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QUALITY AND RELIABILITY ASSURANCE

TECHNICAL REPORT TR 8

A GUIDE TO QUALITY COST ANALYSIS

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INSTALLATIONS AND LOGISTICS

May 31, 1967

A Guide to Quality Cost Analysis TR 8

Quality and Reliability Assurance

The content of this technical report was prepared by Professors Donald E. Morgan and W. Grant Ireson, Department of Industrial Engineering, Stanford University, under an Air Force Systems Command contract. It was developed to meet a growing need for guidance on the planning, installation, and use of a quality cost data analysis program.

The report is reproduced as a DoD Quality and Reliability Assurance Technical Report to permit ready dissemination of this material to interested Government and industry personnel.

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ABSTRACT

The QUICO system covers the planning, installation, and use of quality cost data analysis. The basic idea is simply to operate a manufacturing unit or complex so that the total of quality related costs is a minimum. Quality related costs are made up of (1) expenses incurred because of not producing the highest possible quality (resultant costs), (2) expenditures made to create conditions resulting in high quality products (quality creation costs), and (3) expenditures made to measure quality levels being produced and causes of deficiencies (quality and defect inference costs).

Analysis of quality cost data provides direct pay-offs in reduction of resultant costs and the major sources are discussed. Secondary benefits come from use of the data as a measurement of the effectiveness of the quality assurance effort, as a motivant to workers who must produce the high quality, and as a management guidance tool. Suggested cost accounts are given along with suggested methods of summarizing and displaying data in the most meaningful way for all levels of use. Almost all companies now have sufficient cost data to estimate cost reductions to be expected from the QUICO system.

1.0 THE QUICO SYSTEM - WHAT IT IS AND WHAT IT WILL DO

The QUICO system provides a clear plan for simultaneously optimizing quality and reducing costs. It can be applied in any production process in which there is a loss because of manufacturing defective parts or finished goods, or because of the inability to operate a process at the point of optimum yield at minimum cost. It reduces costs by effectively cutting these losses, and clearly indicates where early action can reduce costs later

The acronym QUICO was derived from the initial letters of the following phrase:

QUality Improvement through Cost Optimization

Quality cost analysis is extremely simple in concept. The concept is simply that all costs associated with having produced defective parts or goods and all costs associated with efforts to assure producing perfect parts or goods in the first place are determined and summed. Then the optimal program is obtained if the factory is operated so that this grand total is a minimum.

In order to do this, some cost information which is not normally available needs to be generated. Probably a number of new cost accounts need to be set up. At least at first, these accounts will be of no direct benefit to cost accountants, since they will be used entirely by the quality assurance people to gain an insight into the effectiveness of the quality assurance program.

1.1 THE QUICO SYSTEM

The QUICO system is a planned program to minimize the sum of quality related costs. Quality related costs consist of two categories of costs. The first is called controllable costs and is the amount spent in an attempt to create conditions under which high quality can and will be produced and in attempting to measure the quality level being produced and to determine causes for defects. The second is called resultant costs and is the uncontrollable expense both inside and outside the

plant caused by the productio of low quality. The QUICO system strives for an optimum quality level, which is defined as the quality level that gives the minimum of the sum of quality related costs. The notion of optimizing has come to be current fashion, and can be applied to total production costs, or any facet thereof, as well as to quality related costs. However, quality activities and costs affect all phases of production from design to field use, and focus attention on aspects of the program which would most likely be overlooked if attempts were made to minimize total production costs. Therefore, large expenditures in quality assurance effort and program evaluation can be justified because of potentially great reduction in costs of defective goods or parts, or loss of product.

The QUICO system gives a measure of the value of a quality assurance effort. A detailed analysis of the cost data can give a quality assurance manager exact information as to the strong points and weak points in his quality assurance program. It can tell him how the quality assurance dollar may be spent most effectively.

A more sophisticated analysis of these quality related costs is possible when they are available in the proposed form. It is easily possible to predict future sources of trouble by watching the pattern of quality creation expenditures. The guidelines for sophisticated analysis leading to optimization are really in the formative stages and are just emerging as firm principles to be followed.

The QUICO system is not a purely theoretical concept. It is a summarization of many experiences of industry in quality cost analysis and ties together the contributions and experiences of many practical operating systems.

This publication is a detailed implementation guide. It attempts to present general principles in sufficient generality to be adaptable to almost any industry and yet to be specific enough so that detailed plans for particular industrial concern can be drawn from it.

This is not a complete package plan, applicable without analysis to any industry. Instead it is a framework upon which a plan for any firm can be built. In some cases, it is so detailed as almost to insult the intelligence of the reader and in other cases it assumes a generality which requires sophisticated analysis and planning on the part of the reader to develop a workable plan for his company. This is unavoidable in attempting to write specific instructions for a generalized plan.

QUICO is a management tool. Management's job is to control the resources of the organization in order to accomplish its overall goals. The goals are complex, difficult even to define and many times in conflict. However, most of management's goals require minimizing product cost, so that there is almost always a continuous management effort to reduce costs. The QUICO system provides management with a tool by which the total of quality related costs can be controlled and held at or near the minimum level.

The minimum level of quality related costs is dependent upon another management concern, the company's product image to the customer. Actual costs, as determined by a complete and accurate cost accounting system, will not ordinarily reflect effects of the product quality on the company's "good will." Even after the costs for replacing defective products and fulfilling guarantees have been recorded, there is still the indeterminate cost, in the form of lost future business, which results from having an unhappy customer. Therefore, each company must establish a minimum quality standard below which the product will not be allowed to fall. This may result in higher expenditures in the controllable costs category than would be possible if the optimal quality is defined as that level which results in minimizing only the easily determined costs, i.e., not including effects of loss of good will. Management should judge the value of good will, and use that, in conjunction with other quality related cost data, to determine the irreducible minimum quality level which it is willing to ship. Then the QUICO system will assist management in allocating the funds in such a way that the optimal quality assurance program will be attained.

1.2 COSTS OF IMPLEMENTATION AND OPERATION

Costs of implementation in dollars have no meaning unless the costs are related to the size of the company. The time necessary to install a QUICO system and the time before the installation expense would be repaid in savings, i.e., payback period, are significant.

Present accounting systems vary greatly from one company to another; so the time to install a QUICO system will vary because of different starting points. Experience indicates that the time to install would vary from one month to twelve months with an average being three or four months. Many companies have successfully grown into a complete QUICO system by slow and progressive procedure modifications over several years. Payback periods must necessarily be estimates because savings are the difference between the actual sum of quality related costs and an estimate of what the sum would have been. Estimates of payback period range from one month to twelve months with an average of six months. Some companies have stated that the benefits estimated in advance indicate such a long payback period that installation of a QUICO system cannot be economically justified. However, in at least one case, more detailed study resulted in first steps toward implementation.

Experience indicates that the monthly cost of operation is very small compared to the installation expense. There will be an extra cost of preparation of primary records because of the more detailed breakdown of costs. Manual bookkeeping usually consists of recording the cost entries in a single entry set of books separate from conventional cost accounting records and the preparation of weekly or monthly summaries. With electronic data processing equipment, there is some increase in input preparation because of the greater number of accounts and some slight increase in computer processing time.

The savings accomplished by a QUICO system can only come from a reduction in resultant costs. Almost all companies have records that will make an estimate of resultant costs possible. Experience indicates

that the first estimate of the magnitude of resultant costs is almost always too low. However, in considering installation of a QUICO system, a realistic estimate of resultant costs must show the possibility of savings great enough to justify the expense of installation and operation.

