FAILURE TIMES OF BEARINGS

1. Problem Formulation

Materials that survive a single application of stress frequently fail when stressed repeatedly. This phenomenon, known as fatigue, is measured by mechanical tests that involve repeated application of different stresses varying in a regular cycle. A fatigue test may measure the number of cycles required to initiate a crack, as well as the number of cycles to failure.

In the case study we consider a one-way classification experiment performed at Wright-Patterson Air Force Base and discussed in the paper " Analysis of Single Classification Experiments Based on Censored Samples from the Two-parameter Weibull Distribution" by J.I. McCool published in *Journal of Statistical Planning and Inference*, 3(1979), p.39-68. The research unit in the base was experimenting at that time with new materials and technologies to produce turbine engine bearings used in aircraft applications. The goal of the research was to obtain bearings with high resistance to failure fatigue.

The purpose of the experiment described in the above paper was to compare the average times to fatigue failure (in units of millions of cycles) for ten high-speed turbine engine bearings made from five different materials. Three of these material types consisted of AISI M-50 tool steel processed by (a) powder metal (P/M) processing techniques, (b) consumable electrode vacuum melting (CEVM), (c) vacuum induction melting with vacuum are remelting (VIMVAR).

The other two materials were power metal processed versions of (d) AISI-T-15, a cobalt-tungsten type tool steal and (e) EX00007, an experimental high chrome stainless steel alloy.

Ten cylindrical specimens 3 inches in length and 0.375 inches in diameter were prepared from each material and rolled at 10,000 RPM between opposed 7.5 inches diameter disks loaded so as to produce a maximum contact stress of 700,000 psi on the test specimens. The recorded times to fatigue failure are given in the table below in units of millions of test specimen stress cycles.

TYPE OF MATERIAL				
1 (P/M)	**2 (CEVM)**	**3 (AISI-T-15)**	**4 (VIMAR)**	**5 (EX00007)**
3.03	3.19	3.46	5.88	6.43
5.53	4.26	5.22	6.74	9.97
5.60	4.47	5.69	6.90	10.39
9.30	4.53	6.54	6.98	13.55
9.92	4.67	9.16	7.21	14.45
12.51	4.69	9.40	8.14	14.72
12.95	5.78	10.19	8.59	16.81
15.21	6.79	10.71	9.80	18.39
16.04	9.37	12.58	12.28	20.84
16.84	12.75	13.41	25.46	21.51

The problem is also formulated in your text on page 164. These data are available in the Excel file ex0619.xls located on the FTP server.

The following is a description of the variables in the data file:

Column	Name of Variable	Description of Variable
1	TIME	Time to failure in units of millions of stress cycles
2	CODE	Compound Type (an integer from 1 to 5)

We will use SPSS to answer the following questions using the data:

1. Which compounds tend to differ in their performance from the others? In order to answer the question, determine the simultaneous 95% confidence intervals for all possible differences in group means and interpret the results.

2. Which material/processing method should be used to produce bearings having the highest fatigue failure resistance?