



<b>AEROSPACE RECOMMENDED PRACTICE</b>	<b>ARP5256</b>	
	Issued Reaffirmed	1997-03 2014-11
<b>MIXING RESINS, ADHESIVES AND POTTING COMPOUNDS</b>		

RATIONALE

ARP5256 has been reaffirmed to comply with the SAE five-year review policy.

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## 1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) describes and gives general guidelines on use and applicability of the standard method for mixing resins, adhesives, and potting compounds.

### 1.1 Purpose:

The purpose of this document is to provide a standard method for mixing resins, adhesives, and potting compounds that may be referenced in repair documents produced by airlines or airframe and engine manufacturers. It is intended that this document be one of a number of ARPs that will cover other aspects of the techniques required to perform composite repairs. This will provide a suite of available repair techniques that are acceptable for use throughout the commercial aircraft industry.

## 2. REFERENCES:

### 2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

#### 2.1.1 SAE Publications: Available from SAE, Commonwealth Drive, Warrendale, PA 15096-0001.

ARP4916 Masking and Cleaning of Epoxy and Polyester Matrix Thermosetting Composite Materials  
ARP4977 Drying of Thermosetting Composite Materials  
AIR4844 Composites and Metal Bonding Glossary.

#### 2.1.2 Applicable References:

Original Equipment Manufacturers (OEM) Manuals

Engineered Materials Handbook Volume 1 - Composites ASM International Handbook Committee ISBN 0-87170-279-7 (v.1)

Handbook of Composites edited by George Lubin Van Nostrand Reinhold

## 3. GENERAL:

Repairs cured below 212 °F (100 °C) usually require the use of two part laminating resins, adhesives, and potting compounds. The two part systems are made up of a base resin and a hardener. The base resin and the hardener can be in paste or liquid form, and are always supplied in separate air tight containers. To aid mixing, some resins and hardeners have different colors. A homogeneous (uniform) mixture is an important factor for the quality of the bonding.

### 3. (Continued):

The resin and hardener should be stored in a cool dry environment. The storage temperature depends on the specific type of material. Some can be stored at room temperature while others require refrigeration at 40 °F (4 °C) or freezer storage at 0 °F (-18 °C). Refer to the manufacturers storage instructions and the procurement specification for the appropriate storage conditions.

Depending on the resin/adhesive viscosity and the application, a viscosity control additive might be needed. The resin/adhesive should be mixed first with the hardener before adding the viscosity control additive to have a homogeneous (uniform) mixture.

Some manufacturers have pre-measured kits such as sem-kits or blister packs. These offer the advantage of not having to weigh each of the components, but the mixing procedure is just as important as non pre-measured kits. Several mixing machines are also available to assist in the mixing. Follow the manufacturers directions for the mixing procedures. Mixing or blending equipment should produce a smooth, workable mixture that is essentially free from lumps and entrapped air.

### 4. HEALTH AND ENVIRONMENTAL:

General guidelines are given throughout this document regarding the hazards to the user and the environment of the materials and equipment listed. However, the user shall obtain the Material Safety Data Sheet (MSDS) from the supplier prior to using any of the materials. The relevant environmental health and safety organizations shall be consulted regarding safe use of the material. Material suppliers are also a good source of information in the safe use of their materials.

#### 4.1 Personal Protective Equipment:

Personal protective equipment required to handle a specific material safely is identified in the supplier's Material Safety Data Sheet (MSDS).

The areas of the body most likely to be affected when working with resins are the skin, eyes, and respiratory tract. Guidance is given on the kinds of personal protective equipment that may be required and typical uses.

Before using any type of personal protective equipment, training shall be given to ensure that the equipment is used safely and correctly.

- a. Exhaust Systems: When mixing resins and adhesives in a shop environment, a fume cabinet with local extraction should be used. Control of the emissions shall be in accordance with local and national regulations. Local exhaust systems shall be capable of providing a good flow of fresh air to personnel. The system shall be air operated or use flameproof motors if it is to be used in areas where flammable vapors may be present. A local exhaust system may be used as a method of providing a safe environment keeping fume concentrations below the allowable limits in confined spaces where vapors may accumulate.

