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St. Petersburg, Florida

TECHNICAL INFORMATION SERIES

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Summary A detailed computerized method of reporting operating quality costs is explained. Use of this method can provide management with an effective, timely means of measuring and analyzing operating quality costs. This report is a revision of TIS Report No. R66ND1, issued June 1966. It includes: modifications to the previous method of accumulating, reporting, and computing cost information; a Department instruction illustrating involved committed integration in quality cost activity; and some of the analytical techniques used in reducing total quality cost.		
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A COMPUTERIZED METHOD OF REPORTING OPERATING QUALITY COSTS

INTRODUCTION

The purpose of this report is to explain the computerized method of reporting operating quality costs at the Neutron Devices Department (NDD), St. Petersburg, Florida.

Quality Control Management recognized the need to report operating quality costs more meaningfully. With the aid and cooperation of the Finance Section, a GE 415 computerized (COBOL) procedure was developed and implemented at NDD to measure quality cost expenditures more effectively.

The detailed procedure and explanation of pertinent quality cost activities can be found in the Appendices. Figure 1 shows a flow chart of the quality cost reporting procedure.

PREPARATION OF OPERATING QUALITY COSTS REPORT

Figures 1 and 2 illustrate the quality cost reporting procedure that leads into the generation of the monthly Operating Quality Cost Report. Prime inputs to this procedure are: the Operation Cost Statement Cards, Spoilage Data, Master Deck, Master Payroll Tape, Direct Labor Data, and Quality Cost Interview Sheet (FC-139). A quarterly report, which is sent to General Electric Services, is extracted from these monthly reports. A brief description of the procedure used in generating these reports is provided in this section.

Operation Cost Statement Cards

Statement cards of operation cost, issued monthly by the Finance Section, are used as input to the computer for calculating each unit's total operation cost in all accounts which are quality cost related.

Spoilage Data

Spoilage data is taken directly from Quality Control Reports (QCR's) for costing by Cost Accounting. Rework data is also accumulated at this time. Preparation of spoilage cost data cards is done by Data Processing for entry into the reporting system.

Figure 1. Quality Cost Report Flow

Figure 2. Computer Data Processing Program

Master Deck

The most significant phase of the computerized method involves preparation of the master deck. A brief explanation of the accumulation, calculation, and transfer of quality cost data for the master deck is as follows: (Detailed information may be found in Appendix A.)

Data accumulation. Data is accumulated in the quality cost categories of prevention, appraisal, and internal failures as expended by Operation Units. The first two categories are accumulated by interview techniques using Quality Cost Interview Sheets (FC-139), which are compatible with the organizational structure at NDD and Operating Quality Costs as defined in Cost Accounting Bulletin PC-9. Cost Accounting provides data for the internal failure cost category. (Refer to Appendix B for a detailed explanation of Quality Cost Titles-Guidelines as related to the organizational structure at NDD.)

Data for the interview sheet is accumulated by using each individual's estimate of percentage effort expended in the applicable categories of Indirect Operating Quality Costs as assigned to Product Line Units.

Data calculation. All data listed on the interview sheet is related through a common base (weighted factor) for summation of the total percentage effort expended by each Operation Unit in each Quality Cost category for each Product Line Unit. All calculations are now done by the computer. In the past, the weighted factor was calculated manually.

Data transfer. The Quality Cost Interview Sheet (FC-139) is used as the medium for transferring applicable operating cost data to Key Punching via the System Analyst and Programmer. These interview sheets are then used by Data Processing to prepare the master deck.

Account Selector Deck

The account selector deck is used to select predetermined Operation Costs and Direct Labor Accounts for each applicable Operation Unit which is quality cost related.

Direct Labor Cards

Direct labor cards are used as input to the computer for direct labor costs from Quality Control and Manufacturing Operations, where applicable.

APPLIED TECHNIQUES

Some of the applied techniques used in measuring and analyzing quality costs at NDD are detailed in Appendix C. Included in this Appendix are: a Department instruction illustrating involved committed integration in quality cost activity, an example of monthly exception report, and quality engineering aids in quality cost control using marginal analysis techniques and nomograph application.

CONCLUSIONS

This computerized method of reporting quality costs provides management with a practical, effective, administrative means of measuring operating quality costs.

RECOMMENDATIONS

The following sequence of steps is recommended for implementation of a computer approach that would be equivalent to NDD's method of reporting operating quality costs:

1. Establish and communicate a well-documented set of guidelines that are compatible with your organizational structure and Operating Quality Costs as defined in Cost Accounting Bulletin PC-9.
2. Develop a reporting format that will serve your management and planning needs. This procedure permits the accumulation of information either by Product Line or Manufacturing Area as described in this report.
3. Establish a procedure for interviewing individuals on their quality activity effort.
4. Program as much of the reporting procedure as possible.
5. Establish a time period for updating the master deck according to your operational needs.
6. Maintain a close integrated relationship between Quality Control and the Finance Section.

APPENDIX A

Appendix A REPORTING TECHNIQUE

OUTPUT -- OPERATING QUALITY COSTS TAB RUN REPORT FORM COMMENTARY

Figure A1, Page 10 is a combined quality cost tab run report summarizing Department and Section month and year-to-date quality cost expenditures.

Figure A2, Page 11 is a summary report used in reporting operating quality costs as defined in Cost Accounting Bulletin PC-9. As shown in Figure A2, the manufacturing operation at NDD is divided into two product lines: Tube and Systems. This summary report provides tube, system, and total costs information monthly in the categories of prevention, appraisal, and internal failure. External costs are not included due to our customer constraints. Measurement ratios, shown in the bottom portion of the figure, are included to provide indicators of cost trends for analysis purposes.

Figures A3 and A4, Pages 12 and 13 show the breakdown of accumulated cost data by quality cost code and operation unit for each product line unit.

Figure A5, Page 14 is a summary report of cumulative month and four-month moving average costs broken down by product line units and quality cost categories of prevention, appraisal, and internal failure. This report also provides cost ratios of prevention and appraisal to internal failure.

Figure A6, Page 15 is an example of the Operating Quality Costs report sent to General Electric Services quarterly. This report is extracted from the Summary Report shown in Figure A2.

Table AI, Page 16 is included in this section to clarify output reporting by describing product line unit code numbers listed in tube and system cost tab runs. For programing purposes, the category descriptions associated with each category code number are also listed.

