Resource A

PAPER 1

Total quality manufacture of stationery products with FMEA methods

TCS

Teaching Company Scheme

Seminar Proceedings Vol. 2 No. 2

QUALITY

April 1992

QUALITY SEMINAR

22nd APRIL 1992

CHAIRMAN - Professor G Thompson, Nottingham Polytechnic

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Total Quality Manufacture of Stationery Products with FMEA Methods

by

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A paper for the Teaching Company, Quality Seminar, Institute Marine Engineers, London. (April 22nd, 1992).

Introduction

Rexel Engineering limited is part of Acco-Rexel Holdings Plc which is one the world's largest suppliers of office products. Rexel is a medium sized engineering company occupying an 11 acre site in Llangeinor, nr Bridgend, South Wales. Its primary business is the design, manufacture and assembly of stapling machines and manufacture of wire products such as staples. Rexel currently employs 375 people within its 114,000 sq ft of manufacturing space.

Rexel Engineering is the leading manufacture of stapling machines in this country and presently commands over 70% of the U.K. stapler market by having built up a reputation for the quality of its products. In recent years however, Rexel has experienced increasing competition in its traditional home market, particularly from Europe and the Far East. This competition is threatening Rexel's dominant position in the U.K. As approximately 50% of Rexel Engineering's total manufacturing capacity is devoted to producing for the U.K. market, competition in the U.K. is threatening Rexel's long term profitability.

In order to counter this threat to its home market and to provide some insulation against recession in this country, Rexel Engineering has been looking to increase its share of international markets, particularly Europe. Although Rexel Engineering is the dominant player in the U.K. market, its name is not well known outside this country. If Rexel is to break into the European market, then it must compete on the quality and price of its products and not rely solely on the Rexel name. In order to do this Rexel must strive to constantly improve the quality of its products while reducing manufacturing costs.

The first effort to achieve these twin goals was made in the mid 1980's when a major investment program was undertaken. This programme was called Project 90.

The First Improvement Program - 'Project 90'

Project 90 encompassed investment over a wide range of activities aimed at reducing manufacturing costs by improving productivity and reducing work-in-progress. The activities encompassed by Project 90 included:

* Installing a Just In Time (JIT) form of manufacture.
* Carrying out a program of component standardisation to create a product mushroom.
* Undertaking an investment programme in new plant and equipment.
* The installation of a MRP II computerized production control system.
* The obtaining of B.S. 5750 Part 1 approval.

This extensive program was very successful in its aims and led to a vast reduction in the value of Work-In-Progress (WIP), which has been reduced from £1,000,000 in 1984 to £80,000 at present. Injection moulding of thermoplastic parts for staplers, for example, has recently been brought in-house by a substantial investment in new machinery. The reduction in the value of WIP is reflected in stock turns which have increased from 4 to 14 over the same period. Productivity at Rexel Engineering has also seen an improvement of around 100% and has helped keep manufacturing costs of its products stable over a number of years.

Although the investment programme was successful and achieved its aims, the competition faced by Rexel has not stood still. An appraisal was therefore undertaken to examine what else could be done to improve Rexel Engineerings' competitive position. As a result of this appraisal it was felt that since up to-date machinery was in place, the only way to progress in the future was through its people and only by introducing the concept of Total Quality Manufacture (TQM) could the full potential of its workforce be released.

Total Quality Manufacture at Rexel Engineering

The first step to introducing TQM was to appoint a steering team chaired by the managing director. It was made up of representatives from personnel, the existing quality department and a full time TQM project engineer. Outside assistance was provided by an ACAS Work Research Unit. The purpose of the steering team was to oversee the introduction of TQM in Rexel Engineering.

The TQM program has been running at Rexel since September 1991 and the steering team has been developing its strategy for implementing the TQM principles. The first objective of the team was to issue a mission statement and communicate the Managements' commitment to all members of the organisation.