1.3 QUICO SYSTEM BENEFITS

The goals of QUICO then can be considered to be cost reduction, and there are three ways in which it pays off.

1.3.1 Immediate Benefits - Payoff No. 1

As soon as cost information begins to be available, obvious savings will be immediately apparent simply because information is available in a form different from any available previously. This is called Payoff No. 1. The amount of this payoff will vary, depending upon the amount of increased information gained by this new cost accounting procedure. If little information of a cost nature was available before, the payoff at this stage is likely to be large. In most of the examples of Payoff No. 1 that have been encountered, one wonders how it is possible that the members of an organization could let conditions continue to exist that are so obviously out of balance with the other cost matters. It is not always easy for a particular company to accept the fact that such obvious savings can be found to be possible because of the implication of mismanagement. But this implication is incorrect, because, without exception, these obvious savings have occurred even in the best managed companies. Furthermore, without exception, the Payoff No. 1 savings have been dramatic.

1.3.2 Benefits of the Systems Approach and Analysis

Payoff No. 2 results from the analysis of internal and external resultant costs. This failure analysis seldom needs to be treated on a statistical basis, although this will certainly be done after a period of time. Great savings are possible by identifying a few of the more

common causes of failure which result in large costs. The collection and analysis of internal and external resultant costs will reveal those kinds of defects or failures which are accounting for a large percentage of the resultant costs. The question then can be asked: what can be done to prevent these defects from occurring? This will cause the designers, the production engineers, and the quality assurance engineers to examine the manufacturing process, the raw materials, and the product design in order to recommend action which will assure that this defect will not occur again. The estimated cost of making this correction will be compared with the prospective cost of continued defects. It is quite common to find that the cost of prevention is only a fraction of the resultant costs and that the total cost of quality can be reduced substantially by expending a little more money in the quality creation or the quality inference activities.

Thus, the second payoff results from collecting sufficient data to identify the major resultant costs and then help determine the corrective action which will reduce the resultant costs. It is not enough to have information about the major resultant defects; it is necessary to investigate the costs of these defects and further to find the cost associated with making changes so that the quality will be improved to the point where these resultant costs will decrease. In many companies, statistics show that of the total cost of quality, 50 to 60 percent is in the resultant cost area, 10 to 30 percent is in the inference cost area, and only 5 to 10 percent is in the quality creation area. This is not likely to be an optimum situation.

1.3.3 Long Term Benefits

Payoff No. 3 is a result of the more sophisticated analysis of the QUICO data As cost data are acquired and displayed over a period of time (long enough for field results to be shown), it becomes evident that a more organized approach should be used to make the decisions relative to the expenditure of money for quality creation and quality

inference because the resultant costs are usually quite high and provide large opportunities for savings. Mathematical models for the determination of the optimal quality assurance program (and the optimum expenditure) are being developed but these models require an extensive amount of quality cost data. Thus, the third payoff is a long term matter and requires careful analysis of quality related costs over time. In extreme cases, one or two years may be required in order to measure the true effects on resultant costs of expenditures in quality creation and inference. Experience gained over time makes it possible to relate future savings to present expenditures, and thereby help to establish a stable operation. As is perfectly obvious, some of the money expended for quality creation is related in a complex way to resultant costs. For example, the money expended in education and training the employees may not be directly related to the amount of scrap or rework incurred; however, experience indicates (and it can be shown in some companies) that reduction of the education and training program, after the scrap and rework has been reduced considerably, frequently results in an increase in the scrap and rework as the training "wears off". Mathematical models will help to provide an organized long term quality assurance plan without wild fluctuations due to attempts to make immediate adjustments when something does not seem to be exactly right.

1.3.4 Purpose and Uses of Publication

The process of trade offs of controllable inputs against resultant costs has no firm rules. The decision as to what to do at any point can only be left to the perspicacity of the analyst. Usually desirable actions are fairly obvious but amounts of money spent in the various input activities can be so different from one industry to another that only the simplest, generally applicable rules can be stated. (See Implementation Section.)

In December of 1963, the Department of Defense issued MIL-Q-9858A. This specification requires the contractor to accumulate and use certain

quality cost data in the management of his quality program. An effective, responsive, and usable system developed under the QUICO principle would certainly meet this requirement.

This is not to say that the need for quality cost analysis is confined to defense industries. A company in a highly competitive field can use this as a tool to cut its costs and increase its share of the market.

This publication has been prepared as a summarization of the experience of a number of different companies in implementing quality cost analysis programs. The purpose of the publication is to provide general guidelines for any company wishing to install such a program so that the company can avoid the trials and errors which have been experienced by other companies. The publication provides guidance and directions.

The publication also may be the means of establishing a common ground for communication between those responsible for quality assurance and others in the company not directly charged with a concern for quality but who must cooperate to make any quality cost analysis system work. In particular, those responsible for cost accounting will be asked to make changes in their accounting system simply because these data are going to be used to answer questions never asked before. The cost accountants will continue to develop the cost data for all the previous uses and in addition will now be asked to make a number of different breakdowns and summarizations for new purposes. The publication may enable all groups to see the common goal and the necessity for new procedures.

The terms "quality creation", "quality and defect inference", and "resultant" were chosen because they more accurately describe the character of costs within the categories, help in placing particular items of costs in the proper categories, and fit the model concept more exactly. Other terms can be selected by an individual company to fit its own accounting terminology but the concept of "controllable" vs.

"resultant" costs should be maintained. "Planning and analysis" might replace quality creation; "control and review" might replace quality inference. "Prevention," however, implies a too narrow definition of the activities employed to obtain a desired quality level. "Appraisal" implies an evaluation of the existing product quality, but does not indicate the use of quality data to infer what can be done toward quality improvement.

2.0 IMPLEMENTING THE QUICO SYSTEM

In some companies a quality cost analysis system has been implemented by a backdoor approach. The cost breakdowns necessary are at first obtained by the quality assurance department itself, scrounging up data from estimates from foremen, guesses, interpolation of data, and the use of any means to get some rough figures from which to operate the system. This has proved to be difficult and time consuming, but practical, and has been done in some cases. After a number of months or possibly a year of operation, the answers produced by the system become valuable enough and the savings are sufficiently obbious that data collection is then undertaken on a more formal basis. However, the authors do not recommend this method.

Some companies have begun by setting up a test operation in one department or small section of the company in order to gain experience. This usually worked quite well. The results of this small test operation can be used to plan for a larger company unit which will require less changing after being implemented. In any event, whether or not a test operation is made, there must be a period of investigation to determine what changes are necessary, what methods of producing the data are available, and which are best.

A group should be set up which would have the primary responsibility for planning the overall system and the means of implementing it. This group should have representatives from accounting, quality assurance, production, and data processing.

2.1 IMPLEMENTATION STEPS

In outline form, here is a list of the steps to be followed in setting up and implementing a QUICO system. At the end there are notes which amplify the ideas contained in various portions of the outline. The authors have tried to be as specific as possible in this outline and yet to retain sufficient generality for widely diversified operations.