Quality Cost Combined

EXAMPLE
Neutron Devices Department
Operating Quality Costs
_____ 1967

Sect/Oper	Current Month	Year To Date
400 Mfg	100,000	400,000
500 QC	150,000	700,000
600 Eng	20,000	90,000
700 Lab	3,000	10,000
800 Finance	10,000	50,000
Total Department	283,000	1,250,000

Figure A1. Summary - Department and Section Quality Cost Expenditures

Quality Cost Combined

EXAMPLE
Neutron Devices Department
Operating Quality Costs
1967

	Total Cost				Tube Cost				System Cost			
	Current Month Amt	Year To Date %	Current Month Amt	Year To Date %	Current Month Amt	Year To Date %	Current Month Amt	Year To Date %	Current Month Amt	Year To Date %	Current Month Amt	Year To Date %
Prevention												
01 Quality Planning												
02 Process Control Engineering												
03 Design & Dev of Qual Inf Equip.												
04 Quality System Engineering Planning												
05 Quality Training												
06 Process Engineering												
07 Production Engineering												
08 Laboratory												
09 Data Processing												
Appraisal												
21 Inprocess Test & Insp												
22 Quality Audits												
23 Incoming Insp												
24 Lab Test & Insp Inc Mat.												
25 Checking Labor												
26 Lab Test & Insp Inprocess												
27 Production Engineering												
28 Process Engineering												
29 Data Processing												
30 Quality Systems Engineering												
31 Process Control Engineering												
32 Lab Calibration & Verification												
33 Lot Certification Programs												
34 Life Test Programs												
Internal Failure												
41 Scrap at Full Shop Cost												
42 Lab Failure Analysis Inprocess Mat.												
44 Rework at Full Shop Cost												
45 Scrap and Rework - Fault of Vendor												
46 Lab Failure Analysis Vendor Material												
47 Material Procurement												
48 Factory Contact Eng Inprocess Mat.												
49 Factory Contact Eng Vendor Mat.												
Measurement Ratios												
To Direct Labor												
To Contributed Value												

EXAMPLE

Neutron Devices Department
 Operating Quality Costs
 1967
System Cost

	Current Month	Year To Date	Pts Fab	Sub Assm	Gl & Cer	Process	Pure Zone	Exhaust	Inc Insp	Final Test
Prevention										
01	Quality Planning									
01	500									
01	510									
02	Process Control Engineering									
02	500									
02	510									
02	520									
	Total									
Appraisal										
21	Inprocess Test & Insp									
21	500									
21	550									
26	Lab Test & Insp Inprocess									
26	811									
26	813									
27	Production Engineering									
27	660									
27	661									
	Total									
Internal Failure										
41	Scrap at Full Shop Cost									
41	434									
41	435									
41	437									
46	Lab Failure Analysis Vendor Mat.									
46	621									
46	811									
48	830									
49	Factory Contact Eng Vendor Mat.									
49	500									
49	520									
49	521									
	Total									
	Grand Total									

Figure A3. Accumulated System Cost Data

Quality Cost Report

EXAMPLE Neutron Devices Department Operating Quality Costs 1967 Tube Cost

	Current	Year To		Sub	Gl &		Pure		Inc	Final
	Month	Date	Pts Fab	Assm	Cer	Process	Zone	Exhaust	Insp	Test
CD Oper										
Prevention										
01	Quality Planning									
01	500									
01	510									
02	Process Control Engineering									
02	500									
02	510									
02	520									
09	Data Processing									
09	751									
									Total	
Appraisal										
21	Inprocess Test & Insp									
21	500									
21	550									
26	Lab Test & Insp Inprocess									
26	811									
26	813									
27	Production Engineering									
27	660									
27	661									
									Total	
Internal Failure										
41	Scrap at Full Shop Cost									
41	434									
41	435									
41	437									
46	Lab Failure Analysis Vendor Mat.									
46	621									
46	811									
46	830									
49	Factory Contact Eng Vendor Mat.									
49	500									
49	520									
49	521									
									Total	
									Grand Total	

Figure A4. Accumulated Tube Cost Data

EXAMPLE

Operating Quality Costs - 4 Month Moving Average

	Tube Cost																	
	Pts Fabr		Sub Assm		Gl & Cer		Process		Pure Zone		Exhaust		Inc Insp		Final Test		Summary	
	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg
Prevention	3.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	2.00	2.00	2.00	3.00	2.00	2.00	5.00	6.00	23.00	26.00
Appraisal	7.00	7.00	4.00	4.00	5.00	4.00	8.00	7.00	2.00	2.00	2.00	2.00	7.00	7.00	10.00	10.00	45.00	43.00
Total (P+A)	10.00	11.00	7.00	7.00	8.00	7.00	11.00	10.00	4.00	4.00	4.00	5.00	9.00	9.00	15.00	16.00	68.00	69.00
Internal Failure	15.00	11.00	6.00	7.00	20.00	14.00	27.00	12.00	20.00	12.00	16.00	9.00	11.00	10.00	20.00	24.00	135.00	99.00
Ratio of Prev & Appr to Int Fail.	0.60	1.00	1.10	1.00	0.40	0.50	0.40	0.80	0.20	0.30	0.30	0.60	0.80	0.90	0.75	0.75	0.50	0.70

	Systems Cost															
	Pts Fabr		Coils & TTA		Res Cast		Final Assm		Elect Assm		Inc Insp		Final Test		Summary	
	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg	Cur Mo	Mov Avg
Prevention	2.00	3.00	4.00	4.00	4.00	4.00	3.00	4.00	3.00	4.00	6.00	7.00	13.00	14.00	35.00	40.00
Appraisal	2.00	2.00	4.00	4.00	6.00	6.00	6.00	6.00	7.00	7.00	15.00	16.00	20.00	25.00	60.00	66.00
Total (P+A)	4.00	5.00	8.00	8.00	10.00	10.00	9.00	10.00	10.00	11.00	21.00	23.00	33.00	39.00	95.00	106.00
Internal Failure	4.00	3.00	1.00	1.00	8.00	8.00	7.00	5.00	2.00	2.00	4.00	4.00	22.00	13.00	48.00	36.00
Ratio of Prev & Appr to Int Fail.	1.00	1.70	8.00	8.00	1.10	1.10	1.30	2.00	5.00	5.50	5.30	5.80	1.50	3.00	2.00	2.90

