FAILURE TIMES OF BEARINGS

5. Checking the Model Assumptions

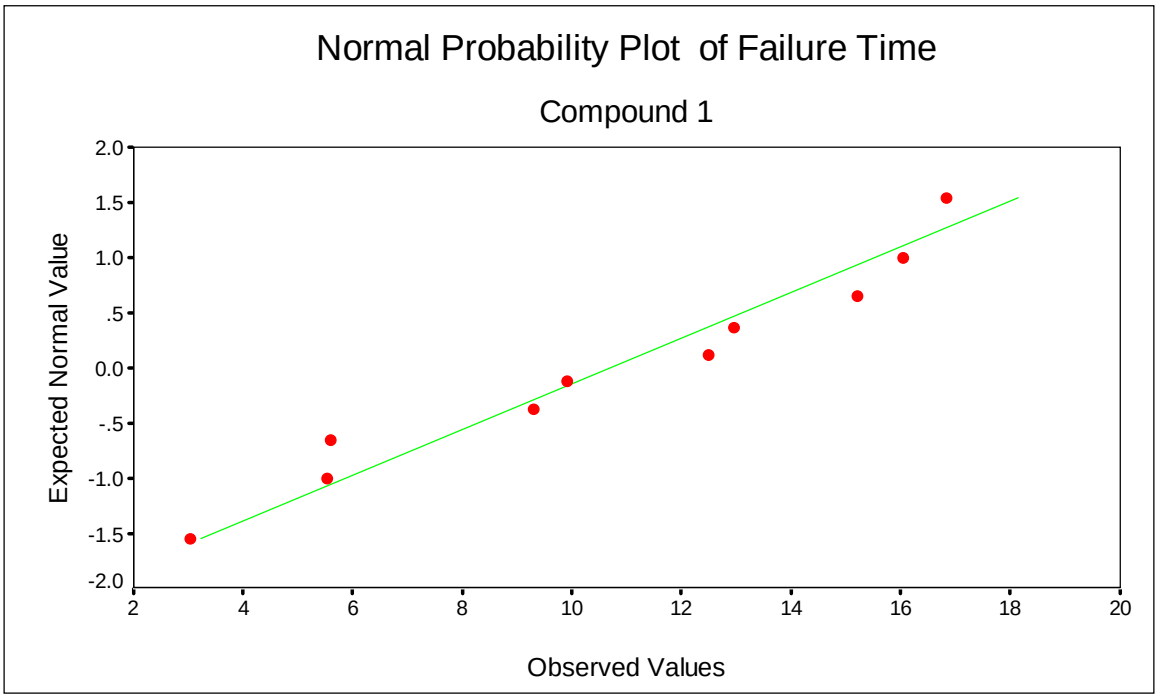
5.1 Checking the Normality Assumption
5.2 Checking the Assumption of Equal Variances
5.3 Checking the Independence Assumption

In order to determine whether there are significant differences among failure times for the five materials, we use one-way ANOVA model. However, the conclusions based on the model are valid only if the underlying assumptions are satisfied. Specifically we assume that:

1. The failure times have normal distributions for each of the five materials.
2. The standard deviations of failure times are all the same.
3. Observations within each group are independent of each other.
4. Observations in any one group are independent of observations in other groups.