1. Prepare list of accounts to be used, broken down by categories. (See 2.2.1)
   A. Analyze needs, establish objectives, and determine what output information is desired periodically by each organizational unit. (See 2.2.2)
   B. Determine what input information is necessary to provide desired output.
   C. List necessary accounts with definitions of contents.
   D. Assign account code numbers.
   E. Set up code numbers for identifying functions.
   F. Set up cause codes by divisions or products.
   G. Set up defect codes by divisions or products.
   H. Decide whether separation is to be by departments or products, etc. (See 2.2.2 and 2.2.3)
2. Design data collection system.
   A. Design time, material, and other necessary record forms for original entry of data.
   B. Designate personnel authorized to make and check original data forms.
   C. Specify the means of processing these data forms. (How, when, and where record forms are sent.)
   D. Specify changes in design of any related systems, such as corrective action requests, materials review board action reports, scrapped material tags, rework authorizations, so that quality related cost information will be submitted in prescribed way.
   E. Design report forms to be prepared manually or by the computer as specified in 1-B. (See 2.2.4)
   F. Prepare computer program (if accounting is not manually performed) to receive, store, and process cost data and to prepare periodic reports. (See item 1-A)
   G. Assign one or more persons the responsibility of monitoring the quality cost analysis system. (See 2.2.5)

3. Prepare Standard Operating Procedures (SOP) to provide specific directions (instructions) to all individuals and organizations concerned in the quality cost analysis system.
   A. Separate SOP's may be prepared for different organizational units, such as machine shops, sheet metal shops, quality engineering, etc. with only the appropriate function codes, cause codes, defect codes, and account numbers given for each.
   B Review all related SOP's (such as MRB, corrective action requests, scrapped material tags, etc.) and revise as necessary to make them compatible with SOP's for QUICO system.
   C. Establish procedures for review and revision, as necessary, of SOP's as experience is gained.
   D. Publish and distribute SOP's.
4. Train personnel
   A. Prepare an educational program to explain SOP provisions, including any audio-visual aids, sample forms, flow charts, etc., for use in training program.
   B. Conduct training sessions for all personnel concerned, emphasizing objectives of quality cost analysis program, benefits to be derived by individuals and organizations, need for accuracy, responsibilities for the successful implementation and uses of report data.
   C. Provide for retraining of employees, if necessary, and for the training of all new employees who will be involved in the quality cost program.
   D. Provide special training for all management personnel (supervisors to top management) regarding the use of output reports.
5. Start operating the QUICO system.
   A Set the date for change-over to use of QUICO system.
   B. Supply all individuals and organizations with new forms in advance of starting date.

C. Advise accounting, data processing, and other service groups not to accept the old forms after the start-up date (unless they had been initiated before that date) and to require that new forms be submitted to replace any old forms received after that time.

D. Review report forms daily, for the first week or so, to be sure that everyone is using them properly and submitting the correct information. Provide instruction for everyone who is not completing form correctly.

E. At end of first period (when first report is due) check the reports very carefully before distribution to be sure that they reflect the correct information. (See 2.2.6)

F. Hold meetings of supervisors and higher management to discuss the results shown on reports and to plan any necessary changes either in the QUICO system or in the quality assurance program. This procedure should be followed after each set of reports until each person is well enough acquainted with the QUICO system to take proper action without group discussion.

6. Continuing operation of quality cost analysis system.

A. Provide all responsible management personnel with weekly and/or monthly reports, similar to those in Section 3.0, upon which decision for action should be based. The use of these reports is the subject of Section 3.0.

B. The person responsible for monitoring the QUICO system shall keep careful records of difficulties encountered, desired information not supplied by the system, superfluous information, errors in following SOP, and suggestions for improvement of the system so that at appropriate intervals (every 3 to 6 months) he can submit specific proposals for the revision of SOP's, form designs, information to be processed, and management use of data.

C. Hold periodic management meetings to approve or disapprove the proposals submitted in 6-B, and to review progress toward the optimization of the quality assurance program.

2.2 COMMENTS ON STEPS IN IMPLEMENTATION

2.2.1 Considerations in Establishing Accounts

No two industrial concerns will use exactly the same list of accounts in order to operate the QUICO system. Each organization must study its own operations very carefully and determine which accounts are applicable to its own operations.

Due to limitations normally encountered, few companies will attempt to identify more than 30 to 50 basic cost items in all categories, although departments, function, personnel, and activity codes may make it feasible to identify several hundred separate cost items. For example a ten digit code may be used to identify the basic cost item. The first three digits may be used to identify the contract, the program, or the product; the next four digits may be used to identify the work order or other authorization number; and the final three digits may identify the task, department, group, or type of work. Of the last 999 possible identities, perhaps only 50 can be reserved for all categories of quality related costs.

Even if only 50 accounts can be handled in the stored computer tapes, additional codes can be used so that the input tab cards can be sorted for the purpose of obtaining greater detail of costs. Several possibilities are available. The time and material cards can provide space for activity and/or function codes, departmental identification, cause codes and defect codes. Thus, the computer can be used for the accumulation of total amounts for each of the identified accounts, but the input tab cards can be sorted by departments, functions, cause codes, etc., and the totals by these items can be printed out very quickly to provide as minute details as is desired at any level. Total cards can be punched out, and these can then be used to print weekly and monthly reports by departments, categories, functions, etc. (See Section 3.0 for examples of reports.)

Most readers will be quite experienced in the development of coding systems to indicate types of defects, causes, functions, activities, etc., so it is assumed that specific instructions are not necessary. It is, perhaps, advisable to suggest that great care be given to the development of these lists so that future changes will be minimized. It is important to avoid an excessive number of classifications in each list, and to define the classifications in such a way that the person making a record will have no difficulty in making a correct selection from the codes available. Vague definitions and overlap in definitions reduce the value and usefulness of the reports. It often helps improve the accuracy of information if the definitions of causes, defects, functions, and activities are so written that the same lists can be used in all departments.

Ideally all these quality related costs should be kept separate for each product and the sum should be minimized for each product, however, this is seldom practicable. Thus a company may be forced to keep records which are in a sense averaged over all or may products. Under these conditions, it must be assumed that the controllable costs are apportioned to various products in about the same proportions that these products contribute to the resultant costs. It may be possible to examine the data to find out if this is approximately true.

After a determination by management of the least number of significant accounts to be included, a model can then be used to predict the least necessary costs in each of these accounts. Allocated burden and fixed costs, however, should not be included in the accounts because their arbitrary composition may distort the results. Changes in the amounts of direct labor employed in controllable (quality creation and quality or defect inference) costs and in resultant costs (repair, rework, MRB actions, etc.,) usually do not affect overhead or burden costs in any way. If a "standard" hourly cost, composed of both direct salaries or wages and an overhead charge, is used for reporting purposes, the changes in either costs or savings are exaggerated. For example, direct labor savings may be obtained through an increase in overhead, as when a more automatic testing or inspection machine is purchased to

replace a manual operation. The use of a standard hour cost reflects just the opposite condition. Consequently, attempts to optimize the quality program may have erroneous results if allocated costs are included in the model.

It will often happen that particular items of cost will be difficult to place in the proper category. When these difficulties arise, use the Black Box Decision Rule (See Fig.1) to place the item into its proper category.

2.2.2 A Psychological Tool for Motivating Employees

A major advantage of the QUICO system is that reports can be fed back showing costs of defects in dollars. To a foreman, supervisor or workman, the dollar cost is something he can understand easily. For example, a workman may be shown a report by his foreman that $100 worth of parts were scrapped because of his mistake. They both can translate this into cans of beans or baby shoes and the motivation to improve is stronger than when such reports are made in terms of hours, units or whatever.