Figure A5. Summary Report of Cumulative Month and Four-Month Moving Averages

NEUTRON DEVICES DEPARTMENT
OPERATING QUALITY COSTS
2ND QUARTER CY-67

Prevention	Total Cost
01 Quality Planning	\$
02 Process Control Engineering	
03 Design & Dev of Qual Inf Equip.	
04 Quality System Engineering Planning	
05 Quality Training	
06 Process Engineering	
07 Production Engineering	
08 Laboratory	
09 Data Processing	
Appraisal	
21 In-Process Test & Inspection	
22 Quality Audits	
23 Incoming Inspection	
24 Lab Test & Inspection Inc Mat.	
25 Checking Labor	
26 Lab Test & Insp In-Process	
27 Production Engineering	
28 Process Engineering	
29 Data Processing	
30 Quality Systems Engineering	
31 Process Control Engineering	
32 Lab Calibration & Verification	
33 Lot Certification Programs	
34 Life Test Programs	
Internal Failure	
41 Scrap at Full Shop Cost	
42 Lab Failure Analysis In-Process Material	
44 Rework at Full Shop Cost	
45 Scrap and Rework - Fault of Vendor	
46 Lab Failure Analysis Vendor Material	
47 Material Procurement	
48 Factory Contact Eng In-Process Mat.	
49 Factory Contact Eng Vendor Mat.	
Total Operating Quality Costs	
Measurement Ratios	
Net Sales Billed	
Total Direct Labor	
Total Contributed Value	

Figure A6. Report of Operating Quality Costs
Sent to General Electric Services Quarterly

Table AI
QUALITY CATEGORY AND PRODUCT LINE UNIT CODES

COST CODE

Prevention

01	Quality Planning
02	Process Control Engineering
03	Design and Dev of Quality Inf Equipment
04	Quality System Engineering Planning
05	Quality Training
06	Process Engineering
07	Production Engineering
08	Laboratory
09	Data Processing

Appraisal

21	In-Process Test & Inspection
22	Quality Audits
23	Incoming Inspection
24	Laboratory Test & Insp - Incoming Mat.
25	Checking Labor
26	Laboratory Test & Inspection (In-Process)
27	Production Engineering
28	Process Engineering
29	Data Processing
30	Quality Systems Engineering
31	Process Control Engineering
32	Laboratory Calibration & Verification
33	Lot Certification Programs
34	Life Test Programs

Internal Failure

41	Scrap at Full Shop Cost
42	Laboratory Failure Analysis - In-Process Material
44	Rework at Full Shop Cost
45	Scrap and Rework - Fault of Vendor
46	Laboratory Failure Analysis - Vendor Material
47	Material Procurement
48	Factory Contact Eng - In-Process Material
49	Factory Contact Eng - Vendor Material

PRODUCT LINE UNIT CLASSIFICATION CODES

Tube

51	Parts Fabrication
52	Subassembly
53	Glass and Ceramics
54	Process
55	Purezone
56	Exhaust
57	Incoming Inspection
58	Final Test

System

61	Parts Fabrication
62	Coils & Tube Transformer Assembly
63	Resin Casting
64	Final Assembly
65	Electronic Assembly
66	Incoming Inspection
67	Final Test

INPUT -- QUALITY COST DATA CALCULATIONS

Indirect Operating Quality Costs are based on the estimate of percentage effort expended in the applicable cost categories as defined in the Operating Quality Cost Guidelines (Appendix B), and as assigned to Product Line Units. These percentages of estimated effort are obtained by interviewing managers who are, or supervise other personnel, involved in the product quality activity. Each manager interviewed must comprehend the quality activities as related to their function and as defined in the established guidelines.

Prior to the actual interviews, Quality Cost Interview sheets (FC-139) are prepared for each operation unit to be interviewed, with all personnel listed thereon according to the latest organization chart. Figures A7 and A8, Pages 18 and 19 provide instructions for filling out these interview sheets. During the interview or preparation of the FC-139 interview sheet, all required entries are checked and changes are made as required.

Each individual's quality effort or contribution in an overall unit is calculated and noted as a weighted factor. The computer calculates this weighted factor from the actual salary extracted from the master payroll tape. (Manual approach: a weighted factor is calculated based on the mid-point of the levels and the high point of the grades and rate.) Salary information is retained on the master payroll tape and is not extracted. The weighted factor is retained, being calculated, and like quality cost information remains Company proprietary.

Procedure for Preparing "Quality Cost Data" - FC-139 Interview Sheet

The following procedure is used to prepare FC-139 interview sheets:

1. Each interviewing manager reviews the current organization chart to ensure listing of contemplated personnel changes.

QUALITY COST DATA
FC-139 (9-67)

SHEET OF

QUALITY COST DATA				QUALITY COST CATEGORIES										COST BREAKDOWN APPLICABLE TO MANUFACTURING UNIT																	
				Note: 5 Category Codes Maximum Per Person										BY		DATE		REV.		UNIT TITLE											
														51	52	53	54	55	56	57	58	61	62	63	64	65	66	67			
														PARIS FABRI LATION 434 T	SUB ASSEMBLY 435 T	CERAMIC 8-10-435 437 T	PROCES SING 438 T 439 T	PUREZONE 441 T	EXHAUST 442 T 443 T 444 T	INCOMING INSPEC TION 551 T 552 T	FINAL TEST 553 T 554 T	PARTS FABRI CATION 434 S	COILS 445 T 446 T 447 T	RESIN CASTING 448 S 449 S	FINAL ASM 450 S	ELEC TRONIC ASM 451 S	INCOMIN INSPEC TION 521 S	FINAL TEST 555 S 556 S			
JOB TITLE	BADGE No.	UNIT NUMBER	WEIGHTED FACTOR	CD	%	CD	%	CD	%	CD	%	CD	%	CD	%	33-35	36-38	39-41	42-44	45-47	48-50	51-53	54-56	57-59	60-62	63-65	66-68	69-71	72-74	75-77	
1. (1)	(1)	(2)	(3)	(5)	(6)	(5)	(6)	(5)	(6)	(5)	(6)	(5)	(6)	(4)																(4)	
2. (5) FOR EACH POSITION TITLE LIST THE QUALITY COST CATEGORY THAT REPRESENTS THE QUALITY EFFORT THAT WAS SHOWN IN ITEM (4) ABOVE.																															
3.																															
4.																															
5. EXAMPLE																															
6. A	0000	XXX		01		03		22		48						030			010	001	020										
7. B	0000	XXX		22		26																	100								
8. C	0000	XXX		02		05		27		30		49					050	040													
9.																															
10. (6) APPORTION EACH INDIVIDUAL'S TOTAL QUALITY EFFORT AS LISTED IN ITEM (4) ABOVE TO THE QUALITY COST CATEGORIES (AS LISTED IN ITEM (5) ABOVE)																															
11. ON A CODED BASIS, THE APPORTIONMENT BY QUALITY COST CATEGORY MUST TOTAL 100%.																															
12.																															
13. EXAMPLE																															
14. A	0000	XXX		01	010	03	030	22	040	48	020					030			010	001	020										
15. B	0000	XXX		22	050	26	050																100								
16. C	0000	XXX		02	010	05	010	27	010	30	010	49	060				050	040													
17.																															
18. FOR THIS EXAMPLE, THE APPORTIONMENT OF QUALITY EFFORT TO QUALITY COST CATEGORY IS AS FOLLOWS:																															
19. A B C																															
20. 10% IN QUAL. COST CATEGORY 01 50% IN QUAL. COST CATEGORY 22 10% IN QUAL. COST CATEGORY 02																															
21. 30% IN QUAL. COST CATEGORY 03 50% IN QUAL. COST CATEGORY 26 10% IN QUAL. COST CATEGORY 05																															
22. 40% IN QUAL. COST CATEGORY 22 TOTAL 100% 10% IN QUAL. COST CATEGORY 27																															
23. 20% IN QUAL. COST CATEGORY 48 10% IN QUAL. COST CATEGORY 30																															
24. TOTAL 100% 60% IN QUAL. COST CATEGORY 49																															
25. TOTAL 100%																															
26.																															
27.																															
28.																															

