Failure Appraisement

An Online Continuing Education Course for Engineers

Course Number: F-2001

Credit: 2 Hours / 2 PDH / 2 CPD

Failure Appraisement

Preface

Failure! Why did it happen? Good question! It may have happened to a technical product, an economic investment, a biological condition, or in many other circumstances. Chances are, someone will want to know why such a failure occurred.

Engineers are frequently called upon to find, or are faced with the need to know, the reason for a failure. In the course of your engineering career, you may have on occasion been faced with the task of determining why, or how, a failure has occurred. Besides the economic issues associated with such a failure, there may be safety or other important consequences. Determination of the characteristics of and the reason for failure may be vital. In order to properly, and successfully, assess failures it is necessary to follow a suitable procedure.

This course describes principles and techniques that are helpful in guiding a successful failure appraisal.

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Introduction:

This course is called "Failure Appraisement" because it deals with general principles and methods in investigating failures. More detailed, rigorous, and mathematically-based evaluation of failures is usually called "failure analysis". The approach presented in this course could be sufficient for the evaluation of a simple failure or it could be a good starting point for the more detailed investigation of extensive and complicated failures and may afford a saving of analysis time and effort.

The student is reminded that the generalized principles and approaches presented in this course may have to be modified in a particular failure investigation. The circumstances and effects of different failures vary widely and the selected approach needs to be adapted to the characteristics of the failure being considered.

In this course, the following definitions apply:

1. Failure - a loss of function resulting in the inability to perform a duty or expected action; a state of instability resulting in loss of capacity to perform a normal function.

2. Appraisement - an evaluation of the worth, significance, or status of; an expert judgment of the significance or reason for.

3. Root Cause – the basic or fundamental cause of the failure being investigated; the cause which, if changed or corrected, can prevent recurrence of the problem.

4. Limit – a confining or restricting object, agent, or influence.

Appraisement Bases:

In approaching the appraisement of a failure, a first step is to identify the bases for action. These bases should include a characterization of the value and importance (the significance) of the failure. For instance, the bases of a failure investigation might be:

- Safety - loss of life or injury to persons; possible danger to persons or property; disaster or catastrophe avoidance.

- Economic - property damage, loss of product, increased costs, loss of needed service, basis for design change, or similar requirements.

- Necessity , the subject service or operation is needed, replacement(s) is/are not available; it is essential to find out what needs to be repaired.

- Knowledge - why did this item fail?; personal education for future guidance.

Identification of the bases for investigating a failure is important in;

- establishing how the investigation is to proceed; for instance, determining the course(s) of action, the care and protection that is to be provided for the items involved, the timing that is to be observed, and the records that are to be kept.

- determining what resources are to be assigned to the investigation; this may include the access of special equipment or personnel that must be arranged for, obtaining necessary funds and authorization, and checking for regulations or constraints that apply.

- specifying what is to be done with the findings; the extent of the records and reports that are to be prepared, their format, and the recipient(s) of them.

Following the characterization of the bases for failure investigation, an important next step is to determine (and document if appropriate) the available information. One needs to consider:

(1) what is known - all the facts that are pertinent to this situation should be recognized; especially important in the case where investigation or other activity may disturb the item and any important surroundings. If the first choices of action do not lead to the location of the underlying cause and

alternative routes must be investigated, information that initially seemed trivial may become important. All available information should be noted.

(2) what is noted or observed about the failure - care must be taken to assure that as much pertinent data as possible is collected; this includes data that, at the time may seem to be irrelevant, but may later be found to be important. This is especially important in the case of accidents or other situations where the conditions or circumstances may be eliminated or contaminated after initial inspection.

(3) what is not known, but which may be related or important. Here the items, conditions, or influences that are missing or are expected, but absent, are important. Also, the condition of items related to or associated with missing or absent items may be important in helping to explain the absence.