Many companies are attempting to motivate individuals through "motivational" campaigns, poster programs, and appeals to "quality mindedness." These campaigns are usually effective only for a short time. Pride of workmanship seems to be missing in a great number of American workmen, and the company motivational programs seem to be doing very little to bring about its return on a large scale. The dollar costs reported through the QUICO system provide a means of measuring the quality of work being performed, and individual workmen can be given the recognition so necessary to encourage pride of workmanship and self esteem.

2.2.3 Costing Scrapped Defective Material

Very often standard costs are available for each stage of manufacture. This is necessary information for costing scrapped material. If not available, the accounting system should be designed to obtain labor and material costs at each cost center.

BLACK BOX DECISION RULE
FOR CATEGORIZING COST ITEMS

Input:	Controllable Costs		Output:	Resultant Costs
1.	Quality Creation	→ Black Box →	1.	Internal
2.	Quality & Defect Inference		2.	External

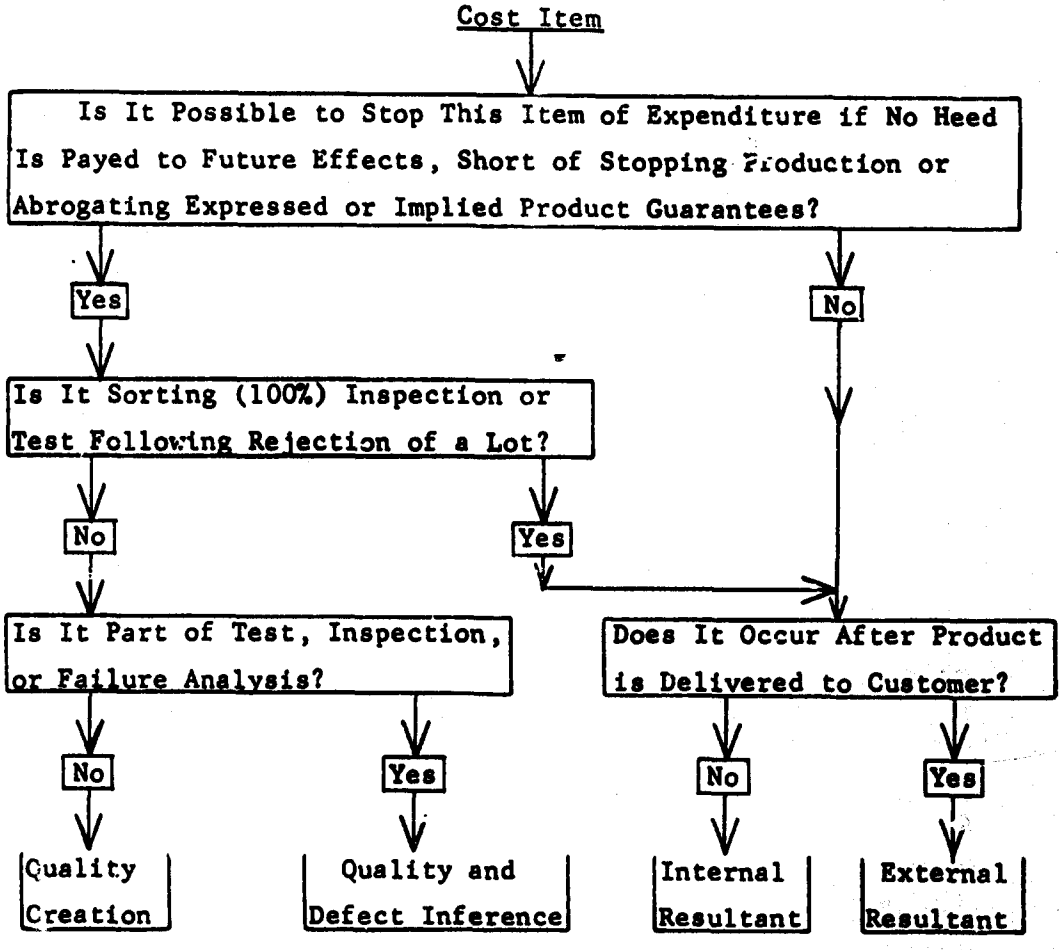


Fig. 1

2.2.4 Manual Accounting During Service Test

It will sometimes work well to operate the QUICO system in one department as a test by manual bookkeeping. The experience gained can be used to design a system for a larger unit of a company using electronic data processing equipment.

2.2.5 Monitor for the QUICO System

The monitor for the QUICO system could be the quality assurance chief, his designee, or a key person from accounting. This person will have a lot to do in educating people in how to report, what to report, and why it needs to be reported. Commonly, several months are required to get the accurate collection of cost information functioning well, and the speed and success will largely depend upon his enthusiasm and managerial ability.

2.2.6 Accuracy of Data

Accuracy is always a problem in any program designed to determine costs and identify responsible persons. Even company policies may dictate that cost data be deliberately distorted as when costs for one work authorization is charged to another because the budget for the first was exhausted before the work was completed. If cost information is to be used for decision making purposes, the information must reflect the true conditions. Therefore, top management must make it abundantly clear that it will not tolerate deliberate distortion of facts. Discipline regarding deliberate inaccuracy must be firm and prompt.

At the same time, another question regarding accuracy arises. The cost of operating a system increases rapidly as the degree of accuracy increases. The previous paragraph was concerned with deliberate inaccuracy in order to hide something; this paragraph is concerned with the "granularity" of the information. Improvement in accuracy of individual accounts from an error range of say $\pm$2.0% to $\pm$1.0% might double the accounting expense, due to the increased number of detail accounts necessary and the increased amount of information required to be recorded on each input record. The QUICO system should be designed around specific decision needs and provide only the degree

of accuracy required to avoid major decision errors. Thus, the system design must be a balance between the cost of increased accuracy and value of increased accuracy, but management must have confidence that the information obtained is complete and honest within the limits of the system.

3.0 MANAGEMENT USE OF QUALITY COST DATA

3.1 GENERAL MANAGEMENT INFORMATION

The whole purpose of the QUICC system is to provide appropriate and timely data to all levels of management so that the best decisions can be made regarding the quality assurance program. What information is to be supplied to management determines what information must be collected and the accounts that must be used. It is imperative that the data collected be summarized in such forms as to make it very easy for management quickly to grasp and understand their significance. Each company will need to design its own forms in order to provide the answers to specific questions for its management, and to enable the data processing center to produce the reports with maximum efficiency. Some suggestions of the type of reports which may be desired follow.

Top management will be interested in the overall progress of the quality cost improvement program and each organizational unit manager will want a similar progress report for his unit. Therefore, a trend chart, such as Figure 2, will be desired. This chart permits the results of each week's reports to be presented graphically on one chart for each organizational unit. A summary chart for the entire company or division can be plotted from the totals of the separate departmental or organizational charts. The data for each of the charts can be produced very easily by the computer, and the labor to plot the points on the charts is negligible.