It was done initially through a series of TQM workshops,, which were attended by 12 to 15 employees at a time. They discussed the mission statement and 10 broad quality principles (Figure 1.0). The workshop were attended by every employee at Rexel Engineering and each workshop was chaired by the managing director. They took several weeks to complete and although they proved to be disappointing from a communication viewpoint, they did get the TQM programme started.

In order to progress further, several things were required: a method for bottom-up communication between the shop floor and management, a physical display of Managements' commitment to TQM and a method of involving operators in quality problems. In order to achieve all these aims a problem solving technique called CEDAC was introduced and piloted in the paint plant. The paint plant was chosen as the problems in that area were visible to all, and it was thought to be an area which had a good chance of achieving improvements quickly. If the technique proved to be successful in the paint plant then it would be expanded into other areas.

CEDAC

CEDAC stands for Cause and Effect Diagram with Added Cards and is basically a variation on an "Ishikawa" or cause and effect diagram. CEDAC works by displaying a problem on a large diagram (Figure 2.0) and when anyone has an idea relating to the cause of the problem, he adds a card to the board describing the potential cause.

The diagram is displayed on a large board and is placed in a prominent location. Having the diagram (referred to as the CEDAC board) in a prominent, visible location is central to the operation of the technique and provides a visible display that the problem is being examined.

At regular intervals the CEDAC board is reviewed in a CEDAC meeting. Present at this meeting is a production engineer, a CEDAC leader and between 3 and 4 operators in the area concerned. The CEDAC meeting discusses each card on the board and describes on a course of action.

The state of progress of a particular card is marked on the card by using a series of dots.

o One dot on a card signifies that a particular suggestion has been examined.

oo Two dots signifies that some action has taken on the suggestion.

ooo Three dots signifies that action on the suggestion is close to completion.

oooo Four dots signifies that the action has been closed out.

Minutes are taken of the CEDAC meeting, the minutes listing all the actions taken on the cards together with completion dates and persons actioned. These minutes are added to the CEDAC board to maintain communication.

CEDAC has now been in operation in the paint plant for 12 weeks and in that time 22 comment cards have been added to the board and examined in the CEDAC meeting. The number of comment cards and their subject is shown in Figure 3.0. It can be seen that paint standards and cleanliness are the major concern. Since CEDAC has been running great efforts have been made to set quality standards and improve the cleanliness in the paint plant. One result has been a sharp fall in scrap products (Figure 4.0).

The programme now commits paint operatives to quality in their area. As a result of the initial success of CEDAC in the paint plant, the technique is to be expanded to all areas of the factory.

The main advantage of CEDAC is that it uses operator knowledge to address quality problems in the area in which they work. This promotes operator involvement *in* and the ownership *of* quality. CEDAC by its very nature is a visible technique and this helps to give it a high profile and communicates Management commitment to total quality.

Finally CEDAC provides a much needed vehicle for bottom-up communication, allowing for the first time a link to be forged between the operators on a particular process and the existing Engineering Change system. This link means that operators now have a vehicle to suggest changes to a particular product to improve its quality.

So far the paper has discussed Rexel's attempts to improve the quality of its products by addressing manufacturing problems. However, if Rexel is to become a genuine low cost producer then it must examine the other sides of total quality, namely product design.

Quality by Design

For stapler products, 70% of the final product cost is fixed at the design stage. Product design has thus the greatest potential for reducing the manufacturing cost of future products. In addition to the cost, product quality is also largely fixed at the design stage. If the product is poorly designed a good quality product will not be produced, irrespective of the quality of the manufacturing process. For this reason, it is vital for the final quality of the product reaching the customer that quality is designed into the product right from the start. If the ultimate aim of TQM is to please the customer, then it can only be achieved by quality design *and* quality manufacture.

Rexel Engineering has been striving to improve the quality of its designs. It took a major step ahead when Forward Engineering principles were introduced into Rexel's design process in early 1989. Forward Engineering requires that multi-functional teams are used in the design of new products. The main advantage of this approach is that all functions of the organisation have their input into the new design at an early stage. By using Forward Engineering, a considerable improvement was made over the existing method of design and it has opened the door to using new design techniques. Although a number of these techniques were investigated, FMEA was the first to be applied and implemented successfully.