In this information collection, it is also important to list assumptions that are used as guides in the investigation. In listing these assumptions, it may be desirable to indicate the degree of certainty that each one has. And during the investigation these assumptions should be confirmed or modified as the findings direct. If the findings in the investigation do not produce satisfactory results, it may be that the assumptions made are not correct or suitable. Here the indicated degree of certainty may be helpful in modifying the assumption or in selecting a new direction for the investigation. Investigators must be willing to change direction or approach to ascertain the basic cause or reason that the failure in question has occurred.

Failure causes are frequently not what seems to be most obvious or what is first suspected. And failures seldom have a single cause. Usually failures occur because of a combination of two or more degrading factors.

The appraisement process:

Generally the objective of failure appraisement is the determination of a basic reason that the failure occurred. This basic or fundamental reason is also known as the Root Cause of failure. (See Introduction – Definitions.)

Failure, in the context considered here, may be as trivial and simple as one's pen being unable to write or as important and complicated as the Columbia tragedy or the NYC twin towers collapse. Appraisement of the fundamental reason for these failures is based on a common process; but the degree of detail, effort, and cost is different.

In expanding the process to enable the inclusion and evaluation of greater detail, much care should be used. In some cases, such as the Columbia loss, it may be possible to recover most, or many, of the pieces or parts. These may then be grouped in positions that afford a visible clue as to what articles or components were affected most. Special attention should be given to missing items. What cannot be found may be very important.

On the other hand, the primary evidence may not be available. A ship or airplane may have sunk and cannot be retrieved. Pieces and parts of items involved may have been destroyed by fire, carried away by a flood or tornado, or have been destroyed or dissipated and are not available. In these cases, secondary evidence such as transmitted data, design or fabrication records, pictures, historical descriptions, and information supplied by witnesses or observers may be important.

Appraisement Procedure:

A suggested procedure is first to enumerate;

1. The bases for the particular investigation.

2. Constraints that exist or may be encountered; e.g. access, regulations, hazards.

3. The requirements to be met; e.g. time schedule, findings recipient, results format.

4. Aids, facilities, and services needed. These may include personnel, structures, money, tools, equipment, and information.

Then to;

5. Describe the failure as well as possible. Describe the item, the situation, the existing conditions, anticipated failure modes, etc.

6. List pertinent known data. This includes relevant information and evidence on components and observations such as items available/found – yes or no --, where found, what condition/damage, and estimates of how this condition might have occurred.

7. List what is not known that would be of assistance.

8. Describe the assumptions. The assumptions may be crucial to the success of the investigation. There are cases where an action seemed to be possible, but a review of the assumptions on which the action was based showed that some of the assumptions were incorrect and the predicted action was therefore impossible.

This writer was once involved in the resolution of a problem in which an electro-mechanical system that used balanced electronic networks in its operation was operating erratically. One of the assumptions was that the individual components were proper and suitable. A detailed examination of the circuits showed that some of the components, while meeting the procurement specifications, had slightly different performance characteristics over their range of operation. When these components were replaced with matched

sets, the erratic operation of the system was eliminated.

9. Select an approach to find causes. Here it is important to watch out for false trails; to carefully review assumptions, unknowns, and evidence to most effectively use resources and time. It may be that repeatedly asking "why" (did this occur) and finding an answer will lead to the discovery of the Root Cause. Or, alternatively, doing the same with "Because" would be more suitable.

It may be helpful to employ diagrams in structuring the investigation. Such diagrams are especially useful in cases where there are many pieces to the puzzle and no clear direction for investigation. Diagrams are also very useful when the investigation is being conducted by [illegible] as they enable all involved to understand [illegible]y.

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10. [illegible]ous steps, associate evidence and obse[illegible]pected behavior or performance. Perform experiments or analyses if necessary to confirm relationships. Analyses may include examinations (e.g. metallurgical, microscopic, medical, etc.) and computations utilizing probabilities and graphs. Use the results of these analyses to guide and substantiate conclusions.

At some point in the questioning or investigation, a limit will be encountered. This limit may be a natural law, a regulation, an