## 4.1 (Continued):

- b. Eye Wash: The eye wash facility shall conform to the local standards and shall be capable of hand free operation to allow the user to hold the eyelids open while operating the eye wash. Eye wash facilities shall be used if eyes are exposed to resin, hardener, fillers, milled fibers, cleaning materials, or solvents.
- c. Gloves: The gloves shall allow full hand dexterity and shall not be coated with any material that may contaminate the repair materials or repair area.

## 5. CONSUMABLE MATERIALS/EQUIPMENT:

The basic consumable materials/equipment that are used for resin mixing are identified below. Since there is such a large selection of each of these items, only general guidance is given. The user needs to evaluate the application and determine the appropriate selection.

- a. Spatula: Clean spatulas are needed to transfer the resin and hardener to the mixing container and to mix the resin in the container. Typically, a metal spatula or a wooden tongue depressor is used. Use separate spatulas for each resin component to prevent cross contamination. A single tongue depressor can be split in half length wise to make a spatula with a sharp end to get into corners better (see Figure 1).

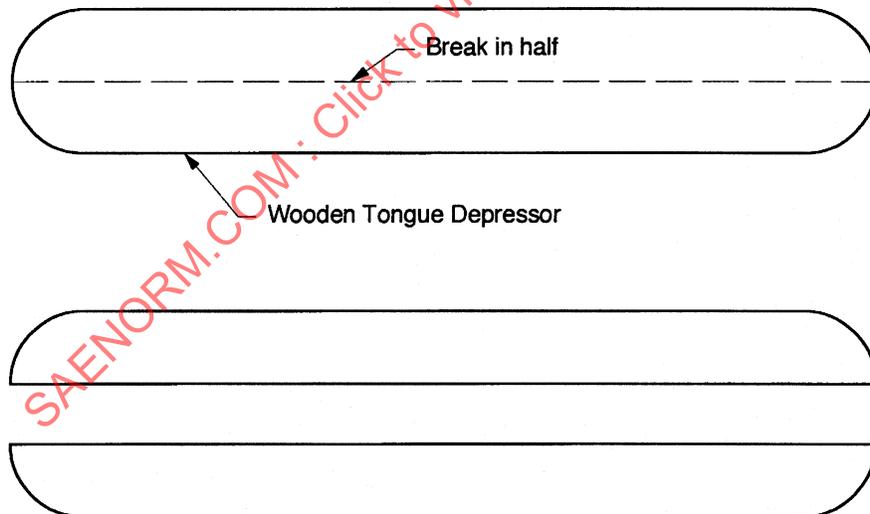


FIGURE 1 - Tongue Depressor for Spatula

## 5. (Continued):

- b. Container: A clean container is needed to contain the resin during measuring and mixing. The recommended containers are translucent High Density Polyethylene (HDPE), glass, metal, coated paper, PTFE or polypropylene with a height to diameter ratio of one. The split tongue depressor shown in Figure 1 can be used with a rounded bottom container or a straight bottom container as shown in Figure 2. Make sure the spatula is able to scrape all unmixed resin from the sides and bottom of the container. The translucent sides allow the user to inspect for any unmixed resin. Metal containers with rust on the inside or wax coated paper should not be used.