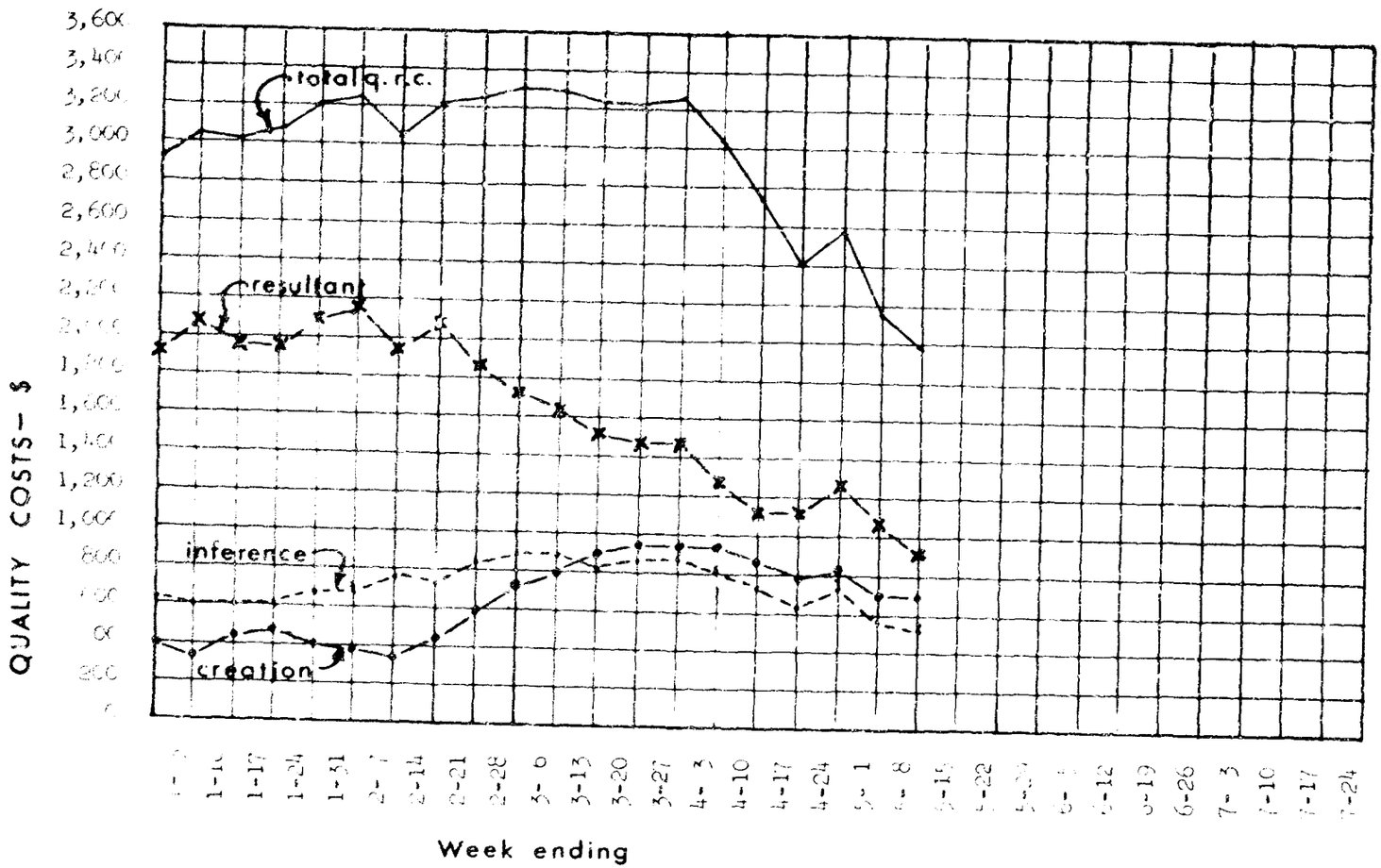
The great advantage of the trend chart is that it gives a clear visual picture of the relative magnitude of the different classes of quality related costs, and shows how each is behaving relative to the others. It is obvious that increases in the expenditures for quality creation and inference will not show immediate reduction in resultant costs because there is a time lag between the cause and the effect. Internal resultant costs will normally be affected fairly quickly by changes in the quality assurance program; however, it may be many months before the reductions show up in external resultant

costs. The trend charts assist in determining the expected lag between changes in the input costs and the effects on the output or resultant costs.

It may be desirable to indicate on the trend chart when major changes in the quality assurance program were made. This will specifically call attention to the fact that some results should be expected, and will cause each manager to be watching for the evidence of the expected improvement. For example, a note on Figure 2 might be used to indicate that on 2-7 the decision was made to step up the in-process control activities and the rate of finished parts inspection. It would be appropriate to expect some reduction in the internal resultant costs to occur in the near future. The creation and inferance activities are stepped up gradually until 3-20. A note then might indicate on 4-3 that the quality creation and inference activities were to be reduced gradually, unless resultant costs begin to rise. These notes would alert management that changes in resultant costs can be expected.

3.2 INFORMATION FOR DEPARTMENT MANAGERS

The whole process of Payoff No. 2 revolves around the identification of the causes of defectiveness, poor quality, and poor reliability, and the corrective actions taken to prevent a re-occurrence of those causes. Therefore, many managers will want to have a weekly report of the internal and external resultant costs, broken down by cause codes and responsible organizational units. Figure 3 is an example of an internal resultant cost report. Normally, a report of this kind will be prepared for each responsible organizational unit, since the manager of that unit will be responsible for initiating corrective action following the occurrence of a defect, malfunction, or other event that indicated trouble. Each company will have its own procedures for investigating the causes of defects and requesting corrective action. Normally these procedures are triggered by the rejection or failure report which requires that some disposition (scrap, rework, use as [illegible]n to vendor, etc.,) be made on a piece of hardware or a lot of product.



Organization M-5 Machine Shop

As of 8 May 1964

Fig. 2

Before this report can be closed out, it is normal to require that appropriate corrective action be determined and initiated. The investigation usually determines what the cause of the defect was and assigns the responsibility for it. This assignment established that all costs associated with that defect be accumulated and "charged" against the responsible department.

The costs resulting from the defect may actually occur in one or more organizational units other than one responsible. Thus, the reject report number or the corrective action request number may become the control number against which the resultant costs are accumulated. Figure 4 is a report which summarizes the costs relative to a part number and the original reject report number. The accounting procedures accumulate the information shown on this report, and the computer can prepare the report of Figure 3 without going through the stage of the report in Figure 4, if that is desirable. Some companies prefer to have both reports (that is, both Figure 3 and Figure 4). There is a specific advantage of having a report similar to Figure 4 in that it helps to identify parts which should cause a lot of trouble and which, perhaps, should be redesigned, or for which new materials or manufacturing processes should be specified.

Reports similar to those shown in Figures 3 and 4 can be developed for each of the different classes of quality related costs: quality creation, quality inference and defect inference, internal resultant costs, and external resultant costs. These reports can then be summarized in a weekly report similar to Figure 5. Actually, with a computerized accounting system, it is not necessary to have any reports like Figure 3 and 4. The computer can be programmed to accumulate all the costs by a large number of identifying codes and then print out a report similar to Figure 5 directly from the computer memory. Figure 5 lists only a few illustrative accounts under each main heading, but this report can be made as detailed or as condensed as desired. Also, Figure 5 indicates that different columns are used for different departments within one organizational unit. These columns could just as easily be used for the

INTERNAL RESULTANT COSTS

Organization D-15 Coil Winding Project B-156

Week ending 28 March 1964

Acc't. Code	Cause	Labor		Materials $	Total $	Total $ Month	Total $ Prev. Mo.	Cum. Yr. Total $
		Hours	Dollars					
	22	[illegible]	13.50	16.00	29.50	18,392.00	16,479.00	48,928.00
	19	400.0	2,000.00	-	2,000.00	5,649.00	9,843.00	22,496.00
	32	3,460.0	14,929.00	9,695.00	24,624.00	30,269.00	54,292.00	102,464.00
	TOTALS		17,942.50	9,710.00	26,652.50	54,310.00	80,614.00	173,888.00

Fig. 3

DEFECT COSTS BY PARTS

Responsible Organization D-21 Machine Shop Project B-52

Week ending 25 March 19--

Reject Report No	Part No	Defect		Organ. Affected	Labor $	Material $	Total $
		Type	Cause				
[illegible]	[illegible]	24	42	E-24	264.00	195.00	459.00
[illegible]	[illegible]	22	8	D-21	100.00	321.00	681.00
[illegible]	[illegible]	22	16	E-18	15.00	5.00	20.00
[illegible]	[illegible]	9	8	D-21	75.00	62.00	137.00
[illegible]	[illegible]	31	34	B-16	270.00	89.00	359.00
					784.00	872.00	1,656.00
	TOTALS						

Fig. 4

accumulation of the costs by projects, products, subsystems, or other categories. In addition, a column may be provided to show the total for the previous month and the accumulated total for the year. All of these matters are determined by the degree of breakdown desired by the various managers and the original procedures, defect codes, functional codes, organizational codes, etc., and the proper programming of the computer.

