A race against the clock

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Introduction

There are numerous considerations when specifying adhesives for any application. Not only are manufacturers looking for an adhesive which bonds well to their required substrates, but one which also meets the functional requirements of its application. In addition to these, there are also time-based considerations to factor in.

Shelf Life

The shelf life of an adhesive is the length of time from the date of manufacture during which the material is under warranty to behave according to the technical data sheet, assuming the storage conditions have been met. It often appears on the label as the expiry date – referring to the date that the shelf life ends – or as a manufactured date, where you can find the shelf life and calculate the expiry date.

An adhesive that remains unused in the original packaging and has been stored under recommended conditions, may begin to see negative effects beyond the shelf life. Manufacturers should be aware that the effects can be nearly immediate or be part of a slow decay in performance. Changes in the adhesive may include longer cure time, failure to cure, gelling in the package, changes in viscosity, syneresis/separation, or a decrease in performance. After the shelf life, the risk is entirely up to the user.

Figure 1 – Adhesives are clearly labelled with expiry or production dates for easy reference

Past the expiry date, a quick indicative test would be to check cure speed under your exact process/cure conditions and compare it with your original process evaluation tests on the expired products as you can to see if it still meets the needs of your process. A guide would

be the testing you did initially to validate the adhesive in the application – the ultimate arbiter of suitability of the adhesive for your application.

The conditions the adhesive is stored in can affect the shelf life. For best results, store your adhesives according to the manufacturer's recommendations. Choosing an adhesive with limited shelf life will mean working with a supplier with an appreciation of the inevitable supply chain challenges.

Working Life and Pot Life

While pot life and working life are often taken to mean the same thing, there are distinctions between the two. Both, however, refer to the period of time after mixing or preparing an adhesive for use during which the material remains suitable for application.

Adhesives based on chemistries like epoxy, polyurethane and methacrylate are often two-part systems; once mixed, the clock starts ticking, cure commences and the material starts to thicken, meaning viscosity increases. In this case, pot life is a data point liked by chemists, as it is defined as the amount of time it takes for an initial mixed viscosity to double, and it is something they can measure. There are variations on this theme – the test is affected by the mass of the material mixed and the temperature, so these factors should either be standardised or detailed (e.g. 100 grams mixed at 25ºC) if you want to make comparisons.

Many thermoset materials will generate heat (exotherm) and increase the temperature during cure. Since this exotherm is related to the mixed mass, the more you mix, the shorter the pot life. UV curing adhesives, which are typically single part and require no mixing, might be said to have an indefinite pot life.

Working life, on the other hand, is the amount of time a mixed material remains low enough in viscosity so that it can still be readily applied to a part or substrate in your application, with the appropriate accuracy and tolerance – it is application dependent. Size and shape of bond line, geometry, orientation, and even dispensing/dosing methodology will all play a role.

Figure 2 – Working life for two-part systems like epoxies will be an important selection factor

Data sheet pot life can act as a guide in figuring out your working life, but some practical experimentation will be useful. Working life is generally shorter than pot life. There are risks in using a material beyond its stated pot life, even if it is still thin enough to apply, because if the cross linking has gone too far, then adhesion and other physical characteristics may be compromised.

Not all manufacturers quote pot life or working life in the same way, so be careful of making data sheet comparisons and use the figures as a guideline. Always test the material in your application and talk to an authoritative supplier. If, for performance reasons, you must use a material with a shorter pot life than ideal for your process, then one likely ramification is increased material wastage from frequent mixing nozzle replacement or auto-purge functions on metering, mixing and dispensing machines.

Cure Time

Cure time can vary from almost “instant” (cyanoacrylate adhesives), seconds (UV curing adhesives) to hours or even days (two-part ambient temperature epoxy or single part silicone RTV adhesive sealant). There is a distinction to be made between “handling time” or “fixture time”, and cure time. The former terms refer to the time it takes for the adhesive to cure enough so that the parts can be moved with moderate care – perhaps to a holding area for full cure to occur, or to the next stage of the manufacturing process.

In an ideal world, adhesive cure time would fit in with the production line speed as determined by the takt time. Adhesive specification is about compromises, however, so other selection factors may have trumped the ideal cure time factor. This may mean production bottlenecks, off-line curing, increased WIP, and the resultant required resources (space, time, energy). If assembly jigs or fixtures are required, then longer adhesive handling times invariably mean more jigs, with the associated costs.

Figure 3 – UV curable adhesives offer fast and controllable bonding processes

If circumstances allow, then fast curing adhesives like cyanoacrylate adhesives or UV light curing adhesives can offer production efficiency. Applications such as bonding surgical instruments and crutches may require a two-part structural adhesive based on epoxy or methacrylate chemistry. In this situation, there is often a balance to be drawn between working life and cure time.

Manufacturers usually seek to establish processes that are highly efficient and repeatable. However, fast cure time after mixing also implies a short working life, and this may present a number of processing challenges. Higher volumes of continuous production will require careful planning in order to reduce material waste. Some of these two-part structural adhesives have cures readily accelerated by heat, although this may need to be done off-line in batch ovens unless volumes allow costly in-line ovens, or for example, by induction heating.

Faster is not always better, as it is possible for an adhesive to cure too quickly. For example, if you are working on a very large laminating job, where it takes 10 minutes to apply and spread the adhesive before applying and positioning the laminate, you will need an adhesive with a working life longer than 10 minutes.

Conclusion

Shelf life, working life and cure speed are selection factors to consider when specifying an adhesive for your application. It is worth noting that the cost of processing the adhesive is often more than the cost of purchasing the adhesive, so using these features to gain production efficiency will save both time and money, reduce material wastage and enhance productivity.

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