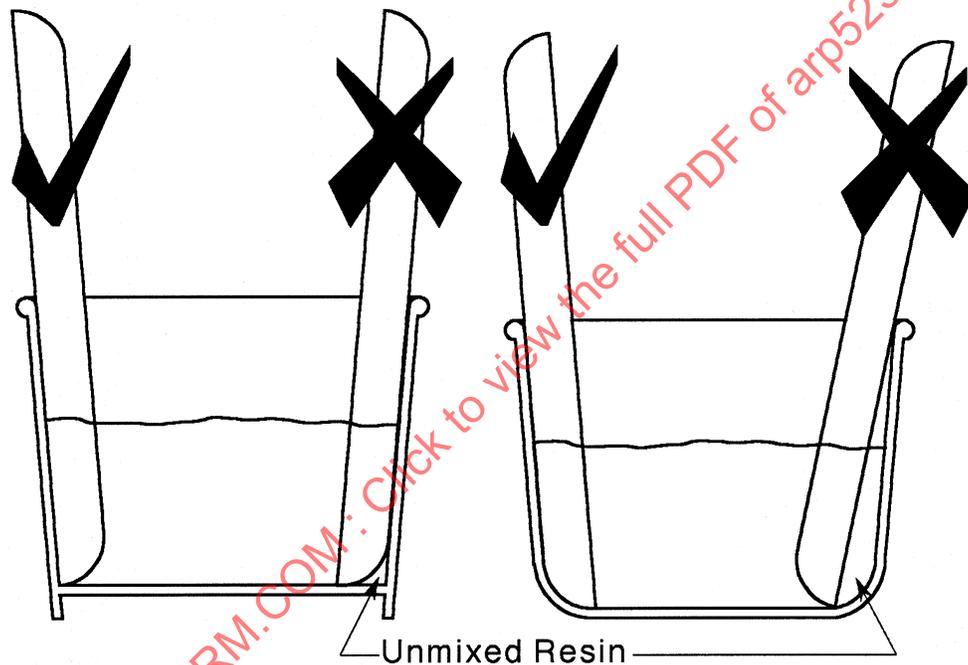


FIGURE 2 - Proper Positioning of Spatula When Mixing

**CAUTION:** Do not use waxed or coated containers. The coating may dissolve and contaminate the material.

- c. Shallow Tray: A shallow tray may be used to maximize the pot life when using large portions of mixed resin. The shallow tray must use the same material considerations as the mixing container or may be covered in Mylar or Nylon film. The recommended maximum resin depth in the tray is 0.25 in (6.35 mm).
- d. Spreader: (sometimes called a squeegee) A broad flexible spatula used to spread the mixed resin over a large area, for example to spread resin over fabric.

5. (Continued):

- e. Scale: A scale is required to weigh the resin components. The scale may be electronic, triple beam or equal arm with a single beam. The accuracy must be better than 1% of the smallest amount being weighed, e.g., if the smallest amount of hardener to be weighed is 10 g, then the accuracy of the scale shall be 0.1 g. Spring scales shall not be used. A tare feature is useful in minimizing weighing errors by allowing the balance to be rezeroed after the container and each component are added.

6. RESIN COMPOUNDS AND ADDITIVES:

6.1 Potting Compounds:

Potting compounds are a combination of a resin or adhesive with an additive such as aluminum powder, fumed silica or microballoons. They can be supplied premixed or can be prepared before use by mixing the additive with the mixed resin and hardener. Potting compounds are used to fill dents or pits and to reinforce broken honeycomb core.

The amount of additive is usually called out as a percentage of mixed resin weight. The base resin and hardener should be mixed first before adding the additive to have a more homogeneous (uniform) mixture.

The mixing techniques for the potting compounds are the same as for the resins as defined in Section 7.

Note that some potting compounds can be purchased ready mixed and kept frozen so that no mixing is required by the user.

6.2 Paste Adhesives:

Paste adhesives are usually supplied in 2 part kits. The adhesive is filled, typically with a fine aluminum powder. Paste adhesives are used for adhesive bonding particularly where the fit is uncertain and gap filling capability is required. They also have better strength at higher temperatures than their unfilled counterparts. In repair situations they may be used as a potting compound. The mixing techniques are the same as for the resins as defined in Section 7, however particular care to ensure thorough mixing is required as the components often have very different viscosities

6.3 Additives:

The sections below describe some of the more widely used additives that are added to epoxy and polyester resins. Most of the additives are fine powders or fibers and require thorough mixing to form a homogeneous (uniform) product.