3.3 TWO TYPES OF REPORTS AND CHARTS

The QUICO system generates data for reports and charts which are of two types in terms of usefulness. The first type is timely information for the daily decision makers, the quality assurance and department managers. Speed of processing data is of utmost importance here.

The information from the QUICO system is of direct interest to top management of the company, the quality assurance department, production and the various production units, the reliability department, the engineering and design department, and quality assurance functional unit managers. Usually, each program change requires the cooperation of two or more organizational units in order to arrive at a proposed action which will be effective and acceptable to all concerned. Consequently, the reporting system should be designed to serve the specific needs of each of the functional units. Both in the planning and in the revision stage of the QUICO system the planning group should constantly check to see that information and data is supplied to the group in a position to take effective corrective action, if any is necessary. For example, information on defects must be provided to the analysis group and this group must report the results of its analysis to the groups who are in a position to make the necessary changes.

The second type is longer term trend information for higher management. This information is used for policy, organizational, and budgetary decisions which will guide and determine day to day actions by the first group of managers. Presentation of data in a form which is readily and quickly interpretable and in which important relationships stand out clearly is extremely important here.

QUALITY COSTS—WEEKLY SUMMARY

Organization E-17 Electronics Assembly

Week ending 23 June 1964

Acc't. No.	Account Name	Dept. A	Dept. B	Dept. C	Total
	Quality Creation				
	Quality Engr.	300.00	250.00	500.00	1,050.00
	Corrective Engr.	200.00	200.00	100.00	500.00
	Planning-Test & Insp.	300.00	300.00	100.00	700.00
	Process Control	400.00	400.00	500.00	1,300.00
	Total	1,200.00	1,150.00	1,200.00	3,550.00
	Quality Inference				
	Failure Analysis	200.00	300.00	100.00	600.00
	Final Test	400.00	300.00	400.00	1,100.00
	Inspection & Test	200.00	200.00	100.00	500.00
	Receiving Test & Insp.	200.00	300.00	200.00	700.00
	Total	1,000.00	1,100.00	800.00	2,900.00
	Resultant Internal				
	Screening Test & Insp.	400.00	375.00	430.00	1,205.00
	M.R.B.	250.00	400.00	450.00	1,100.00
	Rework	600.00	550.00	700.00	1,850.00
	Scrap	550.00	600.00	800.00	1,950.00
	Total	1,800.00	1,925.00	2,380.00	6,105.00
	Resultant External				
	Field Complaints	1,200.00	1,500.00	1,800.00	4,500.00
	Billing Adjustments	1,500.00	2,000.00	2,500.00	6,000.00
	Total	2,700.00	3,500.00	4,300.00	10,500.00
	Admin. & Fixed				
	Administrative	800.00	900.00	700.00	2,400.00
	Total	800.00	900.00	700.00	2,400.00
	GRAND TOTAL	7,500.00	8,575.00	9,380.00	25,455.00

Fig. 5

3.4 INTERPRETATION AND USE OF DATA

The real payoffs and benefits of the QUICO system come through the analysis of the program activities or elements in light of the cost information that is made available. In general, there are two kinds of actions that can be taken: (1) increase the expenditures of effort in creation and inference activities in order to reduce resultant costs and improve quality, and (2) reduce the expenditures on certain creation and inference costs if we have evidence that the value contributed is less than the costs incurred.

The first action stems from the occurrence of high resultant costs. The reports identify resultant costs which are higher, proportionally, than others, and suggest that more effort in prevention might be in order. The procedure, then, is to determine what activities could have prevented the occurrence of the defects or malfunctions, and to estimate the cost of such activities, the estimated preventive costs. Also, the resultant costs may indicate that prevention activities are not needed constantly, but only when some unidentified condition exists. This would indicate that more money might be spent on inference activities so that the need for specific preventive action would be signalled. A series of possible actions can be formulated and priced, along with the corresponding estimates of savings that can be expected. The most promising of these alternatives would then be initiated. Naturally, the results of this trial will be watched very carefully to see if the expected results materialize. It may require anything from several days to several months for the action to be thoroughly evaluated.

Many changes in quality assurance programs may be made more or less simultaneously, and it may be difficult to determine which of these actions really produce the desired effects. This is one of the principal arguments for having a fairly large number of detailed accounting breakdowns, in that the larger the number of the specific accounts that exist the more accurately the effects of individual program changes can be measured. The longer it takes for the effects of changes to

show up in the resultant costs, the more important it is to be able to measure the effects accurately, and the more important it is to have an ample number of accounts to provide the desired accuracy.

The second action, that of reducing quality program activities when there are very poor or no measures of their contribution, is probably not practiced as often as it should be. The fear is that this action will cause unusually high resultant costs, and, since the activities are already budgeted, why take a chance? The QUICO system will provide a means of measuring overall effectiveness, and carefully planned experiments can be conducted. For example, there are seldom any direct measures of the benefits from expenditures to visit and survey prospective vendors' plants before placing an order or subcontract. An experiment can be designed to omit this activity for certain new procurements and use normal procedures for a comparable set of new procurements. The results can be measured in terms of fraction defective of the presented lots as determined by receiving inspection. If no significant difference occurs, then this activity may be cautiously withdrawn over a period of time, while constantly watching the data to detect deterioration of incoming materials.

For internal activities, the quality assurance manager may rely upon the opinions of persons supposedly affected by the activity, to guide his decision to reduce or limit the activity, and at the same time, look for specific places where adverse effects may become apparent. How frequently should employees be tested and retrained for specific jobs? How much design review should be done on products which closely resemble products which have been produced for many years? How much investigation should be performed whenever a rejection or malfunction occurs? Are there measures which can be used to determine how much effort should be devoted to some of these activities? The purpose of this discussion is to call attention to the fact that habits develop in quality assurance work, and functions may be continued to be performed long after their need has ceased, or substantially more effort may be devoted to certain activities than is justified on

a continuing basis. Superficial evidence seems to indicate that not enough of the sales dollar is spent in the creation of quality and that what is being spent is not necessarily spent wisely. Therefore, both questions, increasing or decreasing budget allocations, must be considered to arrive at an optimal quality level.

Here are five obvious rules to keep in mind when analyzing data for the possible benefits:

1. There is a first obvious rule which can give gross guide lines. Almost always the sum of controllable costs and resultant costs is reduced by increasing controllable costs and thereby achieving a greater reduction in resultant costs. If total figures for the four categories indicate that some reducible "fat" exists in the resultant categories, then methods should be sought by which this reduction might be obtained and these methods evaluated. This situation probably exists if resultant costs are larger than controllable costs.