FMEA Studies at Rexel Engineering

FMEA stands for Failure Modes and Effects Analysis and is an analytical tool used to identify potential failures of a product or process at the design stage so that action can be taken to eliminate them before they occur.

FMEA was first used some 60 years ago, but only used on a regular basis in the 1960's by the aerospace industry (where it is known as FMECA, Reference 1). This industry is more interested than most in picking up potential failures *before* they occur, as failure in service could lead to fatalities. Since then, FMEA has become more widely used by the motor industry particularly by Ford and Jaguar (2, 3). These companies have encouraged their suppliers to adopt FMEA, so making it a customer-driven technique. It is also widely used in the electronics industry (4).

FMEA was initially adopted at Rexel at the same time as Forward Engineering in early 1989, but after some initial attempts its use soon petered out.

It was picked up again about a year later when we visited Flymo Ltd in Darlington. Flymo had been using FMEA for three years at the time of the visit. It had originally adopted the Ford method (2) but over the three years, it had adapted the technique to suit their own product range. Flymo were able to pass on its experience to Rexel and we were able to jump ahead on the learning curve.

The first step when conducting a study is to define the machine or process under study. In the case of a stapling machine its functions are as follows:

* Stapling paper sheets together.
* Loading staples into the feed mechanism.
* Acceptable appearance for user.
* Not be harmful when used normally.

Any failure of the product will effect one of these functions. Once the functions of the machine have been defined, then components are considered one at a time and all potential failure modes suggested by the design team are then recorded. The best way to explain how FMEA handles the failure modes is to consider an actual example. The example quoted is from a recent study on a new product and is a good example of FMEA in operation. The study identified a potential failure of a product for the internal customer at a time when the necessary action required to rectify the problem could be done easily and cheaply.

It concerned a plastic component known as a cover cap, as seen in Figure 5.0. This cover cap was a replacement for an existing cap which was very similar in design. The difference between the old and the new cap was mainly aesthetic, involving a new company logo. As the new cap was to clip-assemble with the same existing component (a metal cover) all functional dimensions were copied across onto the new one.

When the design FMEA study was conducted on the new cover cap, it was brought up by one of the assembly line operators that the old cap was difficult to assemble. As a result, operators had to wear plasters to protect their hands from blisters. After investigation it was discovered that an interference fit existed between the old cover cap and the steel cover, and the interference fit causing the difficulty had been copied across to the new cap. This failure mode is shown in Figure 6.0, with a final RPN (Risk Priority Number = Severity x Occurrence x Detection) of 160. Action is initiated at Rexel for all failure modes with an RPN value greater than 120.

Immediately after the study, the tolerances on the new cover cap were changed to eliminate the interference fit. As this was done at the design evaluation stage of the design process, the necessary change took no more than 10 minutes at very little cost. If this change had been made once the cover cap was in production the same change would have cost in the region of £4,000. Thus it can be seen from the above example that FMEA improves the quality of the product for the internal customer as well as the final customer and that by involving non-engineers, the final design can be improved. Other examples included trying to anticipate product failure where the *user* could be injured, such as handle design and the surface texture of handles on pliers and tackers.

Like all quality techniques FMEA is relatively simple in operation but to conduct an FMEA study successfully there are several things which need to be considered. The first of these is the timing.

The Timing of a FMEA Study

FMEA is conducted at Rexel at the design evaluation stage of the new product development process. As this stage the design of the product is largely complete but production tooling has yet to be manufactured. Clearly if the study was conducted earlier then the study may not identify potential failures on later design changes. If the study is conducted later, then action may not be possible or may be very costly as the production tooling has been produced.

The FMEA Team Structure

The second factor is the team structure, the size and structure of which is vital to the success of FMEA.