Care should be taken to ensure that all additives are thoroughly dry before adding to the resin mixture. For small quantities a drying cycle of 12 h at 150 °F (66 °C) is sufficient. The additives can then be kept dry by packaging in air tight sealed plastic containers.

- 6.3.1 **Microballoons:** Microballoons consist of small hollow spheres of glass, phenolic or ceramic with a typical diameter range of 6 to > 200  $\mu\text{m}$ . The microballoons look like a fine powder with bulk densities ranging from 4.4 to over 15.6  $\text{lb/ft}^3$  (70 to over 250  $\text{kg/m}^3$ ) and a true or liquid displacement density range of 7.8 to 37.5  $\text{lb/ft}^3$  (125 to 600  $\text{kg/m}^3$ ) depending on the grade.

They are widely used for filling liquid epoxy resin systems to make a lightweight paste or syntactic potting compound that has a variety of uses. Typical applications are the edge filling or local reinforcing of composite honeycomb panels, as a low temperature curing core splice particularly for repair applications and in the engine as a shroud material for the fan blades.

Material used for making syntactic epoxies typically has an average diameter of 90  $\mu\text{m}$  and a true density of 15.6  $\text{lb/ft}^3$  (250  $\text{kg/m}^3$ ). The addition of approximately 20% by weight of this typical filler gives a 40  $\text{lb/ft}^3$  (640  $\text{kg/m}^3$ ) syntactic foam.

- 6.3.2 **Fumed Silica:** Fumed silica sometimes known as colloidal silica consists of a very pure amorphous silicon dioxide in the form of three dimensional chains of approximately spherical particles (aggregates). The average aggregate length is 0.2 to 0.3  $\mu\text{m}$ . The bulk density is 2.5 to 3.0  $\text{lb/ft}^3$  (40 to 50  $\text{kg/m}^3$ ) with a true density of 137  $\text{lb/ft}^3$  (2200  $\text{kg/m}^3$ ).

Fumed silica is added to liquid epoxy resins and paints to impart thixotropy. The shear stress dependent change in viscosity that is imparted allows the resin to be applied to vertical surfaces by brushing (the shearing action of the brushing reducing the viscosity). After application, the viscosity increases, due to hydroxyl linking of the aggregates being reestablished, preventing sag or slump of the applied resin.

The addition of up to 5% by weight of fumed silica usually imparts sufficient thixotropy for most epoxy resins.

NOTE: Not to be used as a filler, only to be used to control viscosity.

- 6.3.3 **Powdered Aluminum:** The powdered aluminum usually comes in the form of a 45 to 90  $\mu\text{m}$  powder of mostly spherical particles. Similar material is sold as a plasma spray powder.

Aluminum filled epoxies are widely available commercially however the user may need to make up their own formulation to ensure adhesive compatibility or to minimize material types. Many of the popular paste adhesives contain aluminum filler and are used for a wide variety of bonding applications, especially where their gap filling capabilities are required. They may also be used for core splicing in wet lay-up repair applications.

Where user formulation is desired the addition of 30 to 70% by weight will usually form a suitable paste depending on the viscosity of the original resin. Powdered aluminum is normally added by the resin supplier during the formulation of the resin.

- 6.3.4 Milled Fibers: Milled fibers are fibers usually of glass or carbon that are hammer milled and screened to a range of lengths from 0.016 to 0.25 in (0.4 to 6.3 mm).

Milled fibers are added to epoxy resins and adhesives to reduce exotherm and to add toughness to the resin mix. Resins with milled fibers added may be used as a tough filler used to restore airflow surface contour in areas susceptible to erosion.

Up to 10% by weight of milled fibers are added for most applications.

- 6.3.5 Chopped Fibers: Chopped fibers are fibers usually of glass or carbon that are chopped into lengths from 0.5 to 3.0 in (13 to 76 mm). The most common use of chopped fibers is for the manufacture of chopped strand mat (CSM). CSM is usually used with polyester resin in wet lay-up construction of small boats and some light aircraft.