2. On the other hand, controllable costs which are larger than resultant costs may very well indicate that a minimum of quality related costs could be achieved by reducing controllable costs. (This suggests the heretical concept that quality can be too high and wise economy is to lower quality in this case.) This is the unusual sort of situation, but does represent a second obvious rule.

3. A third obvious rule is that one should always look for obvious low expenditures in the quality creation accounts. These are easy to spot and often indicate sources of possible future increased resultant costs. For example, no money being expended for maintenance of inspection and test devices might well indicate that trouble can be anticipated.

4. A fourth rule is really more of a suggestion that comparisons be made of cost accounts with other companies of a similar nature. This may be difficult if not impossible to do in our competitive world. There does not seem to be much that can be done to help those to whom no comparison is available. Perhaps future work will provide a simulation so that a company can, in effect, compare itself

with an ideal model of itself. Such a model has been prepared and is being tested.

The fifth rule is to examine controllable and resultant costs as to proportions which are spent on particular products or particular product classes. Clearly, one would want the proportions to be approximately the same. For example, it would be wrong to spend 90% of the quality creation budget on a class of products which accounts for only 10% of the resultant costs. If exact figures are not available to determine this balance, estimates are certainly better than nothing.

4.0 LIST OF ACCOUNTS

The following is a suggested list of accounts for first use in implementing a QUICO system. The list must be general enough to include all accounts which may be needed by any industry. As a consequence, no industry will wish to use all of these accounts; indeed, each industry must choose those accounts that will be meaningful and useful.

Further, the list must be general enough to fit the organization of any industry. The accounts for a particular company must be functionally oriented, accounts which cut across organizational boundaries simply lead to obfuscation. Accounts must be tailored in size to fit organizational units so that data to be used for control relates only to the functions controllable by the organization unit to which the data are supplied and further that complete data be supplied to the organizational unit for the functions over which it has control.

The list here makes no attempt to select accounts for a particular industry nor to group or delineate accounts to fit a particular organization. This task must remain for the user.

The user probably will have good reasons for his particular industry to subdivide some accounts in this list. The appendix gives a complete list of all accounts that have been used by any companies contacted by the authors. It is intended as a check list for the user. In any such list, there is certain to be overlapping and inconsistencies. No attempt has been made to resolve these.

1. QUALITY CREATION COSTS
   - A. Vendor control and rating
   - B. Quality engineering in designs
   - C. Planning, formulating, issuing, and implementing test and inspection procudures and process controls
   - D. Design and construction of test, inspection, measurement, and control devices

E. Training and education

F. Corrective engineering on designs and processes

G. Analysis and evaluation of data and programs

H. Operation of in-process controls

I. Review of material handling and packing

2. QUALITY AND DEFECT INFERENCE COSTS

A. Maintenance, calibration, and control of test, inspection, and control equipment

B. Failure analysis to determine causes

C. Incoming test and inspection

D. In-process and final test and inspection

E. Product, process, and procedures audit

F. Special final product tests

G. Test and inspection of product packing and handling

H. Audit of corrective action effectiveness

I. Field test

J. Quality check by production employees

K. Approval by regulative agencies

L. Data handling

3. INTERNAL RESULTANT COSTS

A. Scrap

B. Rework

C. Sorting (100%) inspection and test resulting from rejections

D. Material Review Board activities

E. Downgrading of product

F. Loss of product yield of a process

Downtime of production facilities

H. Handling damage of product

I. Extra vendor advice and conference

4. EXTERNAL RESULTANT COSTS

A. Field complaints

B. Billing adjustment or allowance

C. Loss of quality or reliability incentive fees

D. Loss of customer good will

E. Product service and repair

5. GENERAL COSTS

A. Invariant costs

5.0 APPENDIX: CHECK LIST OF ACCOUNTS

A. QUALITY CREATION COSTS

1. Vendor charges for quality engineering in process planning
2. Vendor charges for quality engineering in product design
3. Quality engineering in designs for product including examination of tolerances.
4. Quality engineering in new designs of processes.
5. Vendor charges for corrective engineering for product
6. Vendor charges for corrective engineering for process
7. Corrective engineering for product - not failure analysis (possibly caused by quality or reliability failure analysis)
8. Corrective engineering for processes - not analysis (possibly caused by quality or reliability failure analysis)
9. Planning control of vendor audits, surveillance and surveys
10. Travel costs for other quality purposes (not failure analysis)
11. Vendor contacts for quality purposes not failure analysis efforts
12. Verification and review of information supplied to vendor
13. Travel costs for vendor rating
14. Vendor contracts for vendor rating
15. Vendor rating; analysis of performance records
16. Vendor rating; keeping performance records
17. Vendor rating; evaluating quality capabilities
18. Vendor rating; evaluating reliability capabilities
19. Planning incoming test
20. Planning incoming inspection
21. Formulation and issuance of test procedures
22. Formulation and issuance of inspection procedures
23. Implementing test and inspection procedures
24. Purchase of test or material for devices (not capitalized) including procurement planning
25. Purchase of inspection devices or material for devices (not capitalized) including procurement planning
26. Construction of test devices (not capitalized)
27. Construction of inspection devices (not capitalized)

28. Design and development of test devices (not capitalized)
29. Design of inspection devices (not capitalized)
30. Design of measurement devices (not capitalized)
31. Design and development of control devices (not capitalized)
31. Rental or use charges for others' inspection equipment
33. Rental or use charges for others' test equipment
34. Depreciation write-off for capitalized inspection and test equipment (may be different from tax write off)
35. Formulation, issuance, and implementation of process controls
36. Development of process controls
37. Review of product packing
38. Training and education of inspection employees for quality
39. Training and education of test employees for quality
40. Training and education of special process evaluation employees for quality
41. Planning quality training and education
42. Conducting quality training and education
43. Employee certification and training for training for certification and recertification (does not include instruction for achievement of normal proficiency)
44. Training and education of production employees for quality
45. Reliability engineering benefitting quality
46. Other reliability activities benefitting quality
47. Retooling because of corrective engineering
48. Rework of patterns, molds, or jigs due to low quality
49. Redesign of patterns, molds, or jigs due to low quality
50. Refabrication of patterns, molds, or jigs due to low quality
51. Quality review of tool design
52. Tool use coordination
53. Production equipment qualification and recertification
54. Customer contacts for quality purposes not failure analysis efforts
55. Evaluation of customer quality requirements and existing plant capabilities

56. Formulation, issuance, and implementation of quality plans
57. Formulation and interpretation of quality standards
58. Formulation and coordination of specifications
59. Prescribing and recording policies and procedures for quality assurance
60. Planning and performing process capability experiments
61. Analysis of pre-production run data
62. Analysis of quality inference data prior to product shipment
63. Evaluation and audit of entire quality assurance program
64. Evaluation and analysis of entire quality cost data
65. Quality inference data analysis
66. Defect inference data analysis (failure analysis data analysis)
67. Process control data analysis