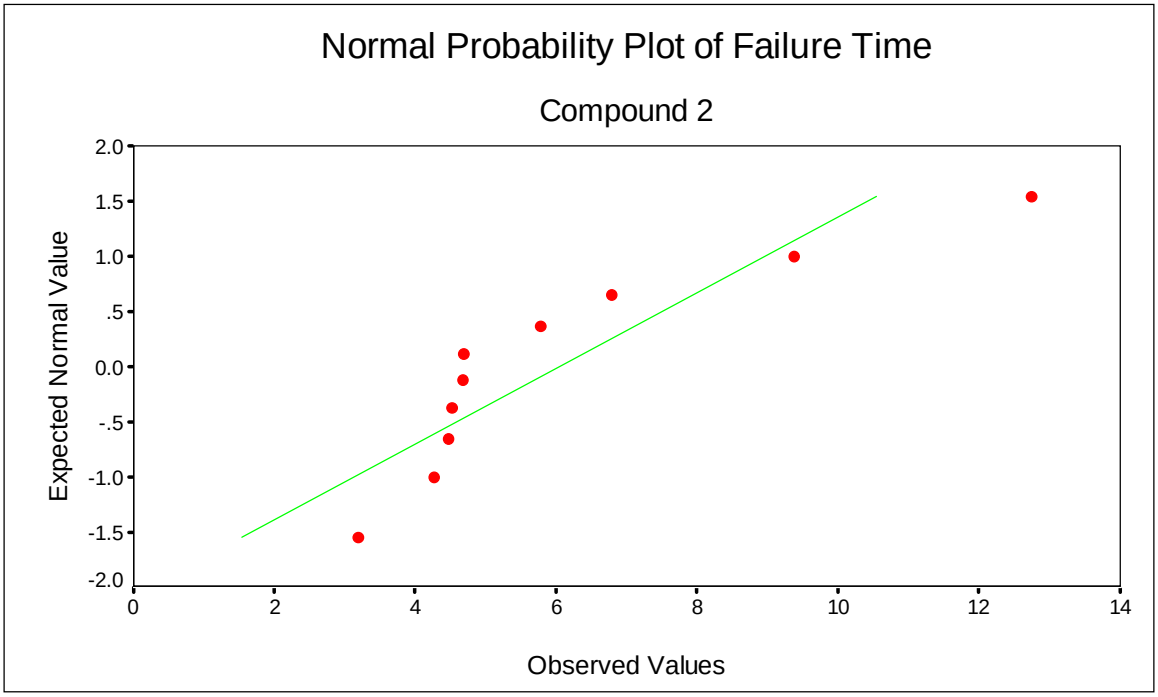
5.1 Checking the Normality Assumption

In order to verify whether the assumption of normality is plausible for our data, you can use either normal quantile plot of observations or the normal quantile plot of residuals, the differences between each observation and its group mean. As SPSS doesn't provide a normal quantile plot for the residuals, we will obtain a normal quantile plot for each of the five experimental groups.

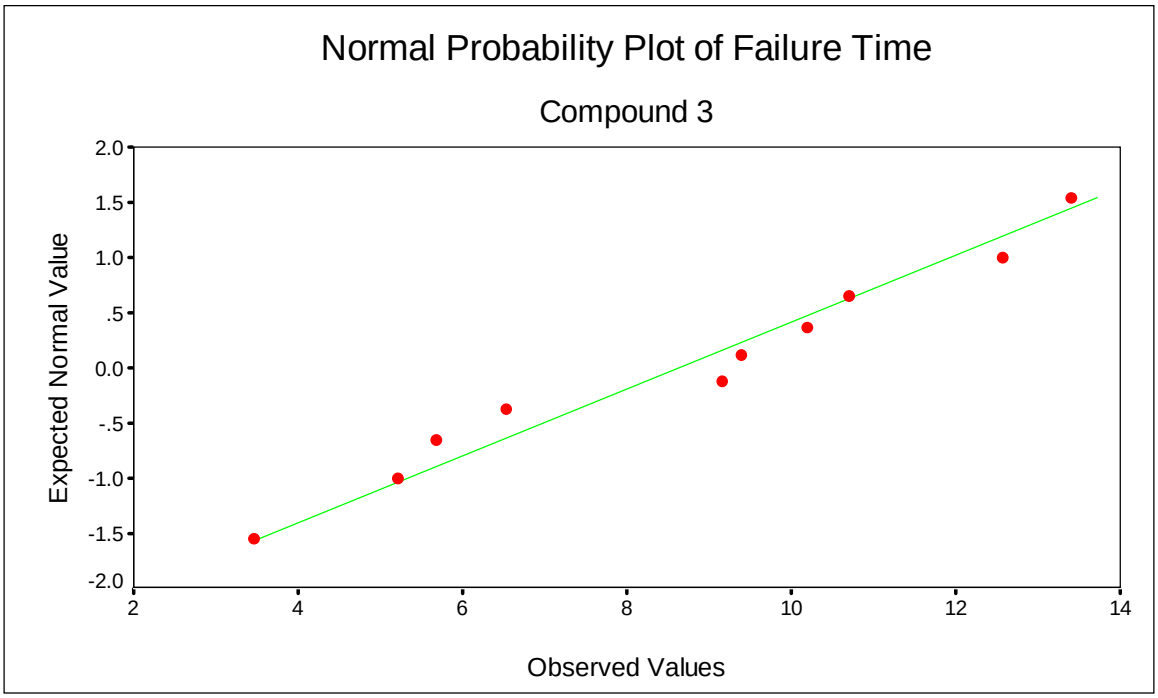


In the normal quantile plot of failure time for the compound 1 displayed above, most of the points lie close to a straight line, indicating that the normality assumption is not violated. The data provided are consistent with the assumption of normality. However, notice that the sample size is relatively small which makes our conclusion about the general pattern weak.