Figure A7. Example of Filling Out FC-139 Interview Sheet

2. Each interviewing manager reviews and applies Quality Cost Guidelines for the quality activity of his unit.
3. Each interviewing manager records in the appropriate columns, under the heading CD, the quality cost category codes (prevention, appraisal, and internal failure) that apply to an individual's quality activities. Not more than five category codes per individual are used. Note in the examples shown in Figures A7 and A8 that the first individual (Example "A") has recorded 01 and 03 categories under prevention, 02 under appraisal, and category 48 under internal failure.
4. After establishing the types of effort in Step 3, the interviewing manager then records, in the appropriate remaining columns, the percentage of each individual's quality effort that is applicable. This percentage can range from 100 - 0%. Decimals or fractions of a percent must not be recorded. Whole numbers are used in steps of 1 or larger, for example: 5% = 005, 10% = 010, etc.
5. The total percentage effort recorded under all Manufacturing Units (Product Line Units) represents 100% of each individual's quality effort. Of this quality effort, the percentage that applies to each selected code (Step 3) is recorded by the interviewing manager. The total percentage for all applicable category codes must equal 100%.

Method I Calculation Procedure - Computer

After all interviews are complete and each individual's effort and contribution are allocated properly, it is necessary to calculate a weighted factor based on salary.

Since the total percentage effort allocated to each manufacturing unit and each quality category for each operation unit is desired, the following calculations are necessary to place all data on a common base for summation:

1. To calculate the weighted factors, Data Processing refers to the individual's current salary or hourly rate appearing on the master payroll tape. A summarization is performed to determine the overall effort of an operation unit. By computer, each individual's actual salary is equated to the total. This decimal value is the weighted factor and represents each individual's contribution to the overall operation unit quality effort.
2. The decimal value to be delegated to a particular operation unit for a particular category code, by individual, is calculated by multiplying the percentages recorded under each product line unit by the applicable weighted factor. These decimal values are then multiplied by the percentage in the applicable category code column.
3. To calculate the total decimal value for a particular category code, by individual, add all decimal values calculated for all applicable operation units.
4. The total decimal figure for each category code is obtained by adding the values listed in the category code columns. This decimal, when multiplied by operation unit dollars, indicates the correct dollars to be allocated to a particular category code for a particular operation unit.

5. The total decimal figures for each manufacturing unit are obtained by adding the values listed in each manufacturing unit column. These decimal totals, when added together, must equal the total value calculated in Step 4. The individual totals, when multiplied by total operation unit dollars, indicate the correct dollars to be allocated to each product line unit for a particular category code.
6. To calculate the total percentage contribution of each operation unit to operating quality costs, the total decimal values for all category codes are summarized.
7. The total indirect expense of each operation unit that is to be used in the calculation of operating quality costs, as referenced in Steps 4 and 5, is calculated by determining the accounts containing quality costs. Refer to Table AII, Page 23. This table gives the accounts that apply to the recorded Department organizational sections; it indicates which accounts are quality cost related. These accounts are totaled by computer for each reporting period. For proper allocation of quality cost dollars, the account totals are multiplied by the applicable percentage (Steps 4 and 5).

Calculations must start at the lowest organizational level to reflect the accumulated percentage distribution of each unit, etc. When managers are interviewed individually and separate percentages are accumulated to reflect their personal work effort distribution, the preceding starting point does not apply and the overall calculations become much simpler. Since all calculations are performed independently to reflect the manager's work effort distribution of his unit, it is necessary to carry over to the next higher organizational level, etc. all totalized calculations for each manufacturing unit under each code. These decimals become the percentages for the next level of calculations for each manager involved.

Table AII
INDIRECT EXPENSE STATEMENT

Account Class No.	Finance		Quality Control		Laboratory		Engineering		Manufacturing	
611-00	X	C	X	C	X	C	X	C	X	C
612-00	X	C	X	C	X	C	X	C	X	C
613-20			X		X	C			X	C
614-10			X	C					X	C
614-20			X	C					X	C
614-92			X	C					X	C
614-93			X	C					X	C
614-94			X	C					X	C
621-11	X	C	X	C	X	C	X	C		
621-12	X	C	X	C	X	C	X	C	X	C
621-13			X	C	X	C			X	C
621-14			X	C					X	C
625-11			X	C	X	C			X	C
625-12			X	C	X	C			X	C
625-13			X	C	X	C			X	C
625-14			X	C	X	C			X	C
626-13	X	C	X	C	X	C			X	C
626-14	X	C	X	C	X	C			X	C
631-99	X	C	X	C	X	C	X	C	X	C
641-01	X		X		X		X		X	
641-03			X	C	X					
642-02	X	C	X	C	X	C	X	C	X	C
642-05			X	C	X	C			X	
643-11			X		X		X			
643-12			X		X		X			
644-02	X	C	X	C	X	C	X	C	X	
648-01			X	C	X	C	X	C		
649-02	X	C	X	C	X	C	X	C	X	
649-04	X		X	C	X	C				
649-05	X		X	C	X	C				
649-07			X	C	X		X		X	
649-08	X		X	C	X		X			
649-09			X	C	X		X			
649-22			X	C			X			
649-49			X				X			
649-52			X	C	X	C	X	C		
651-01			X	C						
651-02	X	C								

Legend

X = Budgeted

C = Quality Cost Related

The computed weight factors provide an audit trail to ensure that input information into the tab runs is correct. All operation unit weighted factors summarize to equal one and are verified in the computer run.