The team that conducts the study should be between four and six people plus the facilitator. If the team consists of more than seven people then it will be difficult for the study team to reach a decision and thus slow the meetings down to an unacceptable degree. If the study team consists of less than four people then the knowledge base is likely to be too small.

The Rexel team contained a good mix between engineers and non-engineers in order to use the knowledge base which existed throughout the company. All major areas of Rexel were represented at each of the meeting to gain the widest possible experience, the structure of a typical team being shown in Figure 7.0.

The FMEA Facilitator

The role of the facilitator is a very important and in the case of Rexel was undertaken by the Associate (A. Finley). The facilitator arranged the data, time and place of the teams and made sure that all necessary information was available to the meetings. The information which is necessary in an FMEA meeting are prototype models, component drawings, rating tables (see Table 1 and 2) and customer return information. The quality of the FMEA study will be improved if the quality of information available to the study is good. It is also the responsibility of the facilitator to disseminate the results of the study to ensure that the evaluation is carried out and completed. In the meetings the facilitator was responsible for entering the results of the study into a computer-generated data base and generally keeping the meetings flowing and on track.

One particular area which generally caused problems when the study was being conducted by a team which was new to FMEA, was the confusion about the difference between a failure mode and its effect. The facilitator in such cases must continually point out the difference as this confusion can distort the study.

Computerised FMEA

When it conducted its FMEA studies, the Rexel team put all its results directly into a computer-generated database. The software used (Dataease) proved acceptable for the purpose. The advantages of using a computer are several, the main ones being listed in Figure 8.0. The main advantage however was found to be that the computer provided a focus of attention for the FMEA meeting. Thus by having a computer in the meeting crosstalk is prevented so helping to speed up progress of the analysis.

Final Evaluation

Probably the most important part of the FMEA process is the final evaluation. The FMEA study cannot be considered complete until all components have been evaluated. This stage of the FMEA process involves ensuring that all actions which are required as a result of the study are carried out and completed. If the evaluation of the study is not carried out the FMEA becomes simply a paper exercise.

Conclusion

In conclusion, FMEA is just a small part of a wider TQM programme and although its use has been successful in improving the quality of Rexel products, it cannot substitute for good quality design.

Perhaps one of the most important contributions FMEA will make to the quality of Rexel products is by promoting the principles of Total Quality. As only by involving all areas of the Rexel Organisation in the design of its products and process can the Rexel achieve a goal of becoming a world class manufacture.

Acknowledgements

The authors would like to thank Mark Harris and Lyn Jones of Rexel Engineering as well as Flymo Ltd for contributing to the success of the FMEA programme. We would like to thank Phil Prevel, Director and General Manager of Rexel Engineering for permission to publish this article. Tony Smith and Steve Collins of the Poly of Wales also helped significantly through the Teaching Company Scheme, a collaboration between the University of Salford, The Open University, the Poly of Wales and the Acco-Rexel Group.

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(2) Ford Motor Company 'Practical Failure Mode and Effects Analysis in Design and Process' Instruction Manual (1988).

(3) Society of Motor Manufacturers and Traders 'Guidelines to FMEA' London (1989).

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MISSION STATEMENT & 10 QUALITY PRINCIPLES

Mission Statement

"To ensure the future prosperity of Rexel Engineering Limited by establishing it as a world class manufacturer renowned for total quality of its people, product, cost and working environment"

Ten Quality Principles

1: Management led
2: Company wide
3: All responsible for quality
4: Prevention not detection
5: Right first time
6: Continuous improvement
7: Delight the customer
8: Focus on the process
9: Scientific, statistical methodology
10: Pride in the job

