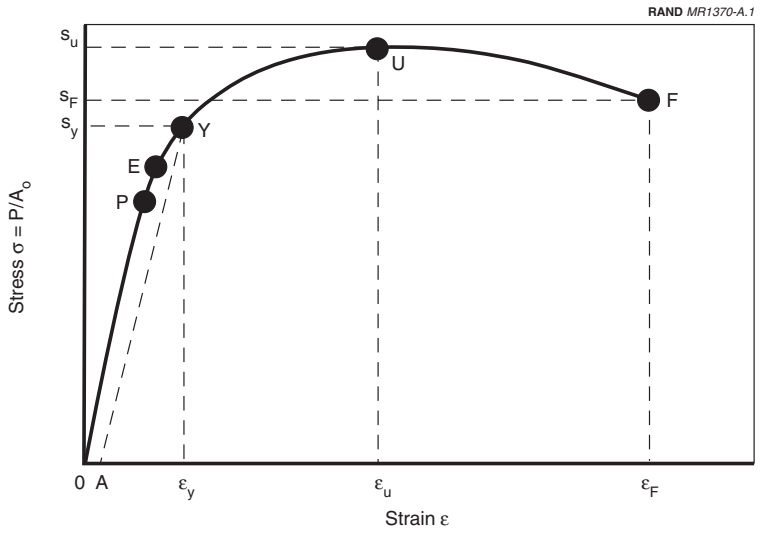
Appendix A

STRESS-STRAIN DIAGRAM

A tensile test is used to determine a variety of mechanical characteristics of a material. A test specimen composed of a rod made of a material for which the properties are to be determined is mounted in a test machine and gradually loaded in tension in increasing increments. The total elongation over the original length is measured at each increment of load. The loads (*stress*) are observed and the changes in length (*strain*) are recorded and then plotted in a *stress-strain diagram* (Figure A.1).



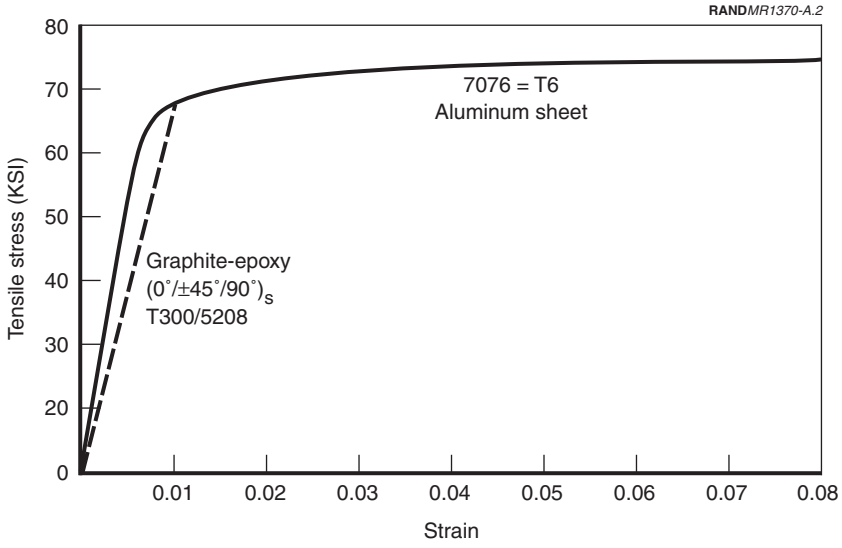
SOURCE: J. E. Shigley and C. R. Mischke, *Mechanical Engineering Design*, 5th ed., New York: McGraw-Hill, 1989. Reprinted by permission of The McGraw-Hill Companies.

Figure A.1—Notional Stress-Strain Plot

Point *P* is called the proportional limit where stress is proportional to strain. The slope of the line 0P is the *modulus of elasticity*. Point *E* is the *elastic limit;* that is, if a part is loaded to a stress level below point *E*, no permanent deformation will be sustained.

During the tension test, many materials reach a point where the strain begins to increase rapidly without an appreciable increase in stress. This point is called the *yield point*. The *ultimate or tensile strength* is represented by point *U*. This is the *maximum stress* that can be withstood by a part. Point *F* is where the part ruptures.

Figure A.2 compares the stress-strain plot of sheet aluminum with carbon-epoxy laminate.



SOURCE: R. E. Horton and J. E. McCarty, "Damage Tolerance of Composites," in T. J. Reinhart et al., eds., *Engineering Materials Handbook*, *Vol. 1: Composites,* Materials Park, OH: ASM International, 1987. Reprinted by permission of ASM International.

Figure A.2—Stress-Strain Plot of Sheet Aluminum with Carbon-Epoxy Laminate