B. QUALITY AND DEFECT INFERENCE COSTS

1. Maintenance of test equipment
2. Maintenance of inspection equipment
3. Calibration of test equipment
4. Calibration of inspection equipment
5. Calibration of production equipment
6. Maintaining primary standards
7. Calibration laboratory for gauges and measuring devices
8. Failure analysis including cause of scrap and cause of rework; can be further broken into wages, rental of equipment, equipment not capitalized, supplies, and vendor contacts
9. Failure analysis of purchased parts including investigation of cause of scrap and cause of rework; can be segregated into wages, equipment not capitalized, rental charges for equipment, supplies, travel costs, and vendor contacts
10. Field failure analysis for purpose of taking corrective action for future production
11. Failure analysis consisting of special tests and inspections

12. Vendor charges for failure analysis
13. Final test at customer's site; can be broken into salaries, equipment not capitalized, rental charges for equipment, supplies, travel expense, and subsistence
14. Final test in plant by sampling techniques; can be broken into wages, equipment not capitalized, rental of equipment, and supplies
15. Final inspection in plant by sampling techniques; can be broken into wages, equipment not capitalized, rental of equipment, and supplies
16. Portion of 100% final test chargeable to quality inference
17. Portion of 100% final inspection chargeable to quality inference
18. Outside laboratories charges for tests on finished goods
19. Portion of 100% laboratory final test chargeable to quality inference
20. Inspection and release of finished prototypes or first finished units
21. Test of finished prototypes or first finished units
22. Incoming test by sampling techniques; can be broken into wages, equipment not capitalized, rental of equipment, and supplies
23. Incoming inspection by sampling techniques; can be broken into wages, equipment not capitalized, rental of equipment, and supplies
24. Portion of 100% incoming inspection chargeable to quality inference
25. Portion of 100% incoming test chargeable to quality inference
26. Outside laboratories charges for tests on incoming material
27. Vendors charges for tests on incoming material
28. Laboratory test of incoming materials by sampling techniques; can be broken into wages, equipment not capitalized, rental of equipment, and supplies

29. Portion of 100% laboratory test of incoming materials chargeable to quality inference
30. First piece inspection; can be broken into wages, equipment not capitalized rental for equipment, and supplies
31. First piece test; can be broken into wages, equipment not capitalized, rental for equipment, and supplies
32. In-process inspection by sampling procedures; can be broken into wages, equipment not capitalized, rental for equipment, and supplies
33. In-process test by sampling procedures; can be broken into wages, equipment, and supplies
34. Portion of 100% in-process inspection chargeable to quality inference
35. Portion of 100% in-process test chargeable to quality inference
36. Portion of 100% laboratory in-process test chargeable to quality inference
37. Outside laboratories charges for tests on in-process material
38. Process control tests; can be broken into wages, equipment not capitalized, rental for equipment, and supplies
39. Cost of product destroyed in testing; can be divided into incoming, in-process, first piece, and process control
40. Auditing systems and procedures
41. Auditing product quality
42. Auditing process control and process control tests
43. Audit of product packing
44. Vendor audit
45. Audit activities to evaluate end product quality and reliability; including auditing systems, procedures, calculations and performance
46. Surveillance of special operations and processes
47. Vendor quality surveillance
48. Inspection supplies

49. Test supplies
50. Tests for evaluating end product quality and reliability, includes life, environment and reliability tests
51. Set-up for test
52. Set-up for inspection
53. Test of product packing
54. Inspection of product packing
55. Quality checking operations by production employees
56. Inspection and test activity to review templates and tools
57. Reinspection of jigs and fixtures
58. Requalification tests of tools and processes
59. Inspection and test activity to give data on effectiveness of corrective actions
60. Reports of inspections
61. Reports of tests
62. Data processing, filing, and summarizing

C. INTERNAL RESULTANT COSTS

1. Portion of 100% final test due to need to eliminate defective product
2. Portions of 100% final inspection due to need to eliminate defective product
3. Portion of 100% laboratory final test chargeable to need to eliminate defective product
4. Portion of 100% incoming test chargeable to need to eliminate defective product
5. Portion of 100% incoming inspection chargeable to need to eliminate defective product
6. Portion of 100% laboratory test of incoming materials chargeable to need to eliminate defective product
7. Portion of 100% in-process test chargeable to need to eliminate defective product
8. Portion of 100% in-process inspection chargeable to need to eliminate defective product

9. Portion of 100% laboratory in-process test chargeable to need to eliminate defective product
10. Material Review Board activities either formal or informal; may be subdivided into disposition is scrap, disposition is rework, disposition is downgraded material
11. Rework (includes failure correction in defective product); may be divided into (a) produced internally and (b) purchase material; (a) may be then divided in. > inspection and test error or production error, (b) may be divided into ordered incorrectly or defective
12. Evaluation of reworked material inspection and test data
13. Inspection of reworked material
14. Test of reworked material
15. Rework fault of vendor
16. Scrap; production error; may be divided into produced internally or purchased material
17. Scrap; test or inspection error; may be divided into produced internally or purchased material
18. Scrap; material in stock or received before effective cancellation which failure analysis shows to be inadequate
19. Charges for cancelling orders when defect analysis shows material to be inadequate
20. Scrap; fault of vendor
21. Downgrading; loss in value of product due to not meeting planned requirements but still has more than salvage value
22. Downtime; loss of production time due to failure analysis or defective product
23. Reinspection due to product defects (not after rework)
24. Re-test due to product defects (not after rework)
25. Extra production operations added because of presence of defectives
26. Extra inspections due to product defects (not 100% screening)

27. Extra tests due to product defects (not 100% screening)
28. Incidental costs of scrap
29. Incidental costs of rework
30. Replacement of lost material
31. Replacement of material damaged between departments
32. Rejection report writing and processing
33. Extra record keeping due to defective products
34. Burden arising from excess production capacity necessitated by defectives

D. EXTERNAL RESULTANT COSTS

1. Field complaint investigation for purposes of taking voluntary corrective action on equipment now in customers' use; may be divided into wages, travel expense, subsistence, equipment, and supplies
2. Field complaint investigation for purpose of in-guarantee corrections; may be divided into travel, subsistence, wages, equipment, and supplies
3. Field complaint negotiations with customers
4. Field repair performed voluntarily to prevent future customer complaints
5. Field service performed voluntarily to prevent future customer complaints
6. Engineering for in-plant correction of field complaint because of expressed or implied guarantees
7. Engineering for field correction of field complaint because of expressed or implied guarantees
8. Repairs for in-plant correction of field complaint because of expressed or implied guarantees
9. Repairs for field correction of field complaint because of expressed or implied guarantees
10. Production for in-plant correction of field complaint because of expressed or implied guarantees
11. Production for field correction of field complaint because of expressed or implied guarantees

12. Service for in-plant correction of field complaint because of expressed or implied guarantees
13. Service for field correction of field complaint because of expressed or implied guarantees
14. Billing adjustment or allowance because of expressed or implied guarantees
15. Loss of quality or reliability incentive fees
16. Loss of customer good will
17. Business policy concessions to customer (not part of quality related costs)

E. GENERAL COSTS

1. Planning quality cost analysis system
2. Administration costs; includes elements not logically a part of quality creation, quality inference, or defect inference
3. Accounting and data processing costs incurred in accumulating, analyzing and reporting quality and reliability data
4. Handling and records control of equipment in storage or in transport to calibration laboratory
5. Cost of power consumed in test, inspection, or quality assurance department
6. Value of floor space used primarily for inspection or test
7. Equipment depreciation; remaining book value at time of replacement of capitalized equipment
8. Approval by outside agencies such as Underwriters Laboratory fees, product indorsement fees, insurance underwriters, and outside test labs
9. Control of stores tools
10. Periodic inspection of stored tools
11. Quality and reliability studies for bid proposals

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