Figure 1.0

CEDAC DIAGRAM

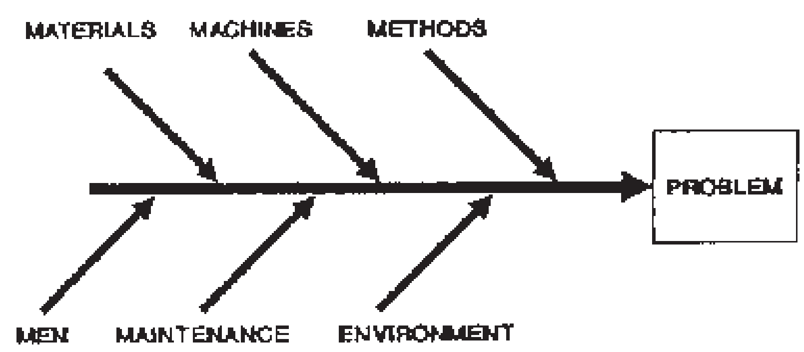

Figure 2.0 Cards are added to this by the operator

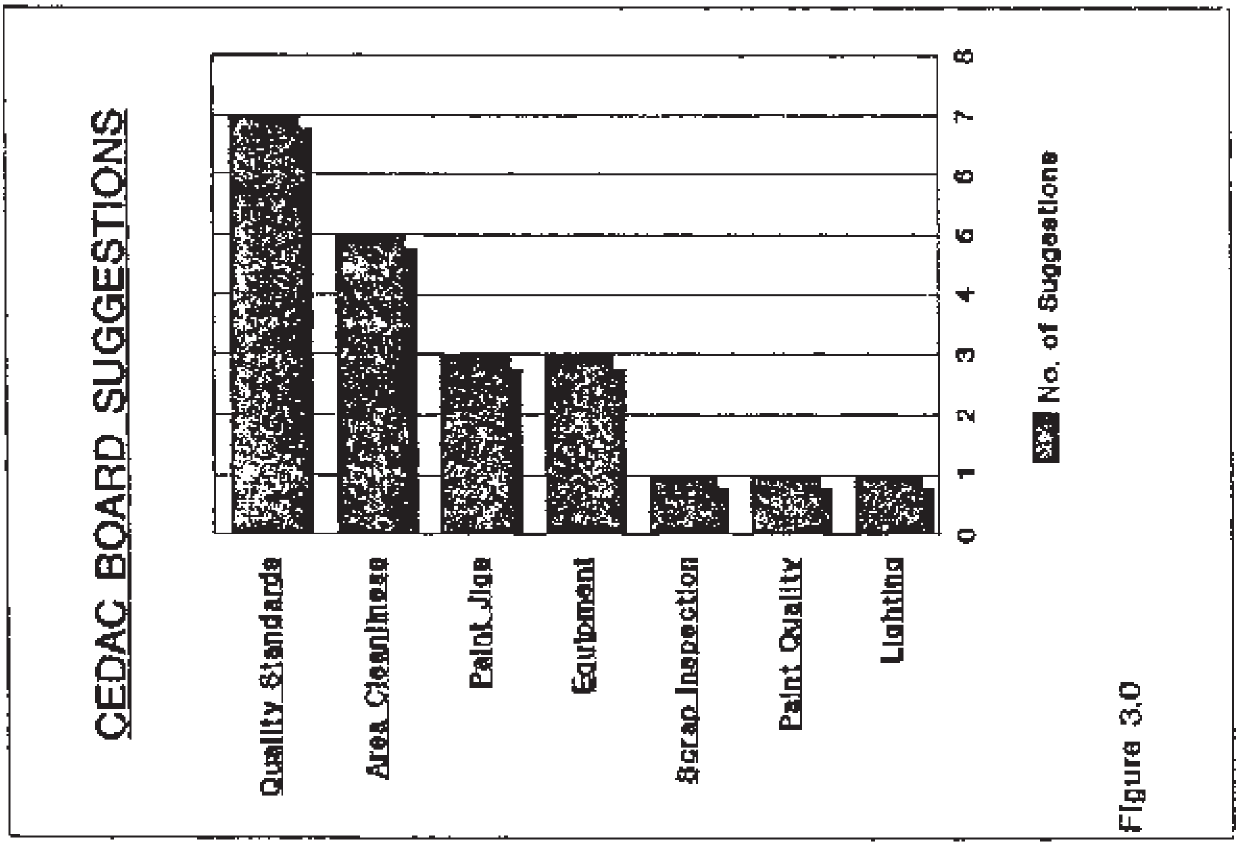

Figure 3.0

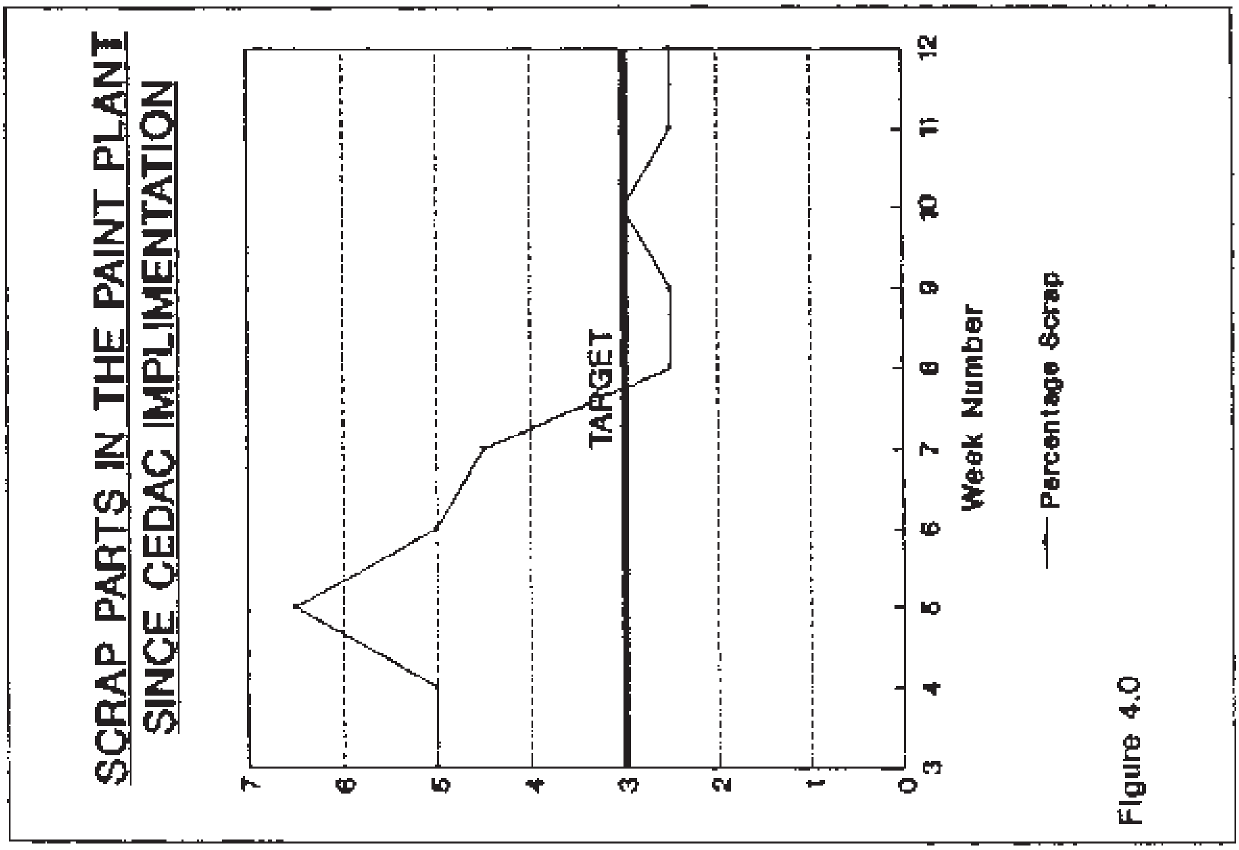

Figure 4.0

THE METEOR MACHINE WITH NEW COVER CAP

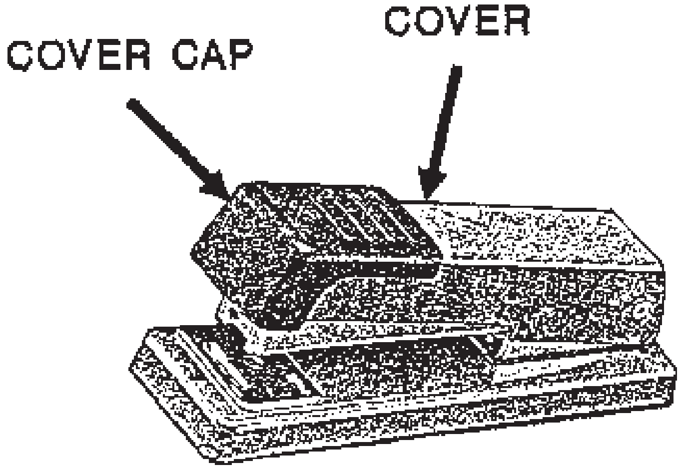

Figure 5.0 Shows the New machine in the FMEA study

EXAMPLE OF FMEA AT REXEL

Machine: METEOR

Component: COVER CAP → FM 1 | FM 2 | FM 3

Machine Function

- Staple out
- Load staple
- Not be harmful to use

Failure Mode: Tight fit with cover

Effect: Harmful to operator

Cause: Interference fit with cover

Severity - 4 (Major Nuisance)
Occurrence - 10 (Every component)
Detection - 4 (Will be detected in Rexel)
RPN Value - 160

Figure 6.0

FMEA TEAM STRUCTURE

- 4 – 6 Team members plus facilitator
- Representatives from all areas of the organisation
- Ideally a 50 – 50 mix between engineers and non – engineers

A Typical Study Might Consist of :-

- Facilitator
- Production Engineer
- Design Engineer
- Design Engineer
- Assembly Operative
- Press Shop Operator
- Quality Inspector

Figure 7.0 Shows the structure of the teams used when conduction FMEA studies at Rexel