Method II Calculation Procedure - Manual

After all interviews are complete and each individual's effort and contribution are allocated properly, it is necessary to calculate a weighted factor based on salary.

The weighted factors are calculated by referring to the exempt salary structure chart, nonexempt structure chart, or hourly rate structure chart, whichever is applicable. For exempt personnel, the value representing the midpoint of the level is used. For nonexempt and hourly personnel, the value representing the high point of the grade or rate is used. These values are accumulated for a given operation unit and represent, in dollars, the overall effort of an operation unit. Each individual's estimated salary is equated to the total. This decimal value is the weighted factor and represents each individual's contribution to the overall operation unit effort.

The weighted factor information is transferred to the FC-139 interview sheet. All data is keypunched and it is run similarly to the computerized method.

APPENDIX B

Appendix B
DETAILED EXPLANATION
OF QUALITY COST COLUMN TITLES - GUIDELINES

The definition and disposition of preproduction and design improvement costs and managers' activities are as follows:

Preproduction Costs:

Include only costs which are directly associated with the accomplishment of First Production Unit (FPU) activity.

Exclude costs associated with developmental work, Production Engineering Notices (PEN), and Experimental Engineering Notices (EEN).

Design Improvement Costs:

Include minor design changes to correct quality problems.

Include new design criteria not requiring Tool Made Sample (TMS) activity.

Include changes in criteria for old design to meet new design criteria without changing product design and for which the criteria does not exceed original functional design intent.

Include continued inherent design deficiency.

Include single source vendors when vendor is specified by design agency and specification is impossible to verify.

Exclude costs associated with major design improvements which would require a special TMS run.

Exclude changes in criteria for old design to meet new design criteria without changing product design when the criteria does exceed original functional design intent.

Exclude failure of lot samples after time that results from an initial design defect.

Managers' Activities:

Include with their respective units.

The following outline provides a detailed explanation of the items which comprise prevention, appraisal, and internal failure costs:

I. Prevention - Represents costs which are incurred for planning, implementing, and maintaining a quality system that will assure manufacturing conformance to quality requirements and at economic levels of quality.

A. Quality Planning (Unit Code No. 01) - Represents costs associated with time that personnel in the Quality Control function spend in: 1) planning the quality system, and 2) translating product design and customer quality requirements into specific manufacturing controls on quality of materials, processes, and products through formal methods, procedures, and instructions.

1. Activities identified under Quality Planning:

a. Effort expended by Quality Control Engineering organization:

(1) Determining the quality objectives.

(2) Planning, organizing, and documenting the Quality Control Plan to meet the quality objective.

(3) Measuring to assure compatibility between the Quality Control Plan and the Department Quality System.

(4) Developing new control techniques.

b. Effort expended in developing and generating inspection plans.

- c. Effort spent by Quality Control personnel (Incoming Materials Subsection) in establishing the Quality Plan in assigned area.
- d. Review Quality Plans for equipment and gaging applications.
- e. The Quality Planning category does not include Department Quality Control Manager's salary.

B. Process Control Engineering (Unit Code No. 02) - Represents costs associated with the implementation of the Quality Plan, evaluating its effectiveness, and maintaining it in applicable areas.

- 1. Activities identified under Process Control Engineering:
 - a. Time spent in programing and measuring process capability studies.
 - b. Time spent on control charts.
 - c. Effort spent in studying and analyzing manufacturing processes to establish or re-establish control.
 - d. Effort applied to selecting, preparing, and approving limit samples.
 - e. Process Control Engineer (Incoming Material) and Quality Control Field Engineer efforts are in this category.
 - f. Review of TMS and FPU performance.

C. Design and Development of Quality Information Equipment (Unit Code No. 03) - Represents costs associated with planning and designing test and inspection equipment used to measure in-plant product, processes, and vendor materials to the Quality Plan.

1. Activities identified under Design and Development of Quality Information Equipment:

- a. Schedule, design, procure, check out, certify, and determine capability of Quality Information Equipment.
- b. Analysis of measurement techniques on pre-production equipment (TMS only).
- c. Review drawing requirements to assure measurability of specific product characteristics.
- d. Issuing Operating Instructions for test and inspection equipment and calibration and verification instructions.
- e. Documenting Quality Information Equipment for outside procurement.
- f. Time spent by Process and Production Engineering in assisting in the planning and designing of Quality Information Equipment.
- g. Designing and developing Laboratory Quality Information Equipment for Quality Assurance activities used by the Laboratory.

(1) Examples of Laboratory Quality Information Equipment (preproduction is not included):

- (a) Laboratory test equipment.
- (b) Laboratory inspection equipment.
- (c) Reliability testing equipment.
- (d) Life testing equipment.
- (e) Special measuring equipment for new materials, components, and processes.

- (i) Writing calibration and verification procedures for Department measurement equipment. (Note: Qualification - effort for multiple usage equipment should be appropriately proportioned.)

D. Quality Systems Engineering Planning (Unit Code No. 04) - Represents time spent by Quality Systems Engineering organization in planning the Quality System.

1. Activities included under Quality Systems Engineering Planning:

- a. Time spent by Quality Systems Engineering personnel and Statistical Engineers in initiating and maintaining the data requirements for the Quality Plan.
- b. Manager, Quality Systems Engineering, and his staff are included.
- c. Time spent by Quality Systems Auditors in performing procedure type audits which measure the effectiveness of the Quality System.

E. Quality Training (Unit Code No. 05) - Represents internal training in Quality Control techniques for personnel involved in preventive activities such as quality training given to Quality Control, Process, and Product Engineers.

1. Activities included under Quality Training:

- a. Quality planning.
- b. Capability studies.
- c. Source control.
- d. Sampling.

F. Process Engineering (Unit Code No. 06) - Represents time spent by the Process Engineer and Tool and Gage Designers as required by quality planning.

1. Activities included under Process Engineering:
 - a. Incorporating source control, first piece inspection, or other quality plans into the manufacturing plan. (QC Flow Chart activity)
 - b. Gage designing.
 - c. Review of Process Capability Studies.
- G. Product Engineering (Unit Code No. 07) - Represents time spent by Production Engineering as required by quality planning.
 1. Activities included under Product Engineering:
 - a. Functional classification of characteristics.
 - b. Review of Quality Control operation sheets.
- H. Laboratory (Unit Code No. 08) - Represents time spent by the Laboratory Operation (refer to Preproduction definition).
 1. Activities included under Laboratory:
 - a. Planning preproduction tests and feedback systems.
 - b. Assisting in establishment of special quality standards such as photographing limit samples, etc.
 - c. Instructions written by Laboratory personnel for use of other Laboratory personnel in performing tests on the product, components, or material.
- I. Data Processing (Unit Code No. 09) - Represents effort exerted by Data Processing personnel in setting up, generating, and maintaining Quality Control data requirements.

