Engineering Ethics Cases with Numerical Problems

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Mechanical Engineering Case 2

To Ship or Not to Ship

A Case Study in Industrial Ethics

Authors:

William Jordan, Ph.D., P.E. (jordan@engr.siu.edu)

Michael A. Latcha, Ph.D. (latcha@oakland.edu)

Suggested Courses:

Strength of Materials; Engineering Statistics; Materials Properties

Level:

Sophomore & Junior

I. Narrative

A steel mill has been asked to produce high strength low alloy steel (H.S.L.A.) that has a minimum yield strength of 60,000 psi. You are the quality control supervisor for the steel mill. As the steel is produced, each coil is tested for strength. The data shown at the end of the case study has been obtained. There are three options to this case study. Option #1 assumes that you only made one test per coil. Option #2 assumes you made three tests per coil, and Option #3 assumes you made five tests per coil.

The product is a thin sheet steel that is several feet wide and several thousand feet long. The strip has been rolled into coils to make them easier to handle. The samples are taken from the outside ends of each coil. The samples are nominally 0.5 in width, 0.030 in thick and 2.0 in length. The samples are tested to yield in tension and the load at yield is read directly from the load displacement plot produced by the testing machine. The yield point can normally be determined within +/- 3 pounds.

Your job is to decide whether or not to ship any of the coils of steel A-E. Carry out any numerical calculations necessary to assume that the steel shipped satisfies the minimum requirements of 60,000 psi yield strength. Calculations that may be important for you are the mean value of strength, standard deviations, and confidence intervals. You need to decide where (and how) these calculations may be useful.

The production control department has put you under pressure to ship all of the coils, since they all were produced from the same heat of steel (same batch) and have all been processed in the same manner, thus all have the same nominal properties.

II. Scenarios to consider:

1. Your customer requires you to certify that your coils meet the required minimum strength levels. This means that you need to sign your name next to a statement that you have tested the coils and you guarantee they meet the specifications. How would this additional requirement affect your decision as to which coils you should ship? False certifications are considered a violation of the engineering codes, and could cost you your engineering license.

2. Your customer "requires" that your coils meet the specifications, but does not ask you to certify them. Your customer has no way to test the coils that you ship him. How would these facts affect your decision as to which coils should be shipped? Explain your answer.

3. Suppose that the customer had approached your company for advice on the steel properties needed for his product. The 60,000 psi minimum has been developed by a young engineer in your department. You have not checked his work, but he has been known to be conservative in his previous estimates. Are you more willing to ship coils in violation of an internal standard than a customer's standard? Explain your answer.

4. If you knew the product for which this steel was intended, would it influence your decision? You should answer this question for each of the three possible assumptions described above in scenarios 1-3. Suppose:

a. The steel was ordered by an aircraft manufacturer.

b. The steel was to be used for non-critical equipment supports in restaurants.

c. The steel was ordered by a subcontractor who was going to sell the steel to an unknown manufacturer.

d. The steel will be used in the outside door panels of automobiles.

e. The steel was ordered by a manufacturer that makes, among other things, automotive wheels.

III. Ethical Issues to Consider:

There are several different ethical issues that you should consider.

1. The first issue is to decide what basic ethical analysis method you will use to analyze the problem. One way to consider the cases is to examine them as a line drawing problem. In a line drawing problem, you set up a scenario where the choice made was obviously good, and one where the decision that is made was obviously bad. You set up various intermediate cases, where the ethical correctness of each choice is less clear. You can use this to draw the line between acceptable and unacceptable choices. When you examine your calculations you may find that some coils are obviously good, and some obviously unacceptable. You can then concentrate on the coils that are in the middle, in which the shipping decision may not be obvious.

Another way to consider some cases is to examine them as if they were a conflict between two different people or standards. If you use this technique, you may wish to consider whether some middle way might be obtainable,

that will satisfy all parties in the conflict. If that is not possible, then you may have to make a hard choice that may not satisfy all parties in the conflict.

2. A second ethical issue relates to how you will use various mathematical tools. Your choice of tool is not neutral, for it may change your decision as to which coils can be shipped. This has definite ethical implications. Using the wrong mathematical tool could result in you shipping bad coils. This could have safety implications, as well as damaging your own and your company's reputation. On the other hand, if you do not ship coils that are actually good, then you are costing your company money and not fulfilling your obligation to be a faithful trustee for your company's resources.

You may wish to use various math tools in doing options 2 and 3. The use of these math tools is designed to make the decision process easier. Depending upon the data, that may or may not be true. You will fact the decision as to whether you should use the mean as your acceptable criteria, or whether you will also use the standard deviations and confidence intervals as well.

Using either standard deviations or confidence intervals will produce a range of strengths that could be used to represent the strengths of each coil. When you use these intervals, you are faced with several options:

a. You could ship only the coils whose entire interval is above the minimum.

b. You could ship only the coils who have some part of their interval above the minimum. You would need to decide which portion of the interval must be above the minimum strength.

c. You could decide to ignore the issue of these intervals, and just make the decision using the mean values of strength.

Engineers frequently define their data interval as the mean plus or minus the standard deviation. An analysis of your data may show that the confidence intervals are smaller than those produced using a standard deviation (in some cases) and larger than a standard deviation (in other cases). These two different methods may result in different recommendations as to shipping a particular coil. You will then need to decide which of these methods to use.

3. The fourth scenario described above also has ethical implications. If the application is determined to be a critical one in terms of protecting human life, then you may wish to use some type of respect for persons test. This examines the issue of whether the advantages of using this particular coil outweigh a potential damage to human life. If you use a cost benefit approach to this problem, then you would need to decide what is the value of the damage to human life. If the part is not in a critical application, then you may wish to use a more utilitarian approach which examines the benefits and costs of each decision.

This scenario also brings out the issue of loyalty. The engineer is required to be a "faithful agent" of his employer. To what extent does this loyalty conflict with his need to protect the public?

4. There is a potential ethics problem relating to whether these samples are representative of the entire coil. It is well know that the properties at the ends of the steel strips are frequently different from the properties in the middle of the coil. What ethical issues are involved in using such data?

If you use poor data, and ship coils that are not satisfactory, you are not fulfilling your obligation to provide satisfactory steel to your customer. You also may be guilty of deception, for you know that the data may not be

representative of the properties of the bulk of the coil. If unrepresentative data causes you not to ship a good coil, then you are not being a faithful trustee of your own company's resources.

What other alternatives could you suggest that would allow you to obtain more representative data? Rewinding the coil to allow you to get samples for the other end is a rather expensive operation. The customer's requirement for a certain minimum weight coil makes it unlikely that you will get permission to cut every coil into half so that you could get test samples for the middle of the original coil.

Data for Option 1:

Coil Load where yielding begins (lbs)

A 938

B 903

C 899

D 890

E 843

Data for Option 2:

Coil Load for test Load for test Load for test

1 (lbs) 2 (lbs) 3 (lbs)

A 970 943 947

B 925 888 894

C 884 898 910

D 872 871 901

E 832 838 864

Data for Option 3:

Coil Load for Load for Load for Load for Load for

test 1 test 2 test 3 test 4 test 5

(lbs) (lbs) (lbs) (lbs) (lbs)

A 966 968 960 932 931

B 877 907 917 926 918

C 905 919 889 917 914

D 884 885 893 888 880

D 825 819 868 862 869