Chopped fibers are added to resins as a three dimensional reinforcement. Resins with chopped fibers added may be used to repair dough molded parts. They are rarely used in exterior aerospace applications but find limited application in interior repairs.

Up to 25% by weight of chopped fibers are added for most applications.

- 6.3.6 Fire Retardant Additives: While resins such as phenolic and halogenated resins are naturally more fire resistant than others, additives are also used to enhance fire resistance. Additives such as aluminum trihydrate are used with a variety of resins while antimony and ferrous oxides are synergists with the halogenated resins.

These are specialized additives usually added by the resin formulator and comprehensive testing of a particular formulation is required. The OEM should be contacted if the need for these additives is envisioned.

- 6.3.7 Resin Extenders:

CAUTION: Resin extenders should not be used for any aerospace structural applications.

Resin extenders, such as calcium carbonate and talc, are materials added to resins to provide a thicker laminate at a lower cost. Although there is increased flexural stiffness, imparted by the increased thickness, tensile and impact properties are reduced.

## 7. MIXING:

Always refer to the supplier data, unless otherwise directed by the OEM, for information on:

- a. Resin/hardener mixing ratio and tolerance
- b. Temperature range for application
- c. Pot life/gel time
- d. Cure schedule

## 7. (Continued):

After mixing the resin and hardener the cure process starts. The cure process is an exothermic reaction which generates heat. If the environment can dissipate this heat then the pot-life is relatively long. The lack of heat dissipation, which results in a temperature increase of the mixture, can cause a very short pot-life, which can be a fire hazard. So be aware of the pot-life in relation to the resin mass and the wetted area of the mixture.

**WARNING:** Mixing too large of a quantity of resin is not recommended as dangerous heat build-up can occur causing damage to the material and/or component being repaired.

## 7.1 Laminating Resin Quantity Determination:

The following method determines the amount of laminating resin that is needed for the impregnation of dry fabric. This is general guidance and can vary depending on the efficiency of the user. Individual judgment should be used based on prior experience when available. For further understanding of this method an example is provided.

- a. Determine the weight of dry fabric material that is required to be impregnated. This can be done by weighing the piece(s) of fabric or calculating the weight based on the fabric area and areal weight of the fabric.
- b. The amount of resin needed for a typical wet lay-up is 50% by weight. Therefore the weight of the mixed resin should equal the weight of the fabric. It is recommended that an additional amount be added to the gross weight of the mixed resin to allow for transfer inefficiencies or other uses such as brush coating the laminate. OEM's may specify another ratio for certain applications, therefore always refer to the OEM manuals.
- c. Determine the resin/hardener mixing ratio. Use the manufacturer's information sheet for the appropriate mixing ratio, unless directed otherwise by the OEM.
- d. Determine the weight of the resin and the weight of the hardener.

**EXAMPLE:** A piece of fabric 20 in x 10 in is to be impregnated. Since most manufacturers specify their products in metric units, the area is converted to metric units. The conversion factor is  $0.000645 \text{ m}^2/\text{in}^2$ . The fabric area is:

$$(20 \text{ in} \times 10 \text{ in}) \times 0.000645 \text{ m}^2/\text{in}^2 = 0.129 \text{ m}^2 \quad (\text{Eq.1})$$

Based on the fabric manufacturer's data, the areal weight of the fabric is  $320 \text{ g/m}^2$ . The weight of the fabric is:

$$0.129 \text{ m}^2 \times 320 \text{ g/m}^2 = 41.28 \text{ g} \quad (\text{Eq.2})$$

Since the weight of the mixed resin should equal the weight of the fabric plus 20% (for example), the required amount of mixed resin is:

$$41.28 \text{ g} + (0.20 \text{ g} \times 41.28 \text{ g}) = 49.5 \text{ g} \quad (\text{Eq.3})$$