II. Appraisal - Costs which are incurred in measuring and evaluating products, materials, or components to assure conformance to quality standards.

A. In-Process Test and Inspection (Unit Code No. 21) - Represents costs associated with the time that inspection personnel spend in evaluating the quality and technical performance of the product in the shop, and applicable costs of supervisory and clerical personnel.

B. Quality Audits (Unit Code No. 22) - Represented by the following:

1. Time that Quality Assurance Auditors spend in performing routine quality review on in-process or finished product.

C. Incoming Inspection (Unit Code No. 23) - Represented by the following:

1. Time that Inspection and Test personnel spend on evaluating the quality of purchased material.
2. Field Engineers' activities associated with the verification of vendors' process controls and evaluation of purchased materials.

D. Laboratory Test and Inspection - Incoming Materials (Unit Code No. 24) - Represents qualification and acceptance testing provided by the Laboratory to evaluate the quality of purchased materials including destructively tested samples.

E. Checking Labor (Unit Code No. 25) - Represents time spent by shop operators in the performance of a manufacturing operation under the following conditions:

1. Performance of a manufacturing operation that fulfills the Quality Assurance function and which Quality Control would be required to perform if it were not done by Manufacturing operations.

2. Performance of sorting operations which are required to segregate a good part from a deviating part in rejected lots.
- F. Laboratory Test and Inspection - In-Process (Unit Code No. 26) - Represents costs associated with the Laboratory effort in testing and evaluating in-plant product per Quality Plan.
- G. Production Engineering (Unit Code No. 27) - Represents time spent by Production Engineering in assuring that the product or process meet design intent. This includes only items requested by Process Control Engineering, Quality Control Engineering, or Quality Assurance.
- H. Process Engineering (Unit Code No. 28) - Represents time spent by Process Engineering in assuring that the product or process meet design intent. This includes only items requested by Process Control Engineering, Quality Control Engineering, or Quality Assurance.
- I. Data Processing (Unit Code No. 29) - Represented by the following:
1. Collecting of data and generating of quality oriented reports.
 2. Establishing a check system and subsequent correction system.
 3. Key punching and machine operators' time in generating Quality Control reports.
- J. Quality Systems Engineering (Unit Code No. 30) - Represents time spent in accumulating, reporting, and analyzing quality control data on production material.
- K. Process Control Engineering (Unit Code No. 31) - Represented by the following:
1. Time spent in reviewing inspection and test data prior to release of product for shipment.

2. Time spent in interpreting product, material, or component quality attributes data prior to the generation of a deviating material report.
3. Process Control Engineer (Incoming Material) and Quality Control Field Engineer efforts are included in this category.

L. Laboratory Calibration and Verification (Unit Code No. 32) -

Represents time spent by Laboratory personnel in calibrating and maintaining Department measurement equipment including maintenance of an associated record system. Limited to equipment required for control of process and product to provide quality information for meeting intent for certification.

1. Areas included under Laboratory Calibration and Verification:
 - a. General Instrumentation.
 - b. Test Equipment Instrumentation.
 - c. Electrical and Physical Standards.

M. Lot Certification Programs (Unit Code No. 33) - Represents losses incurred in stressing the product beyond the limits allowable for shippable product or otherwise rendering it unsuited for delivery.

N. Life Test Programs (Unit Code No. 34) - Represents material and labor costs incurred during life and other special testing programs which are not a part of the customer's specification.

1. Programs included under Life Test Programs:
 - a. Shelf Life Programs.
 - b. Operational Life Programs.

III. Internal Failure - Represents costs which arise when it is determined prior to shipment that products, materials, and components fail to meet a specified level of quality. (Note: Preproduction and obsolescence losses are not included.)

A. Scrap at Full Shop Cost (Unit Code No. 41) - Scrap costs representing material and labor which must be discarded due to nonconformance of material to fabrication specifications. This category does not cover losses incurred by faulty vendor material.

1. Examples of losses included under Scrap at Full Shop Cost:

- a. Production Design Deficiency Losses - Attributed to any deficiency in the design or engineering of the product.
- b. Specification or Instruction Error Losses - Attributed to incomplete or inaccurate preparation of drawings, operation sheets, or other written processing or test and inspection instructions. Misinterpretation of specifications in the procurement of materials are included in this category.
- c. Operator Error Losses - Attributed to failure of Manufacturing or Quality Control personnel to conform to instructions or specifications or from improper set up, operation of test equipment, etc.
- d. Equipment Malfunction Losses - Attributed to malfunctioning of Manufacturing or Quality Control process, test, or inspection equipment.
- e. Defective Tools, Jigs, and Fixtures Losses - Attributed to improper design; worn, broken or otherwise defective tools, jigs, fixtures, or gages.
- f. Non-homogeneity Losses - Attributed to a determination that a portion of a lot of material is not homogeneous to the remainder of its lot and not recoverable by the creation of a sub-lot.

- B. Laboratory Failure Analysis - In-Process Material (Unit Code No. 42) - Represents costs associated with evaluating defective material or product to determine a cause. (Note: Preproduction or special evaluation for design change are not included.)
- C. Rework at Full Shop Cost (Unit Code No. 44) - Represents the cost of labor and material that is expended in bringing nonconforming material to an acceptable level of quality.
- D. Scrap and Rework - Fault of Vendor (Unit Code No. 45) - Represented by the following:
1. Losses, including direct labor incurred on in-process material, attributable to defective vendor material.
 2. Losses resulting from defective material found prior to acceptance by Incoming Inspection.
 3. Material that does not meet specification at Incoming Inspection and is not returned to the supplier.
- E. Laboratory Failure Analysis - Vendor Material (Unit Code No. 46) - Represents costs associated with evaluation of faulty vendor material as to a cause.
- F. Material Procurement (Unit Code No. 47) - Represents additional Purchasing costs associated with handling both deviating material and complaints on purchased material.
1. Examples of costs included under Material Procurement:
 - a. Review of Deviating Material Reports.
 - b. Preparation of telegrams, etc.
 - c. Discussion time with appropriate engineer.
 - d. Preparation of necessary paperwork such as letters, shipping notices, etc.
 - e. Expediting replacement material.

