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# NASA TECH BRIEF

*Lewis Research Center*



## Improved Epoxy Resin for Constructing Cryogenic Filament-Wound Pressure Vessels

A newly developed epoxy resin has been successfully tested for use in cryogenic applications of glass-filament-wound composite structures. Mechanical properties at cryogenic temperatures are substantially improved over similar composite structures utilizing conventional resins, while properties at ambient temperature are identical to conventional resin composites.

The successful use of filament-wound, glass-reinforced-resin pressure vessels (particularly in solid propellant rocket motor cases) at ambient temperatures has suggested possible use at cryogenic temperatures. Although data on the mechanical properties of various glass-filament-wound-resin composites at cryogenic temperatures are relatively scarce, certain trends are evident. At cryogenic temperatures, the composites show a reduction in elongation and an increase in strength and modulus of elasticity in tension, compression, and flexure, as compared to the values at room temperature. A 50% or greater increase over the room-temperature strength is not uncommon. Unfortunately, these improvements are accompanied by a marked increase in the brittleness of the conventional resins used in the composites.

It is important that the mechanical properties of the matrix (plastic resin or adhesive) material complement those of the fiber (glass filament) material, since the matrix's primary structural function is to provide an efficient transfer of shear loads between the fibers. In an effort to overcome the brittleness of epoxy matrices, modified epoxy resins (epoxy/phenolic, epoxy/nylon, and epoxy/polyamide) were formulated for increased extensibility. These resins showed markedly improved tensile-shear properties. Epoxy/nylons, in particular, gave consistently high shear strengths at cryogenic temperatures and certain other epoxys showed better performance than phenolic, polyester, and silicone resins at both ambient and cryogenic temperatures. Because of their overall superior structural properties and suitability for composite fabrication, epoxy systems are therefore prime candidates for the filament winding of cryogenic vessels.

A modified (flexible and high strength) epoxy system consisting of a bisphenol, an A-type commercial epoxy, dodecenyl succinic anhydride (a flexibilizing curing agent), a high-molecular-weight tricarboxy acid, and benzyldimethylamine (a cure catalyst) has recently been developed for use in cryogenic applications of glass-filament-wound-composite structures. The resin system, in the form of glass fiber/resin composites, has been extensively tested at cryogenic and ambient temperatures. Mechanical properties at cryogenic temperatures were substantially better than for similar composites made from conventional filament-wound epoxy resins. Properties at ambient temperature were identical to conventional resin composites. Shelf life of the modified-epoxy preimpregnated glass fiber is excellent.

### Notes:

1. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

(continued overleaf)

Reference:
NASA-CR-72114 (N67-25076), Cryogenic Resins for Glass-Filament-Wound Composites

2. Technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B71-10261

**Patent status:**

No patent action is contemplated by NASA.

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