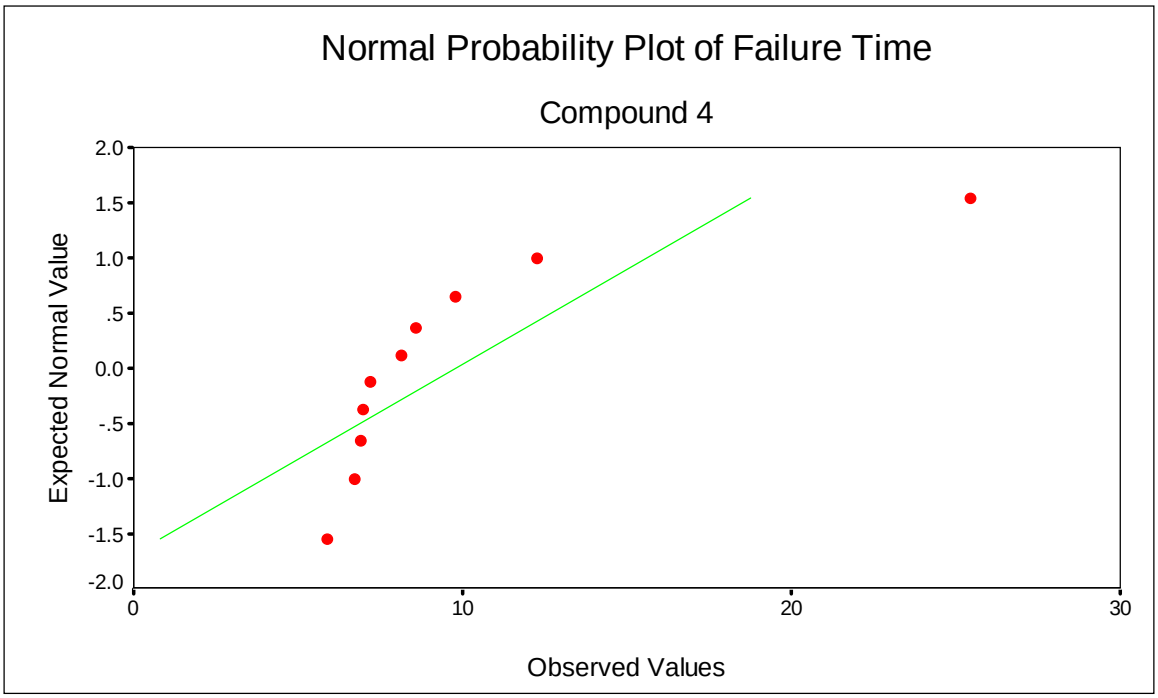
Let us examine the plots for the remaining groups.