G. Factory Contact Engineering - In-Process Material (Unit Code No. 48) - Represents time spent by engineers engaged in in-process production problems involving quality, such as material which does not conform to quality specifications. (Note: This category does not include vendor material nor engineering development activities.)

1. Examples of costs included under Factory Contact Engineering - In-Process Material:

a. Time spent by the following on production material or components not conforming to quality specifications:

- (1) Process Control Engineer
- (2) Quality Control Engineer
- (3) Statistical Engineer

b. Time spent by engineers and other personnel associated with Material Review Board (MRB) activities.

c. Time spent by Quality Control Foremen, Engineers, and Clerks in processing deviating material and reports.

H. Factory Contact Engineering - Vendor Material (Unit Code No. 49) - Represents time spent by engineers engaged in vendor material problems involving quality such as material which does not conform to quality specifications.

1. Costs included under Factory Contact Engineering - Vendor Material:

a. Time spent by the following on production material or components not conforming to quality specification:

- (1) Process Control Engineers
- (2) Production Engineers
- (3) Quality Control Engineers

- b. Time spent by Quality Control Foremen, Engineers, and Clerks in processing deviating material and reports.
- c. Time spent by engineers and other personnel associated with material review activities.

APPENDIX C

Appendix C
EXAMPLE OF DEPARTMENT QUALITY CONTROL INSTRUCTION
SUBJECT

FC1124 (9-44) NEUTRON DEVICES DEPARTMENT QUALITY CONTROL INSTRUCTIONS GENERAL ELECTRIC COMPANY	CALCULATING AND REPORTING OPERATING QUALITY COST
OPERATION QUALITY SYSTEMS ENGINEERING	TAB QUALITY MEASUREMENTS
	INSTRUCTION NO. I. Q.1.01

PURPOSE

This instruction is for the purpose of outlining:

- A. The procedure to be followed in collecting Operating Quality Cost data.
- B. The method for reporting Operating Quality Costs.

GENERAL

- A. This procedure applies to those individuals and their respective managers who are involved in activities directly associated with Operating Quality Costs, which are defined as: 1) Cost of Prevention, 2) Cost of Appraisal, 3) Cost of Internal Failure.

DEFINITIONS

- A. Costs of Prevention - Represent costs which are incurred for planning, implementing, and maintaining a quality system that will assure manufacturing conformance to quality requirements and at economic levels of quality.
- B. Costs of Appraisal - Represent costs which are incurred in measuring and evaluating products, materials, or components to assure conformance to quality standards.
- C. Costs of Internal Failure - Represent costs which arise when it is determined prior to shipment that products, materials and components fail to meet a specified level of quality requirements.

PROCEDURE

- A. Flow Chart and Linear Responsibility Chart (See pages 2 and 3).

* Retyped, no procedure changes

APPROVED BY	DATE ISSUED	SUPERSEDES	PAGE
Manager - Quality Systems Engineering	11/30/67	6/20/67	1 of 3

LINEAR RESPONSIBILITY CHART

Q.C.I. Q.1.01
11/30/67

FUNCTION	FINANCE	QUALITY CONTROL	PRODUCTION ENGINEERING	MANUFACTURING	LABORATORY
Distribute Operating Quality Cost Forms (FC-139)		■			
Responsible for providing correct and timely Operating Quality Cost input data on Form 139	■	■	■	■	■
Calculate weight factors	■				
Provide New York Services with Operating Quality Cost Report	■				
Key Punch data	■				
Review and analyze Operating Quality Cost input data		■			
Provide Spoilage data and Rework data	■	0	0	0	0
Edit, plot Operating Quality Cost Trend data, and distribute report		■			
Prepare Operating Quality Cost Tab Runs	■				
Review Tab Runs output for Processing errors	■	S			
Process Operating Quality Cost data	■				
Maintain an integrated program to assure all Quality Costs input are current		■			

DEGREE OF PARTICIPATION

0
S
■

= Concurrence

= Consult

= Work is Done (See Flow Chart & Instructions)

FLOW CHART

Appendix C
EXAMPLE OF MONTHLY EXCEPTION REPORT

Subject: Quality Cost

To: Managers, Manufacturing
Laboratory
Engineering

Issued by: Manager, Quality Control

Date: November 10, 1967

Enclosed are the Quality Cost Charts reflecting the current year trends.

In summary, the charts reflect:

- A. YTD Quality Cost Expenditure Chart shows a YTD expenditure in excess of last year's expenditure at this time.
- B. Total YTD Operating Quality Cost as a percentage to net sales is running approximately 3% lower than FY-67.
- C. Monthly Quality Cost Expenditure Graph No. 3 shows an increasing failure trend. This situation warrants review of Graph No. 4 to determine the specific areas where these losses are occurring.
- D. Trend Graph No. 5 reflects a constant trend in operational quality cost.
- E. The Operation Detail Breakdown Graph No. 4 continues to show high failure costs at Final Test in both Systems Operations and Tube Operations. Five major contributors in order of dollar loss to the failure costs for the month of June were as follows:

<u>Component</u>	<u>Drawing</u>	<u>Failure Symptoms</u>
Widget - large	A	End Fracture
Widget - small	B	Incorrect Dimensions
Widget - medium a	C	Operator Error
Widget - medium b	D	Operator Error
Widget - medium c	E	Operator Error

STATUS REPORT: DEPARTMENT QUALITY COST TRENDS

1 (a)

YTD Quality Cost Expenditure (\$1000)

MONTH	J	A	S	O	N	D	J	F	M	A	M	J
FY-67	200	300	400	500	750	825	900	1000	1100	1200	1350	1500
FY-68	150	250	650	750								
Incr'd Cost Over FY-67			250	250								

1 (b)

YTD QUALITY COSTS
COMPARISON: FY 68-67

2 (a)

Total YTD Operating Quality Cost - % to Gross (PS&S)*

MONTH	J	A	S	O	N	D	J	F	M	A	M	J
FY-67	6.2	5.2	5.5	5.7	5.8	5.9	5.9	5.9	5.8	5.7	5.5	5.6
FY-68	4.6	4.0	5.0	5.2								
Increase % Over FY-67												

* Product Storage & Surveillance

2 (b)

YTD QUALITY COST TO PS&S
COMPARISON: FY 68-67

3. Analysis of FY-68 - Monthly Quality Cost Expenditure
(Internal Failure \$ Versus Prevention + Appraisal \$)

4. Operation Detail Breakdown (4-Month Moving Average) - FY-68

5. Trend Chart of Responsibilities for Managing Quality Costs

Appendix C QUALITY ENGINEERING AIDS IN QUALITY COST CONTROL

INTRODUCTION

This section of Appendix C provides summary statements on marginal analysis techniques and nomograph application (1), (2), (3). These techniques are in the prototype stage of development at NDD, and they are aimed at improving the analysis effectiveness of Quality Cost.

