. Single components come ready to use, however, they require frozen storage conditions to obtain the optimum shelf life.

Two component adhesives can be pre-mixed and frozen (creating a single component), thereby offering the combined features of both systems.

B. Pot Life

Pot life is the time span in which a two component adhesive must be used after mixing for best results. Once the hardener is combined with the resin, a polymerization reaction starts to occur. During the process viscosity will steadily increase. The end of the pot life is generally indicated when the adhesive can no longer be applied efficiently. A summary of application techniques (e.g. air pressure, screen print, stamp technique) will be discussed later in the guide.

The workability of an adhesive with increasing viscosity depends mostly on the selected application technique and function. Therefore, the pot life does not only depend on the adhesive itself, but also on the specific application technique. Depending on the methods (application, process & function) used, the pot life (at room temperature) can vary drastically from minutes to days. Therefore, the data for the pot life given in the adhesive specification are only approximations.

For some application techniques, doubling of the viscosity can be tolerated without problems. Many EPO-TEK one-component adhesives have a pot or shelf life of 1-4 months at room temperature. The shelf life of one-component adhesives can be prolonged considerably (> 1 year) when stored in a freezer at –40°C. The pot life of two-component adhesives (at room temperature) varies between a few minutes and a week or more.

C. Viscosity (ASTM D2393)

Viscosity is defined as the resistance of a fluid to flow. It is commonly referred to as thickness or flowability. The viscosities of epoxy adhesives range from very liquid (low viscosity) to viscous (high-viscosity) and are very sensitive to temperature. Viscosity is measured in milli-Pascal-seconds (mPas) or, more commonly, in centipoises (cPs). One cPs is equal to one mPas.

Examples:	Water	1.0 cPs
	Maple Syrup	1,000 cPs
	Honey	20,000 cPs
	Peanut Butter	50,000-150,000 cPs

Determination of the viscosity for filled adhesives is more difficult, because filled adhesives are more thixotropic (paste like) and sensitive to shear.

Thixotropic substances are characterized by the fact that they are “inherently stable” at rest, and under mechanical stress (stirring, scraping) they assume a limited flow. The viscosity of a thixotropic material changes with time under constant shear rate until reaching equilibrium.

An example of a thixotropic material is mayonnaise. It is very stationary and does not flow on a piece of bread but spreads very nicely when shear is applied, i.e. the knife spreading the mayonnaise.

D. Cure schedule

The cure schedule is a combination of the temperature and the amount of time to which an adhesive must be exposed in the curing environment for "complete" curing. For the same adhesive several cure schedules may be selected for optimal cross-linking.

Depending on the selected cure schedule or cure method (convection oven, tunnel furnace, hot plate etc.), there are different degrees of hardness or cross-linkage. Generally, with high temperature curing (high temperature, short time) the adhesives cross link almost 100% and therefore, reach optimal adhesive strength and chemical properties. Also, electrically and thermally conductive adhesives will achieve the best conductivity properties with high temperature curing. However, with high temperature curing, adhesives become brittle resulting in greater stress on the adhesive bond..

Different curing conditions result in different properties of the cured adhesive. The optimal curing condition depends on many variables and is often optimized through testing and experience. Data sheets list the minimum cure conditions. A doubling of the curing times at the respective temperatures may be necessary to achieve optimum properties.

Note: You can easily cure too little, but seldom too much.

Because the curing time is a function of the curing temperature, the following rule of thumb should be noted:

For every 10°C decrease in cure temperature, you would typically have to double the time needed to cure. For every 10°C increase in cure temperature, it is possible to cut the cure time in half.

E. Operating Temperature

Epoxy and polyimide-adhesives are organic compounds, which degrade or vaporize under high temperatures.

In the tables, four important borderline temperatures are distinguished:

- Maximum continuous operating temperature
- Maximum increment temperature
- Degradation temperature
- Glass transition temperature

These important borderline temperatures are explained in greater detail in the following:

i. Maximum Continuous Operating Temperature

The maximum continuous operating temperature is the temperature to which the adhesive can be exposed for an unlimited period of time without any damage

These temperatures are for epoxy adhesives in the range between 100-200°C and for polyimide adhesives in the range of up to 350°C.

