[The following is an excerpt from the book *Failure of Materials in Mechanical Design: Analysis, Prediction, Prevention*, by Jack Collins, copyright 1993, John Wiley & Sons. Inc.]

2.1 DEFINITION OF FAILURE MODE

In the first chapter it was suggested that mechanical failure might be defined as any change in the size, shape, or material properties of a structure, machine, or machine part that renders it incapable of satisfactorily performing its intended function. With this definition in mind, one might define *failure mode* as the physical process or processes that take place or combine their effects to produce failure.

It has been suggested* that a systematic classification might be devised by which all possible failure modes could be predicted. Such a classification is based on defining three categories: (1) manifestations of failure, (2) failure-inducing agents, and (3) locations of failure. These categories are specifically defined in the text that follows. Each specific failure mode is then identified as a combination of one or more manifestations of failure together with one or more failure-inducing agents and a failure location. Literally hundreds of combinations can be systematically listed. To explain the system in more detail, we may develop the three categories in more detail, as follows.

The four *manifestations of failure*, some with subcategories, are:

1. Elastic deformation
2. Plastic deformation
3. Rupture or fracture
4. Material change
   A. Metallurgical
   B. Chemical
   C. Nuclear

The four *failure-inducing* agents, each with subcategories, are:

1. Force
   A. Steady
   B. Transient
   C. Cyclic
   D. Random
2. Time
   A. Very short
   B. Short
   C. Long
3. Temperature
   A. Low
   B. Room

    C. Elevated
    D. Steady
    E. Transient
    F. Cyclic
    G. Random
4. Reactive environment
    A. Chemical
    B. Nuclear

The two *failure locations* are:

1. Body type
2. Surface type

To be precise in describing a specific mode of failure, it is necessary to select appropriat3e categories from those just listed without omitting any of the three major categories. For example, one might select *plastic deformation* from the first category, *steady force* and *room temperature* from the second category, and *body type* from the third category. Thus, the failure mode selected could be properly described as body-type plastic deformation under *steady force* at room temperature. This failure mode is commonly called *yielding*. Note, however, that the term *yielding* does not imply all of these restrictions; it is more general than that.

Many other failure modes of special interest have been defined that refer to general patterns of the three categories listed. To be useful, these terms require additional description and elaboration, but the terms are commonly used and very useful because of the importance of the failure phenomena that they represent. Twenty-three such specific failure modes are listed in Section 2.2. Later in the text, entire chapters are devoted to some of the more important failure modes.

2.2 FAILURE MODES OBSERVED IN PRACTICE

The following list of failure modes includes those most commonly observed in practice. In reviewing the list, it may be noted that certain failure modes are unilateral phenomena, whereas others are combined phenomena. For example, corrosion is listed as a failure mode, fatigue is listed as a failure mode, and corrosion-fatigue is listed as still another failure mode. Such combinations are included because they are commonly observed, important, and usually synergistic. That is, in the case of corrosion-fatigue, for example, the presence of active corrosion *aggravates* the fatigue process, and at the same time the presence of fluctuating fatigue loads aggravates the corrosion process. The following list is not presented in any special order, but it includes all commonly observed modes of mechanical failure.

1. Force and/or temperature induced elastic deformation
2. Yielding
3. Brinnelling

4. Ductile rupture
5. Brittle fracture
6. Fatigue
    a. High-cycle fatigue
    b. Low-cycle fatigue
    c. Thermal fatigue
    d. Surface fatigue
    e. Impact fatigue
    f. Corrosion fatigue
    g. Fretting fatigue
7. Corrosion
    a. Direct chemical attack
    b. Galvanic corrosion
    c. Crevice corrosion
    d. Pitting corrosion
    e. Intergranular corrosion
    f. Selective leaching
    g. Erosion corrosion
    h. Cavitation corrosion
    i. Hydrogen damage
    j. Biological corrosion
    k. Stress corrosion
8. Wear
    a. Adhesive wear
    b. Abrasive wear
    c. Corrosive wear
    d. Surface fatigue wear
    e. Deformation wear
    f. Impact wear
    g. Fretting wear
9. Impact
    a. Impact fracture
    b. Impact deformation
    c. Impact wear
    d. Impact fretting
    e. Impact fatigue
10. Fretting
    a. Fretting fatigue
    b. Fretting wear
    c. Fretting corrosion
11. Creep
12. Thermal relaxation

13. Stress rupture
14. Thermal shock
15. Galling and seizure
16. Spalling
17. Radiation damage
18. Buckling
19. Creep buckling
20. Stress corrosion
21. Corrosion wear
22. Corrosion fatigue
23. Combined creep and fatigue