MARGINAL ANALYSIS TECHNIQUES AND NOMOGRAPH APPLICATION

Total Quality Cost Programs in actual practice have been successful when they have met the twin challenge of better quality at lower cost.

The purpose of this report section is to present two complementary techniques which are aimed at demonstrating potential areas of Quality Cost reduction. Both of these techniques illustrate opportunities of turning the cost cycle downward by adjustment of either prevention and/or appraisal dollars. This adjustment is based on the premise that total Quality Cost warrants analysis, because in itself it is either high in dollar value or it is high in relation to a comparison base.

In the marginal analysis technique, Quality Cost information is converted into an arithmetic relationship for marginal decision making, e. g., cost data as given in Table CI.

Table CI
ARITHMETIC RELATIONSHIP OF QUALITY COST DATA

Month	Given Information	Computed Results	
	Total Year-to-Date (QC) Dollars	Average (QC) Dollars/Mo.	*Marginal Dollars/Mo.
0	0	-	-
Oct	10	10	10
Nov	22	11	12
Dec	33	11	11

June	99	11	14
$\bar{X}$		10.72	

*The amount of Quality Cost dollars added to the total each month.

The plot of average and marginal prevention, appraisal, and failure dollars illustrates significant trends in the cost expenditures, see Figure C1.

When observing the data information trend in this manner, consideration needs to be given in factoring in the theorems on resource allocation, whereby:

1. The total figure is always the sum of the preceding marginal figures.
2. For the average to rise, the marginal figures must be above the average figures; for the average to remain unchanged, the average and marginal figures must be equal; for the average to fall, the marginal figures must be below average.

The second statement is often misunderstood and can be reasoned as follows:

When the average figure falls, the marginal figure must also fall; when the average remains unchanged, the marginal figure remains unchanged. This faulty reasoning, however, is easily refuted, as shown in Table C1, where the average monthly cost in the month of December was 11 and remained constant for two periods. In this same period of time, the marginal figure changed from 12 to 11.

In the four area examples, illustrated in Figure C1, it can be noted that the Quality Cost areas of activity cost trends either go down, remain stable, or increase:

Area A illustrates an increasing trend in appraisal costs and a decreasing trend in failure costs. Both failure and appraisal costs are significantly high in dollar value in comparison to prevention costs.

Area B illustrates an increasing trend in both appraisal and failure costs with no adjustments in prevention effort.

Prevention Costs

Appraisal Costs

Failure Costs

Area A

Area B

Area C

Area D

Figure C1. Plot of Average Versus Marginal Data (Area Examples A - D)

Area C illustrates an increasing trend of failure cost with no commensurate adjustment of either prevention or appraisal effort.

Area D illustrates a decreasing trend in appraisal costs and a constant trend in prevention and failure dollars.

Figure C2 is an overlay of quality cost data, and it provides an additional perspective in making trend comparisons.

To amplify the analysis process prior to any action, it is highly recommended that Quality Cost dollar data be plotted on the Total Quality Cost dollar nomograph. The grand averages of the prevention, appraisal, and failure dollars for all areas are computed and listed on one sheet (Table CII). All area operations are viewed in perspective relative to each other. This information is then applied to the nomograph.

Figure C3 illustrates a blank Total Quality Cost Nomograph. Figure C4 illustrates the use of the nomograph and the concept of balancing the input (prevention plus appraisal) dollars versus the output (failure) dollars. The point on the vertical line representing the area of Total Quality Cost provides the fulcrum point in this balance, wherein the weights to be balanced are input dollars versus output dollars. The arrows placed in the proximity of the input dollar point (prevention plus appraisal dollar value) direct attention to potential opportunity areas.

Notations from both the marginal analysis techniques and the nomograph are presented in Table CII. From this information, experienced Quality Engineers can evaluate the scope of action to be taken in any of the various work areas. However, constraints need to be considered, e. g., excessively imposed special testing, the opportunity for rework in the area, whether existent or nonexistent, and other substantiating reasons. These factors are needed to mitigate callous observation and are factored in prior to taking any action in adjustment of prevention and appraisal work effort.

$$\text{Total Quality Cost \$} = \text{Prevention \$} + \text{Appraisal \$} + \text{Failure \$}$$

Solution:

Extend a straight line from the selected value on the P scale to the selected value on the A scale. From the intersection of this line with the P + A scale, extend another line to the selected value on the F scale. Where this line intersects the T scale, read the Total Quality Control Dollar value.

Figure C3. Total Quality Cost Dollar Nomograph

$$\text{Total Quality Cost \$} = \text{Prevention \$} + \text{Appraisal \$} + \text{Failure \$}$$

Solution:

Extend a straight line from the selected value on the P scale to the selected value on the A scale. From the intersection of this line with the P + A scale, extend another line to the selected value on the F scale. Where this line intersects the T scale, read the Total Quality Control Dollar value.

Figure C4. Total Quality Cost Dollar Nomograph Plot of Table CI Data

Table CII
QUALITY COST EXPENDITURE PER EACH AREA

Work Areas	P	XX	A	XX	P+A XXX	F	XX	Total Cost
G	3.53		5.11		↑	21.31		29.95
B	3.03		2.01		↑	14.47	↑	19.51
H	10.72		10.70	↑	↑	25.83		47.23
L	5.81		10.37		↓	2.55	↑	18.73
C	9.92		17.84	↑	↓	3.14	↑	30.90
D	15.63		40.88	↑	↓	30.90	↓	87.41

Note:

XX = Marginal analysis indication of action occurring, e. g., cost increase.

XXX = Nomograph indication of required action to be taken on (P+A) expenditure, e. g., increase, decrease effort.

$$\bar{X} = \frac{\Sigma \bar{X}}{n} = \frac{\Sigma (\text{Average Total Cost/Month})}{\text{No. of Monthly Increments}}$$

e. g., $\frac{64.32}{6} = 10.72$

P = Prevention

A = Appraisal

F = Failure

Note:

Data listed in \$1000's, e. g., 3.56 = \$3650

The techniques of marginal analysis and nomograph applications are not restricted to Quality Cost analysis. It is recommended that their use be made by the Quality Engineer in other areas where variable trend solutions are sought and/or repeated use of equations exist.

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