Ceramics are very versatile; they have mechanical properties, thermo chemical properties, optical properties, magnetic properties, and electrical properties. These properties allow ceramics to be used in a wide range of materials. Ceramics are used for or in such things as bearings, cutting tools, furnace linings, space shuttle tiles, lasers, fiber optics, computer disks, power line insulators, capacitors and many other products.

Ceramics are brittle materials and their surfaces are not perfect, they contain flaws (cracks, notches, pores, sharp corners, etc.) These flaws make ceramics prone to brittle fracture. When a fracture starts it propagates rapidly. Ceramics are stronger than metals and plastics, but not tougher. They lack the ductility of metals or plastic. In tougher (ductile) materials like metals and plastics, plastic deformation can occur at a crack or flaw and measures such as polishing can be taken to blunt the crack or flaw. Thus metals and plastics are not flaw or notch sensitive. However in brittle materials, plastic deformation is difficult, so those sharp flaws remain sharp. In very brittle materials, crack tips tend to form at a radius or curvature of atomic dimensions. Thus, most ceramics are flaw and notch sensitive.

- Ceramics are hard, strong, and stiff materials
- They have a large modulus of elasticity and very strong bonds
- They are brittle materials with limited damage tolerance and plastic deformation is difficult
- Ceramics are much stronger in compression than in tension so stresses are concentrated at flaws
- Ceramics have a high melting temperature, are corrosion and reaction resistant, have a low thermal expansion coefficient, and are low in thermal conductivity
- Optically, some ceramics are transparent, can be manufactured to contain colors, electronic transitions, a refraction index, luminescence, phosphorescence, etc.
- Finally, some ceramics have magnetic properties.

In general, the most desirable properties of plastics are that they are light in weight, have relatively high strength, have good corrosion resistance, and have electrical insulating properties. Finally, plastics fail in many of the same ways that metals do. They deform, they fracture, they become brittle, they crack, and they experience melt fracture. All plastics are polymers. While not all polymers are plastics, plastics do have the same properties as polymers. To compare plastics with ceramics, polymers will be used.

**Polymers** are materials that can be easily deformed. Polymers range in strength from weak to very strong. For example, polystyrene, which is used in cups, is a weak polymer, while Kevlar and Spectra, aramid polymers that are used to make military helmets and bulletproof vests, are very strong. There are some natural polymers like cellulose in plants, rubber, and the collagen in skin. Most polymers, however, are man made. Polymers are lighter than ceramics and enjoy a wide variety of applications. Many of the mechanical properties of polymers (strength, stiffness, toughness, and yield behavior) can be determined from stress/strain measurements. Many of the same measurements used for metals can also be used for polymers.
Polymers consist of long chains of large molecules. Molecular weights of one million are not uncommon for some polymers like polyethylene. Most synthetic polymers are composed of a Distribution of Chain length. Therefore we have to express the molecular weight of polymers in terms of Average value. Microscopically polymer chains look like cooked spaghetti. The medical field is now beginning to use polymers to replace body parts. Because of their lower density and lower weight, polymers are now being used to replace hip joints, knees, bones, legs, etc. Throughout the home polymers are used in everything from cookware to upholstery. In automobiles, airplanes, sports, and business nearly the same is true. Polymers are used everywhere.

William (Bill) C. Worsham was a Senior Consultant for Reliability Center, Inc. Mr. Worsham had over 30 years experience in the field of Maintenance and Reliability program management. He had participated in and led teams in the development, design and implementation of three separate maintenance management systems. He had also participated in the design and implementation of specialized reliability inspection programs such as lubrication scheduling, vibration monitoring, instrument inspection and preventive maintenance. Mr. Worsham was a practitioner of root cause analysis in the field with his clientele as well as an educator. Our friend and colleague has passed away since writing this article. If you would like to make an inquiry on this topic please contact us at 804/458-0645 or info@reliability.com.