AIRCRAFT AND RUBBER

Some Uses for Various Grades

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IN few fields of application are the standards so exacting for the manufacturer and the risk of failure so great as that of aircraft construction. On each of the manufacturers of its components the aircraft industry imposes stringent conditions; and specifications laid down by the Directorate of Technical Development, Ministry of Supply, must be rigidly adhered to. These demands have set the rubber industry, which supplies so many aircraft components, numerous problems.

Parts of modern aircraft must be capable of operating at temperatures as low as −60 deg C, and in extreme cases as low as −75 deg C. As the temperature drops, the characteristics of rubber change. At ordinary temperatures it has very considerable elasticity, whereas at extremely low temperatures it is virtually a rigid material with little or no power of shock absorption. Between these extremes there is an intermediate condition where there is still some deflection and shock absorption, but a very slow recovery.

In the proximity of the powerplants rubber may encounter high temperatures, and considerable heat can also be generated on the external surfaces of aircraft flying at supersonic speeds. In view of such conditions, components must be capable of meeting temperatures as high as 260 deg C and still retain their essential properties.

Not only are the variations of temperature to which aircraft components are exposed great, but these changes are often very rapid, particularly with modern, high-performance military aircraft. Taking an extreme case, such machines can leave a ground ambient temperature of 40 deg C and climb in three minutes to a region where the air temperature is as low as −70 deg C.

Sunlight, which can be very intense in the tropics, also has a well-known adverse effect upon the properties of rubber. Even in temperate zones aircraft operate above cloud for a great deal of their time and so are frequently exposed to the effects of sunlight. A further difficulty is that much of the rubber is in contact with various fluids, such as water, mineral and vegetable oils, antifreeze liquids, petrol and kerosine. It may even be exposed to bare flames.

Modern Materials.—So much for the problems. How does the rubber industry deal with them? The characteristics of natural rubber make it ideally suitable for certain applications. Natural rubber compounds have the merit of retaining their basic properties at low temperatures. They are also preferable for such purposes as the inner linings of certain types of hose, because of their lower volume increase resulting from swelling in vegetable oils. But they have a lower resistance to mineral oils and are more liable to ageing under the effects of bright sunlight, and to ozone cracking, than some of the man-made products available today.

Two synthetics, chloroprene and nitrile copolymers, are being used for their oil- and heat-resistant properties. Chloroprene synthetics are also highly resistant to the effects of ultra-violet light and ozone, and have excellent resistance to most corrosive solutions and a moderate degree of abrasion resistance.

Synthetics of this type, however, are in general more sensitive to low temperatures than is natural rubber, although certain types are being developed which are actually better in this respect. Chloroprene synthetics are frequently used in the manufacture of aircraft components, especially as an outer covering for protection against sunlight and for lining certain types of hose. They are, for example, being used for such purposes as bomb-door seals, and sealing strips round pilots' canopies, doors and windows.

With the introduction of pressurization for high-flying aircraft, inflatable rubber seals made of this material are finding considerable application in sealing gaps in metal-to-metal surfaces round doors and the like, and in places where distortion of the metal might affect air-tightness. The seals are of various extruded forms and are inflated before take-off.

Another use for the chloroprene-type synthetics is for spraying radomes. The latter are made from a special material through which radar signals can pass; unfortunately they are liable to erosion through contact with rain (particularly in high-speed flight), so spraying with synthetic rubber has been introduced to lengthen their life.

Synthetics of the nitrile copolymer type have a high resistance to petroleum-based fuels and lubricants, and to other solvents, and they also possess good ageing and heat-resisting properties.

Sandwiches of this type of rubber synthetic and steel, shaped into strong, compact, vibration-damping brackets are being used to support cabin blowers in some of the latest American airliners. The brackets, mounted on the outboard engine nacelles, are subjected to severe operating conditions; in addition to supporting the 145 lb weight of the superchargers, the brackets must absorb extreme vibration strains developed during landings, take-offs, and engine run-ups.

Another range of synthetics finding increased use in the aircraft industry are the silicones. These remain unaffected throughout a wide temperature range. For example, in the lower ranges of temperature, where the best natural rubber compounds begin to stiffen, silicone rubber shows no stiffening and in certain special grades will remain flexible at temperatures as low as −75 deg C.

Their resistance to heat is another advantage. Special grades of silicone rubber will withstand prolonged exposure to temperatures as high as 200 deg C. They are highly resistant to ultra-violet light and to ozone, and their electrical properties are comparable to other insulating materials at ordinary temperatures, and at high temperatures are superior.

Other synthetics now being used in the aviation field include polyvinyl chloride and butyl rubber, both of which possess a high degree of chemical inertness and ageing resistance, as well as being flame resistant. Butyl rubber is particularly good for its heat-resistant properties, and it also has outstanding resistance to ozone attack. One of its applications is in hydraulic components involving the use of non-inflammable polyester fluid for which natural rubber, chloroprene, silicones and other substitutes are all unsuitable.

Other Uses.—One of the most important applications of rubber to the aircraft industry is in the field of hosing. Apart from the requirements already mentioned, much of the hosing used in aircraft has to work at pressures of 3,000-4,000 lb/sq in with bursting pressure of up to 12,000 lb/sq in. Most of these hoses are of small bore, and wire-braid reinforcing is generally used instead of cotton.

The importance of airframe de-icing has been well demonstrated, and in the past this has mainly been done by using de-icing fluids. At present more attention is being given to rubber heating mats, inside which are embedded electrical heating elements. Some aircraft also use inflatable rubber strips for de-icing the leading edges of the wings and tail.

Among the many small but important uses for rubber in the modern aircraft might be listed flexible crash-proof fuel tanks, made from fabric-covered rubber sheet; cabin heating and refrigeration equipment; corrugated hard-rubber coverings on control handles; natural-rubber bonding strips between the double transparent layers of mist-free windows; and bellows units to seal control levers and braking components.

One application of rubber in aircraft which, though not very apparent, is considerable in scope and importance, is that of adhesives. The problem of securing effective adhesion between rubber and metal in aviation components has been studied exhaustively. Bonding techniques have developed considerably in recent years and it can now be claimed that rubber and most rubber-like plastics can be made to adhere to almost any rigid base. With light-alloy metals, isocyanate or special synthetic-resin adhesives are used most frequently.

Rubber adhesives play their part in attaching de-icing strips to the wings and airscrew blades; in sealing the cabins of high-flying aircraft; and in the construction of fuel tanks, both of the metal and of the rubber "bag" type. In the production of self-sealing tank covers for military aircraft, special rubber adhesives play a vital part in ensuring that the cover acts properly and seals the entry and exit damage caused by projectiles. In civil aircraft, rubber adhesives are used for fixing various fabrics to the fuselage, rubber coverings to cabin floors, and in the construction of upholstery.

Outside the realm of airframes and powerplant in aircraft, a considerable amount of rubber is used in the manufacture of rubber-proofed cloth for such vital items as anti-g suits for combat aircrew, air-sea rescue equipment and so on.

Experiments in rubberizing nylon, terylene and other man-made fibres are taking place, and should lead to the development of waterproof materials of great strength and light weight. A new vapour-permeable cotton cloth which has recently been produced will also offer a useful material for the waterproofing of flying clothing. This cloth, although extremely light, allows water vapour to escape, and thus frees the wearer from the discomfort often associated with waterproof equipment.