ADVANTAGES OF COMPUTERISED FMEA

- Time is saved in documenting FMEA.
- Data can be easily modified and updated.
- It allows easy storage, retrieval and manipulation of the FMEA data.
- Greatly improves presentation of FMEA results
- Provides a focus for the FMEA meetings

Figure 8.0 Lists the advantages of using a computor when conducting FMEA studies

SEVERITY RATING

1. Failure of this part/function will not be noticed.

2. Failure of this part/function may or may not be noticed.

3. Failure of this part/function causes a minor nuisance in manufacture.

4. Failure of this part/function causes a major nuisance in manufacture.

5. Failure of this part/function causes great difficulty in manufacture.

6. Failure of this part/function causes a minor nuisance to the customer.

7. Failure of this part/function causes a major nuisance to the customer.

8. Failure of this part/function causes the product to be operated by the customer only with difficulty.

9. Failure of this part/function causes the product to operate only intermittently.

10. Failure of this part/function causes the product to totally fail and become useless.

TABLE 1.

TABLES OF VALUES FOR OCCURRENCE, DETECTION AND SEVERITY

OCCURRENCE

1.	Remote probability of occurrence. It would be unreasonable to expect the failure to occur.	0
2,3:	Low failure rate. Generally associated with Designs similar to previous designs experience	1/20,000 1/10,000
4,5,6:	Moderate failure rate. Generally associated with designs similar to previous designs that have experienced occasional failures.	1/2,000 1/1,000 1/200
7,8:	High failure rate. Generally associated with failures of similar designs that have caused problems in the past.	1/100 1/20
9,10:	Very high failure rate. Almost certain that failure will occur on major proportions.	1/10 1/2

DETECTION

1: Normal manufacturing processes will detect fault.

2: Normal manufacturing processes should detect fault.

3: Normal manufacturing processes may detect the fault.

4: Assembly processes will detect fault.

5: Assembly processes should detect fault.

6: Assembly processes may detect fault.

7: Quality audit should reveal fault.

8: Increased quality audit should reveal the fault.

9: Fault may be noticed by the customer

10: Will not be detected until failure occurs.

TABLE 2.