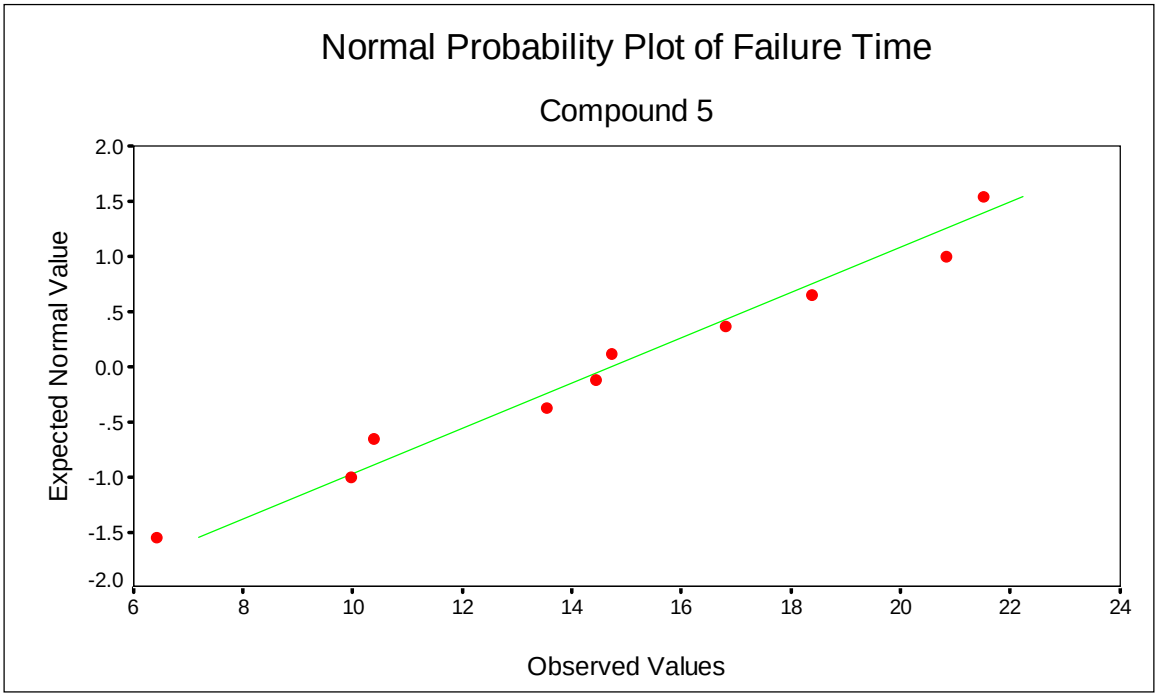
There is a serious departure of the points in the plot from a straight line. Thus, it is very likely that the normality assumption is violated. The point on the right lying far away from the line indicates a high outlier. However, the plot is obtained for just 10 observations making the statement about nonnormality very weak.



The plot shows that the normality assumption is reasonable for the data.



Similarly as for the compound 2, there is a serious departure of the points in the above plot from a straight line. Thus, it is very likely that the normality assumption is violated. The point on the right lying far away from the line indicates a high outlier. However, the plot is obtained for just 10 observations making the statement about nonnormality very weak.



All points in the above plot lie close to a straight line, indicating that the assumption of normality is plausible for the data.

5.2 Checking the Assumption of Equal Variances

Now we examine the assumption of equal variances. The assumption is crucial while making any inferences about the data.

The side-by-side boxplots obtained in Section 3 although obtained for just 10 observations in each group indicate that the normality assumption might be seriously violated. Formal tests for the equality of standard deviation in several groups share lack of robustness against nonnormality. Because ANOVA procedures are not extremely sensitive to unequal standard deviations, it is not recommended to carry out a formal test of equality of standard deviations as a preliminary to the ANOVA. Instead, the following rule of thumb is used: If the ratio of the largest sample standard deviation to the smallest sample standard deviation is less than 2, the assumption of equal standard deviations is plausible.

In Section 4 we obtained the following summary statistics:

Group	Count	Mean	Standard Deviation
1	10	10.693	4.8193
2	10	6.050	2.9150
3	10	8.636	3.2906
4	10	9.798	5.8062
5	10	14.706	4.8634

A quick glance at the data ensures us that the assumption of equal variances is plausible in our case. However, the ratio of the two standard deviations is almost equal to the threshold value of 2. As the number of observations in each group is relatively small (10), it is difficult to make strong claims about the assumption for the data.

Remark:

If the number of observations in each group is the same, inferences made about means assuming a common variance are not seriously affected by unequal population variances. Thus the experimenter should try to arrange for equal sample sizes. If we couple this requirement with our requirement for minimizing the effects of nonnormality, we should try to arrange for equal and reasonably sample sizes. In our case the sample sizes are equal but they are small and this is why it is difficult to detect nonnormality or violation of equal variances assumption.

5.3 Checking the Independence Assumption

Of the all assumptions, independence is the most crucial. If this assumption is violated, the effect on inferences about the average failure times for the five groups can be severe.

In order to test independence, it is recommended to obtain a plot of failure times versus the order the observations were obtained for the fifty bearings. If a pattern emerges, it is likely that the requirement is violated.

In our case, we do not have any information about the order the observations were obtained.