Normally, the maximum continuous operating temperature is determined with a test lasting 1000 hours. In addition, the proportionate weight is measured and extrapolated over a period of 5000-20,000 hours.

ii. Maximum Intermittent Temperature

For a short period (up to several hours) it is possible to exceed the maximum continuous operating temperature up to 300°C without noticeable damage to the adhesive.

This is of particular importance if there are any post cure processing steps such as soldering, encapsulating, thermo-compression wire bonding or other post cure processing. It is important that the material is capable of withstand these temperatures.

It is also imperative to be aware that with SMT processing, where adhered components such as chip caps are bonded via a soldering bath, it is possible to exceed the maximum continuous operating temperature for a short period of time.

The maximum intermittent temperature is the temperature at which less than a 5% weight-loss occurs within five-minute dwell.

The value of the maximum intermittent temperature is not exactly defined. When the adhesive is the exposed to a shorter time for a somewhat higher temperature, it is possible that the weight-loss will be less than 5%. The same is true when the adhesive is exposed for a longer time to a somewhat lower temperature. Therefore, the value for the maximum intermittent temperature should be only used.

iii. Degradation Temperature

The degradation temperature is determined by Thermo Gravimetric Analysis (TGA). TGA measure the weight changes as a function of temperature. With a specified ramp rate, typically 10 or 20 or 40°C/minute, the degradation temperature is defined as the temperature under which the weight loss is less than 10%. Degradation temperature is a good indicator of the thermal stability of the adhesive material.

Above the degradation temperature the adhesive decomposes quickly to vaporized gaseous particles and a solid residue or ash.

iv. Glass Transition Temperature (Tg)

TG is normally a temperature below the maximum continuous operating temperature. Tg is defined as the temperature at which the cured adhesive transitions from a “glass-like hard” to a “rubber-like soft” state. The temperature at which this change of condition occurs is the glass temperature (Tg).

Below the Tg the adhesive is hard and rigid hard, and above the Tg it becomes rubber-like (comparable to a pencil eraser).

When the adhesive is operating at or above its Tg, the physical properties of the material are lower and the coefficient of thermal expansion (CTE) is 3-4 times higher. When the adhesive is cooled from a temperature above the Tg to room temperature, the adhesive will regain its original properties.

Tg is affected by the cure time and temperature. Generally, when the curing temperature is high, the glass transition temperature is also high. Therefore, in many adhesive tables, the Tg is indicated as parameter together with the curing schedule.

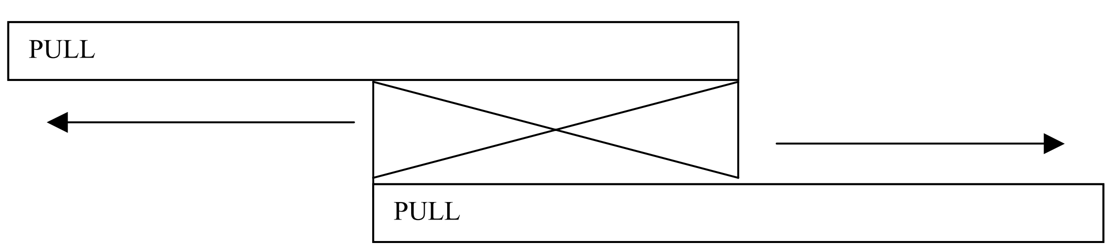
Typical Tg values are:

EPO-TEK H20E	85°C
EPO-TEK E3081	>200°C depending on the cure cycle
EPO-TEK E3001	110°C
EPO-TEK 353ND	100 -125°C depending on the cure cycle
EPO-TEK 301	60°C
EPO-TEK T6117	95°C

F. Lap Shear Strength

The shear force necessary to break a lap joint. A lap joint, as below, is an overlapping joint made by placing two pieces of aluminum together with a ½ inch overlay. The resultant force will determine the strength of the adhesive.

Figure: lap joint



The strength is usually reported in the units of PSI (pounds per square inch).

G. Moisture Resistance

Moisture resistance is the measurement for which a cured adhesive absorbs water. It is measured by exposing the cured adhesive to humid (e.g. 96%) conditions or submerging in a water bath for a defined period of time and temperature. The measurement is the percent gain when comparing the initial weight and the weight after the moisture exposure.